Mar. 13, 1923.

1,448,420

P. C. SMITH

TELEPHONE EXCHANGE SYSTEM

Filed Sept. 30, 1919

5 sheets-sheet 1

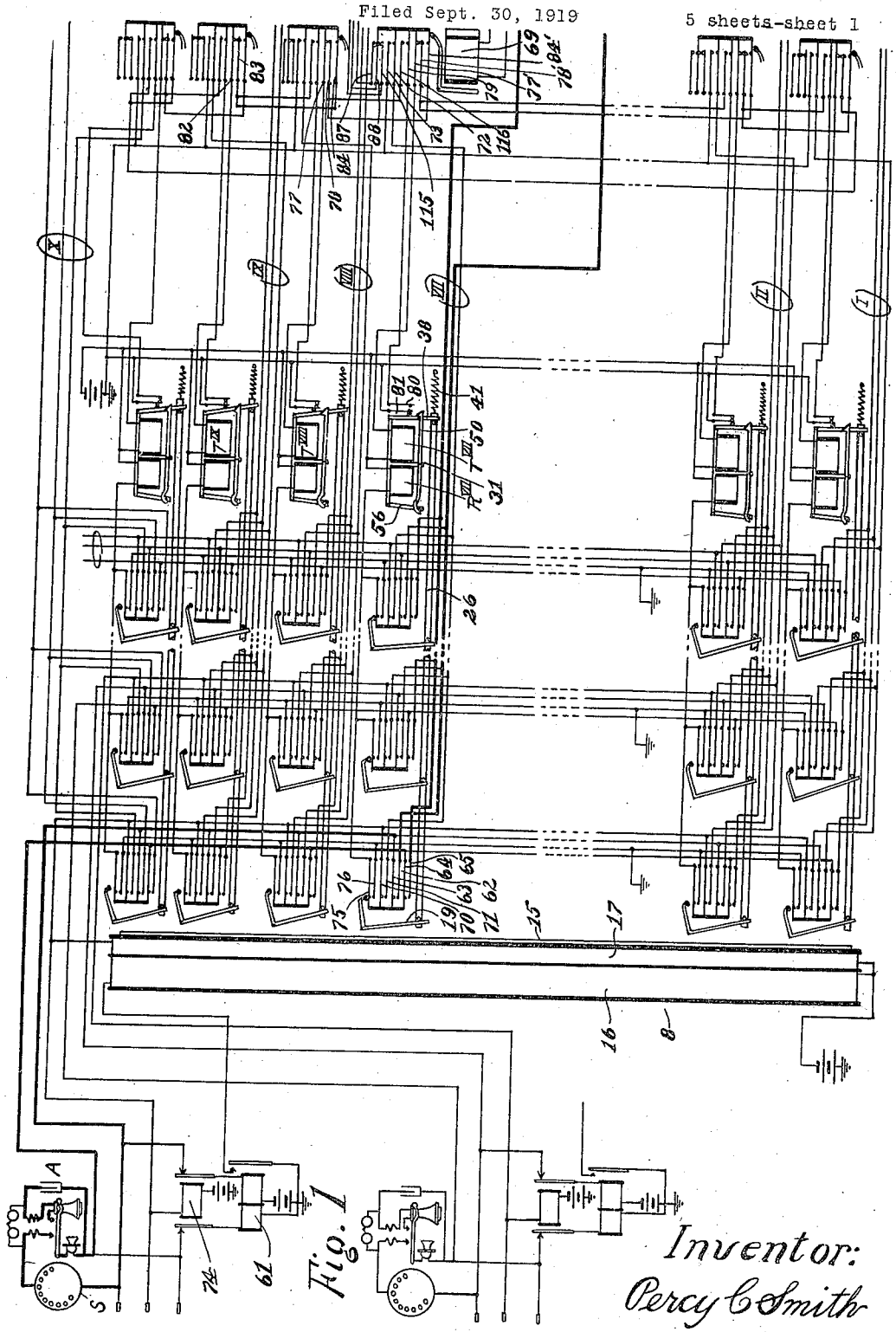

Fig. 1

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Mar. 13, 1923. 1,448,420

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Filed Sept. 30, 1919. 5 sheets-sheet 2

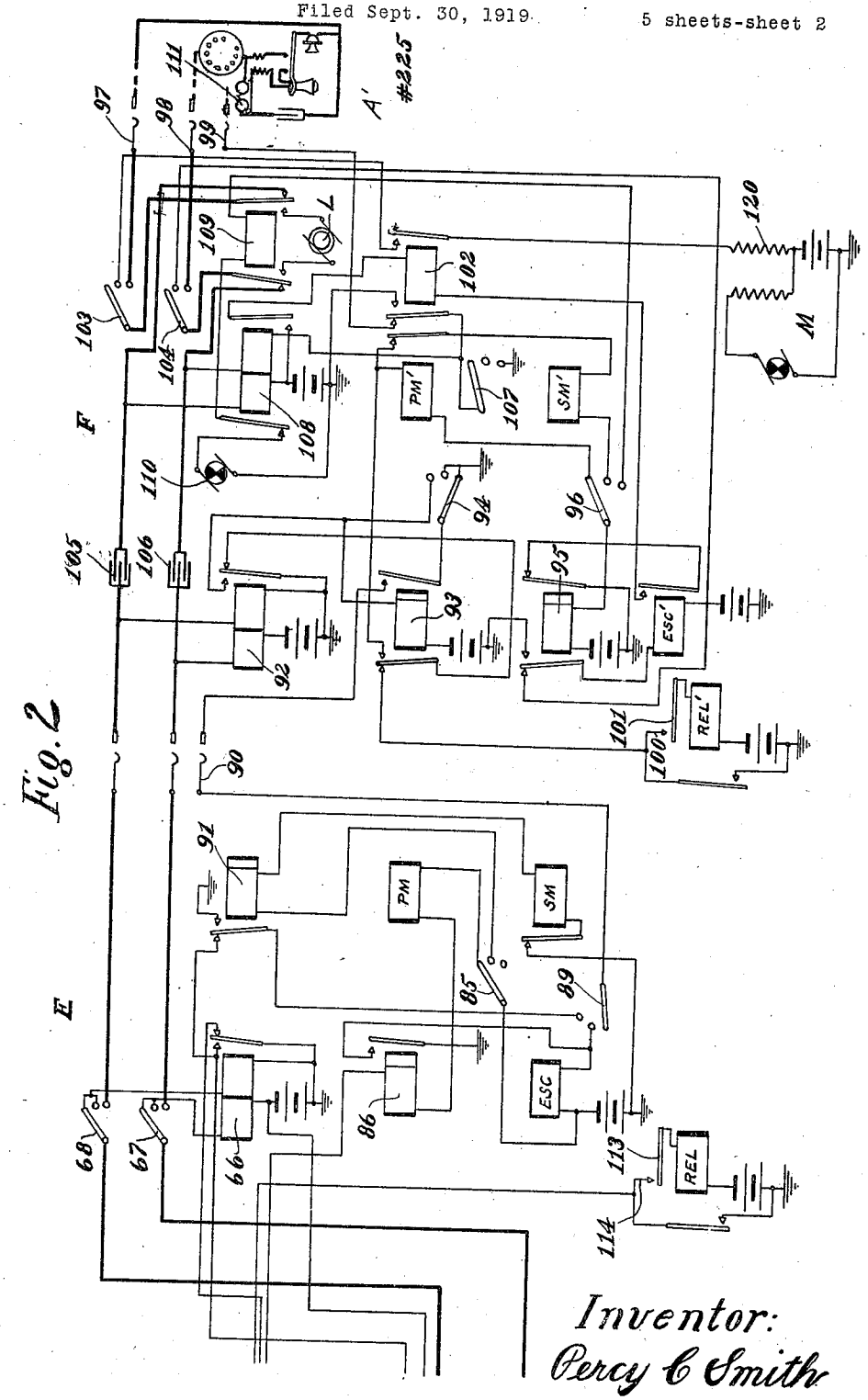

Fig. 2

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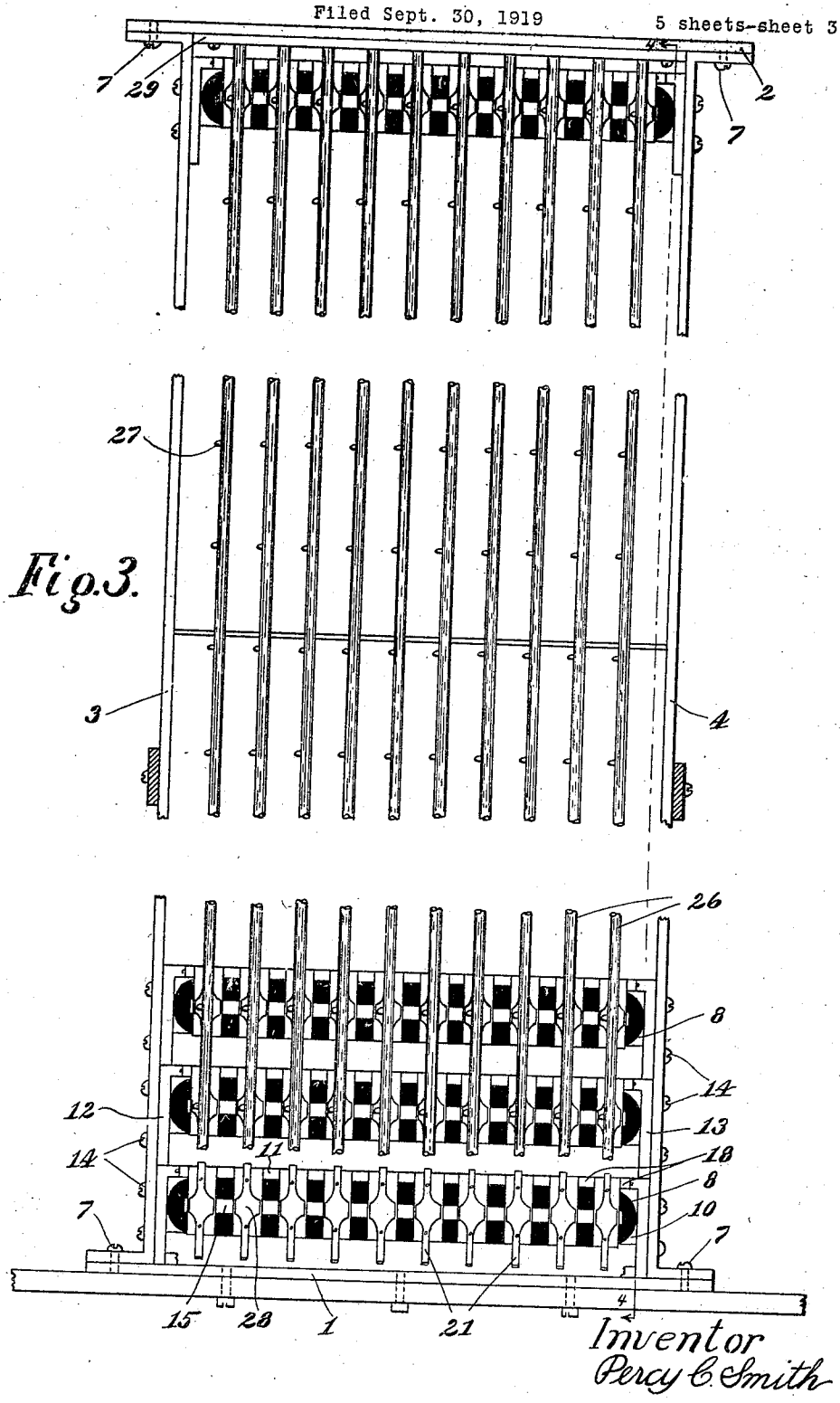

Fig.3.

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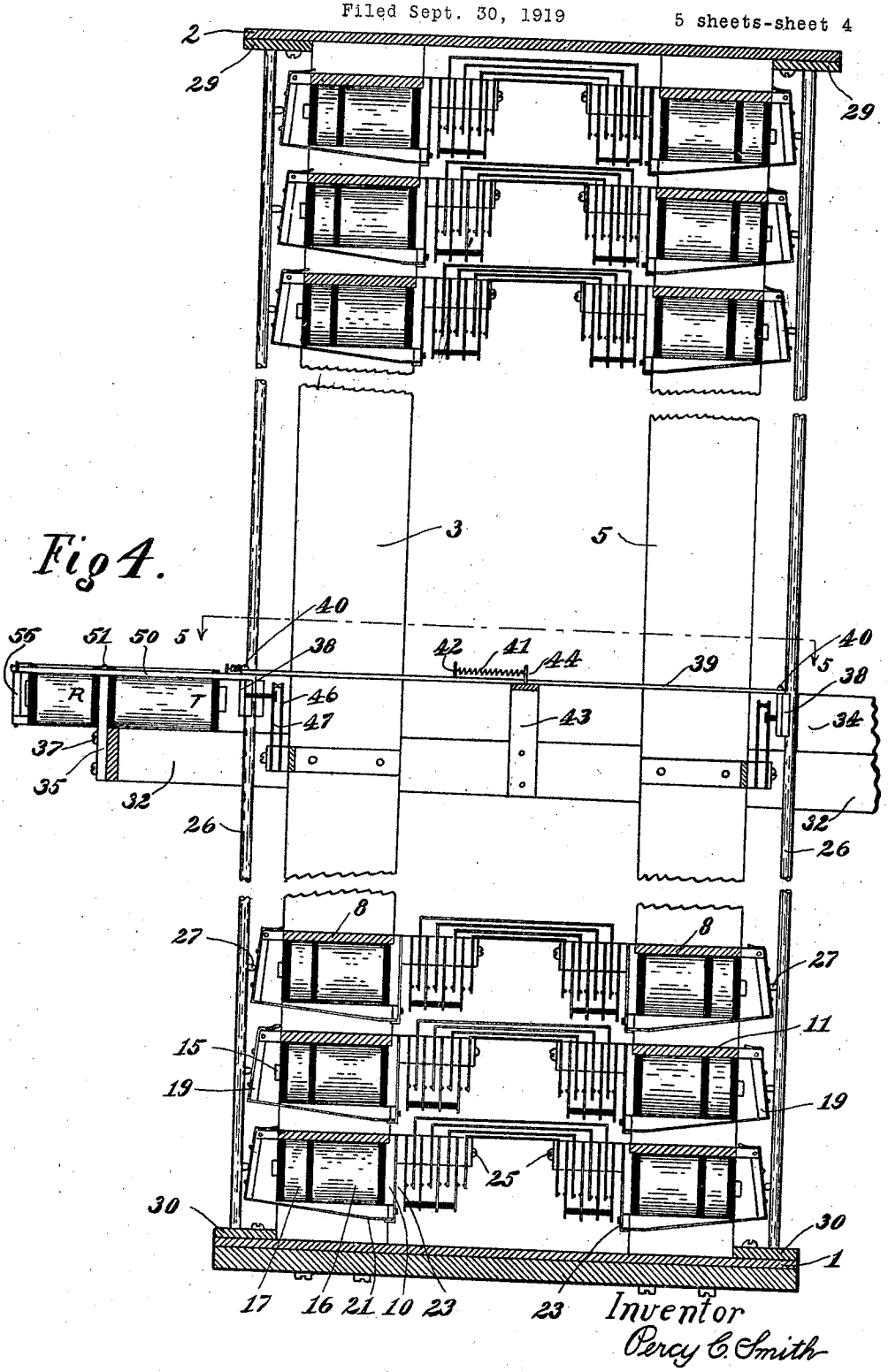
Fig 4.



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TELEPHONE EXCHANGE SYSTEM

Filed Sept. 30, 1919

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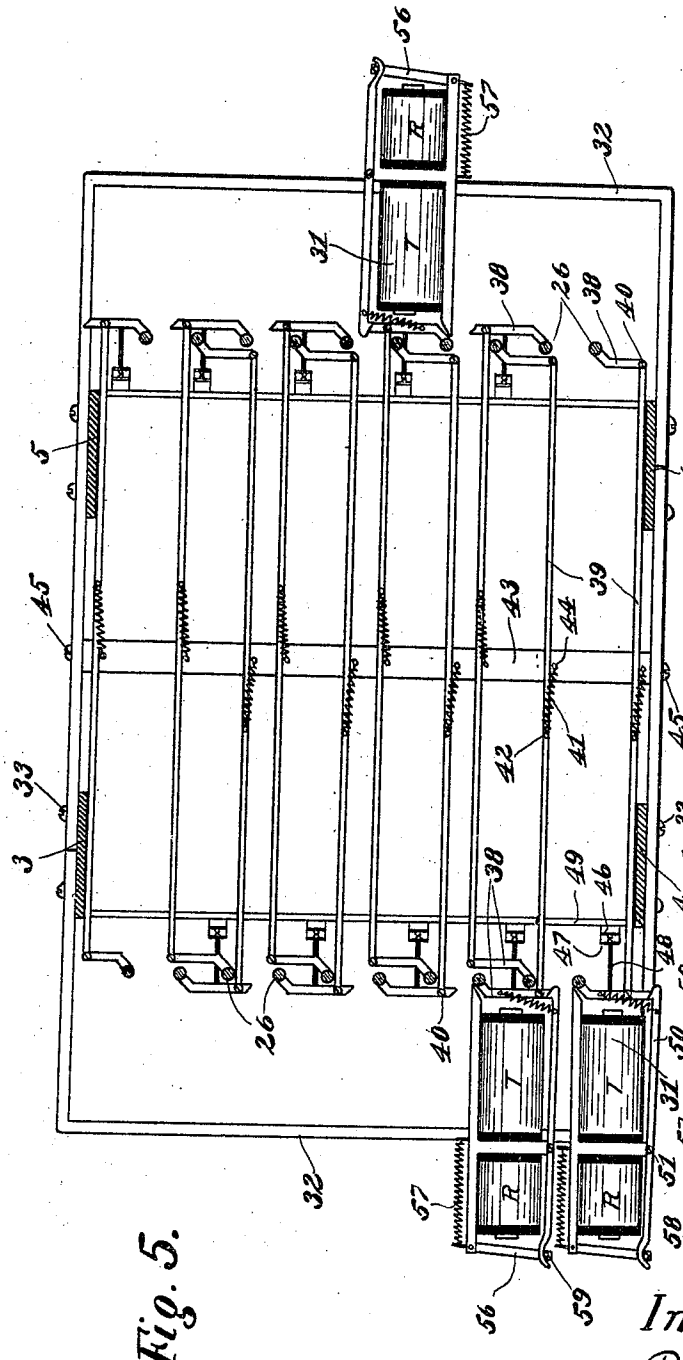

Fig. 5.

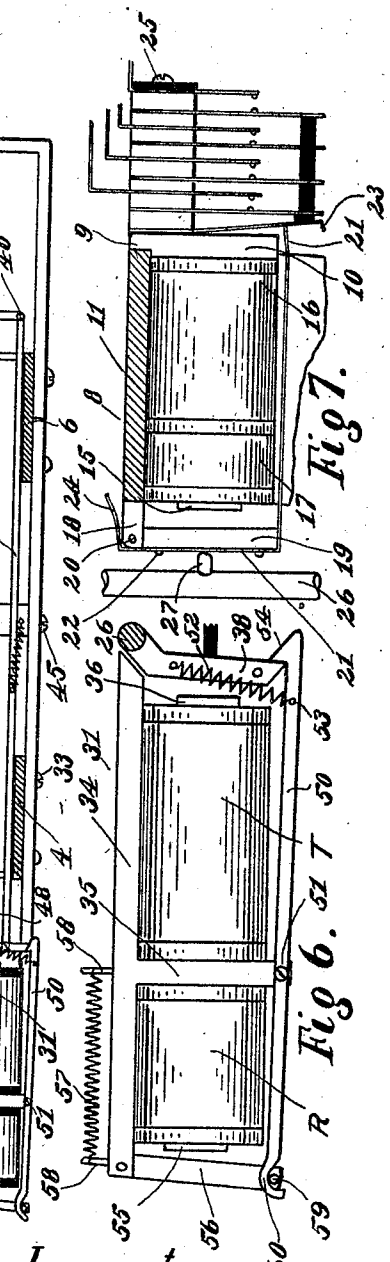

Fig 6.

Fig 7.

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Patented Mar. 13, 1923. 1,448,420

UNITED STATES PATENT OFFICE.

PERCY C. SMITH, OF WORCESTER, MASSACHUSETTS, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed September 30, 1919. Serial No. 327,545.

To all whom it may concern:

Be it known that I, PERCY C. SMITH, a citizen of the United States, residing at Worcester, in the county of Worcester and State of Massachusetts, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a specification.

This invention relates to telephone systems, and more particularly to systems in which the talking connection from the calling to the called subscriber's line is established by means of automatic or mechanically controlled switching devices.

Heretofore it has been the common practice to extend a calling subscriber's line to an idle selector switch by means of a switch of the rotary type, either individual to the calling line or individual to the first selector trunk. The object of this invention is to obviate the necessity of employing rotary switches by providing a connecting switch of the relay type, thereby avoiding rotary switch parts, increasing the speed of connection, and simplifying the switch structure.

In its broadest aspect the invention resides in the provision of a switch preferably having a capacity for serving one hundred calling lines and having access to a group of ten trunks, which is adapted to extend a calling line terminating therein, to a pre-selected trunk line through the operation of a single relay individual to the calling line. The line extension is therefore substantially instantaneous and need not be delayed during the search for an idle trunk as has been necessary in systems employing rotary finder switches.

In a further aspect the invention resides in the provision of a compact switching unit comprised wholly of relays and electromagnets and so co-ordinated that a minimum of relays is necessary, one for each calling line having access to the switch and one for each trunk outgoing from the switch. Thus for example in a unit serving one hundred lines and having access to ten trunks there are only one hundred and ten relays.

The invention will now be described in connection with one specific embodiment of the genus of my invention. In the accompanying drawings:

Figures 1 and 2 when placed end to end with Fig. 2 at the right of Fig. 1 show a diagram of circuit connections illustrating the manner in which my invention is incorporated in an automatic telephone system. Fig. 1 shows the circuit of my improved line switch and Fig. 2 shows the circuit of a selector and a connector switch;

Figure 3 is a front elevational view of my improved line switch unit, the trunk pre-selecting relays having been omitted for the sake of clearness;

Figure 4 is a vertical sectional view taken on the line 4—4 of Fig. 3;

Figure 5 is a transverse sectional view taken on the line 5—5 of Fig. 4;

Figure 6 is a detail plan view of one of the trunk pre-selecting relays; and

Figure 7 is a detail elevational view of one of the line extending relays.

Any step-by-step two-movement switch may be employed with the circuits shown. A switch of this general character is shown in the patent to Keith and Erickson No. 815,176, although preferably a switch so constructed as to operate in the circuits disclosed in the patent to Martin No. 1,155,672 is employed. Although the features of the invention are disclosed in a system employing step-by-step switches of the general type above referred to, they are equally applicable in a system employing switches of other types, as for example, power driven switches.

With each directively controlled switch is associated a circuit changing device for controlling the operating circuits of its respective switch. These devices may be of the general character of the switch which is shown in the above mentioned patent to Keith and Erickson and referred to as a side switch.

Referring to Figs. 3 to 7 inclusive of the drawings, I have disclosed an improved line switch unit for extending a calling line to an idle trunk terminating in a first selector switch. This switch unit preferably has a capacity sufficient to serve a line group of one hundred lines, and on the customary basis of ten per cent trunking, to extend any line of the group to an idle one of ten trunk lines. The switch comprises a base plate 1 and a top plate 2 connected together by four vertically disposed frame bars 3, 4, 5 and 6, these vertical bars being provided upon their

ends with out-turned extensions by means of which they are secured to the top and bottom plates by machine screws 7.

Supported between the vertical bars 3 and 4 is a series of super-imposed relays or line magnets 8, preferably fifty, and supported between the bars 5 and 6 is a second series of similar relays, the relays of the two series being positioned back to back as most clearly disclosed in Fig. 4.

Each relay 8 comprises an L-shaped tail piece 9 having a vertically disposed arm 10 and a forwardly extending horizontally disposed arm 11 bent downwardly at each end as at 12 and 13 for attachment to the vertical frame bars. In Fig. 3 the extensions 12 and 13 are shown attached to the frame bars 3 and 4 by machine screws 14. The extensions also serve to space the superimposed relays at suitable intervals from each other, the extensions of the lowermost relay spacing that relay from the bottom plate 1 and the extensions of each successive relay resting upon the horizontal arm 11 of the relay tail piece next beneath it to space such relays apart. Extending horizontally from the arm 10 of the tail piece is a core-piece 15. This core-piece lies parallel with the arm 11 of the tail piece and extends substantially the whole length of the tail piece. Wound upon the core-piece 15 is a double wound winding comprising a high resistance operating winding 16 and a low resistance locking or holding winding 17.

The forward edge of the horizontal arm 11 of the tail piece is suitably notched and between the projecting ears 18 thus formed, a plurality of depending armatures 19 are pivoted by means of a pivot pin 20 extending through apertures in the ears and in the armatures. Each relay is preferably equipped with ten armatures which are adapted to be attracted toward the core piece 15, the magnetic circuit for each armature comprising a core 15, the vertical arm 10 of the tail piece 9, the horizontal arm 11 thereof and the armature.

Normally each armature of each relay is held away from the forward end of the core 15 by means of a finger 21 secured to the front face of the armature as by rivets 22, and engaging a hooked spring 23 secured to the tail piece 9, a distance sufficient to remove the armature from the influence of the core 15 so that in such position it is not possible for the core 15 to attract the armature. The retractive movement of each armature is restrained by the engagement of the rearwardly extending portion 24 of the spring 21 with the arm 11 of the tail piece. Each armature through the finger 21 is adapted to control a set of contact springs as shown most clearly in Fig. 7. The ten sets of springs of each relay are suitably mounted between strips of insulating material and are supported upon the tail-piece of the relay by screws 25. The springs of the several relays of the switch unit are multipled together in the manner shown in Fig. 1.

Pivotally supported in plates 29 and 30 secured to the top and bottom plates 2 and 1 respectively of the switch, immediately in front of the armatures of each series of relays 8, is a group of ten vertically disposed rods or actuating bars 26. Each rod is assigned to an outgoing trunk line and is provided with a series of fifty pins 27 for co-operation with an armature of each of the series of fifty relays. Thus the first trunk rod of each group is adapted to co-operate with the No. 1 armature of each relay, the second trunk rod of each group with the No. 2 armature of each relay etc. Normally these rods stand in a position with their pins resting upon the widened portions 28 of the fingers 21 of the armatures, permitting the springs 23 to force the armatures away from the pole pieces of the relays and out of the magnetic influence thereof. Upon the rotation of one of these rods the pins 27 thereon force an armature of each relay toward the pole pieces of the relays so that upon a subsequent energization of one of the relays its armature which has been positioned by the rotated trunk rod 26 will be attracted.

For the purpose of rotating the trunk rods 26, ten magnets 31 are provided. For convenience in mounting and to enable a more compact arrangement of the switch, these magnets are divided into two groups secured respectively upon opposite sides of the switch and preferably at a point midway of its height, to bracket members 32 attached to the upright members 3, 4, 5 and 6 of the switch frame by screws 33. Each magnet comprises a tail-piece 34 having a horizontally extending portion 35, a core 36 and a winding T, the portion 35 also extending downwardly below the lower edge of the tail-piece 34 to form means by which the magnet is secured to the bracket member 32, as shown most clearly in Fig. 4. Any suitable means of attachment may be employed such as screws 37.

Secured to each rod 26 is an arm 38, the arms of alternate rods of each series of rods extending from the rods in the same direction and serving as armatures for the magnets 31, the arms of the remaining intermediate rods of each series extending in the opposite direction, as most clearly disclosed in Fig. 5. The arms 38 of corresponding rods of the two series, that is of rods individual to the same trunk and positioned on opposite sides of the switch frame, are interlinked by links 39 secured to the arms by screws 40 in such manner that when a trunk magnet 31 attracts an arm 38 of a trunk rod 26 which it controls, the trunk rod 26 cor-

responding thereto upon the opposite side of the switch is also operated. By this arrangement the energization of a trunk magnet 31 is enabled to position an armature of each of the one hundred line connecting relays of the group in a position to be attracted upon the initiation of a call by any line of the group. By reference to Fig. 5 it will be noted that only alternate arms 38 on each side of the switch serve as armatures, the arms of corresponding rods upon the opposite side of the switch and linked thereto, serving merely as rocker-arms for transmitting the reciprocatory movement of the connecting links 39 into a rotary movement of the rods 26.

The armature arms 38 are normally held in retracted position by springs 41 secured thereto by pins 42 and connected to a central bar 43 by pins 44, the bar 43 being secured at either end to the bracket members 32 by screws 45. In its retracted position each of these armatures maintains a pair of contact springs 46 and 47 in contact by means of a stud 48 of insulating material attached to the back of the armature and resting against the end of spring 46, but permits the springs to separate when attracted toward its core 36. The springs are suitably insulated from each other and insulatedly mounted upon a bracket strip 49 extending between the side bars of the switch frame. As shown most clearly in Fig. 6 the tail piece 34 of the magnet 31 is extended into close association with the rod 26 which it controls to establish a substantially closed magnetic circuit between the tail piece and the armature 38 thereby increasing the efficiency of the magnet.

After having been rotated by the magnet 31 through the energization of the winding T, the trunk rod 26 is locked in its rotated position by a hook member 50 which is pivoted to the member 35 of the magnet as by a screw 51 and which engages the end of the armature 38. The hooked end of the member 50 is urged toward the end of armature 38 by a spring 52 which is secured at its ends to the hook member and to the armature by pins 53 as most clearly shown in Fig. 6. Normally in the retracted position of the armature 38 the beveled end 54 of the hook rests in contact with the beveled end of the armature 38 as shown in Fig. 5 but snaps back of the hook upon being attracted. The locked up armature is released by means of a releasing magnet R which is mounted upon the tail piece 34 with its core 55 secured in the extension 35 of the tail piece in alinement with the core-piece 36 of the winding T. The two magnets R and T thus are united in a single unit but have separate magnetic circuits. The armature 56 of the magnet R is pivoted to the end of the tail piece 34 and held in its retracted position by means of a spring 57 secured to the end of the armature and to the tail-piece by pins 58.

The free end of armature 56 is provided with a laterally extending pin 59 which engages the cammed end 60 of the hook member 50. Upon energization of the magnet winding R the armature through the pin 59, forces the left hand end of the hook member 50 toward the magnet winding as viewed in Fig. 6, thereby moving the hooked end 54 away from the end of armature 38 to release it.

Having thus described the general character of the apparatus which is used in the system embodying the principles of my invention, I will now describe the process by which a calling subscriber A whose station is illustrated at the left in Fig. 1, establishes connection with the subscriber A' whose station is illustrated at the right in Fig. 2 and whose exchange number we will assume to be 225.

When the subscriber A removes his receiver preparatory to making a call, a circuit is completed in the usual manner through the windings of the line relay 61, which is energized and completes a circuit from grounded battery, through winding 16 of the relay 8, and through the front contact of relay 61 to ground. The connecting relay 8 is energized and upon the assumption that trunk No. VII leading to a group of first selectors to which the group of lines in which subscriber's station A is located, has been preselected for use in a manner hereinafter described and the trunk rod 26 has positioned the No. 4 armature of each connecting relay 8 of the group of lines in a position to be attracted by the relay 8, the armature 19 of the calling subscriber's connecting relay will be attracted. Since however the remaining armatures of the energized relay 8 are normally out of the field of magnetic influence of the relay, they are not attracted. The armatures of the remaining relays of the group which have been positioned by the trunk rod 26 are not attracted at this time since their respective relays 8 are not energized.

Upon the attraction of the armature 19 of relay 8 the set of normally open contacts with which it cooperates is closed. The closure of contacts 62 and 63, and 64 and 65 extends the talking conductors of the calling line by the heavy conductors to the line relay 66 of the idle first selector E which has been pre-selected for use. This circuit extends from grounded battery in Fig. 2, through the left hand winding of the line relay 66, through the first position contact and wiper 67 of the side switch of the first selector, over the lower heavy trunk conductor to the spring 62, through the spring 63, through the calling subscriber's line loop,

through the springs 64 and 65, over the upper heavy trunk conductor, through the side-switch wiper 68 and its first position contact, through the right hand winding of the line relay 66, and back to the ground.

The line relay 66 energizes and closes a circuit for the slow acting release relay 69, shown at the right in Fig. 1, which extends from grounded battery, through the winding of relay 69, through the front contact and armature of relay 66 to ground. Relay 69 upon energizing closes a locking circuit for the relay 8, an energizing circuit for the cut-off relay of the calling line, closes an energizing circuit for a trunk relay T^{VII} of the next idle trunk of the group of trunks to which the line switch has access, and prepares the stepping circuit of the selected first selector. The locking circuit of the connecting relay 8 may be traced from grounded battery through the locking winding 17 of the relay 8, through the closed contacts 70 and 71 of relay 8, through the closed contacts 72 and 73 of relay 69, to ground. The locking winding 17 while energizing the relay 8 sufficiently to maintain its armature 19 attracted, does not provide a sufficiently strong energization to attract other armatures should other trunk rods be operated to position other of its armatures within the field of force.

A branch of the locking circuit just traced extends through the winding of the cut off relay 74 of the calling line to grounded battery. This relay upon energizing opens the circuit of the line relay 61 in the usual manner, which upon deenergizing opens the initial energizing circuit through the winding 16 of the connecting relay 8.

Upon the energization of the relay 8 a circuit was also closed through the releasing or unlocking magnet R^{VII}, which extends from grounded battery through the winding R^{VII} through contacts 75 and 76 to ground. The magnet R^{VII} upon energization attracts its armature 56, thereby oscillating the hook 50 to release the locked up armature 38 of the trunk magnet T^{VII}, which upon releasing permits the restoration of the trunk rod 26 under the influence of the spring 41. The rod 26 in turn permits the restoration of all the armatures of relays 8 which it controls, out of the field of magnetic influence of the relays 8 with which they are associated, with the exception of the armature 19 of the energized relay 8 which through the influence of holding winding 17 is maintained attracted.

When the relay 69 became energized it closed a circuit to preselect another idle trunk for the next call, and assuming that the next trunk in the series No. VIII is at this time idle, a circuit is established for its winding T^{VIII} which extends from grounded battery through the winding T^{VIII}, through the normally closed contacts 77 and 78 of the release relay individual to the selector to which the trunk No. VIII extends, through the alternate contacts 116 and 79 of the energized relay 69 through the contacts 80 and 81 corresponding to contacts 46 and 47 disclosed in Fig. 4 of magnet T^{VII} of the trunk seized by the calling line, which contacts closed when the armature 38 was released as above described, and back to ground. Upon the energization of winding T^{VIII} the trunk rod 26 of trunk VIII is rotated to position the armatures of the relays 8 as previously described, and is locked in the rotated position by the hook member associated therewith independent of the continued energization of relay 69.

If upon the energization of the relay 69 the next trunk VIII had been busy, the following circuit for the magnet winding T^{IX} of trunk No. IX would have been established from the grounded battery, through the winding T^{IX}, through the normally closed contacts 82 and 83 of the releasing relay associated with the trunk IX, through the alternate contacts 84 and 78 of the release relay associated with the busy trunk VIII, through the alternate contacts 116 and 79 of the energized release relay 69 of the busy trunk VII, through the contacts 80 and 81 of the magnet T^{VII} of the trunk seized by the calling line, and back to ground. It is thus apparent that the trunks are seized in rotation.

The foregoing operations occur upon the removal of receiver at the sub-station A, and before the impulses are sent in for the first digit of the desired number. When the subscriber's dial 8 is operated in the usual manner for the first digit two, it causes the subscriber's line to be momentarily opened twice, to break the energizing circuit of the line relay 66 of the selector E twice. The release relay 69 being slow-acting, does not de-energize, as its circuit is momentarily broken at the front contact of the relay 66; therefore the engagement of the armature of the relay 66 with its back contact completes a circuit for the primary stepping magnet PM of the selector E which extends from grounded battery, through the side switch wiper 85 and its first position contact, through the winding of the primary magnet PM, through the winding of the slow-acting relay 86, through the alternate contacts 87 and 88 of the slow-acting relay 69, through the back contact of line-relay 66, and back to ground. The primary magnet PM energizes twice over this circuit to lift the shaft and shaft wipers two steps opposite the second level of bank contacts. The relay 86 energizes on the first impulse, but, being slow-acting, does not de-energize until the last impulse is sent in. In its energized position the relay 86 completes a circuit through the private magnet ESC over

a circuit extending from grounded battery through the winding of the magnet ESC, and through the front contact to relay 86 to ground. As soon as the slow-relay 86 de-energizes, the circuit of the private magnet is broken, which in turn de-energizes and permits the side switch to pass to the second position. The passing of side switch wiper 85 to second position shifts the battery connection from the primary to the secondary magnet SM. The wiper 89 in second position, connects the private wiper 90 with the private magnet ESC. As soon as the battery is shifted to the circuit of the secondary magnet SM, a circuit is closed extending from grounded battery, through the side switch wiper 85 and its second position contact through the winding of the slow-acting relay 91, through the winding of the secondary magnet SM, through the armature and back contact of the magnet SM to ground.

The secondary magnet energizes over this circuit to rotate the shaft and shaft wipers one step, breaks its own circuit at its armature and contact, and presses down the private magnet armature. The breaking of its own circuit at its armature contact causes it to de-energize. If the first contact is idle, the private magnet armature will return to normal position, thereby permitting the side switch to pass to third position. If, however, the first contact is busy, the first private bank contact will have a guarding ground upon it, as will be explained later. The private wiper, 90, upon engaging the grounded contact, completes a circuit extending from the bank contact through the private wiper 90, side switch wiper 89 (in second position) and winding of the private magnet ESC to grounded battery. Thus it is evident that the side switch remains in second position, and, consequently, the secondary magnet continues to energize to rotate the shaft and shaft wipers to an idle contact.

The passing of the side switch wipers 67 and 68 to third position extends the calling line to the connector F. The extending of the line to the connector closes the circuit of the line relay 92 of the connector in the same manner as it did that of the relay 66 of the first selector. The energizing of the relay 92 closes a circuit through the slow-acting relay 93, which energizes to provide a holding circuit for the relay 69 over a circuit extending from grounded battery through the winding of the relay 69, through the back contact and armature of the relay 91, through the third position contact and side switch wiper 89, over the private wiper 90, and the corresponding bank contact of all the selectors that have access to the connector F, through the front contact and armature of the relay 93, and through the side switch wiper 94 and its first position contact to ground. A short period of time elapses between the time that the side switch wiper 89 leaves the second position and the time that the guarding ground is supplied to the private bank contact by the connector. The relay 91 is put in for the purpose of supplying a guarding ground to the private bank contacts during this time. It will be remembered that the relay 91 was energized in series with the secondary magnet and, being a slow relay, it remains held up a short time after the side switch has passed to third position, thereby putting a ground on the private wiper from ground at its front contact, through its armature in its alternate position, through the side switch wiper 89 and its third position contact to the private wiper 90. It is evident that the relay 69 must be slower than the relay 91 to prevent the selector from releasing. The apparatus is now ready for the second digit two.

The subscriber A operates the dial for the second digit in the same manner as for the the first digit. The relay 92 de-energizes twice to close a circuit through the primary magnet PM′ extending from grounded battery through the winding of the slow-acting relay 95, through the side switch wiper 96 and its first position contact, through the winding of the primary magnet PM′, through the front contact and left hand armature of the slow-acting relay 93, and through the back contact and armature of the line relay 92 to ground. The primary magnet PM′ energizes over this circuit to raise the shaft and shaft wipers 97, 98 and 99 two steps and opposite the second level of bank contacts. As soon as the shaft is lifted the springs 100 and 101 engage preparing a circuit for the release magnet REL′. The relay 95 also energizes in the circuit with the vertical magnet to cause its armatures to break with their back contacts and to make with their front contacts. The left hand armature closes a circuit which extends from grounded battery through the private magnet ESC′ through the left hand armature and front contact of slow relay 95 to ground. The relay 95 remains energized until after the last impulse of the digit has been sent when it de-energizes thereby breaking the circuit of the private magnet. Upon deenergization of the private magnet, the side switch wipers escape to the second position.

The passing of the side switch wiper 96 to the second position disconnects the primary magnet and places the secondary magnet SM′ in the circuit with the slow relay 95. The switch is now in position to receive the impulses for the third or last digit five. As the dial is operated for this digit the circuit of the relay 92 is broken five times, as before. The relay de-energizes five times,

each time closing a circuit extending from grounded battery, through the winding of slow relay 95, through the side switch wiper 96 and its second position contact, through the winding of the secondary magnet SM', through the outer left hand armature and back contact of relay 102, through the front contact and armature of slow relay 93, and through the back contact and armature of line relay 92 to ground. The secondary magnet energizes five times to rotate the shaft and shaft wipers onto the bank contacts of the called line #225. The relay 95 energizes on the first impulse as before, and de-energizes a moment after the last impulse has been sent in, thereby permitting the side switch to pass to the third position. The passing of wipers 103 and 104 to third position connects the calling line to the called sub-station through the condensers 105 and 106. The passing of the wiper 94 from the second position to the third position removes the ground connection, which during the first and second positions of the side switch has been placed on the circuit extending through the right hand armature and front contact of slow relay 93 to the private bank contacts of all selectors having access to the connector F, for guarding the switch F against seizure and for holding the release relay 69 of selector E energized, and connects a new holding ground for this circuit, from the armature and front contact of line relay 92. In its third position the wiper 107 extends a ground connection to the relay 108, and completes a circuit through the inner left hand armature and back contact of relay 102, through the private wiper 99 and back contact to the cutoff relay of the called line (similar to cut-off relay 74 of the calling line). The side switch wiper 96 of the connector in its third position, serves to close a circuit for the ringer relay 109. This circuit extends from grounded battery through the slow relay 95, through the side switch wiper 96 and its third position contact, through the winding of the ringer relay 109, through the left-hand back contact of relay 108, through the ringing interrupter 110 to ground. The ringer relay is energized intermittently to disconnect the calling line and connect the called line with the ringing current generator L. A ringing current then flows from generator L through the front contact and left hand armature of ringer relay 109, through the side switch wiper 104, through the switch wiper 98, through the bank contact and lower line conductor, through the bell 111 at the called subscriber's station, through the upper line conductor, bank contact, switch wiper 97, through the side switch wiper 103, through the right hand armature and front contact of relay 109, back to the generator L.

The subscriber at sub-station A' removes the receiver in response to the signal, and thereby closes an energizing circuit as soon as relay 109 again de-energizes, should it be pulled up at the time, through the back bridge relay 108 of the connector. This circuit extends from grounded battery through the left-hand winding of relay 108, through the back contact and right hand armature of relay 109, through the side switch wiper 103 through the switch wiper 97, out over the subscriber's line, back through the switch wiper 98, side switch wiper 104, left hand armature and back contact of relay 109, through the right hand winding of back bridge relay 108 to ground at the side switch wiper 107. Thus the called subscriber is supplied with talking current. The relay 108 energizes over the circuit just traced to break the circuit of the ringer relay 109 at its left hand armature contacts.

After the conversation is completed, the release of the central office apparatus used in the foregoing call is initiated by the calling subscriber hanging up his receiver. The release is as follows: The breaking of the line at the sub-station, breaks the circuit of line relay 92 at the connector F, which in turn deenergizes thereby breaking the holding ground for the release relay 69 of selector E and for the release relay 93 of connector F. The release relay 69 upon de-energizing closes a circuit for the release magnet REL which extends from grounded battery through the winding of the magnet REL, through the contact 113 and 114 closed when the switch E took its first step off normal, through the contacts 115 and 88 of the release relay 69, and through the back contact and armature of line relay 66 to ground. The release circuit for connector F, extends from grounded battery through the winding of release magnet REL', through contacts 101 and 100, through the back contact and left hand armature of relay 93, and to ground through the back contact and armature of line relay 92. Upon the de-energization of release relay 69, the locking circuit for connecting relay 8 of the calling line and the circuit through the calling line cut-off relay 74 are opened.

The de-energization of the calling line cut-off relay, and de-energization of relay 8, restores all apparatus individual to the calling line to normal. The energization of the selector release magnet REL permits the switch to return to normal thereby separating the springs 113 and 114. The energization of the connector release magnet REL' in a similar manner permits the switch to return to normal thereby separating the springs 100 and 101. Thus all apparatus is restored to normal position and in readiness for another call.

Returning now to that point in the operation of the connector while the side switch is yet in the second position, had the called line been busy, the side switch would not have passed to the third position, but would have been locked in the second position by the private magnet remaining energized. The circuit through the private magnet would have been from the bank contact upon which the wiper 99 is resting, which contact would have been grounded, through the wiper 99, back contact and inner left hand armature of relay 102, right hand winding of back bridge relay 108, back contact and left hand armature of ringer relay 109, side switch 104 and its second position contact, back contact and armature of relay 95, and through the winding of private magnet ESC′ to grounded battery. The simultaneous energization of private magnet ESC′ and relay 108, closes a circuit through the busy relay 102. This circuit extends from ground through the right hand armature and back contact of relay 95, through the armature and front contact of private magnet ESC′, through the busy relay 102 and through the right-hand armature and front contact of relay 108 to grounded battery. The relay 102 energizes over this circuit to disconnect the secondary magnet SM′ at its back contact and outer left hand armature and to shift the holding ground for relay 108 and private magnet ESC′ to ground through its inner left hand armature and front contact. Relay 102 also causes a busy signal to be sent to the calling subscriber over a circuit extending from grounded battery through the secondary of the induction coil 120 of the busy signalling machine M, through the right hand armature and front contact of relay 102, through the side switch wiper 103 and its second position contact, through the right hand armature and back contact of ringer relay 109, through the condenser 105, thence over the heavy conductors to and through the sub-station A, back over the heavy conductors through the left-hand winding of the relay 92 to ground.

The object in shifting the ground from the private wiper 99 to ground at the front contact of the inner left hand armature of relay 102 is to prevent the side switch magnet from de-energizing should the guarding potential be removed before the switch F has been released. The release of the switches in case the called line is busy is the same as if the connection had been obtained.

Many modifications of the invention other than those enumerated will readily suggest themselves to those skilled in the art, and the invention should therefore be limited merely by the scope of the claims.

I claim:

1. In a telephone exchange system, a subscriber's line, a group of trunk lines, multiple contact sets for said subscriber's line for connecting said line to any one of said trunk lines, a connecting relay for said subscriber's line, armatures for said relay each individual to a contact set, means individual to each trunk line for predetermining an armature for response to the energization of said relay, and means for pre-selecting an idle trunk line whereby said last named means is rendered effective.

2. In a telephone exchange system, a subscriber's line, a group of trunk lines, multiple contact sets for said subscriber's line for connecting said line to any one of said trunk lines, a connecting relay for said subscriber's line, normally inoperative armatures for said relay each individual to a contact set, means individual to each trunk line for operatively positioning an armature for response to the energization of said relay, and means for pre-selecting an idle trunk line whereby said last named means is rendered effective.

3. In a telephone exchange system, a subscriber's line, a group of trunk lines, multiple contact sets for said subscriber's line for connecting said line to any one of said trunk lines, a connecting relay for said subscriber's line, armatures for said relay normally positioned outside of its stray magnetic field and each individual to a contact set, means individual to each trunk line for positioning an armature for response to the energization of said relay, and means for pre-selecting an idle trunk line whereby said last named means is rendered effective.

4. In a telephone exchange system, a subscriber's line, a group of trunk lines, multiple contact sets for said subscriber's line for connecting said line to any one of said trunk lines, a connecting relay for said subscriber's line, armatures for said relay each individual to a contact set, means tending normally to position said armatures beyond the magnetic influence of said relay, means individual to each trunk line for moving an armature to such a position that upon energization of said relay said armature is attracted, and means for pre-selecting an idle trunk line whereby said last named means is rendered effective.

5. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, a switching unit for connecting any subscriber's line of the group to any trunk line of the group of trunks, said switching unit comprising a connecting relay individual to each subscriber's line, each said relay having an armature corresponding to each trunk line for controlling the connection of the line to said trunks, means individual to each trunk line for predetermining the relay armature corresponding thereto for re-

sponse to the energization of said relay, and means for pre-selecting an idle trunk line of the group whereby said last named means is rendered effective.

6. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, a switching unit for connecting any subscriber's line of the group to any trunk line of the group of trunks, said switching unit comprising a connecting relay individual to each subscriber's line, each said relay having a normally inoperative armature corresponding to each trunk line for controlling the connection of the line to said trunk lines, means individual to each trunk line for operatively positioning the armature corresponding thereto for response to the energization of said relay, and means for pre-selecting an idle trunk line of the group whereby said last named means is rendered effective.

7. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, a switching unit for connecting any subscriber's line of the group to any trunk line of the group of trunks, said switching unit comprising a connecting relay individual to each subscriber's line, each said relay having an armature normally positioned outside of the stray magnetic field thereof corresponding to each trunk line for response to the energization of said relay, means individual to each trunk line for positioning the armature corresponding thereto for response to the energization of said relay, and means for pre-selecting an idle trunk line of the group whereby said last named means is rendered effective.

8. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, a switching unit for connecting any subscriber's line of the group to any trunk line of the group of trunks, said switching unit comprising a frame, connecting relays individual to said subscribers' lines superimposed in said frame, each said relay having a normally inoperative armature corresponding to each trunk line for controlling the connection of the line to which it is individual to said trunk lines, and means individual to each trunk line for operatively positioning the armature corresponding thereto of each relay for response whereby upon the energization of one of said relays its operatively positioned armature will become attracted to extend the calling line to the trunk.

9. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, a switching unit for connecting any subscriber's line of the group to any trunk line of the group of trunks, said switching unit comprising a frame, connecting relays individual to said subscribers' lines superimposed in said frame, each said relay having an armature normally positioned beyond the magnetic influence of said relay and corresponding to each trunk line for controlling the connection of the line to which it is individual to said trunk lines, a trunk rod individual to each trunk line journaled in said frame and provided with means for moving the armature corresponding thereto of each relay into magnetic proximity to such relay, and a magnet for operating each of said rods.

10. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, a switching unit for connecting any subscriber's line of the group to any trunk line of the group of trunks, said switching unit comprising a frame, connecting relays individual to said subscribers' lines superimposed in said frame, each said relay having an armature normally positioned beyond the magnetic influence of said relay and corresponding to each trunk line for controlling the connection of the line to which it is individual to said trunk lines, a trunk rod individual to each trunk line journaled in said frame and provided with means for moving the armature corresponding thereto of each relay into magnetic proximity to such relay, a magnet for operating each of said rods, and means for energizing one of said magnets to pre-select a trunk line for use.

11. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, a switching unit for connecting any subscriber's line of the group to any trunk line of the group of trunks, said switching unit comprising a frame, connecting relays individual to said subscribers' lines superimposed in said frame, each said relay having an armature normally positioned beyond the magnetic influence of said relay and corresponding to each trunk line for controlling the connection of the line to which it is individual to said trunk lines, a trunk rod individual to each trunk line journaled in said frame and provided with means for moving the armature corresponding thereto of each relay into magnetic proximity to such relay, a magnet for operating each of said rods, means for energizing one of said magnets to pre-select a trunk line for use, and means for locking said operated rod in its rotated position.

12. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, a switching unit for connecting any subscriber's line of the group to any trunk line of the group of trunks, said switching unit comprising a frame, connecting relays individual to said subscribers' lines superimposed in said frame, each said relay having an armature normally positioned beyond the magnetic influence of said relay and corresponding to each trunk line for control-

ling the connection of the line to which it is individual to said trunk lines, a trunk rod individual to each trunk line journaled in said frame and provided with means for moving the armature corresponding thereto of each relay into magnetic proximity to such relay, a magnet for operating each of said rods, means for energizing one of said magnets to pre-select a trunk line for use, means for locking said operated rod in its rotated position, and means for unlocking said rod upon connection of a subscriber's line to the pre-selected trunk.

13. In a telephone exchange system, a switching unit comprising a frame, a plurality of superimposed relays supported in said frame, a plurality of armatures for each of said relays normally held beyond the magnetic influence of said relay windings, vertically disposed rods journaled within the frame in alinement with corresponding armatures of each of said relays, cam pins on said rods for engagement with said armatures, and a magnet for each of said rods for rotating said rods to selectively position the armatures of said relays for attraction.

14. In a telephone exchange system, a switching unit comprising a frame, a plurality of superimposed relays supported in said frame, a plurality of armatures for each of said relays normally held beyond the magnetic influence of said relay windings, vertically disposed rods journaled within the frame in alinement with corresponding armatures of each of said relays, cam pins on said rods for engagement with said armatures, a magnet for each of said rods for rotating said rods to selectively position the armatures of said relays for attraction, and means for locking each rod in its operated position.

15. In a telephone exchange system, a switching unit comprising a frame, a plurality of superimposed relays supported in said frame, a plurality of armatures for each of said relays normally held beyond the magnetic influence of said relay windings, vertically disposed rods journaled within the frame in alinement with corresponding armatures of each of said relays, cam pins on said rods for engagement with said armatures, a magnet for each of said rods for rotating said rods to selectively position the armatures of said relays for attraction, means for locking each rod in its operated position, and means for unlocking each of said rods.

16. In a telephone exchange system, a subscriber's line, a group of trunk lines, multiple contact sets for said subscriber's line for connecting said line to any one of said trunk lines, a connecting relay for said subscriber's line, operating means individual to said relay for each of said contact sets, means individual to each trunk line for predetermining one of said first named means for operation, and means for preselecting an idle trunk line whereby said last named means is rendered effective.

17. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, switching mechanism comprising multiple contact sets for each subscriber's line for connecting such subscriber's line to any trunk line of the group of trunk lines, a connecting relay for each subscriber's line and operating means individual to said relay for each of said contact sets, a relay individual to each of said trunk lines, and means comprising said last named relays, operative upon connection of a subscriber's line to a trunk line for preselecting the next succeeding idle trunk line of the group whereby said trunk lines are selected for use in rotation.

18. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, switching mechanism comprising multiple contact sets for each subscriber's line for connecting such subscriber's line to any trunk line of the group of trunk lines, a connecting relay for each subscriber's line and operating means individual to said relay for each of said contact sets, a relay individual to each trunk line and operative upon the extension of a subscriber's line thereto, and means comprising the interconnected contacts of said last named relays for preselecting an idle trunk line for use whereby said trunk lines are selected in rotation.

19. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines, switching mechanism comprising multiple contact sets for each subscriber's line for connecting such subscriber's line to any trunk line of the group of trunk lines, a connecting relay for each subscriber's line and operating means individual to said relay for each of said contact sets, a relay individual to each trunk line and operative upon the extension of a subscriber's line thereto, means for interconnecting the contacts of said last named relays, a selecting magnet for each of said trunk lines for predetermining one of said operating means for operation, and means comprising said relays and interconnecting means for operating a selecting magnet corresponding to the next succeeding idle trunk line of the group whereby said trunk lines are selected for use in rotation.

20. In a telephone exchange system, a group of subscribers' lines, a group of trunk lines terminating in a group of first selector switches, a switching unit comprising multiple contact sets for each subscriber's line for connecting such subscriber's line to any trunk line of the group of trunk lines,

a connecting relay for each subscriber's line and operating means individual to said relay for each of said contact sets, a relay in each of said selector switches adapted to be energized upon the extension of a subscriber's line thereto, trunk preselecting magnets in said switching unit corresponding to and controlled by said last named relays respectively predetermining one of said operating means for operation, and means comprising said first named relays, operative upon connection of a subscriber's line to a preselected trunk line for causing the energization of the trunk preselecting magnet of the next succeeding idle trunk line of the group whereby said trunk lines are selected for use in rotation.

21. In a telephone system, a cross-bar switch comprising a plurality of line magnets, a plurality of trunk bar magnets, a relay associated with each of said trunk bar magnets, means controlled by said relays for holding a single one of said trunk bar magnets operated, and means controlled by said line magnets for energizing said relay associated with said operated trunk bar magnet.

22. In a telephone system, a cross-bar switch comprising a plurality of line magnets, a plurality of trunk bar magnets, a relay associated with each of said trunk bar magnets, means controlled by said relays for holding one of said trunk bar magnets operated, and means controlled by said energized line magnet and said operated trunk bar magnet for energizing the relay associated with said trunk bar magnet.

23. In a telephone system, a cross-bar switch comprising a plurality of line magnets, a plurality of trunk bar magnets, a relay associated with each of said trunk bar magnets, means controlled by said relays for holding a single one of said trunk bar magnets operated, means controlled by said line magnets for energizing said relay associated with said operated trunk bar magnet, and means controlled by said energized relay for releasing said operated trunk bar magnet and operating the next in order of said trunk bar magnets.

24. In a telephone system, a cross-bar switch comprising a plurality of line magnets, a relay associated with each line magnet, a plurality of trunk bar magnets, a relay associated with each of said trunk bar magnets, means controlled by said last relays for holding one of said trunk bar magnets operated, means controlled by said relays associated with said line magnets for energizing said associated line magnet, means controlled by an energized line magnet for energizing said relay associated with said operated trunk bar magnet, and means controlled by said last relays for releasing said associated trunk bar magnet and causing the operation of the next in turn of said trunk bar magnets.

25. In a telephone system, incoming lines, outgoing lines, switching mechanisms for connecting said incoming lines to said outgoing lines, a magnet for each of said incoming lines, an actuating bar for each of said outgoing lines, said bars cooperating with said magnets to operate said switching mechanisms, a relay associated with each of said outgoing lines, and means under the control of each of said relays for preoperating an actuating bar.

26. In a telephone system, incoming lines, outgoing lines, switching mechanisms for connecting said incoming lines to said outgoing lines, a magnet for each of said incoming lines, an actuating bar for each of said outgoing lines, said bars cooperating with said magnets to operate said switching mechanisms, a relay associated with each of said outgoing lines operated upon connection with said outgoing lines, and means under the control of each of said relays for preoperating the next in order of said actuating bars.

In testimony whereof I have affixed my signature this twenty-seventh day of September, 1919.

PERCY C. SMITH.