T. G. MARTIN.

TWO WIRE ROTARY CONNECTOR TELEPHONE SYSTEM.

APPLICATION FILED OCT. 11, 1909. RENEWED JUNE 7, 1918.

1,291,990.

Patented Jan. 21, 1919.

3 SHEETS—SHEET 1.

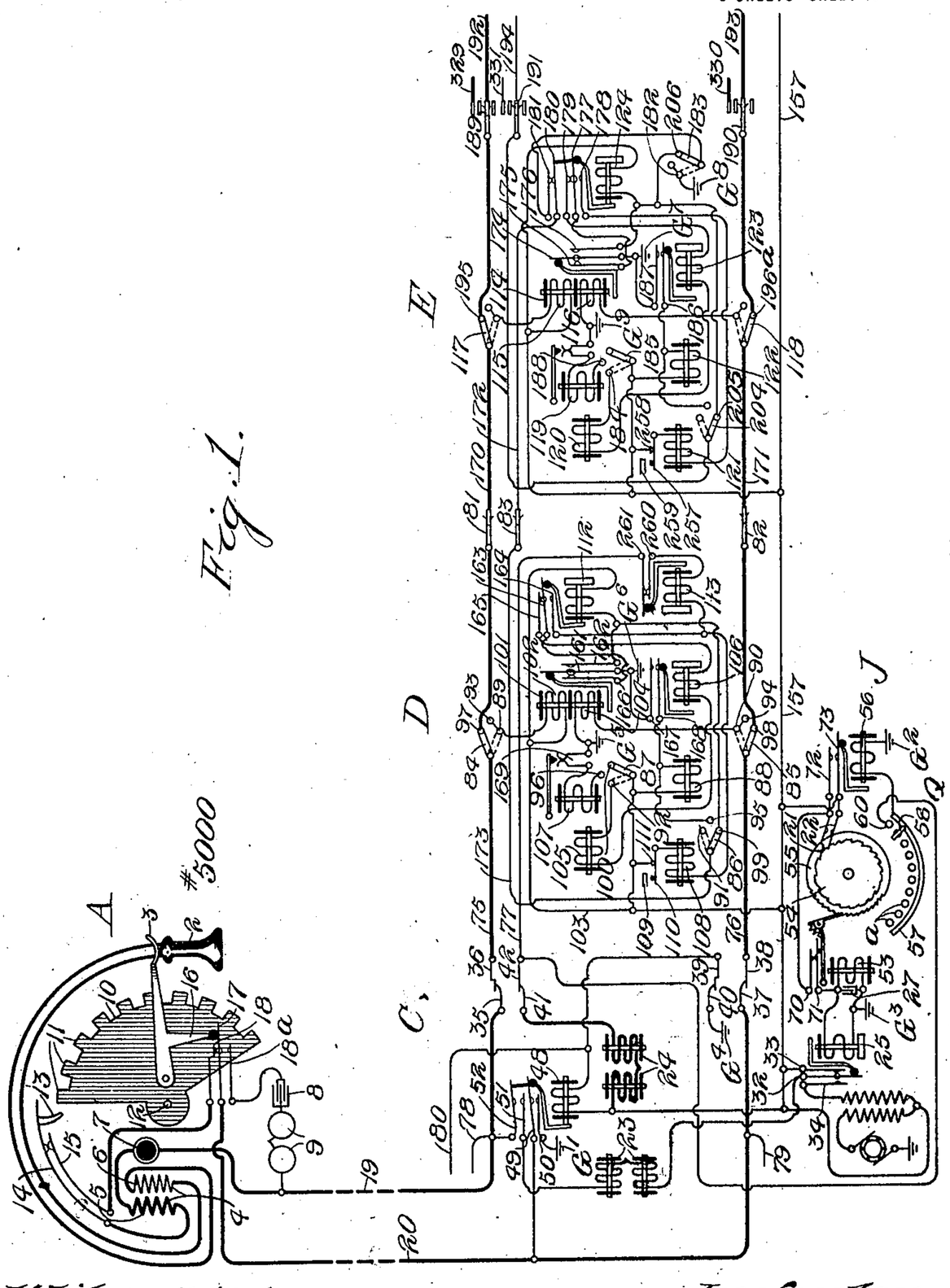

Fig. 1.

Witnesses.
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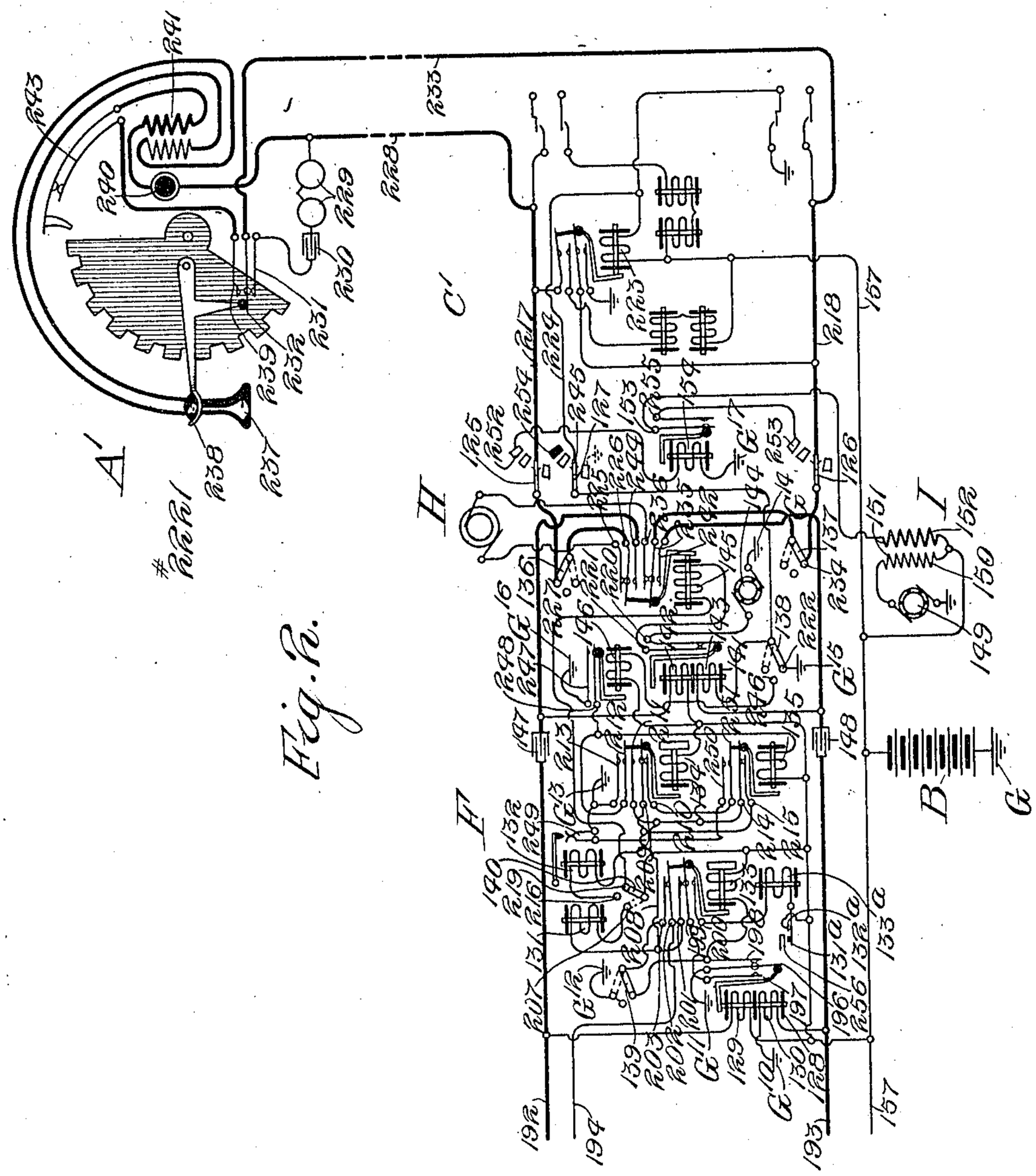

Fig. 2.

Witnesses.
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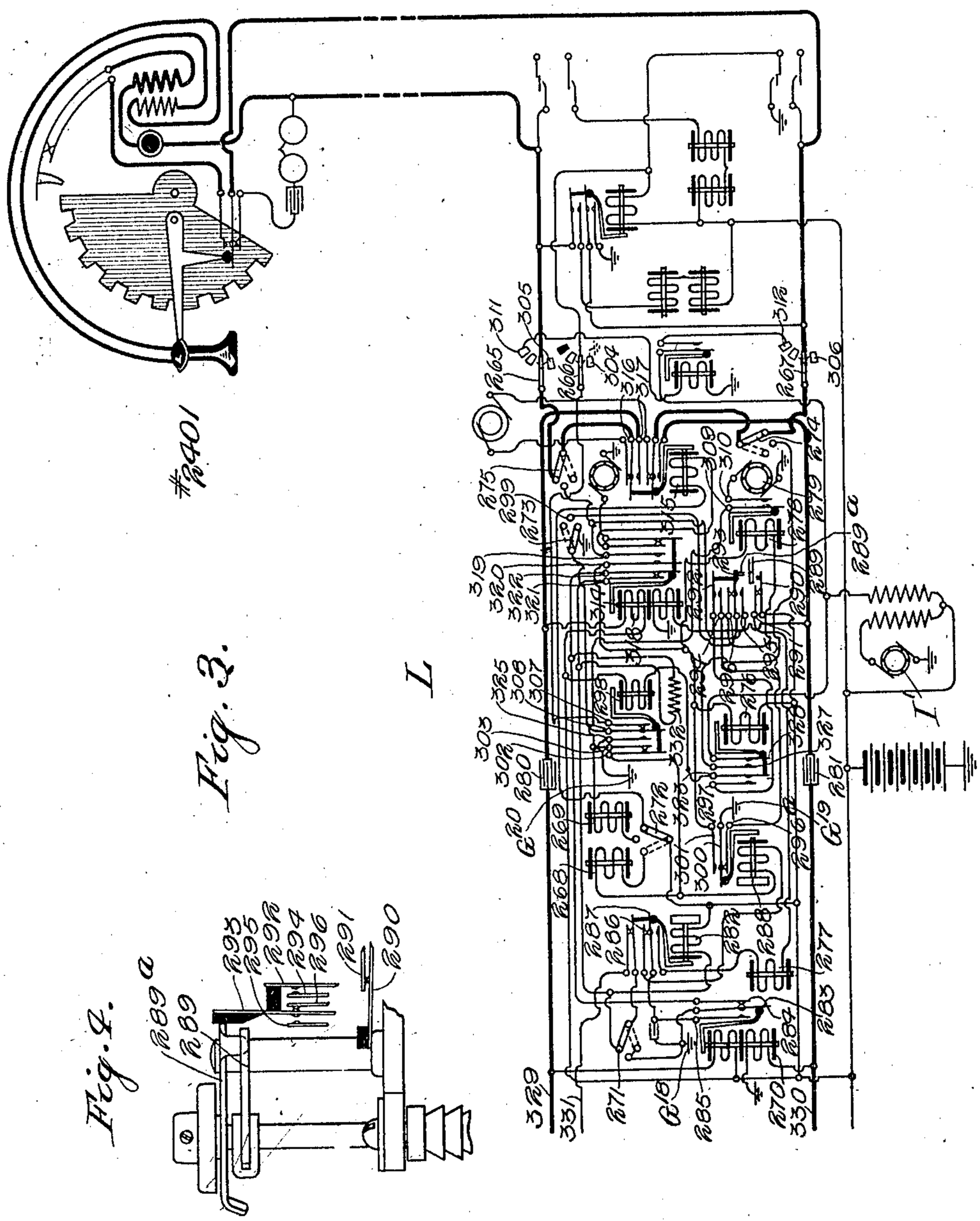

Fig. 3.

Fig. 4.

Witnesses
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UNITED STATES PATENT OFFICE.

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TWO-WIRE ROTARY-CONNECTOR TELEPHONE SYSTEM.

1,291,990. Specification of Letters Patent. Patented Jan. 21, 1919.

Application filed October 11, 1909, Serial No. 522,065. Renewed June 7, 1918, Serial No. 238,795.

To all whom it may concern:

Be it known that I, TALBOT G. MARTIN, a citizen of the United States of America, and resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Two-Wire Rotary-Connector Telephone Systems, of which the following is a specification.

My invention relates to telephone exchange systems in general, but more particularly to automatic or semi-automatic exchange systems, and especially to systems in which provision is made for controlling automatic switches, such as selectors and connectors, over metallic line circuits.

For certain broader purposes of my invention the talking current may be supplied either from a common battery or from local batteries at the subscribers' stations. Also, for the broader purposes of my invention the first selectors may be employed on a percentage basis or as individual switches for the subscribers' lines. I have, however, elected to illustrate my invention in connection with that specific form of automatic telephone exchange system in which common battery means are employed for furnishing the talking current, and in which the first selectors are employed on a percentage basis. With this arrangement, as will hereinafter more fully appear, means are provided for automatically selecting idle first selectors. In this way each calling subscriber does two things before operating the first selector and other numerical switches in accordance with the called number. First, the calling line is automatically connected with a preselected idle trunk leading to an idle first selector; second, another idle trunk is selected for the subscriber who makes the next call. Thus each calling subscriber obtains connection with an idle first selector through the medium of a preselected trunk line. As herein disclosed, these switching operations are all controlled by the calling subscriber over metallic line circuits. In other words, no operating grounds are employed at the substations of the system.

In the practice of automatic telephony it has often been found desirable to give a subscriber more than one telephone line, or to provide a plurality of trunk lines leading to a private branch exchange. In such case means are provided for automatically selecting an idle one of the said telephone lines, the same all being given the same number, inasmuch as any one of these lines will serve the purpose of the calling subscriber. This is also true where a number of trunk lines are provided for a private branch exchange, as in such case a calling subscriber is satisfied to obtain connection with any one of said trunk lines. These trunk lines all have the same number, and if one or more of them are busy it will serve the purpose of any calling subscriber to obtain connection with any one of the remaining idle trunk lines. For this automatic selection of an idle one of a number of telephone lines, or of an idle trunk line, it has been the practice to employ what are ordinarily known as rotary connectors—that is to say, connectors which are capable of rotating automatically in one or more or even all of the bank levels thereof, very much as a selector automatically rotates to find an idle trunk line. There is, however, this difference between the automatic selective operation of a rotary connector and the similar automatic selective operation of a selector. In a selector the wipers are raised step by step to the desired level under the control of the calling subscriber, or of an operator. When the wipers of the selector reach the predetermined level, they then automatically rotate in that level, without the necessity of any further act on the part of the calling subscriber, until an idle trunk line is found. In a rotary connector, however, the wipers thereof, when raised to the desired level, do not at once commence rotating in that level, but to the contrary remain opposite that particular level of bank contacts until made to proceed in a rotary manner by some further act on the part of the calling subscriber. For example, a selector is responsive to the impulses for only one digit of the called number. These impulses raise the wipers of the selector to the desired level, and without the transmission of any further impulses the said wipers proceed to rotate automatically until an idle trunk line is found. On the other hand a rotary connector responds to the impulses for a plurality of the digits of the called number, usually the last two digits thereof. The rotary connector is, therefore, adapted to respond to a number of impulses sufficient to carry its wipers up to the desired level, in accordance with one digit of the called number, and to then

come to rest. After that the calling subscriber, or switch board operator, depending upon the character of the exchange, will transmit another set of impulses to rotate the wipers of the connector onto any desired set of contacts in the level. If these contacts are idle the wipers remain in contact therewith, but if they are busy the wipers will continue to rotate automatically, and without any further control by the subscriber or operator, to find an idle telephone line, or an idle trunk line leading to a private branch exchange. Thus in a selector the entire rotary operation is automatic, whereas in a rotary connector the rotary operation is only automatic after it is once started by an operator or calling subscriber. Such rotary connectors, as stated, have been employed for giving service to private branch exchanges, or to substations where more than one line was found to be necessary or desirable.

Prior to my invention, so far as I am now aware, these rotary connectors had never been operated or controlled over metallic line circuits. They were used in what are known as three-wire systems—that is to say, systems in which the switches are controlled by grounding first one side of the line and then the other at the calling substation. It had never been proposed, so far as I now know, to equip what is known as a two-wire system with rotary connectors, or to control a rotary connector over a metallic circuit. By a "two-wire system" I mean one in which no operating grounds are employed at the subscribers' stations, and in which the switches, such as selectors and connectors, are controlled over metallic line circuits.

The principal object of my invention is, therefore, the provision of a rotary connector which is controllable over a metallic line circuit.

Another object is to provide a two-wire system in which rotary connectors are employed for giving service to one or more private branch exchanges, or to one or more substations, where more than one telephone line is necessary or desirable. I believe I am the first to propose and successfully operate a rotary connector in a two-wire system.

My invention also consists in certain novel details and features of construction, circuit arrangements and combinations, as will hereinafter more fully appear. To the foregoing and other useful ends my invention consists, therefore, in matters hereinafter set forth and claimed.

In the accompanying drawings Figures 1 and 2 taken together illustrate diagrammatically two substations (A and A′) of an automatic telephone system connected together by means of central office switching apparatus embodying the principles of my invention.

As shown in Fig. 1, the line of substation A (#5000) terminates in a line switch C, and in Fig. 2 the line of substation A′ (#2221) terminates in a like line switch C′.

At B (Fig. 2) is shown a central battery having its positive terminal preferably grounded at G.

In Fig. 1 the line switch C is shown operated and connection thereby established with a first selector switch D. The first selector switch D is also shown operated and in connection with a second selector switch E, which last-mentioned switch is also shown operated and connected with an improved rotary connector switch F which is rotary on all levels thereof.

The central office is also provided with a ringer generator H and a busy-signaling machine I.

At J (Fig. 1) is represented diagrammatically one of the master switches which controls a number of line switches known as a group or unit. As shown, the switch C is a member of the group or unit controlled by this switch J.

Fig. 3 is a diagrammatic representation of an improved rotary connector switch which is rotary on only certain levels. Other additional connectors, such as shown in Fig. 3, but not rotary at all, are used in the system for single line connections.

Fig. 4 shows a portion of the upper part of the connector L, illustrating how certain springs are operated, as will hereinafter be explained.

In this system each subscriber's line is, of course, provided with a line switch similar to the line switch C, and usually one hundred of these form a group. Also, to each such group there is allotted a group of first selector switches in common. The first selector switches may in turn be operated, first, to select any one of a number of groups of second selectors, and then some one of the selectors in the group which may be idle. The second selector switches may in turn be operated to first select any one of a number of groups of connector switches, and then some one of the connectors of the elected group which may be idle. Usually each group of connector switches is also arranged to take care of one hundred subscribers—that is, if any subscriber in the system wants to call another subscriber he must, through the medium of the first selector and second selector, pick out a certain group of connectors, any one of the connectors of which group is capable of establishing the final connection with the desired subscriber in a particular hundred.

It will be understood, of course, that the first and second selectors and the connectors are equipped with banks of contacts, and

that these contacts are arranged in levels, each level containing ten sets of bank contacts, to each of which one line is allotted. In this case it is assumed that the second level of the second selector banks are provided with trunks to rotary connector switches similar to those shown in Fig. 2, while the trunks from the fourth level terminate in connector switches similar to those shown in Fig. 3. Trunks from the remaining levels terminate in connectors, as shown in Fig. 3, but said connectors have no automatic rotary selective operations.

The substations may be of any suitable or approved type. As shown, it will be seen that substation A is arranged to operate in connection with a two-wire system—that is, a system in which no ground connection is used at the subscriber's substation. Substation A, for example, comprises the usual receiver 2, switch hook 3, induction coil 4 which consists of the primary winding 5 and secondary winding 6, transmitter 7, condenser 8, ringer 9, and impulse wheel 10 which has the usual impulse teeth 11. The impulse wheel 10 is secured to the shaft 12, to which shaft there is also secured the dial (not shown). As the dial returns to normal position after being rotated to call a digit the impulse teeth 11 are adapted to engage the cam 13 upon the end of the spring 14, and thereby carry the latter out of engagement with the spring 15. Upon the switch hook 3 there is the cam arm 16 which, when the switch hook is up, permits the springs 17 and 18 to engage, thereby bridging across the subscriber's line conductors 19 and 20 the primary circuit including the transmitter 7 in series with the primary winding 5; but when the switch hook is lowered the spring 17 is carried out of engagement with the spring 18 and into engagement with the spring 18[a], whereby the ringer 9, in series with the condenser 8, is bridged across the line conductors 19 and 20 instead.

The line switch C may be of any suitable or approved type. For instance, it may be a modified form of the line switch disclosed in British Patent No. 26,301 of 1906, and described in the *American Telephone Journal* of Chicago, Illinois, of June 6, 1908. In its general form it comprises a trip magnet 23, a release magnet 24 and a bridge-cut-off relay 48. The trip magnet 23 is designed to operate the usual plunger for pressing the bank springs 35 and 36, 37 and 38, 39 and 40, and 41 and 42 into engagement. This plunger is so arranged that when in normal position it is under the control of the master switch J, whereby the said plunger may always be removed from opposite a busy trunk to a position opposite an idle trunk. The release magnet operates to restore the plunger to normal position. The bridge-cut-off relay 48 operates to shift the springs 49 and 52 out of engagement with the springs 50 and 51, respectively.

The master switch J may be of any suitable or approved type. For instance, it may be a modified form of the master switch described and illustrated in the said *American Telephone Journal* of June 6, 1908. In its general form it comprises a motor magnet 53, a motor magnet relay 56, the circuit-opening relay 25, ratchet wheel 55, interrupter wheel 54, master switch bank Q, wiper 58 and condenser 27. The switch shaft controls the plungers of several line switches, usually one hundred, always holding them in readiness to engage an idle trunk. This particular master switch shaft has a step-by-step reciprocating motion, and all idle plungers are held in locking engagement with said shaft. The plungers of the line switches, as described in the publication mentioned, are not self-alining—that is, a plunger does not automatically come into locked engagement with the shaft until the master switch shaft again resumes the original position where the plunger was tripped. When one line switch operates, its plunger is tripped and engages the springs of the bank terminals of an idle trunk. The motor magnet relay 56 is accordingly energized. This relay operates to close the motor magnet circuit and the circuit of the relay 25. The motor magnet operates to rotate the ratchet wheel and interrupter wheel. When the ratchet wheel is rotated one notch the interrupter wheel has rotated enough to close the springs 21 and 22, which keep the motor magnet operating until the idle plungers are directly opposite the bank terminals of an idle trunk. When this position is reached the springs 21 and 22 separate, and as the master switch wiper 58 has been moved to a position on the master switch bank corresponding to an idle trunk, the motor magnet is deënergized. While the motor magnet is operating, the circuit-opening relay 25 is energized, thereby shifting the spring 32 out of engagement with the spring 33 and into engagement with the spring 34. In this way all the trip magnets are disconnected from the battery lead and connected to the busy-signaling current similar to the busy-signaling current furnished by the apparatus I in Fig. 2, thus preventing the selection of a busy trunk and giving a subscriber the busy-signal if all the trunks are busy.

The first selector switch shown at D is an improved form of the selector described in United States Letters Patent No. 815,321, granted March 13, 1906, to Keith, Erickson and Erickson, and is adapted to operate in connection with a two-wire system. Among other details it embodies the following features: The switch shaft (not shown) carries

the vertical and rotary wipers 81 and 82, respectively, and the private wiper 83. The side switch is well known and comprises the side switch wipers 84, 85, 86 and 87, which may be designated as the vertical, rotary and private side switch wipers and the rotary magnet wiper, respectively. The side switch is under the control of the private magnet 88, and when the side switch is in normal or first position the wipers 84, 85, 86 and 87 occupy the contact points 89, 90, 91 and 92, respectively. In the second position the wipers rest on the contact points 93, 94, 95 and 96, respectively; and in third position the contact points 97, 98, 99 and 100 are engaged by their respective wipers. The windings of the usual vertical and rotary line relays are, in this case, combined into one double wound relay 101 comprising the winding 102 which is connected with the battery lead 103, and also with the vertical line trunk conductor when the side switch wiper 84 is in first or second position. The second winding 104 is connected to ground, and also to the rotary line trunk conductor when the side switch wiper 85 is in first or second position. Through the medium of this double wound relay, and while the side switch is in first position, the subscriber controls the vertical magnet 105, which operates to raise the switch shaft and wipers 81, 82 and 83 vertically. This line relay 101 also controls the private magnet relay 106, which latter in turn controls the private magnet 88. The private magnet, as usual, controls the side switch. While the side switch is in second position the rotary magnet 107, which operates to carry the switch shaft and wipers 81, 82 and 83 in a rotary direction, is energized. The release magnet 108 provides means for restoring the selector switch to normal position. Upon the switch shaft, which carries the wipers 81, 82 and 83, there is mounted the arm 109 which, when the shaft is raised one or more steps, permits the spring 110 to engage the contact point 111, whereby the release magnet 108 is connected to the battery. The release relay 112 is provided for closing the energizing circuit of the release magnet 108 after the switch is operated. The back-release relay 113 is provided for opening the energizing circuit through the release magnet 24 of the line switch. The relays 106, 112 and 113 are slow-acting relays—that is, they are so provided with a copper shield that when energized, and the energizing circuit then broken, the said relays remain for a moment in an operated position. In other words, they do not instantly return to normal position after the energizing circuit is broken.

The second selector E is similar to the first selector D, and is provided with the usual double-wound line relay 114 having the windings 115 and 116 connected with the vertical and rotary side switch wipers 117 and 118 in the same manner in which the windings of the relay 101 of the selector switch D are connected to their vertical and rotary side switch wipers.

Since like parts are similarly represented, the rotary magnet 119 and vertical magnet 120 will be recognized and understood. The release magnet 121 is operated in the same manner in connection with the switch E that the release magnet 108 is operated in connection with the switch D. The private magnet 122 is controlled by the private magnet relay 123. The release relay 124 of the second selector switch E performs the same function in connection with this switch as the release relay 112 and the back-release relay 113 perform in connection with the first selector switch D—that is, the springs controlled by the relays 112 and 113 are so arranged in the second selector switch E that they are controlled by a central relay 124. In the switch E the relays 123 and 124 are so arranged that they deënergize slowly, the same as the relays 106, 112 and 113 of the selector switch D.

The rotary connector switch F is an improved form of the connector switch disclosed in United States Letters Patent No. 815,176, granted March 13, 1906, to Keith, Erickson & Erickson. In this rotary connector F means are provided whereby the shaft may be automatically rotated, like the shaft of the selector switches, when the private wiper engages a busy contact, and also whereby it is adapted to operate in connection with a two-wire common battery system. The connector switch shaft (not shown), like the shaft of the selector, carries the line wipers 125 and 126 and the private wiper 127. The connector switch is also controlled by the calling subscriber through the medium of a double-wound line relay 128. The line relay 128 is provided with the windings 129 and 130. One terminal of the winding 129 is connected to the battery lead, while the other terminal is connected with the vertical trunk line conductor 192. The winding 130 is connected with ground and also with the rotary trunk line conductor 193. This line relay 128 directly controls the vertical magnet 131. The purpose of the vertical magnet 131 is to give the shaft and shaft wipers a vertical motion, and the rotary magnet 132 imparts to the shaft and shaft wipers a rotary or circular motion. The connector switch is also provided with the slow-acting release relay 133, which is similar to the release relay 124 of the second selector switch. The private magnet relay, as usual, controls the private magnet 135, which latter, under certain conditions, controls the rotary magnet 132 and also the side switch wipers 136, 137, 138, 139 and

140. The private magnet 135, as arranged to operate in connector switch E, plays a very important part, and controls the rotary action to a great extent. The object in providing the connector with this automatic selective feature is as follows: A business house or private branch exchange, for example, may be provided with three lines, all of which are given the same number; and it may become desirable to so arrange the system that if one line is in use, the calling switch will automatically extend the calling subscriber's line into connection with the second line; if the second line is also busy connection may be carried to a third line, and so on. The calling subscriber would, of course, have no control over the apparatus as to which one of the lines he makes connection with. This, however, does not concern him, since any trunk line to the said office or private branch exchange will serve his purpose. The arrangement of the connector banks themselves will be as follows: If the office at which the number 2221 is located wishes three telephones it will be given three lines, one terminating in the first contact of the second level of the connector banks, and the second in the second contact of the second level, etc. Now, if the number 2221 is called, the connector is raised to the second level and then rotated into engagement with the first contact of the second level; but if the said contact is busy the connector is automatically rotated onto the second set of contacts. It becomes desirable, of course, to provide means for notifying the calling subscriber in the event that all the trunk lines are busy. For this purpose a fourth set of bank contacts of the second level are connected with a busy-signaling circuit, at which contacts the connector must stop in the event that all lines are busy. A busy-signaling current is then sent to the calling subscriber's line over a circuit including this fourth set of contacts of this level. This arrangement, however, is not confined to any particular level, as any level may be divided in the same way, and any subscriber may thus be given any number of lines, depending on the number of contacts in each level. The back-bridge relay 141, comprising the windings 142 and 143, provides means whereby the called subscriber is provided with battery current for talking purposes. As here shown, the connector switch has provision for automatic ringing—that is, the signaling of the called subscriber is not dependent upon the calling subscriber pressing a signaling button, but as soon as connection is established with the desired line the interrupter 144 intermittently closes an energizing circuit through the ringer relay 145, whereby the terminals of the ringer generator H are intermittently bridged across the normal conductors of the called line. The relay 146 is arranged in the private wiper circuit, and when the said wiper engages the busy contact an energizing circuit is closed through this relay 146, which operates to close an energizing circuit through the private magnet 135. The means whereby the connector switch may be restored to normal position consists of the usual release magnet 133ª which, when the connector switch shaft is raised one or more steps, is connected to the battery lead through the normal springs 131ª and 132ª. By means of the condensers 147 and 148 the circuit through the connector switch is divided into two sections. The busy-signaling apparatus I comprises the interrupter 149 in series with the winding 150 of the induction coil 151. The winding 152 is connected with the spring 153, and when the relay 154 energizes, as will be explained, the busy-signaling apparatus is connected with the connector switch wiper 126.

The connector switch L shown in Fig. 3 combines the automatic rotary feature of the connector F with the ordinary features of a simple connector. The connector L is so arranged that if the wipers are brought into engagement with a busy line on certain levels, said wipers remain on the terminals of that line, the side switch becomes locked in second position to prevent the calling line from being extended into connection with the busy line, and the calling subscriber is given the busy-signal. If, however, the wipers are brought into contact with a busy line on certain other levels, the said wipers are then automatically rotated onto an idle line in a manner similar to that of the connector F. On top of the frame of the connector is mounted a group of springs (292, 294, 296, 293 and 295) which is adapted to be operated by the arm 289ª which is attached to the top of the switch shaft. As long as these springs are in normal position—that is, with the spring 293 in contact with the spring 295—the connector L operates the same as an ordinary connector; but after the shaft has been raised high enough to force the springs 293 and 292 into the position shown in Fig. 4 the connector then operates like a rotary connector. By changing the length of the bushing on the end of the spring 293 the connector L may be made rotary on as many levels as desired. For example, if it is desired to provide two rotary levels the bushing on the spring 293 may be made of such length as to be engaged by the arm 289ª only after the shaft wipers are raised above the eighth level. Each of the bank levels that is engaged by the wipers before the springs 292 and 293 are operated can accommodate ten single subscribers, while each level which is engaged by the wipers after said springs are operated can accommodate one or more groups of

lines, all the lines of each group being accessible by calling one number. This division of bank contacts into groups is the same as explained for the connector F, the last contacts of each group being connected to the busy-signaling machine I'. The connector L is also provided with a relay 278 for the purpose of connecting the ground interrupter 279 with the rotary magnet 269 under certain conditions, as will hereinafter appear.

The operation of the system may be more clearly disclosed if each step, during the process of a call, is followed up in detail. It will be assumed that the substation A wishes to call the office which is registered as 2221 and which is provided with the substation A' and A^3, of which only substation A' is shown.

To call the number 2221 (substation A', Fig. 2) the subscriber at substation A (Fig. 1) removes his receiver from the switch hook and operates the calling device for each digit of the called number, in the well-known manner—that is, when the receiver is removed from the switch hook a preliminary impulse provides an energizing circuit for the trip magnet 23 of the line switch C, whereby the line switch C is operated to seize an idle trunk line leading to a first selector switch. The dial is turned for the first digit, and upon returning to normal position operates the first selector switch to establish connection with an idle trunk line leading to a second selector switch. In a similar manner the dial, upon returning to normal position for the second digit, operates the second selector switch E to establish connection with an idle trunk line leading to a connector switch. The impulses delivered by the dial for the last two digits are directed toward the connector F, which operates to place the shaft wipers in connection with the contacts corresponding to the desired office. The preliminary impulse for energizing the trip magnet 23 occurs when the receiver 2 is removed from the switch hook 3, and the cam arm 16 permits the spring 17 to engage the spring 18, thereby removing the ringer from across the line and bridging the primary circuit instead. When the primary circuit is thus bridged across the line, the energizing circuit for the trip magnet 23 is completed and extends from ground G' through the springs 50 and 49, rotary line conductor 20, through the springs 17 and 18, impulse springs 15 and 14, primary winding 5, transmitter 7 to the vertical line conductor 19, springs 52 and 51, through the winding of the trip magnet 23, springs 32 and 33 of the circuit-opening relay 25 to the battery lead 157, thence through battery B to ground G. As soon as the trip magnet 23 energizes, the plunger arm is tripped and the plunger engages the bank terminal springs of an idle trunk, as previously described. When the bank contacts are thus closed, the line conductors 19 and 20 are cut through to the trunk line conductors 75 and 76, whereby the line relay 101 of the selector D is energized. This circuit extends from ground G^5 through the winding 104 of the double-wound line relay 101, contact point 90, side switch wiper 85, trunk line conductor 76, springs 38 and 37, line conductor 20, primary circuit of substation A, line conductor 19, springs 35 and 36, trunk line conductor 75, side switch wiper 84, contact point 89, winding 102 of the relay 101 to the battery lead 157, thence through battery B to ground G. The line relay 101 upon energizing operates to disengage the spring 161 from the spring 166 and to place it in contact with the spring 162. The former action clears the release trunk 77 of the ground G^6, which prevents the release magnet 24 of the line switch from energizing; the latter action establishes an energizing circuit through the release relay 112, said circuit extending from ground G^6 through the springs 161 and 162, release relay 112 to the battery lead 157. The release relay 112 upon energizing operates to carry the spring 163 out of engagement with the spring 164 and into engagement with the spring 165. This is the condition of the first selector D when the subscriber operates the dial for the first digit. Furthermore, when the bank springs 39 and 40 are closed in contact, after the line switch plunger trips, the bridge-cut-off relay 48 is energized over a circuit extending from ground G^4 through said bank springs, bridge-cut-off relay 48 to the battery lead. The relay operates, forcing the springs 49 and 52 out of engagement with the springs 50 and 51, clearing the line conductors of the line switch circuits. The engagement of the bank springs 39 and 40 also provides a guarding potential over the private normal conductor 80 to the connector bank terminals corresponding to the line of the calling subscriber to prevent another subscribed from calling the said line after the calling subscriber at substation A removes his receiver preparatory to making a call. When the bank springs 41 and 42 are closed in contact an energizing circuit is established through the motor magnet relay 56 of the master switch J, it being understood that the ground connection G^6 to the release trunk 77 at the selector D is removed almost instantaneously. Said energizing circuit extends from ground G^2 through the motor magnet relay 56, common segment 57 of the master switch bank Q, wiper 58, individual segment 60, bank springs 42 and 41, release magnet 24 to the battery lead 157, thence through battery B to ground G. It will be seen that the motor magnet relay 56 and release magnet 24 are both included in this circuit; but the flow of current is not

sufficient to operate the magnet while the relay is operated, closing the motor magnet circuit and the circuit of the circuit-opening relay 25. The motor magnet circuit extends from ground G^3 through the magnet 53, interrupter springs 70 and 71, motor magnet relay springs 72 and 73 to the battery lead 157. The circuit of the circuit-opening relay 25 extends from ground G^3 through the circuit-opening relay 25, interrupter springs 70 and 71, relay springs 72 and 73 to the battery lead. The relay 25 is slow-acting—that is, slow to deënergize, and thus remains in an operated condition while the motor magnet is operating, the interrupter springs 70 and 71 being intermittently opened. The circuit-opening relay 25 when operated disconnects the battery lead from all trip magnets in the group, thus making it impossible for a trip magnet to release a plunger while the circuit of the motor magnet and relay 25 is closed. The circuit-opening relay 25 when operated also shifts the spring 32 into engagement with the spring 34, thus connecting the trip magnets to a source of busy-signaling current. The motor magnet operates as a buzzer by means of the springs 70 and 71, successively energizing and deënergizing, to advance the ratchet wheel 55 and the interrupter wheel 54, which in turn advance the shaft and all idle plungers that are in locking engagement with the shaft to a position opposite the next idle bank terminal. As soon as the motor magnet advances the ratchet wheel one step, the auxiliary springs 21 and 22 close in contact, thereby establishing the energizing circuit of the motor magnet 53 and the relay 25 independently of the motor magnet relay 56. When the wiper 58 leaves the individual contact 60, if the next individual contact is not guarded by a battery potential, the motor relay 56 will be deënergized. However, the motor magnet will continue to rotate the ratchet wheel until the idle plungers are in a position directly in front of the waiting idle trunk. This is accomplished by the springs 21 and 22 (which are arranged in multiple with the springs 72 and 73) making contact until forced apart by the interrupter cam wheel 54. It will be seen that to give this condition the interrupter wheel 54 must be set in a position to operate these springs 21 and 22 according to the relative position of the idle plungers. It will be understood, of course, that the line switch bank terminal shown corresponds to the first segment of the master switch bank Q, and therefore corresponds to the trunk line conductors 75, 76 and 77 which terminate in the selector D. The master switch will accordingly come to rest in a position where the plungers are directly in front of an idle trunk terminal.

The first digit being 2, the impulse spring 14 is twice carried out of engagement with the impulse spring 15. As a result the energizing circuit through the line relay 101 is broken twice, and the spring 161 comes into contact with the spring 166 twice. After the two impulses are thus delivered the line relay 101 again energizes and carries the spring 161 into contact with the spring 162. As previously explained, the relay 112 is a slow-acting relay—that is, slow to deënergize; and when this energizing circuit is momentarily broken during the vertical impulses just delivered, the said relay does not deënergize, but remains in an operated position with the spring 163 in contact with the spring 165. Then when the spring 161 engages the spring 166 two impulses are transmitted to the vertical magnet 105. This circuit extends from ground G^6 through the springs 161 and 166 to the springs 163 and 165, through the private magnet relay 106, through the winding of the vertical magnet 105, contact point 92, side switch wiper 87 to the battery lead 157, thence through battery B to ground G. Two impulses being delivered, the vertical magnet 105 is thereby energized twice, and the shaft wipers are given two vertical steps in the well known manner. It will be seen that the private magnet relay 106 is included in the energizing circuit of the vertical magnet 105. This relay also energizes, but being a slow-acting relay, it energizes on the first impulse and remains so until all the impulses are transmitted. This relay, upon energizing, operates to close the springs 167 and 168 in contact, whereby an energizing circuit is established through the private magnet 88. This circuit extends from ground G^6 through the springs 167 and 168, private magnet 88 to the battery lead 157, thence through battery B to ground G. The private magnet relay 106 deënergizes after the last vertical impulse, since this energizing circuit is no longer maintained after the springs 161 and 166 disengage. Hence, the said relay deënergizes, permitting the springs 167 and 168 to disengage, whereby the energizing circuit through the private magnet 88 is in turn broken, which private magnet now deënergizes and permits the side switch to pass from first to second position, permitting the side switch wipers 86 and 87 to engage the contact points 95 and 96, respectively. The closure of contact between the side switch wiper 87 and the contact point 96 sets up an energizing circuit for the rotary magnet 107 from ground G^5 through the interrupter springs 169, through the winding of the rotary magnet 107, contact point 96, side switch wiper 87 to the battery lead 157, and through battery B to ground G. The said rotary magnet then operates to rotate the shaft wipers 81, 82 and 83 of the selector D into engagement with the first contact of

the second level of the selector banks, from which contact it is assumed the trunk line conductors 170, 171 and 172 lead to the second selector switch E. If the first trunk line is busy, however, and the wipers have to pass over busy contacts, then as soon as the private wiper 83 engages the first private bank contact, the private magnet 88 again energizes, locking the side switch in second position. The energizing circuit for said private magnet extends from the grounded terminal G of the battery B through the switch of the busy trunk, through the private wiper 83, thence through the conductor 173 to the side switch wiper 86, contact point 95, through the winding of the private magnet 88 to the battery lead 157, thence through battery B to ground G. The private magnet 88, upon thus becoming energized, locks the side switch wiper 87 in engagement with the contact point 96, whereby the rotary magnet 107 will be energized step by step until the wipers are carried onto the first idle trunk line. At the instant that the private wiper leaves the last busy contact point the energizing circuit through the private magnet 88 is destroyed, and as a result the selector side switch passes to third position. If, however, there are no busy trunk lines the private magnet 88 releases the side switch to third position, in the well known manner, as soon as the wipers are carried into engagement with the first trunk line. As soon as the side switch passes to third position, as stated, the subscriber's line conductors 19 and 20 are extended to the conductors 170 and 171 which, in this case, it is assumed lead to the second selector switch E. The extending of the line occurs, of course, as soon as the side switch wipers 84 and 85 engage the contact points 97 and 98, respectively. When the subscribers' lines are thus extended to the selector switch E an energizing circuit is established through the line relay 114 in the same manner in which the energizing circuit was established through the line relay 101 of the selector D when the subscriber's line conductors 19 and 20 were extended through the line switch bank to the trunk conductors 75 and 76. The relay 114, upon energizing, operates to shift the spring 174 from the spring 175 to the spring 176. When the springs 174 and 176 engage, an energizing circuit is established through the release relay 124. This circuit extends from ground G^7 through the springs 174 and 176, through the relay 124 to the battery lead 157, thence through battery B to ground G. The relay, upon energizing, operates to shift the spring 177 from the spring 178 to the spring 179, and the springs 180 and 181 are also closed in contact. This operation of the second selector switch E occurs at the instant that the side switch wipers 84 and 85 of the selector switch D pass to third position and extend the subscriber's line conductors 19 and 20 to the second selector switch E. When the second selector switch therefore thus operates, a guarding potential is established at the private multiple contacts for protecting the seized trunk line conductors 170 and 171 against seizure by another calling first selector. This guarding potential extends from ground G^8 to the contact point 182, side switch wiper 183, through the springs 181 and 180, conductor 172 to the contact engaged by the private wiper 83, and to the private multiple contacts (not shown). Furthermore, when the first selector switch D operates, and the side switch passes to third position, a new energizing circuit is established through the release relay 112. This energizing circuit extends from ground G^8 at the selector switch E through the springs 181 and 180, conductor 172, shaft wiper 83, conductor 173, through the side switch wiper 86, contact point 99 and the relay 112 to the battery lead 157, thence through battery B to ground G. The relay 112 thus remains in an operated position with the spring 163 in engagement with the spring 165, but the line relay 101 returns to normal position when the side switch wipers 84 and 85 engage the contact points 97 and 98, respectively. The energizing circuit through the line relay 114 extends from ground G^9 through the winding 116 to the side switch wiper 118, thence through the conductors 171 and 76 and line conductor 20, through the primary circuit of the substation, through the vertical line conductor 19, thence through the trunk conductors 75 and 170, side switch wiper 117, through the winding 115 of the relay 114 to the battery lead 157, thence through battery B to ground G. When the dial returns to normal position for the second digit 2 this circuit through the line relay 114 is interrupted twice, when the impulse spring 14 is carried out of engagement with the spring 15 by the impulse teeth on the wheel 10. The circuit being interrupted twice, the said relay 114 momentarily deënergizes, thus permitting the spring 174 to engage the spring 175, whereby an energizing circuit is completed through the vertical magnet 120, extending from ground G^7 to the springs 174 and 175, springs 177 and 179, through the winding of the private magnet relay 123, through the winding of the vertical magnet 120, contact point 184, side switch wiper 185 to the battery lead 157, and through battery B to ground G. The private magnet relay 123, being included in this circuit, energizes; and since it is a slow-acting relay it remains in an operated position until the last vertical impulse is delivered. After the two impulses are thus delivered, the relay 114

again energizes and carries the spring 174 into contact with the spring 176, whereby the circuit through the private magnet relay and the vertical magnet 120 remains open. When the relay 123 energizes, the springs 186 and 187 are pressed into contact, thereby causing an energizing current to flow through the private magnet 122, said circuit extending from ground G^7, through the springs 187 and 186, through the winding of the private magnet 122 to the battery lead 157, thence through battery B to ground G. When the relay 123 deënergizes and breaks the energizing circuit through the private magnet 122, the private magnet also deënergizes and permits the side switch to pass from first to second position. When the side switch wiper 185 passes to second position and into engagement with the contact point 188, an energizing circuit is established through the rotary magnet 119 which now operates, as explained in connection with the rotary magnet 107 of the selector switch D, to select an idle trunk line leading to the connector switch F. After the switch comes to rest with the side switch in third position, the shaft wipers 189, 190 and 191 are in engagement with the trunk conductors 192, 193 and 194, respectively, which lead to the connector switch F (Fig. 2). At the instant that the side switch wipers 117 and 118 pass to third position and into engagement with the contact points 195 and 196^a, the subscriber's line conductors are extended to the connector switch F, and an energizing circuit is established through the line relay 128 in the same manner in which the energizing circuit was established through the line relay 114 of the selector switch E when the side switch wipers of the first selector passed to third position. The energizing circuit through the line relay 128 extends from ground G^{10} through the winding 130, trunk conductors 193, 171 and 76 to the line conductor 20, thence through the sub-station to the vertical line conductor 19, trunk conductors 75, 170 and 192, thence through the winding 129 to the battery lead 157, and through battery B to ground G. The line relay 128, upon energizing, operates to shift the spring 196 from the spring 197 to the spring 198, whereby an energizing circuit is established through the release relay 133 extending from ground G^{11} through the springs 196 and 198, relay 133 to the battery lead 157, thence through battery B to ground G. When the relay 133 energizes, the spring 199 is shifted out of engagement with the spring 200 and into engagement with the spring 201, and the spring 202 is shifted into engagement with the spring 203. This primary operation of the connector relays 128 and 133 occurs at the instant that the side switch wipers 117 and 118 of the selector E pass to third position and extend the subscriber's line conductors to the connector switch F. The engagement of the springs 203 and 202 establishes a guarding potential for protecting the trunk line conductors 192 and 193 against seizure by another second selector. This potential extends from ground G^{12} to the side switch wiper 139, springs 203 and 202, conductor 194 to the private bank contact engaged by the private wiper 191, and to the private multiple contacts (not shown). Furthermore, when the side switch of the second selector E passes to third position a new energizing circuit is established through the release relay 124, said circuit extending from ground G^{12} at the connector switch to the conductor 194, through the shaft wiper 191, side switch wiper 204, contact point 205, through the release relay 124 to the battery lead 157, thence through battery B to ground G. Also, this same guarding potential established at the contact engaged by the private shaft wiper 191 is extended to the private bank contact engaged by the shaft wiper 83 of the first selector D when the side switch of the second selector E passes to third position. The path over which this potential extends is as follows: From ground G^{12} at the connector switch F (Fig. 2) through the side switch wiper 139, springs 203 and 202, conductor 194, shaft wiper 191, side switch wiper 204, contact point 205, contact point 206, side switch wiper 183, springs 181 and 180, conductor 172 to the multiple private bank contacts of the first selector switches. The energizing circuit of the release relay 112 of the selector D is also extended to the connector F; this circuit, like the one last traced, extends to the conductor 172, thence through the private wiper 83, conductor 173, side switch wiper 86, contact point 99, relay 112 to the battery lead 157. The operation of the dial for the last two digits affects the connector switch, and when the dial is operated for the third digit 2 the impulse spring 14 is twice carried out of engagement with the spring 15, thereby momentarily deënergizing the line relay 128 twice, whereby the spring 196 twice engages the spring 197, thus sending two impulses to the vertical magnet 131 from ground G^{11}, through the springs 196 and 197, springs 199 and 201, through the vertical magnet 131, contact point 207, side switch wiper 140 to the battery lead 157, thence through battery B to ground G. The vertical magnet, upon being energized, operates one step at a time to carry the shaft wipers 125, 126 and 127 two steps to a point opposite the second level. When the line relay 128 thus operates, an energizing circuit is also established through the private magnet relay 134 extending from ground G^{12} through the springs 196 and 197, springs 199 and 201, through the

conductor 208, through the private magnet relay 134 to the battery lead 157, thence through battery B to ground G. The relay 134 energizes and shifts the spring 209 out of engagement with the spring 210 and into engagement with the spring 211; also, the spring 212 is shifted into engagement with the spring 213. When the springs 212 and 213 engage, an energizing circuit is established through the private magnet 135 from ground G^{13} through the springs 213 and 212, private magnet 135 to the battery lead 157, thence through battery B to ground G. The relay 134, being a slow acting relay, remains in an operated position while the vertical impulses are being sent; but after all the impulses are delivered, and the line relay 128 returns to its operated position, the circuit through the relay 134 becomes broken, thus permitting the springs 212 and 209 to return to normal position. When the springs 212 and 213 disengage, the circuit through the private magnet 135 becomes broken, whereby the said magnet deënergizes, permitting the side switch to pass from first to second position. The calling subscriber now operates the dial for the last digit 1, and again the line relay 128 is deenergized; but when the spring 196 engages the spring 197, an energizing circuit is established through the rotary magnet 132 instead of through the vertical magnet 131. This circuit extends from ground G^{11} through the springs 196 and 197, springs 199 and 201, conductor 208, springs 214 and 215, through the winding of the rotary magnet 132, contact point 216, side switch wiper 140 to the battery lead 157, thence through battery B to ground G. The rotary magnet, upon energizing, operates to give the shaft and shaft wipers 125, 126 and 127 one rotary step, and to carry said wipers into engagement with the first bank contact of the second level, from which contact the normal conductors 217 and 218 extend to a trunk line leading to the desired office. Also, when the line relay 128 deënergized for the last digit, and placed the springs 196 and 197 in contact, an energizing circuit was established through the private magnet relay 134 as before. The relay 134, upon energizing, again closes the circuit through the private magnet 135 when the springs 212 and 213 engage, and when the relay 128 returns to its energized position the circuit through the private magnet relay 134 is again broken, and the circuit through the private magnet 135 is in turn also broken if the first trunk line is idle. The side switch, therefore, passes from second to third position. When the side switch wiper 140 engages the contact point 219, an energizing circuit is established through the ringer relay 145, which now operates automatically to bridge the terminals of the ringer generator H across the line of the called subscriber. The energizing circuit through the ringer relay 145 extends from ground G^{14} through the interrupter 144, springs 220 and 221, ringer relay 145, contact point 219, side switch wiper 140 to the battery lead 157, thence through battery B to ground G. When the connector side switch passes to third position, and the side switch wiper 138 engages the grounded contact point 222, a guarding potential is established at the connector private bank to protect the seized line against interference by other calling subscribers. This potential extends from ground G^{15} to the contact point 222, side switch wiper 138, to the shaft private wiper 127 which engages the private contact of the called line, and to the multiple private contacts of the called line. Also, when the side switch wiper 138 engages the grounded contact point 222, an energizing circuit is established through the cut-off relay 223 of the line switch C'. This circuit extends from ground G^{15} through the side switch wiper 138 to the shaft private wiper 127, conductor 224, through the winding of the cut-off relay 223 to the battery lead 157, thence through battery B to ground G. The ringer relay 145, being intermittently energized by the interrupter 144, signaling current is intermittently sent to the called substation A' from the ringer generator H through the springs 225 and 226, side switch wiper 136, contact point 227, shaft wiper 125, normal conductor 217, line conductor 228, ringer 229 and condenser 230, through the springs 231 and 232 to the line conductor 233, normal conductor 218, shaft wiper 126, contact point 234, side switch wiper 137, and through the ringer relay springs 235 and 236 back to the ringer generator H. In response to the signal the called subscriber removes the receiver 237 from the switch hook 238, whereby the spring 232 engages the spring 239, thus bridging the primary circuit, including the transmitter 240 in series with the primary winding 241, across the line conductors 228 and 233. When the primary circuit comes across the line an energizing circuit is established through the relay 141 of the connector F, said circuit extending from ground G^{15} to the side switch wiper 138, winding 143 of the relay 141, thence through the ringer relay springs 242 and 235, side switch wiper 137, contact point 234, shaft wiper 126, conductors 218 and 233, springs 232 and 239, impulse springs 243, primary winding 241, transmitter 240, through the conductors 228 and 217, shaft wiper 125, side switch wiper 136, ringer relay springs 226 and 244, winding 142 of the relay 141 to the battery lead 157, thence through battery B to ground G. The relay 141 thereupon energizes and separates the

springs 220 and 221, whereby the intermittent circuit through the ringer relay 145 becomes permanently broken. The two substations A and A′ are now connected over the circuits shown by the heavy line conductors in Figs. 1 and 2, the substation A receiving battery current for talking purposes through the line relay 128, while the substation A′ receives current for talking purposes through the relay 141. In the preceding it was assumed that the first trunk line, of which there are several, leading to the desired office was not busy. It will now be pointed out how the connector switch F operates, if the first trunk line is busy, to automatically select the first idle trunk line. When the rotary magnet 132 operates for the last digit 1, the private shaft wiper 127 comes into engagement with the first bank contact, which, it will be assumed, is protected by a guarding potential. In that event an energizing circuit is established through the private wiper relay 146. This circuit extends from the grounded terminal G of the battery B through an occupying switch (not shown), through the bank contact, through the shaft wiper 127, side switch wiper 138, contact point 246 (the side switch being in second position), through the winding of the private wiper relay 146 to the battery lead 157, thence through battery B to ground G. The relay 146 thereupon energizes and presses the springs 247 and 248 into contact, closing an energizing circuit through the private magnet 135, said circuit extending from ground G^{16} through the springs 247 and 248, through the private magnet 135 to the battery lead, thence through battery B to ground G.

When the rotary magnet was energized for the last digit the private magnet relay 134 was also energized, being in multiple with it. When thus energized the relay 134 acts as before to close the private magnet circuit, and also to change the energizing circuit of the rotary magnet. The new energizing circuit for the rotary magnet extends from ground G^{11} through springs 196 and 197, springs 199 and 201, conductor 208 as before, through springs 209 and 211, rotary magnet 132, contact point 216, side switch wiper 140 to the battery lead 157. Thus, while the impulses are being delivered, the private magnet relay 134, being slow acting, remains in an operated position. But as soon as the impulses are delivered the relay 134 deënergizes. As previously assumed, if the first trunk is idle the private magnet 135 will be deënergized by the operation of the private magnet relay; but if the trunk is busy, as assumed in this instance, the private relay 146 is energized. This relay closes the circuit of the private magnet 135 before the latter has been deënergized by the opening of its circuit at the relay 134. Therefore, the private magnet continues in an energized condition until the private wiper relay is deenergized, and it in turn is not deënergized until the private wiper is rotated onto a non-grounded contact point. When the private magnet relay 134 deënergizes and the private magnet 135 is still held energized, a new energizing circuit is closed through the rotary magnet 132 and its interrupter springs 249. This circuit extends from ground G^{13} through the interrupter springs 249, private magnet springs 250 and 251, private magnet relay springs 210 and 209, through the winding of the rotary magnet 132, contact point 216, side switch wiper 140 to the battery lead 157, thence through battery B to ground G. The rotary magnet 132 now continues to rotate automatically and carry the shaft wipers 125, 126 and 127 past the last busy trunk line. As soon as the private wiper 127 engages the contact point upon which there is no guarding potential, the energizing circuit through the private wiper relay 146 is broken, whereby the springs 247 and 248 disengage and in turn break the energizing circuit for the private magnet 135, which now permits the side switch wipers to pass from second to third position. In this manner the connector switch automatically rotates to select an idle trunk line out of the group leading to the desired office. If, however, all of the trunk lines allotted to the desired office are busy, the shaft wipers are automatically rotated to the contact points 252, 253 and 254. It will be noted that the private contact 254 is insulated or cut off from the corresponding private contacts in the other rotary connector banks, so that, when the wiper 127 reaches this contact, the private wiper relay 146 is deënergized, which in turn deënergizes the private magnet 135, which in turn opens the rotary magnet circuit permanently and releases the side switch to third position. When the side switch wipers pass to their respective third positions, an energizing circuit is closed through the relays 141 and 154. This circuit extends from ground G^{17} through the busy relay 154, bank contact 252, shaft wiper 125, contact point 227, side switch wiper 136, ringer relay springs 226 and 244, through the winding 142 of the back bridge relay to the battery lead, thence through battery B to ground G. The relay 141 thereupon energizes and opens the ringer magnet circuit, which was closed for an instant when the side switch passed to third position. The relay 154, upon energizing, presses the springs 153 and 255 into contact, whereby the busy-signaling apparatus I is connected with the rotary shaft wiper 126, and a busy-signaling current is sent to the calling subscriber in the usual manner. The release of the central office switching apparatus is brought about when the calling sub-

scriber restores the receiver 2 to the switch hook 3, whereby the spring 17 is pressed out of engagement with the spring 18, and the energizing circuit through the line relay 128 of the connector F is broken. The line relay 128, upon returning to normal position, breaks the energizing circuit through the release relay 133, which also restores its springs to normal position. When the relays 128 and 133 thus deënergize, an energizing circuit is established through the release magnet 133ª extending from ground G¹¹ through the springs 196 and 197, and 199 and 200 to the release magnet 133ª, normal springs 131ª and 132ª and to the battery lead 157, thence through battery B to ground G. The release magnet 133ª, upon energizing, operates in the usual manner to restore the connector switch shaft and side switch to normal position. When the switch shaft returns to normal position the normal arm 256 carries the normal spring 131ª out of engagement with the normal spring 132ª, whereby the energizing circuit through the release magnet 133ª is broken. Also, when the relay 128 deënergizes, the ground potential at the trunk conductor 194 is removed, and in turn the energizing circuit through the release relays 124 and 112 of the selector switches E and D is broken. These relays return to normal position and in turn close an energizing circuit through their respective release magnets. The energizing circuit through the release magnet 121 of the selector switch E extends from ground G⁷ through the springs 174 and 175, springs 177 and 178, through the release magnet 121, normal springs 257 and 258 to the battery lead 157, thence through battery B to ground G. The release magnet thereupon energizes and attracts its armature, whereby the shaft wipers and side switch are restored to normal position in the same manner as in the connector switch: also, when the switch shaft returns to normal position the normal arm 259 carries the normal spring 257 out of engagement with the contact point 258, whereby the energizing circuit through the release magnet 121 becomes broken. The circuit through the release magnet 108 of the selector switch D extends from ground G⁶ through the springs 161 and 166, release relay springs 163 and 164, through the release magnet 108, normal springs 110 and 111 to the battery lead 157, thence through battery B to ground G. The release magnet 108 thereupon energizes and attracts its armature, whereby the switch shaft and side switch are also restored to normal position. As in the preceding switches, the normal arm 109 separates the normal springs 110 and 111, whereby the energizing circuit through the release magnet 108 becomes broken. Furthermore, when the release relay 112 deënergizes and permits the spring 163 to engage the spring 164, an energizing circuit is established through the back-release relay 113 in series with the release magnet 24 of the line switch C. This circuit extends from ground G⁶ through the springs 161 and 166, springs 163 and 164, through the back-release relay 113, springs 260 and 261, trunk line conductor 77, bank springs 42 and 41, release magnet 24 to the battery lead 157, thence through battery B to ground G. The release magnet 24, upon energizing, operates to place the mechanism of the line switch C in position to be released upon the subsequent deënergization of said magnet. The back-release relay 113, upon energizing, disengages the springs 260 and 261, whereby the energizing circuit through the release magnet 24 is broken, thus permitting the line switch C to return to normal position.

In the foregoing it has been shown how selector switches D and E and the rotary connector switch F operates to establish connection with a desired line. It will now be shown how the central office selector switches and connector switch L operate to establish a desired connection with one of the group of lines on the tenth level. Since it has been assumed that the connector L is connected to the fourth level of the second selector banks, the number of the first group of lines ending in the tenth level of said connector L will be 2401. In calling the number 2401 the operation of the line switch C, master switch J, first selector D and second selector E is exactly the same as when #2221 was called, except that the second selector E receives four impulses instead of two and thus selects an idle connector L instead of F. When the connection is thus extended to the connector L the line relay 270 and release relay 282 are energized in the manner explained for the relays 128 and 133 of the connector F. When the calling device at substation A is operated for the third digit 0 the impulse springs are forced out of engagement ten times in the usual manner, thus opening the energizing circuit of the line relay 270 ten times. Each time the relay 270 deënergizes, the spring 283 engages spring 285, whereby an energizing circuit is closed extending from ground G¹⁸ through springs 283 and 285, 287 and 286, private magnet relay 288, vertical magnet 268 and side switch wiper 272 to battery. The vertical magnet 268 receives ten impulses over the circuit just traced and operates to raise the wipers 265, 266 and 267 to a position opposite the tenth bank level. As soon as the switch shaft is raised the first step the arm 289, which is attached to said shaft, permits the off-normal springs 290 and 291 to engage, whereby the release magnet 277 is connected with the battery B. Before the

switch shaft reaches the upper limit of its travel,—that is, with the wipers 265, 266, and 267 standing opposite the tenth level, the arm 289ª forces the springs 292 and 293 out of engagement with the springs 294 and 295, respectively, and forces spring 293 into engagement with spring 296. The separation of springs 292 and 294 disconnects the private magnet relay spring 296ª from the private magnet spring 297 which form part of a locking circuit for the relay 298 when a busy line is called on any of the first nine levels. The shifting of spring 293 shifts the connection of the contact point 299 of the side switch wiper 273, to the relay 278. The private magnet relay 288, which is included in the circuit of the vertical magnet 268, energizes upon the first impulse to that magnet and, being slow-acting, remains in its operated position until after the last impulse. When the private magnet relay 288 energizes, it closes an energizing circuit extending from ground G¹⁹ through springs 300 and 301 and private magnet 276 to battery. After the last impulse to the vertical magnet the private magnet relay 288 deënergizes and opens the energizing circuit of the private magnet 276, whereupon the said private magnet deënergizes and permits the side switch to pass to second position. When the side switch wiper 272 passes from first to second position it shifts the battery connection from the vertical magnet to the rotary magnet 269.

When the calling device is operated for the last digit (1) the line relay 270 is deenergized once in the usual manner, and operates to close an energizing circuit through the rotary magnet 269. This energizing circuit extends from ground G¹⁸ through springs 283 and 285, 286 and 287, relay 288, springs 302 and 303, and through the rotary magnet 269 to battery B. The rotary magnet responds to this impulse to rotate the shaft wipers onto the first set of contacts of the tenth level. The private magnet relay 288 is also energized by this impulse and again closes the energizing circuit of the private magnet 276. When the private magnet relay deënergizes after this impulse to the rotary magnet, it opens the circuit of the private magnet 276, which thereupon deënergizes, if the first line is idle, and permits the side switch to pass to third position, thus completing the connection. If, however, the first line of the group #2401 is busy, there will be a guarding ground potential on the private bank contact 304, and when the wiper 266 strikes this grounded contact a locking circuit is closed through the private magnet 276, independently of the relay 288. This locking circuit extends from ground through some other occupying switch (not shown) to the private bank contact 304, thence through private wiper 266, relay springs 307 and 308, side switch wiper 273, contact point 299, springs 293 and 296, relay 278, and private magnet 276 to battery B. The private magnet thus remains energized and the side switch locked in second position as long as the wipers remain on the first busy bank contacts, even though the private magnet relay 288 deënergizes shortly after the first impulse to the rotary magnet. The relay 278, which was included in the locking circuit just traced through private magnet, energizes and forces the spring 309 into engagement with spring 310. The engagement of springs 309 and 310 completes a connection between the interrupter 279 and rotary magnet 269. The rotary magnet then receives one impulse from the interrupter 279 and advances the shaft wipers to the second line of the group #2401. If this second line is also busy, the private wiper 266 finds another grounded contact, and maintains the energizing circuit of the relay 278 and the private magnet 276, whereupon the rotary magnet will receive another impulse to cause it to rotate the wipers another step. This automatic rotation of the wipers will continue until an idle line is reached, or, in case all the lines of the group are busy, the wipers will be rotated onto the contacts 311, 312 and 313. The private wiper, finding no ground at contact 313, will permit the relay 278 and private magnet 276 to deënergize. The deënergization of the relay 278 disconnects the interrupter 279 from the rotary magnet 269, and the deënergization of the private magnet permits the side switch to pass to third position, whereupon the calling subscriber will receive the busy-signal in the manner explained with reference to the connector F. It has been assumed here, however, that the second line of the group is idle. In this case, when the private wiper 266 passes from the contact 304 the relay 278 and private magnet 276 are deënergized. The deënergization of the relay 278 disconnects the interrupter from the rotary magnet, as before explained, and the private magnet allows the side switch to pass to third position. When the side switch of the connector L passes to third position the connection is completed to the called substation and the bells are rung in the manner explained in connection with the connector F. Also, in this instance, as in the previous one, the removal of the receiver at the called substation causes the energization of the back-bridge relay, which opens the circuit of the ringer relay 315. The energization of the back-bridge relay 314 also opens the short-circuit around the resistance 332 by separating the springs 321 and 322, thus including this resistance in the holding circuit of the release relays 112, 124 and 282 of the switches

D, E and L, and thereby reducing the current consumed by them during a conversation. After a conversation is completed the connector L is released in the manner explained for connector F.

If it is desired to call one of the lines connected to one of the first nine levels of the connector L, as, for instance, #2441, the operation of the central office switching mechanism is the same for the first three digits as that explained in the preceding case, with the exception that the switch shaft is raised only four steps, and consequently the springs 292 and 293 are not operated by the arm 289.

When the calling device is operated for the last digit the rotary magnet 269 receives one impulse, rotates the wipers onto the first contact, and if the called line is idle the side switch is tripped to third position, in the manner explained when it was assumed that the first line of the group 2401 was idle. If, however, the line 2441 is busy when called, the wipers are not automatically rotated to the next contacts, but remain in engagement with the line #2441, and the side switch is locked in second position, thus preventing the completion of the connection to the busy line, and giving the calling subscriber the busy-signal. The manner in which the side switch is locked when a busy line is encountered is as follows: Whenever a line is busy the private connector bank contacts of that line are provided with a guarding ground potential. Thus, when the wipers are rotated to a busy line, and since the side switch is in second position, this ground potential is extended from the private bank contact over wiper 266, relay springs 307 and 308, side switch wiper 273, contact point 299, springs 293 and 295, side switch wiper 275, ringer relay springs 316 and 317 and winding 318 of back-bridge relay 314 to the battery B. The relay 314 thereupon energizes and by forcing spring 320 into engagement with spring 319 closes a locking circuit through the private magnet 276. This locking circuit extends from the grounded private bank contact to the spring 295, as previously traced, and thence through the springs 319 and 320 and private magnet 276 to battery. This locking circuit for the private magnet is established as soon as the wiper reach the busy line, and before the private magnet relay 288 has time to deënergize. The relay 288 deënergizes in the usual manner after the last rotary impulse, and as the private magnet now remains energized a circuit is completed from ground G^{19} through springs 300, 296^a, 294, 292, 297 and 323 and relay 298 to battery. The relay 298, upon energizing, shifts the spring 308 out of engagement with spring 307 and into engagement with the spring 325, whereby the locking ground of the relay 314 and private magnet 276 is transferred from the private bank contact to ground G^{20}. This shifting of the locking ground is for the purpose of maintaining the side switch locked in second position if the guarding potential should be removed from the called line after the wipers of the connector L have stopped on it. The energization of the relay 298 also separates the springs 302 and 303, thereby disconnecting the rotary magnet 269 from the impulse spring 285, so that the said magnet will not be energized when the receiver at the calling substation is restored to the switch hook. While the private magnet 276 is thus energized it locks the side switch in second position to prevent the completion of the connection with the busy line, and also connects the busy-signaling machine I' with the calling line by way of the springs 327 and 328, side switch wiper 274 and condenser 281. When a busy line has been called, the connector L and selectors D and E are released by the restoration of the receiver to the switch hook in the same manner that the connector F was released.

In the description of the operation of the connector F it was explained how the group of trunk lines corresponding to number 2221 might comprise three trunks, the fourth set of bank contacts in the second level being reserved for giving the busy signal in case all three trunks are busy. With this arrangement the next group of trunks in the second level would be reached by calling the number 2225. The five impulses for the digit 5 would cause the connector wipers to be rotated five steps over the three trunks and the blank set of contacts of the first group to the first trunk of the second group. If this trunk is busy the wipers then begin to advance automatically to find an idle trunk in the group after the last impulse from the substation is delivered. Thus it is evident that each bank level of these connectors may accommodate more than one group of lines, the first idle line of any group being accessible by calling the number corresponding to the position of the bank contacts of the first line in the group. Likewise, in the connector L each level in which the automatic rotary feature is provided may accommodate more than a single group of trunk lines. In the case assumed herein the next group in the tenth level would be numbered 2405.

From the foregoing it will be seen that I provide rotary connectors, F and L, for example, which are controllable over metallic line circuits. In this way these rotary connectors are controllable without the necessity of grounding the lines at the substations. Heretofore all rotary connectors, so far as I am now aware, have been controlled by grounding the line at the calling substation, or at the operator's position, depending upon the character of the system. With my im-

proved arrangement, however, efficient private branch exchange service is given in a system of the two-wire type—that is to say, in a system in which no operating grounds are necessary at the substations, or at any other points, for controlling the selectors and connectors or other switches. As disclosed, my invention employs the first selectors on a percentage basis, and involves an arrangement for automatically selecting idle first selectors. Also, as shown, my invention comprises one or more common batteries for furnishing talking current over the subscribers' lines to the substations thereof. For some of the broader purposes of my invention, however, the common battery feature is not necessary, and the first selectors may be given other arrangements. As illustrated, the rotary connector F is rotary in all levels thereof, so that if all of the trunk lines of any particular group are busy the calling subscriber will automatically receive the busy-signal in the manner explained. The rotary connector L, however, is of such character that it may be rotary in one or more levels, and then operate like an ordinary connector in the other level or levels. The wipers of either of the connectors F or L may be rotated to any desired contact in their respective bank levels by impulses from the calling station, the automatic rotation taking place only after the last impulse has been delivered. This connector L is, therefore, equipped with a discriminating busy-test apparatus—that is to say, a busy-test apparatus which will discriminate between busy trunk lines and busy single telephone lines. By this I mean that the busy test is of a discriminating nature, inasmuch as when a trunk line tests busy the connector does one thing, and when a single subscriber's line tests busy the connector does something else. When a trunk line tests busy the connector immediately goes to the next trunk line, and if all of the trunk lines are busy the connector L then rotates onto a busy-signal contact, and the calling subscriber receives the busy-signal. When a single subscriber's line tests busy this same connector then remains locked on that line, and the calling subscriber receives the busy-signal—that is, assuming, of course, that the single subscribers' lines are connected to the bank levels upon which the connector L operates as an ordinary connector, and that the trunk lines are connected to the levels upon which the switch acts as a rotary connector, as has been previously pointed out. Thus the connector is capable of discriminating between busy trunk lines and busy single lines, operating in one way when it finds a busy trunk line, and operating in quite a different way when it encounters a busy single line. This, as explained, is all accomplished in a system in which the switches are controlled over metallic line circuits. In this way rotary connectors are controlled and operated without the necessity of grounding the line at the calling substation.

What I claim as my invention is:—

1. In a telephone exchange system, the combination with subscribers' telephones, a line individual to each telephone, a line switching device having line terminals and a group of trunk terminals, of a moving contact member for said switching device, automatic means for stepping said member to any of said line terminals or the first trunk terminal of said group, means actuated in case said first trunk is busy for stepping said member to a terminal of an idle trunk line, said switching device operated over a circuit including both sides of any one of said lines in series, said circuit passing through the subscriber's telephone instrument.

2. In a telephone exchange system, the combination with a telephone line extending from a substation to a central office individual to a subscriber, of a connecting circuit at the central office, a progressively movable connection switch for uniting said connecting circuit with the telephone line, a line switching device having terminals of lines in the exchange, trunk lines leading to terminals of said device, a contact arm for said device adapted to sweep over said terminals to unite said connecting circuit with said terminals, automatically operated mechanism for advancing said arm over said terminals and over said trunk terminals until an idle trunk line is reached, a busy signal, means actuated in case all of said trunk lines are busy for applying said busy-signal to said connecting circuit, a relay individual to said device, said relay energized over both sides of said line in series for operating said switching device, a receiver switch hook at said telephone, said relay circuit controlled thereby.

3. In a telephone system, a calling subscriber's telephone, a line individual thereto, the combination of a plurality of telephone lines running to the same substation, telephones on said lines, an automatic switch provided with means for extending connection from said calling line to any one of said telephone lines, automatic means for causing the operation of said switch to select the first idle one of said lines, a common battery, relays allotted to said switch and controlling the flow of talking current from said battery to the called telephone line, and a circuit over which the said switching means is controlled comprising the two sides of said subscriber's line circuit in series.

4. In a telephone system, a calling subscriber's telephone, a line individual thereto, a plurality of lines any one of which will serve the purpose of a calling subscriber, means including an automatic switch com-

mon to a plurality of said lines for automatically selecting an idle line for the calling subscriber, means controlled at said automatic switch for supplying all the talking current to a subscriber's substation, and a metallic line circuit over which the said switching means is controlled comprising the two sides of said calling line circuit in series.

5. In a telephone system, telephone lines, each having individually two conductors and a receiver switch hook, a connector, means for transmitting calling current over said conductors to operate said connector, said connector having mechanism operative under substation control to find a called telephone line, means whereby said connector is operative to automatically select an idle trunk line, means for insuring a busy-signal if the called telephone line is busy, and means for insuring a like signal if all the trunk lines are busy, said connector having a relay individual thereto through the medium of which said substation control is exercised, said relay energized over both conductors in any one of said telephone lines in series, said relay circuit including a switch at the telephone directly operated by the switch hook.

6. In a telephone system, a connector, a relay, trunk lines leading from said connector, a calling substation, a line circuit individual thereto, means for transmitting current over two sides of said line circuit in series to said relay to operate said connector in accordance with the last two digits of the called number, a receiver switch hook, a switch at said telephone directly controlled by said hook, said switch included in the circuit of said relay, said connector provided with means for automaticaly selecting an idle trunk line, and means for transmitting a busy-signal over said line circuit if all the trunk lines are busy.

7. In a telephone system, a telephone station, a line circuit individual thereto, means for transmitting calling current over the two sides of said circuit in series, a connector responsive to said current, lines leading from said connector, means whereby when the connector finds one of said lines busy it automatically passes to the next line, and means whereby when the connector finds another line busy it may stop and go no farther, a relay for operating said connector, a receiver switch hook, a switch at said station operated by said hook, said switch included in the circuit of said relay.

8. In a telephone system, a telephone station, a line circuit individual thereto, means for transmitting current over said circuit, a bank of contacts, lines leading from said contacts, a wiper adapted to engage said contacts, mechanism for actuating said wiper, a relay operated over two sides of said circuit in series for operating said mechanism, means for preventing said wiper from passing a busy called line, and means for causing said wiper to automatically select an idle line, a receiver switch hook, a switch at said station operated by said hook, said switch included in the circuit of said relay.

9. In a telephone system, a telephone station, a line circuit individual thereto, a step-by-step mechanism, a plurality of lines divided into two groups, means including a relay whereby said mechanism is operated over two sides of said line circuit in series to select a certain called line from one group whether idle or busy, and means whereby said mechanism is operative to automatically select an idle one of the lines in the other group, a receiver switch hook, a switch at said station operated by said hook, the circuit of said relay including said switch.

10. In a telephone system, a telephone station, a line circuit individual thereto, telephone lines, other lines, switching means including a relay responsive to current sent over two sides of said line circuit in series for testing the lines, means for causing one kind of operation of said switching means when a telephone line tests busy, and means for causing another kind of operation when one of said other lines tests busy, a receiver switch hook, a switch at said station operated by said hook, said switch included in the circuit of said relay.

11. In a telephone system, a telephone station, a line circuit individual thereto, a connector having a relay operated over two sides of said line circuit in series, said connector having a plurality of parallel planes of operation, means whereby said connector is automatically operative in one or more of said planes to automatically select an idle line, and means whereby said connector is operative under substation control in one or more of the planes, a receiver switch hook, a switch at said station operated by said hook, said switch included in the circuit of said relay.

12. In a telephone system, suitable lines, a telephone station, a line circuit individual thereto, a connector having a plurality of parallel planes of operation under manual control, and means whereby said connector is operative automatically in one of said planes to automatically select an idle line, a relay operable over two sides of said line circuit in series for operating said connector, a receiver switch hook, a switch at said station operated by said hook, said relay included in the circuit of said switch.

13. In a telephone system, telephone lines, trunk lines, a connector, a telephone station, a line circuit individual thereto, a relay for operating said connector, means for transmitting calling current over two sides of said circuit in series to said relay to operate

said connector, said connector having mechanism operative under substation control to find a called telephone line, means whereby said connector is operative to automatically select an idle trunk line, means for insuring a busy-signal if the called telephone line is busy, means for insuring a like signal if all the trunk lines are busy, a receiver switch hook, a switch at said station operated by said hook, said relay included in the circuit of said switch, means including first selectors for reaching said connector, and means for automatically selecting idle first selectors, said selectors controllable over the said metallic circuit in accordance with the first digit of the called number.

14. In a telephone system, a connector, a relay, trunk lines leading from said connector, a telephone station, a line circuit individual thereto, means for transmitting current over two sides of said circuit in series to said relay to operate said connector in accordance with the last two digits of the called number, said connector provided with means for automatically selecting an idle trunk line, means for transmitting a busy-signal over said metallic circuit if all the trunk lines are busy, a receiver switch hook, a switch at said station operated by said hook, said relay included in the circuit of said switch, means including first selectors for reaching said connector, and means for automatically selecting idle first selectors, said selectors controllable over the two sides of said line circuit in accordance with the first digit of the called number.

15. In a telephone system, a telephone station, a line circuit individual thereto, means for transmitting calling current over two sides of said circuit in series, a connector having a relay responsive to said current, lines leading from said connector, means whereby when the connector finds one of said lines busy it automatically passes to the next line, means whereby when the connector finds another line busy it may stop and go no farther, a receiver switch hook, a switch at said station operated by said hook, said relay included in the circuit of said switch, means including first selectors for reaching said connector, and means for automatically selecting idle first selectors, said selectors controllable over the two sides of said line circuit in accordance with the first digit of the called number.

16. In a telephone system, a line, a line circuit individual thereto, an automatic switch operative over two sides of said line circuit in series in accordance with the last digits of the called number, one or more grounded private bank contacts and a non-grounded private bank contact for said switch for controlling said switch, means under the control of a subscriber for moving said switch over certain of said grounded contacts, and means for automatically moving said switch over other of said grounded contacts.

17. In a telephone system, a line, a line circuit individual thereto, an automatic switch, a rotary magnet therefor controlled over two sides of said line circuit in series in accordance with the last digit of the called number, a plurality of grounded and non-grounded bank contacts for controlling said operation, and means for energizing said rotary magnet when connection is made with a grounded contact of said bank.

18. In a telephone exchange system, the combination with a line switching device having line terminals and a group of trunk terminals, of a moving contact member for said switching device, automatic means including a relay for stepping said member to any of said line terminals or the first trunk terminal of said group, means actuated in case said first trunk is busy for stepping said member to a terminal of an idle trunk line, a line circuit over two sides in series of which the said switching device is operated, and means at the central station including said relay for supplying talking current over said circuit.

19. In a telephone exchange system, the combination with a telephone line extending from a sub-station to a central office, of a connecting circuit at the central office, a connection switch for uniting said connecting circuit with the telephone line, a line switching device having terminals for lines in the exchange, a relay for operating said device, trunk lines leading to terminals of said device, a contact arm for said device adapted to sweep over said terminals to unite said connecting circuit with said terminals, automatically operated mechanism for advancing said arm over said line terminals and for automatically advancing said arm over said trunk terminals until an idle trunk line is reached, a busy signal, means actuated in case all of said trunk lines are busy for applying said busy-signal to said connecting circuit, a line circuit over two sides in series of which the said relay is operated, and means at the central station for supplying talking current over said circuit.

20. In a telephone system, trunk lines, a line circuit, means for transmitting current over two sides of said circuit in series, means having motion in two intersecting planes responsive to said current for automatically selecting an idle trunk line in accordance with the last digit of the called number, a relay responsive to said current for operating said second means, and means at the central station including said relay for supplying talking current over said circuit.

21. In a telephone system, trunk lines, a

line circuit, means for transmitting calling current over two sides of said circuit in series, means including a relay responsive to said current to select an idle trunk line, means for transmitting a busy-signal if all the trunk lines are busy, and means at the central station including said relay for supplying talking current over said circuit.

22. In a telephone system, a circuit, means for transmitting calling current over two sides of said circuit in series, trunk lines, telephone lines, means including a relay responsive to said current for automatically selecting an idle trunk line or a particular telephone line, means whereby busy-signal current is conducted to the calling party if all the trunk lines are busy, means whereby busy-signaling current is conducted to the calling party if the called telephone line is busy, and means at the central station including said relay for supplying talking current over said circuit.

23. In a telephone system, telephone lines, trunk lines, a connector, a relay for operating said connector, a line circuit, means for transmitting calling current over two sides of said line circuit in series to operate said connector, said connector having mechanism including said relay operative under substation control to find a called telephone line, means whereby said connector is operative to automatically select an idle trunk line, means for insuring a busy-signal if the called telephone line is busy, means for insuring a like signal if all the trunk lines are busy, and means at the central station including said relay for supplying talking current over said line circuit.

24. In a telephone system, a connector, a relay, trunk lines leading therefrom, a line circuit, means for transmitting current over two sides of said line circuit in series to operate said connector through the medium of said relay in accordance with the last two digits of the called number, said connector provided with means for automatically selecting an idle trunk line, means for transmitting a busy-signal over said metallic circuit if all the trunk lines are busy, and means at the central station including said relay for supplying talking current over said line circuit.

25. In a telephone system, a line circuit, means for transmitting calling current over two sides of said line circuit in series, a connector having a relay responsive to said current, lines leading from said connector, means whereby when the connector finds one of said lines busy it automatically passes to the next line, means whereby when the connector finds another line busy it may stop and go no farther, and means at the central station including said relay for supplying talking current over said line circuit.

26. In a telephone system, a line circuit, means for transmitting current over two sides of said line circuit in series, a bank of contacts, lines leading from said contacts, a wiper adapted to engage said contacts, means including a relay responsive to said current for actuating said wiper, means for preventing said wiper from passing a busy called line, means for causing said wiper to automatically select an idle line, and means at the central station including said relay for supplying talking current over said line circuit.

27. In a telephone system, a line circuit, a step-by-step mechanism, a plurality of lines, means including a relay operable over two sides of said line circuit in series for controlling said mechanism to select a certain called line, means whereby said mechanism is operative to automatically select an idle one of said lines, and means at the central station including said relay for supplying talking current over said line circuit.

28. In a telephone system, a line circuit, telephone lines, other lines, switching means for testing the lines, a relay operable over two sides of said line circuit in series for operating said switching means, means for causing one kind of operation of said switching means when a telephone line tests busy, means for causing another kind of operation when one of said other lines tests busy, and means at the central station including said relay for supplying talking current over said line circuit.

29. In a telephone system, a line circuit, a connector having a relay operable over two sides of said line circuit in series, said connector having a plurality of parallel planes of operation, means whereby said connector is automatically operative in one or more of said planes to automatically select an idle line, means whereby said connector is operative under substation control in one or more of the planes, and means at the central station including said relay for supplying talking current over said circuit.

30. In a telephone system, suitable lines, a line circuit, a connector having a plurality of parallel planes of operation under manual control, means whereby said connector is operative automatically in one of said planes to automatically select an idle line, a relay operated over two sides of said line circuit in series for operating said connector, and means at the central station including said relay for supplying talking current over said line circuit.

31. In a telephone system, telephone lines, trunk lines, a connector, a relay, a line circuit, means for transmitting calling current over two sides of said circuit in series to operate said connector through the medium of said relay, said connector having mechanism operative under substation control to

find a called telephone line, means whereby said connector is operative to automatically select an idle trunk line, means for insuring a busy-signal if the called telephone line is busy, means for insuring a like signal if all the trunk lines are busy, means including first selectors for reaching said connector, means for automatically selecting idle first selectors, said selectors controllable over the said line circuit in accordance with the first digit of the called number, and means at the central station including said relay for supplying talking current over said line circuit.

32. In a telephone system, a connector, a relay, trunk lines leading from said connector, a line circuit, means for transmitting current over two sides of said circuit in series to operate said connector through the medium of said relay in accordance with the last two digits of the called number, said connector provided with means for automatically selecting an idle trunk line, means for transmitting a busy-signal over said line circuit if all the trunk lines are busy, means including first selectors for reaching said connector, means for automatically selecting idle first selectors, said selectors controllable over the said line circuit in accordance with the first digit of the called number, and means at the central station including said relay for supplying talking current over said line circuit.

33. In a telephone system, a line circuit, means for transmitting calling current over two sides of said circuit in series, a connector having a relay responsive to said current, lines leading from said connector, means whereby when the connector finds one of said lines busy it automatically passes to the next line, means whereby when the connector finds another line busy it may stop and go no farther, means including first selectors for reaching said connector, means for automatically selecting idle first selectors, said selectors controllable over the said line circuit in accordance with the first digit of the called number, and means at the central station including said relay for supplying talking current over said line circuit.

34. In a telephone system, a line circuit, an automatic switch operative over two sides of said line circuit in series in accordance with the last digits of the called number, one or more grounded private bank contacts and a non-grounded private bank contact for said switch for controlling said switch, means under the control of a subscriber for moving said switch over certain of said grounded contacts, means for automatically moving said switch over other of said grounded contacts, and means at the central station for supplying talking current over said line circuit.

35. In a telephone system, a line circuit, an automatic switch, a rotary magnet therefor controlled over two sides of said line circuit in series in accordance with the last digit of the called number, a plurality of grounded and non-grounded bank contacts, means for energizing said rotary magnet when connection is made with a grounded contact of said bank, and means at the central station for supplying talking current over said line circuit.

36. In a telephone system, a main exchange, a private branch exchange, a plurality of groups of trunk lines extending from said main exchange to said branch exchange, a trunk selector at said main exchange, said selector having motion in one plane to select groups and motion in a plane at right-angles thereto to select sub-groups and then select an idle trunk in a selected sub-group, a relay for controlling said switch, said relay operated over two sides of a line circuit in series, and means including said relay for supplying talking current to said line circuit.

37. In a telephone system, a plurality of lines divided into groups, a selector switch having motion in one plane to select groups and rotary motion in a plane at right-angles thereto to find a line in a selected group, a line relay, a slow-acting relay, means for energizing said slow-acting relay when said line relay is energized, and means for partly rotating said switch when said slow-acting relay is energized and completing the rotation of said switch when said slow-acting relay is deënergized.

38. In a telephone system, trunk lines, means for transmitting current over two sides of a metallic circuit in series, and means common to a plurality of said lines for automatically selecting an idle trunk line in accordance with the last digit of the called number, a relay responsive to said current for operating said selecting means, and means for supplying talking current through said relay to said circuit.

39. In a telephone system, trunk lines, means for transmitting current over two sides of a metallic circuit in series, means common to a plurality of said lines for automatically selecting an idle trunk line in accordance with the last digit of the called number, a relay responsive to said current for operating said selecting means, and means at the central station including said relay for supplying talking current over said metallic circuit.

40. A telephone system comprising a line-switching device having line terminals and a group of trunk terminals, a moving contact member for said switching device, means including a relay for stepping said member to any of said line terminals or the first trunk terminal of said group, means actuated in case said first trunk is busy for stepping said member to a terminal of an idle

trunk line, and a line circuit over two sides in series of which the said switching means is controlled, and means including said relay for supplying talking current to said line circuit.

41. In a telephone system, the combination with a line switching device carrying line terminals and a group of trunk terminals, of a moving contact member for said switching device, automatic means for stepping said member to any of said line terminals or to the first trunk terminal of said group, a guarding potential circuit for the first trunk in said group, means for applying a potential to said circuit when the trunk is busy, said automatic means responsive to said potential for stepping said member to a terminal of an idle trunk line, a line terminating in said switch, and means for controlling said switch over the two sides of the line in series, and for supplying talking current to said line.

42. In a telephone exchange system, the combination with a telephone line extending from a substation to a central office, of a connecting circuit at the central office, a connection switch for uniting said connecting circuit with the telephone line, a line switching device having terminals for lines in the exchange, trunk lines leading to terminals of said device, a contact arm for said device adapted to sweep over said terminals to unite said connecting circuit with said terminals, automatically operated mechanism for advancing said arm over said terminals and over said trunk terminals until an idle trunk line is reached, a busy signal, means actuated in case all of said trunk lines are busy for applying said busy signal to said connecting circuit, and a line terminating in said switch for controlling said switch over the two sides of the line in series.

43. In a telephone system, the combination of a plurality of telephone lines running to the same substation, telephones on said lines, an automatic switch provided with means for extending connection to any one of said lines, automatic means for causing the operation of said switch to select the first idle one of said lines, a common battery, relays allotted to said switch and controlling the flow of talking current from said battery to the called telephone line, and a line terminating in said switch for controlling said switch over the two sides of the line in series.

44. In a telephone system, a plurality of lines any one of which will serve the purpose of a calling subscriber, means including an automatic switch having motion in two intersecting planes common to a plurality of said lines for automatically selecting an idle line for the calling subscriber, means controlled at said automatic switch for supplying all the talking current to a subscriber's substation, and a line terminating in said switch for controlling said switch over the two sides of the line in series.

45. In a telephone system, a line, trunk lines, means for transmitting current over two sides of the line in series, and means having motion in two intersecting planes responsive to said current for automatically selecting an idle trunk line in accordance with the last digit of the called number, a relay for operating said second means, and means for supplying talking current through the said relay to said line.

46. In a telephone system, trunk lines, a line circuit, means for transmitting calling current over two sides of said circuit in series, means responsive to said current to select an idle trunk line, and means for transmitting a busy signal if all the trunk lines are busy, a relay for operating said second means, and means for supplying talking current through the said relay to said line.

47. In a telephone system, a circuit, means for transmitting calling current over two sides of said circuit in series, trunk lines, telephone lines, means responsive to said current for automatically selecting an idle trunk line or a particular telephone line, means whereby busy signal current is conducted to the calling party if all the trunk lines are busy, a relay for operating said second means, and means for supplying talking current through the said relay to said line, and means whereby busy signaling current is conducted to the calling party if the called telephone line is busy.

48. In a telephone system, telephone lines, trunk lines, a connector, a line circuit, means for transmitting calling current over two sides of said circuit in series to operate said connector, said connector having mechanism operative under substation control to find a called telephone line, a relay allotted to said connector for supplying talking current to the called telephone line, means whereby said connector is operative to automatically select an idle trunk line, means for insuring a busy signal if the called telephone line is busy, and means for insuring a like signal if all the trunk lines are busy.

49. In a telephone system, a connector, trunk lines leading therefrom, a line circuit, means for transmitting current over two sides of said circuit in series to operate said connector in accordance with the last two digits of the called number, said connector provided with means for automatically selecting an idle trunk line, means for transmitting a busy signal over said circuit if all the trunk lines are busy, a relay for operating said connector, and means for supplying talking current through the windings of said relay.

50. In a telephone system, a line circuit, means for transmitting calling current over

two sides of said circuit in series, a connector responsive to said current, lines leading from said connector, means whereby when the connector finds one of said lines busy it automatically passes to the next line, means whereby when the connector finds another line busy it may stop and go no farther, a relay for operating said connector, and means for supplying talking current through the windings of said relay.

51. In a telephone system, a line circuit, means for transmitting current over two sides of said circuit in series, a bank of contacts, lines leading from said contacts, a wiper adapted to engage said contacts, means including a relay for actuating said wiper, means for preventing said wiper from passing a busy called line, means for causing said wiper to automatically select an idle line, and means for supplying talking current to said line circuit through the windings of said relay.

52. In a telephone system, a plurality of lines, a line circuit, mechanism controllable over two sides of said line circuit in series for automatically selecting an idle line, a source of busy signaling current, and means whereby if all the lines are found busy the said mechanism is propelled beyond all of said lines without releasing said mechanism and a busy signal transmitted to a calling subscriber to indicate that all the lines are busy.

53. In a telephone system, a line circuit, a step-by-step mechanism, a plurality of lines divided into two groups, means including a relay whereby said mechanism is controllable over two sides of the said circuit in series to select a certain called line from one group, means whereby said mechanism is operative to automatically select an idle one of the lines in the other group, and means for supplying talking current to said line circuit through the windings of said relay.

54. In a telephone system, a line circuit, telephone lines, other lines, switching means responsive to current sent over two sides of said line in series for testing the lines, means for causing one kind of operation of said switching means when a telephone line tests busy, means for causing another kind of operation when one of said other lines tests busy, a relay for operating said switching means, and means for supplying talking current to said line circuit through the windings of said relay.

55. In a telephone system, lines, another line circuit, a connector having a relay operable over two sides of said circuit in series, said connector having a plurality of parallel planes of operation, means whereby said connector is automatically operative in one or more of said planes to automatically select an idle line, means whereby said connector is operative under substation control in one or more of the planes, and means for supplying talking current through the windings of said relay.

56. In a telephone system, telephone lines, trunk lines, a connector, a relay for operating said connector, a circuit, means for transmitting calling current over two sides of said circuit in series to said relay to operate said connector, said connector having mechanism operative under substation control to find a called telephone line, means whereby said connector is operative to automatically select an idle trunk line, means for insuring a busy signal if the called telephone line is busy, means for insuring a like signal if all the trunk lines are busy, means for supplying talking current through the windings of said relay, means including first selectors for reaching said connector, and means for automatically selecting idle first selectors, said selectors controllable over the said circuit in accordance with the first digit of the called number.

57. In a telephone system, a connector, trunk lines leading therefrom, a line circuit, means for transmitting current over two sides of said circuit in series to operate said connector in accordance with the last two digits of the called number, said connector provided with means for automatically selecting an idle trunk line, means for transmitting a busy signal over said circuit if all the trunk lines are busy, means including first selectors for reaching said connector, means for automatically selecting idle first selectors, said selectors controllable over the said circuit in accordance with the first digit of the called number, a relay for controlling the operation of said connector, and means for supplying talking current through the windings of said relay.

58. In a telephone system, a line circuit, means for transmitting calling current over two sides of said circuit in series, a connector having a relay responsive to said current, lines leading from said connector, means whereby when the connector finds one of said lines busy it automatically passes to the next line, means whereby when the connector finds another line busy it may stop and go no farther, means including first selectors for reaching said connector, means for automatically selecting idle first selectors, said seelctors controllable over the said circuit in accordance with the first digit of the called number, and means for supplying talking current through the windings of said relay.

59. In a telephone system, a line circuit, an automatic switch controlled over two sides of said line circuit in series in accordance with the last digits of the called number, one or more grounded private bank contacts and a non-grounded private bank contact for said switch for controlling said switch, means under the control of a sub-

scriber for moving said switch over certain of said grounded contacts, and means for automatically moving said switch over other of said grounded contacts.

60. In a telephone system, a line circuit, an automatic switch, a rotary magnet therefor controlled over two sides of said line circuit in series in accordance with the last digit of the called number, a plurality of grounded and non-grounded bank contacts for controlling said operation, and means for energizing said rotary magnet when connection is made with a grounded contact of said bank.

61. In a telephone exchange system, the combination with a line switching device carrying line terminals and a group of trunk terminals, of a moving contact member for said switching device, automatic means for stepping said member to any of said line terminals or the first trunk terminal of said group, means actuated in case said first trunk is busy for stepping said member to a terminal of an idle trunk line, a line terminating in said switch for controlling said switch over the two sides of the line in series, and means at the central station for supplying talking current over said line.

62. In a telephone exchange system, the combination with a telephone line extending from a substation to a central office, of a connecting circuit at the central office, a connection switch for uniting said connecting circuit with the telephone line, a line switching device having terminals for lines in the exchange, trunk lines leading to terminals of said device, a contact arm for said device adapted to sweep over said terminals to unite said connecting circuit with said terminals, automatically operated mechanism for advancing said arm over said line terminals and for automatically advancing said arm over said trunk terminals until an idle trunk line is reached, a busy signal, means actuated in case all of said trunk lines are busy for applying said busy signal to said connecting circuit, said switching means controlled over the two sides of said telephone line in series, and means including a relay individual to said switching device for supplying talking current over said metallic circuit.

63. In a telephone system, trunk lines, a line circuit, means for transmitting current over two sides of said line circuit in series, means having motion in two intersecting planes responsive to said current for automatically selecting an idle trunk line in accordance with the last digit of the called number, and means including a relay individual to said selecting means for supplying talking current over said circuit.

64. In a telephone system, trunk lines, a line circuit, means for transmitting calling current over two sides of said circuit in series, means responsive to said current to select an idle trunk line, means for transmitting a busy signal if all the trunk lines are busy, and means including a relay individual to said second means for supplying talking current over said circuit.

65. In a telephone system, a circuit, means for transmitting calling current over two sides of said circuit in series, trunk lines, telephone lines, means responsive to said current for automatically selecting an idle trunk line or a particular telephone line, means whereby busy signal current is conducted to the calling party if all the trunk lines are busy, means whereby busy signaling current is conducted to the calling party if the called telephone line is busy, and means including a relay individual to said second means for supplying talking current over said circuit.

66. In a telephone system, telephone lines, trunk lines, a connector, a circuit, means for transmitting calling current over two sides of said circuit in series to operate said connector, said connector having mechanism operative under substation control to find a called telephone line, means whereby said connector is operative to automatically select an idle trunk line, means for insuring a busy signal if the called telephone line is busy, means for insuring a like signal if all the trunk lines are busy, and means individual to said connector for supplying talking current over said circuit.

67. In a telephone system, a connector, trunk lines leading therefrom, a line circuit, means for transmitting current over two sides of said circuit in series to operate said connector in accordance with the last two digits of the called number, said connector provided with means for automatically selecting an idle trunk line, means for transmitting a busy signal over said circuit if all the trunk lines are busy, and means individual to said connector for supplying talking current over said circuit.

68. In a telephone system, a line circuit, means for transmitting calling current over two sides of said circuit in series, a connector responsive to said current, lines leading from said connector, means whereby when the connector finds one of said lines busy it automatically passes to the next line, means whereby when the connector finds another line busy it may stop and go no farther, and means individual to said connector for supplying talking current over said circuit.

69. In a telephone system, a line circuit, means for transmitting current over two sides of said circuit in series, a bank of contacts, lines leading from said contacts, a wiper adapted to engage said contacts, means for actuating said wiper, means for preventing said wiper from passing a busy

called line, means for causing said wiper to automatically select an idle line, and a relay individual to said actuating means for supplying talking current over said circuit.

70. In a telephone system, a plurality of lines, a line circuit, mechanism controllable over two sides of said line circuit in series for automatically selecting an idle line, a busy signal contact, means whereby if all the lines are found busy the said mechanism stops on the said busy signal contact, and means individual to said mechanism for supplying talking current over said circuit.

71. In a telephone system, a line circuit, a step-by-step mechanism, a plurality of lines, means whereby said mechanism is controllable over two sides of the said circuit in series to select a certain called line, means whereby said mechanism is operative to automatically select an idle one of said lines, and means individual to said mechanism for supplying talking current over said circuit.

72. In a telephone system, a line circuit, telephone lines, other lines, switching means responsive to current sent over two sides of said line in series for testing the lines, means for causing one kind of operation of said switching means when a telephone line tests busy, means for causing another kind of operation when one of said other lines tests busy, and a relay individual to the switching means for supplying talking current over said circuit.

73. In a telephone system, lines, a line circuit, a connector controllable over two sides of said circuit in series, said connector having a plurality of parallel planes of operation, means whereby said connector is automatically operative in one or more of said planes to automatically select an idle line, means whereby said connector is operative under substation control in one or more of the planes, and means individual to said connector for supplying talking current over said circuit.

74. In a telephone system, telephone lines, trunk lines, a connector, a circuit, means for transmitting calling current over two sides of said circuit in series to operate said connector, said connector having mechanism operative under substation control to find a called telephone line, means whereby said connector is operative to automatically select an idle trunk line, means for insuring a busy signal if the called telephone line is busy, means for insuring a like signal if all the trunk lines are busy, means including first selectors for reaching said connector, means for automatically selecting idle first selectors, said selectors controllable over the same circuit in accordance with the first digit of the called number, and means individual to said connector for supplying talking current over said circuit.

75. In a telephone system, a connector, trunk lines leading therefrom, a line circuit, means for transmitting current over two sides of said circuit in series to operate said connector in accordance with the last two digits of the called number, said connector provided with means for automatically selecting an idle trunk line, means for transmitting a busy signal over said circuit if all the trunk lines are busy, means including first selectors for reaching said connector, means for automatically selecting idle first selectors, said selectors controllable over the said circuit in accordance with the first digit of the called number, and means individual to said connector for supplying talking current over said circuit.

76. In a telephone system, a line circuit, means for transmitting calling current over two sides of said circuit in series, a connector responsive to said current, lines leading from said connector, means whereby when the connector finds one of said lines busy it automatically passes to the next line, means whereby when the connector finds another line busy it may stop and go no farther, means including first selectors for reaching said connector, means for automatically selecting idle first selectors, said selectors controllable over the said circuit in accordance with the first digit of the called number, and means individual to said connector for supplying talking current over said circuit.

77. In a telephone system, a line circuit, an automatic switch operative over two sides of said line circuit in series in accordance with the last digits of the called number, one or more grounded private bank contacts, and a non-grounded private bank contact for said switch, means under the control of a subscriber for moving said switch over certain of said grounded contacts, means for automatically moving said switch over other of said grounded contacts, and means at the central station for supplying talking current over said circuit.

78. In a telephone system, a line circuit, an automatic switch, a rotary magnet therefor controlled over two sides of said line circuit in series in accordance with the last digit of the called number, a plurality of grounded and non-grounded bank contacts, means for energizing said rotary magnet when connection is made with a grounded contact of said bank, and means at the central station for supplying talking current over said circuit.

79. A telephone system comprising a line switching device having line terminals and a group of trunk terminals, a moving contact member for said switching device, automatic means for stepping said member to any of said line terminals or the first trunk terminal of said group, means actuated in case said first trunk is busy for stepping said member to a terminal of an idle trunk

line, a line terminating in said switching device for controlling said switching device over the two sides of the line in series, and means individual to said switching device for supplying talking current to said line.

80. In a telephone system, a calling and a called line, an automatic progressively movable switch for connecting the two, said switch provided with means for selecting an idle trunk line in accordance with the last digit of the called number, anl one of which trunk lines will serve the purpose of the connection, a relay for operating said switch and for feeding current for talking purposes to the established connection, said relay energized over both sides of the talking circuit in series for operating said switch.

81. In a telephone system, a calling and a called line, an automatic progressively movable switch for connecting the two, said switch provided with means for selecting an idle trunk line in accordance with the last digit of the called number, anl one of which trunk lines will serve the purpose of the connection, a relay for operating said switch and for feeding current for talking purposes to the established connection, said relay energized for operating said switch, and means for transmitting a busy signal if all the trunk lines are busy.

82. In a telephone system, a plurality of lines, a terminal for each line, said terminals arranged in a group and divided up with sub-groups, a progressively movable automatic switch for electing a sub-group of terminals and for thereafter extending a circuit to any one of the lines in the elected sub-group by way of said terminals, the terminals of each sub-group spaced off from the terminals of the adjacent sub-group or sub-groups, a test terminal associated with each line terminal and circuits associated with said test terminals whereby the switch may be advanced from a busy line in a sub-group to another line in the same sub-group whereby if all the lines in a sub-group are busy, the switch is advanced to the space between the last sub-group and the next sub-group, and a busy signal associated with the space between said groups for signaling a calling subscriber, said switch operated over any one of said lines by means of a circuit including both sides of the line in series.

83. An exchange system comprising switching mechanism, a line circuit, said mechanism provided with a plurality of groups of relatively fixed line contacts, an independent movable contact member for coöperation with all of the contacts of each group, telephone lines adapted for one class of service and being connected to contacts in certain groups, telephone lines of another class connected to contacts in other groups, and means adapted, upon connection of said movable contact members with contacts of a busy line having one class of service, to stop the operation of said movable contact member, and upon connection of said contact member with a contact of a busy line having the other class of service, to cause said contact member to connect with the next succeeding contacts, said mechanism controlled over two sides of said line circuit in series and supplying talking current to said line circuit.

84. An exchange system comprising switching mechanism, a line circuit, said mechanism provided with a plurality of groups of relatively fixed line contacts, an independent movable contact member for coöperation with all of the contacts of each group, subscribers' lines connected to contacts in certain groups, trunk lines connected to contacts in other groups, means adapted to prepare said movable contact for cooperation with the contacts of trunk lines only, and means adapted upon the completion of said preparation to cause said switch to automatically connect with an idle trunk line, said mechanism controlled over two sides of said line circuit in series and supplying talking current to said line circuit.

85. In a telephone system, an automatic switch, a plurality of lines accessible to said switch, terminals for said lines arranged in rows or levels, other lines accessible to said switch having their terminals arranged in a separate row, a calling line having access to said switch, means for controlling said switch by impulses delivered over the two sides of said calling line in series to select any one of said first lines or the row assigned to said second lines, and means rendered effective after said latter selection whereby said switch is enabled to select an idle one of said other lines and conductively connect the said calling line thereto.

Signed by me at Chicago, Cook county, Illinois, this 8th day of October, 1909.

TALBOT G. MARTIN.

Witnesses:

EDWARD D. FALES,

ETHEL EDGELL.