

May 5, 1942.

G. R. EATON

2,281,564

AUTOMATIC TELEPHONE APPARATUS AND CIRCUITS

Filed Sept. 10, 1938

6 Sheets-Sheet 1

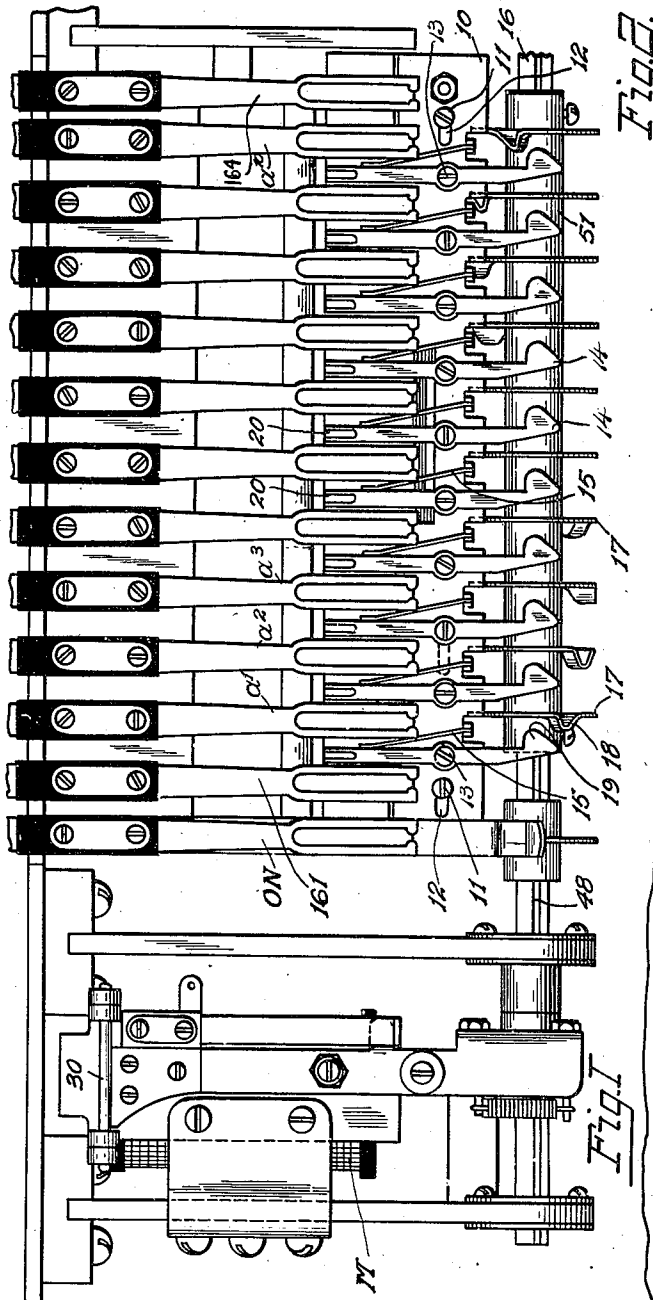


Fig. 1

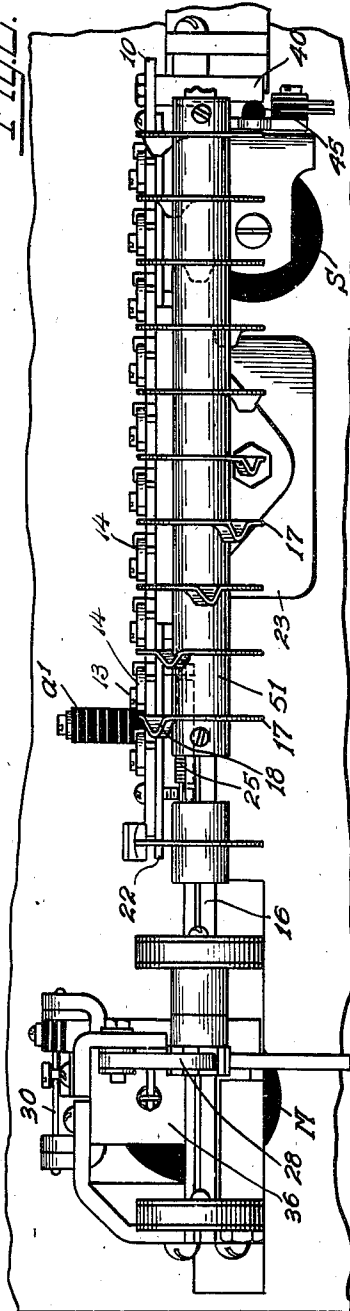


Fig. 2

Inventor:
George P. Eaton
By *C. S. [Signature]*
Att'y

May 5, 1942.

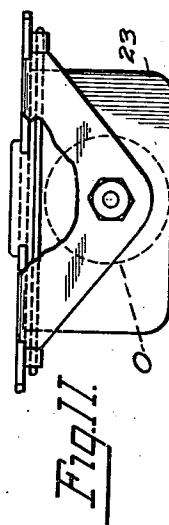
G. R. EATON

2,281,564

AUTOMATIC TELEPHONE APPARATUS AND CIRCUITS

Filed Sept. 10, 1938

6 Sheets-Sheet 2



Inventor:
George F. Eaton.

By CPS
Att

May 5, 1942.

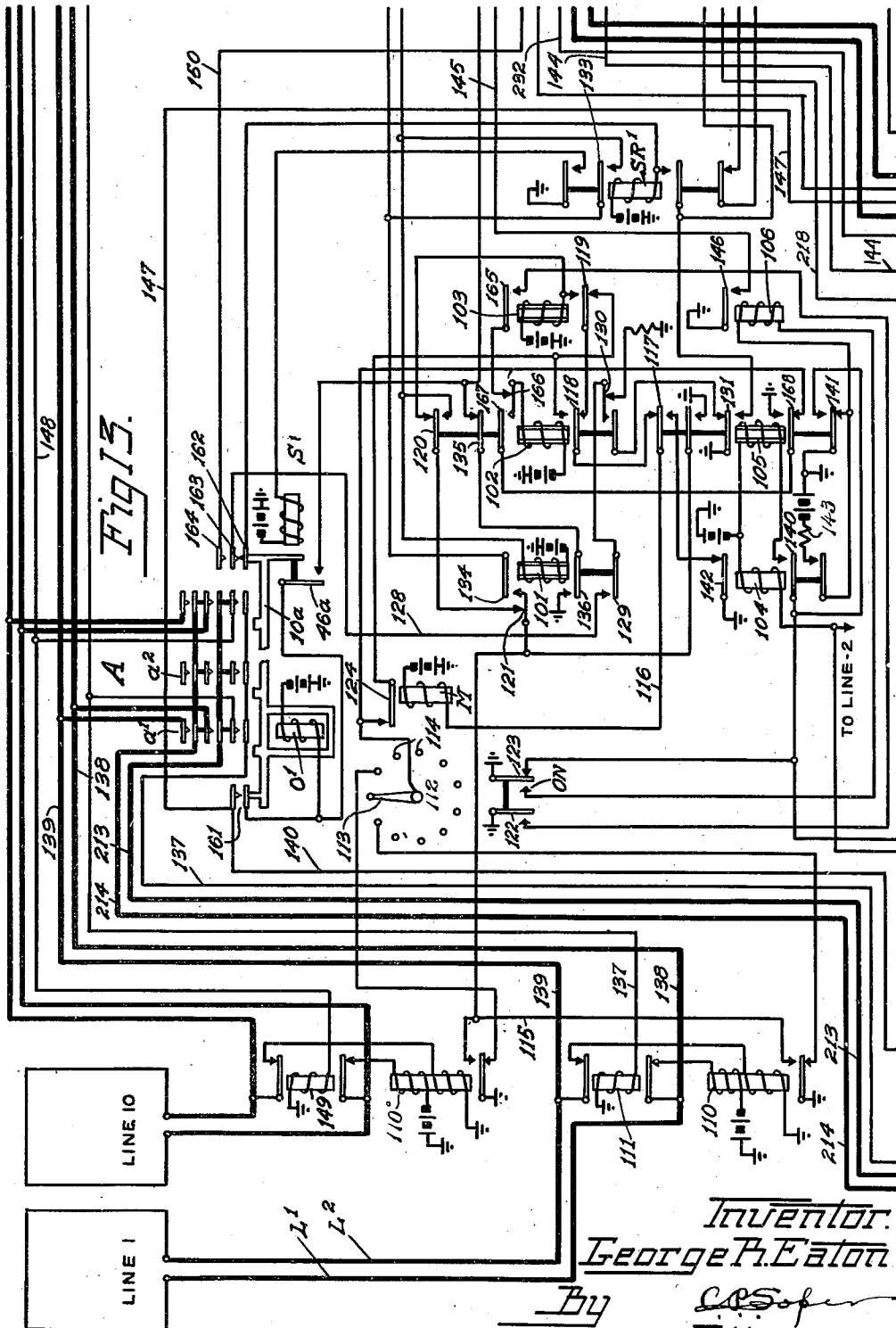
G. R. EATON

2,281,564

AUTOMATIC TELEPHONE APPARATUS AND CIRCUITS

Filed Sept. 10, 1938

6 Sheets-Sheet 4



May 5, 1942.

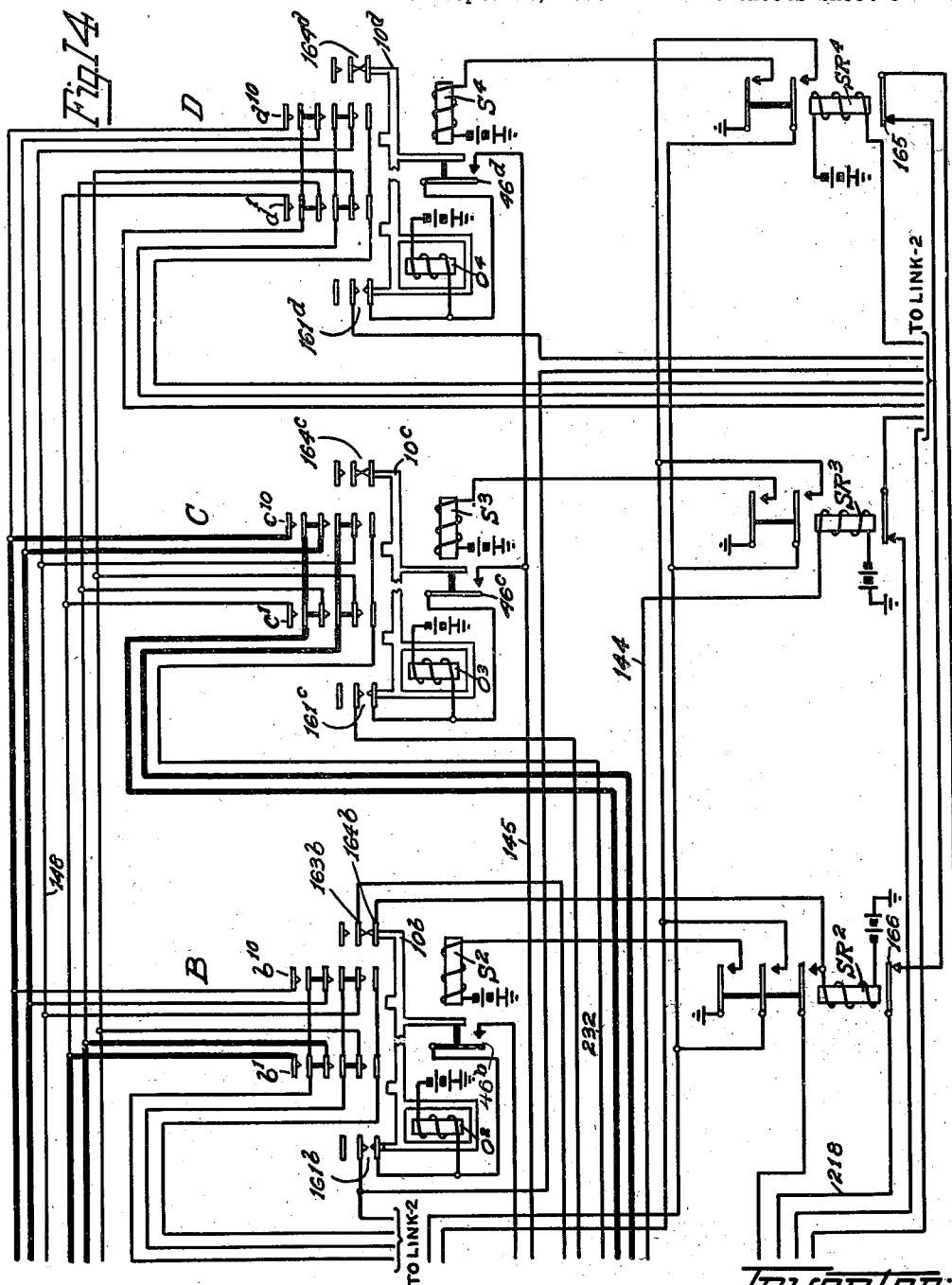
G. R. EATON

2,281,564

AUTOMATIC TELEPHONE APPARATUS AND CIRCUITS

Filed Sept. 10, 1938

6 Sheets-Sheet 5



Inventor:
George P. Eaton
By *CP*
Att.

May 5, 1942.

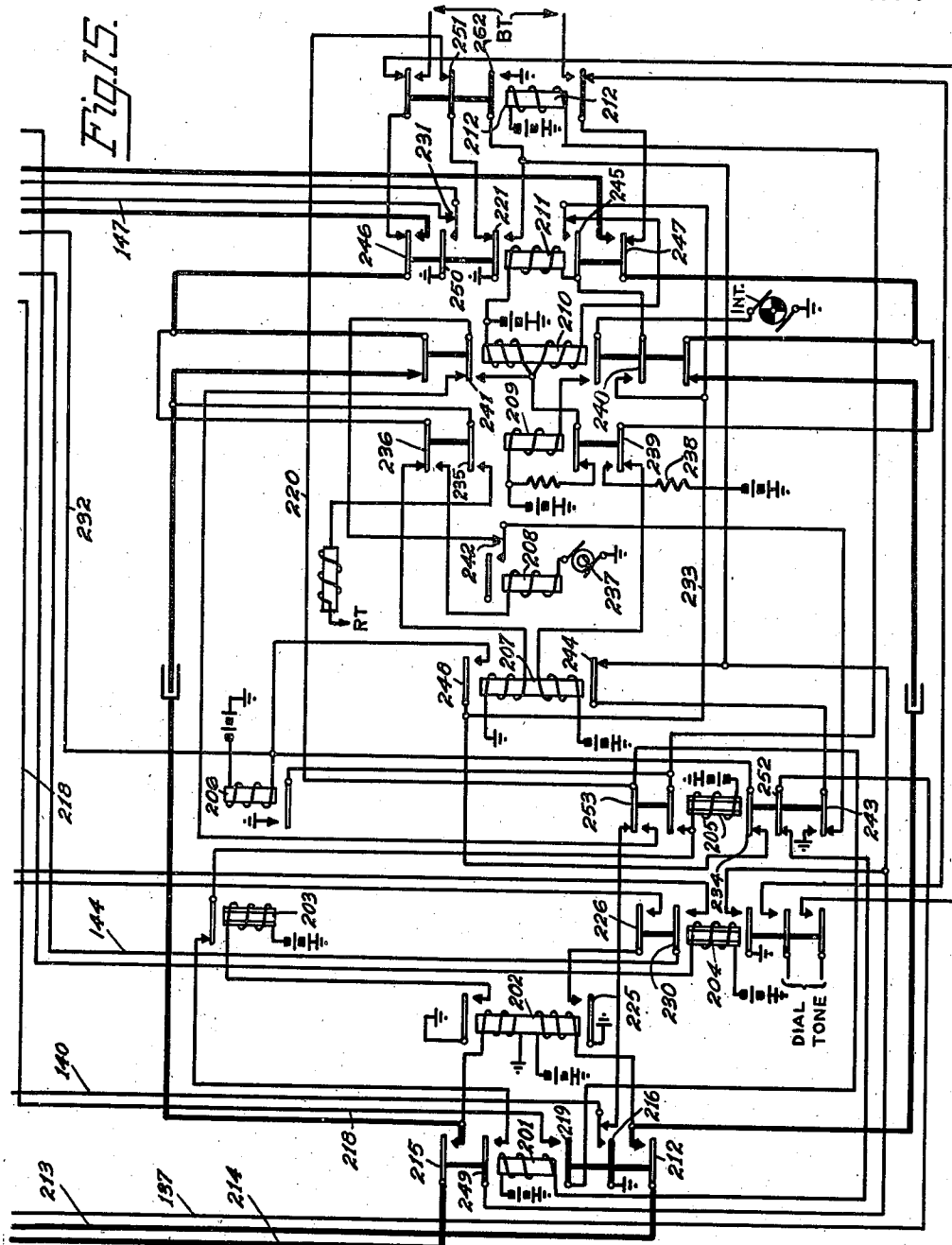
G. R. EATON

2,281,564

AUTOMATIC TELEPHONE APPARATUS AND CIRCUITS

Filed Sept. 10, 1938

6 Sheets-Sheet 6



Inventor:
George P. Eaton
By *CES.*
Att'y.

UNITED STATES PATENT OFFICE

2,281,564

AUTOMATIC TELEPHONE APPARATUS AND
CIRCUITS

George R. Eaton, Oak Park, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill., a corporation of Illinois

Application September 10, 1938, Serial No. 229,266

41 Claims. (Cl. 179-24)

This invention relates to an improvement in automatic telephone apparatus and circuits of the type used to establish connections between the lines of a calling and a called telephone subscriber.

The automatic telephone apparatus which has been generally used, heretofore, has been of two kinds. In one, traveling brushes are arranged to be moved over a series of groups of contacts to select a desired group of contacts corresponding to the line or trunk desired. The other system, at present employed, establishes the desired connections through the medium of gang relays which are controlled and energized in coordinate fashion to establish the connection.

The present invention seeks to combine in a unitary structure the advantageous features of both the prior systems above referred to.

The object of the invention is the provision of a line connecting mechanism which is compact, durable and reliable in operation and cheap to manufacture.

One of the features of the invention resides in the provision of a series of groups or stackups of contact springs which may be similar to those of a gang relay and the provision of selective means, whereby the springs of any desired stackup may be actuated by a single electromagnet. The function of the sets of contact springs may be, in some respects, similar to those of the relays used in establishing connection in the all-relay systems, with the difference that in the prior art, with which applicant is familiar, the operating magnet has been arranged to operate all the sets of springs of a group while, in applicant's device, a single magnet, common to all contact springs of the relay, may be caused to selectively actuate any desired set or stackup of springs in the group.

Another feature resides in the selecting means and operating circuit therefor, whereby the same control apparatus may be employed in joining the connecting link to either a calling or a called line.

A still further feature, closely related to that just mentioned, resides in the arrangement by means of which a set of springs of one group may establish connection to a calling line and a set of springs of another group, arranged to be selected by the same mechanism, may contemporaneously provide connection to a called line. The above-mentioned calling and called line may, in some cases, be united into a single telephonic or other circuit through the instrumentality of con-

tact springs determined by the same selecting mechanism.

In one form, the present invention contemplates the provision of four or more groups of contact spring stackups, a single actuating electromagnet being provided for each group of springs and selecting mechanism common to the several groups of springs, whereby any desired set of contacts in any one of the several groups may be selected and then individually operated by the actuating magnet associated with that group of contact sets.

Other features and advantages will appear from time to time as the description of the invention progresses.

It is believed the details of the invention will be most readily understood from a detailed description thereof, taken in connection with the accompanying drawings in which

Fig. 1 is a plan view showing one group of contact springs and the selecting mechanism associated therewith;

Fig. 2 is a view of the structure shown in Fig. 1 as seen from the bottom of the page;

Fig. 3 is a view similar to Fig. 1, with parts omitted, but showing the commutator mechanism at the right and the stackup selecting mechanism in actuated position;

Fig. 4 is a side view of the motor mechanism by means of which the selecting apparatus is actuated;

Fig. 5 is a cross-sectional view taken through Fig. 1, showing one set of springs and the actuating mechanism associated therewith;

Fig. 6 is another section through the apparatus of Fig. 1, showing further details of construction;

Fig. 7 is a view looking at the end of one of the group contact sections and showing the shift magnet which cooperates with the selecting mechanism shown in Figs. 1 and 2 to actuate a single set of contact springs. In Fig. 7, the springs are shown in actuated position;

Fig. 8 is a cross-sectional view through the apparatus of Fig. 1 showing a group of contacts in actuated position;

Fig. 9 is a detached view of one of the cam discs, forming part of the selecting mechanism;

Fig. 10 is a fragmentary view of the contact actuating magnet and its armature structure;

Fig. 11 is a view of the mechanism of Fig. 10 as seen from the bottom of the page;

Fig. 12 shows the cams of the commutator in detached relation, and

Figs. 13, 14 and 15, with Fig. 14 to the right of Fig. 13 and Fig. 15 below Fig. 13, schematically

indicate circuits illustrating the method of operation of the switch.

Reference will now be made to the drawings in which like reference characters indicate the same parts in each of the several views. In Fig. 1 is shown a single selecting group relay, with the exception of the commutator springs which are shown in Fig. 3. A different view of the same mechanism is shown in Fig. 2. From reference to the drawings, it will be noted that there are ten sets or stackups of springs which in Fig. 1 are designated as a^1, a^2, a^3 , etc., to a^{10} and by reference to Fig. 2, it will be seen that each of the stackups, as a^1, a^2 , etc., comprises three pairs of springs although, obviously, the number may be increased or decreased as desired. Extending adjacent to and underlying the ends of the springs a^1, a^2 , etc., is a plate 10 which is slidably mounted on the screws 11, extending through slots 12 in plate 10. Pivotally supported on the plate 10 by means of screws 13, are ten selecting arms 14, one for each stackup, which are normally maintained in the positions shown in Fig. 1 by means of the respective springs 15. Extending across the front of all four of the selecting relays and the commutator springs shown in Fig. 3, is a shaft or rod 16. Fixed on the rod 16, opposite each relay, are ten discs 17, one for each arm 14 and stackup a^1, a^2 , etc. Each of these discs is provided with an offset or cam portion 18. These cam portions 18 are spirally arranged about shaft 16 at intervals of approximately 32.7 degrees. In other words, shaft 16 has eleven positions—a normal or home position for which there is no corresponding cam 18 and ten actuating positions in each of which a cam 18 is positioned opposite one or another of the laterally extending lugs 19 at the free ends of levers 14. Electromagnetic means, subsequently to be described, are provided for shifting plate 10 to the right, as shown in Figs. 1 and 2. It is now obvious that, as one of the cams 18 is opposite the projecting lug 19 corresponding to the selected stackup a^1, a^2 , etc., as the case may be, the selected lever 14 will be rotated in a clockwise direction about its supporting screw 13, against the tension of its spring 15, and the inner end thereof, will be placed under the lowermost spring of the selected stackup, as shown in Figs. 3 and 8 of the drawings. The inner end of each of the levers 14 is provided with a groove 20 which receives a projecting stud of insulating material 21 on the lowermost spring of the stackup.

Pivotally supported under the sets of springs a^1, a^2 , etc., and extending the entire length of the relay is a plate 22 having fixed, thereto, an armature 23 extending adjacent to a common operating magnet O. Screws 11, on which plate 10 is slidably mounted, have their screw-threaded ends received by threaded openings in plate 22 so that plate 10 is tilted whenever magnet O is energized but is mounted for limited longitudinal movement, relative to plate 22. A spring 25 having one end attached to plate 10 and the other end attached to plate 22, tends to move plate 10 to the left as seen in Figs. 1 and 2.

The means for rotating shaft 16 is best seen in Fig. 4. Fixed to shaft 16 is a ratchet wheel 26 arranged to be engaged by pawls 27 and 28, fixed to arm 29 in any desired manner. Arm 29 is pivotally supported by pivot pin 30 and is arranged to be engaged by the laterally extending end 31 of the armature 32 of actuating magnet M. From an inspection of the drawing, it will be obvious that when magnet M is energized, armature 32

will be drawn into contact with the core of the magnet, causing the right end of arm 29 to move upwardly. Pawl 28, which is in engagement with one of the teeth 34 of ratchet wheel 26 will now operate to rotate shaft 16 one-half step or approximately $\frac{1}{22}$ of a complete revolution. Upon the deenergization of the magnet M, spring 35, one end of which is fixed to arm 29 and the other fixed to the magnetic circuit member 36, acts to draw arm 29 downwardly, and pawl 27 engages a tooth on the opposite side of ratchet wheel 26 to complete the rotary step of shaft 16. Thus, the shaft 16 will be rotated one step or approximately $\frac{1}{11}$ of a complete revolution each time the actuating magnet M is energized and deenergized. Except when the selecting mechanism is in its normal position, each step will act to place one or another of the cams 18 opposite a projecting portion 19 of an arm 18 so that the corresponding contact stackup a^1, a^2 , etc., or whichever it may be, will be actuated, as shown in Fig. 8 of the drawings, as a result of the energization of the common magnet O.

At 112 in Fig. 13 is schematically indicated what I term a commutator. The actual mechanism employed is shown at the right in Fig. 3 of the drawings. This commutator comprises ten pairs of contact springs 37, one pair for each operative position of the shaft 16, which pair is closed whenever the shaft 16 occupies a position corresponding to the spring pair. Only five pairs of springs 37 are shown in Fig. 3, but it is to be understood that five other pairs of springs are located directly below those shown. Positioned on shaft 16, between each two pairs of springs 37, is a disc 38, having a cam projection 39. These cams are shown in their relative positions in Fig. 12 and they are so arranged as to close a pair of springs 37 in each operative position of shaft 16, all of cams 39 as well as cams 18 being inoperative when the shaft is in its eleventh or inoperative position.

In Fig. 7 is shown the means for shifting plate 10 laterally at the time a connection is to be made. Extending downwardly from plate 10 is a pin 40 arranged to be engaged by the arm 41 extending at substantial right angles to armature 42, pivotally supported on pin 43. An electromagnet S is associated with armature 42 and upon its energization, arm 41 engages pin 40 and moves plate 10 to the right, as seen in Figs. 1 and 2 of the drawings. Armature 42 is provided with a lug 45 of insulating material adapted to engage spring 46 and move it into engagement with contact spring 47 when a magnet S is energized. Shift magnets such as magnet S are shown at S^1, S^2, S^3 and S^4 in Figs. 13 and 14. Contact spring 46 is, in like manner, shown at 46a, 46b, 46c and 46d in Figs. 13 and 14.

A very simple expedient is provided for quickly and accurately positioning the various cams on the shaft 16. Shaft 16 is provided, along one side, with a groove or keyway arranged to receive a bar or rod 48 which forms a spline or key. The various discs, such as the cam discs 17 and the commutator discs 38 are provided with eleven equidistant notches 50, as shown in Figs. 9 and 12. Thus, all of the cams 17 may be made alike and all of the commutator cam discs 38 may be formed alike. In mounting the discs, as for instance the discs 17 on the shaft 16, it is only necessary to slip the successive cams one notch to secure the necessary spiral arrangement of the cams on the shaft. The cam discs 38 may also be mounted in the same manner, being

slipped one notch 50 for each cam added to the shaft. Thus, after the first cam disc 17 of the group has been correctly placed on the shaft in relation to the discs 38, the other discs 17 may be added in an obvious manner. Spacers 51 are provided between the various cam discs to maintain them in the proper spaced relation.

The sequence of operations of the contact stack selecting mechanism, above described, is as follows: Shift plate 10 will be moved to the right by magnet S, shaft 16 will be rotated through the medium of the mechanism, shown in Fig. 4, to a position corresponding to the desired spring stackup, whereupon common actuating magnet O will be energized. The energization of magnet O will tilt plate 22 and shift plate 10 carried thereby, into the position shown in Fig. 8. One of the arms 14 will have been rotated in a clockwise direction by means of the operative selecting cam 18, as best seen in Fig. 3. All of the arms 14, except the one corresponding to the operative cam 18, will be in a position such that they will pass idly between the successive contact stacks, as shown in Fig. 3. The selected arm 14, however, will underlie its contact stack and the groove 20 at the inner end thereof will receive the end of the insulating pin 21 carried by the lowermost spring, as indicated in Fig. 8. In the normal operation of the mechanism, the common magnet O will remain energized during a connection. The selecting mechanism, comprising the shaft 16, and the apparatus associated therewith, as soon as it has performed its function, will immediately return to its normal position so it may be used in the establishment of another connection. In other words, the selecting mechanism is tied up only so long as it is actually being used in establishing a connection. The groove or notch 20 at the end of lever 14, will serve to prevent the anti-clockwise rotation of the operative lever 14 by its spring 15 and thus will hold the connection.

Before giving a detailed narrative of the operation of the switch and system by reference to the circuit drawings of Figs. 13, 14 and 15, a brief outline of the manner in which the switch functions, will be given. When a subscriber calls, the switch stepping magnet M will have a circuit completed which will cause the magnet to be intermittently energized and deenergized until a pair of springs 37, corresponding to the calling line, are closed through the medium of one of the cams 39. Thereupon, the stepping magnet will be deprived of current and shaft 16 will cease rotating. Plate 10 has previously been shifted to the right as viewed in Figs. 1 and 2. When shaft 16 ceases to rotate, magnet O corresponding to the relay, will be actuated and cause one of the stackups a^1 , a^2 , or a^{10} , whichever it may be, corresponding to the calling line, to be actuated. The calling line will then be connected to one of the two link circuits herein provided. As soon as the selected stackup has been actuated, stepping magnet M again receives current and immediately returns to its normal or 11th position. Upon receiving a dialing tone, the calling subscriber will operate his dial in accordance with the number of the wanted subscriber. As the present disclosure provides for only ten lines, but one operation of the dial will be necessary. The stepping magnet M will follow the dial and will step shaft 16 into a position corresponding to the line that is called. Again, as previously mentioned, plate 10 has been shifted to the right and magnet O of the relay at the terminating

end of the link circuit will be energized to close the contacts of the stackup corresponding to the wanted line. The wanted line will be tested, and if found idle, it will be rung. Upon response of the called subscriber, the two lines will be connected for conversation, magnets O of the two relays employed being maintained energized so long as the connection exists. The selecting mechanism comprising shaft 16 and the parts directly associated therewith, are always released and restored to normal position immediately after a magnet O of one of the relays is actuated.

Should a call be made by another one of the subscribers, the apparatus will function exactly as just described, except the circuits will be arranged so as to cause the energization of the magnet O of the relay A or B, not in use. As relay A is connected to relay C, and relay B is joined by its connecting circuit to relay D, when the second calling subscriber operates his dial, the relay C or D, corresponding to relay A or B used to select the line, will of course, be actuated to complete the circuit through the connecting circuit to the wanted line called by the subscriber who called second.

When the conversation is completed and the subscribers hang up, the two magnets O, which were maintained energized, are deprived of current and the relay mechanism restores to its normal position.

We will now trace the establishment of a connection from a calling subscriber's line to a called subscriber's line. We will assume that the subscriber on line 1 desires to establish a conversational circuit to the subscriber on line 10.

It may be here explained that the heavily-shaded conductors in Figs. 13, 14 and 15 indicate the talking circuit between the subscribers after the connection has been established. This circuit includes contacts in the set a^1 of relay A and contacts in set c^{10} of relay C. Each line has a set or stackup of contacts in each relay. Thus, the contact sets a^1 , b^1 , c^1 , and d^1 are individual to line 1. Line 1 may be seized as a calling line through the contact set a^1 or b^1 , as the case may be, and it may be seized as a called line through one or the other associated sets c^1 or d^1 . In like manner, contact sets a^2 , b^2 , c^2 and d^2 are individual to line 2; sets a^3 , b^3 , c^3 and d^3 , individual to line 3 and so on for all the other lines. The subscriber on line 1, upon removing his receiver from the hook in the usual manner, will establish a circuit from battery through the upper winding of line relay 110, back contact of cutoff relay 111, conductor L^1 , through the substation apparatus, back over conductor L^2 , through the other armature and contact of cutoff relay 111 and through the second winding of relay 110, back to battery. Relay 110 attracts its armature. This removes ground from that one of the contacts 114 of the commutator 112 which corresponds to line 1. As previously explained, the selecting shaft 16 has eleven positions; a normal or home position and ten operative positions corresponding to the ten lines in the group, respectively. The contacts corresponding to the several lines will be connected to ground at all times, except when the line is initiating a call. The sequence commutator springs 37 of Fig. 3 are schematically indicated in Fig. 13 as a brush 113 arranged to travel over the contacts 114, as the operation of the system can be more easily followed when the structure is thus illustrated. When line relay 110 attracts its armature, it

connects ground to start conductor 115 completing a circuit from ground through normal contacts 121 of relay 101, armature 120 and back contact of relay 102 and through the winding of relay 103 to battery and ground. Relay 103 attracts its armature which completes a circuit for the selecting mechanism motor magnet M which may be traced from grounded battery through the winding of magnet M, conductor 116, armature 117 and back contact of relay 105, armature 118 and back contact relay 102, armature 119 and front contact of relay 103 through armature 120 and back contact of relay 102, contacts 121 and over conductor 115 to ground through the contact of line relay 110. Motor magnet M is energized and moves the wiper 113 one step in an anti-clockwise direction which places it in engagement with the contact corresponding to the calling line. As the line relay 110 is energized, the corresponding contact 114 is not connected to ground. Thus, motor magnet M will cease to operate and shaft 16 will come to rest in a position corresponding to line 1.

When the shaft of the selecting mechanism moved from its normal position, the off-normal contacts ON were shifted so as to close contact 122 to ground and shift contact 123 from the position shown in the drawing to its alternate contact. Upon the closure of contact 122, a circuit was closed from ground through contact 122, armature 165 and front contact of relay 103, normal make-before-break contacts 166 of relay 102 and the winding of relay 102 to battery and ground. Relay 102 is energized and closes an alternate path for its winding from battery through the winding, armature 167 and front contact of relay 102, armature 168 and back contact of relay 105 to brush 113.

If, now, some line other than line 1 was calling, the contact engaged by brush 113 would be connected to ground through the back contact of line relay 110 and a circuit would thus be established from battery, through motor magnet M, conductor 116, armature 117, armature 118 and its front contact, armature 124 of motor magnet M and its back contact, through wiper 113 and the contact engaged thereby to ground through the back contact of the line relay. Under the condition last assumed, motor magnet M will again be energized to step the brush 113 to the next contact. During the automatic stepping operation of magnet M, relay 102 will be maintained energized by its circuit through brush 113, above traced, in parallel with magnet M. Relay 102 being slow to release will not fall off during the brief interruptions to its circuit. Each time motor magnet M energizes, it attracts its armature 124, breaking its own circuit, thus causing the control mechanism to step from position to position so long as brush 113 engages a grounded contact corresponding to a non-calling line. When, however, it reaches a position corresponding to a calling line, the corresponding contact 114 is free of ground potential and the selecting mechanism will come to rest. The circuit for the stepping magnet M will be opened and relay 102 will no longer receive current and will fall back breaking its locking circuit.

On the assumption first made, that line 1 is calling, it is obvious that the selecting mechanism would take but one step before coming to rest. When relay 102 was actuated, it closed a circuit for relay 101 from battery, through the winding of relay 101, front contact and armature

120 of relay 102, normal contacts 121 of relay 101, over conductor 115 to ground, through the armature of line relay 110. Relay 101 completed a circuit for the shift relay SR¹ which may be traced from battery, through the winding of SR¹, contacts 162 and 163, conductor 128, armature 129 and front contact of relay 101, armature 130 and front contact of relay 102 and armature 131 and back contact of relay 105, back to battery. Shift relay SR¹, in operating, closes a circuit for shift magnet S¹ which moves plate 10^a to the right, as shown in Figs. 1 and 2 of the drawings. S¹ also closes contacts 46^a. When relay 101 attracted its armatures, it interrupted its circuit, first traced, but prepared a substitute circuit which extends from battery, through the winding of relay 101, through contacts 133, which are now closed due to the energization of shift relay SR¹, thence through armature 134 and front contact of relay 101 and over conductor 115 to ground, through the armature of the line relay. A circuit is now closed for the operating magnet O¹ which extends from battery, through the winding of this magnet, contacts 46^a of shift magnet S¹, armature 135 and back contact of relay 102, through armature 136 and front contact of relay 101 to ground. Magnet O¹, in energizing, closes the pairs of contacts of the stack indicated at a¹. It also closes contacts 161 and contacts 163 and 164, shown at the opposite ends, respectively, of the selecting group relay in Fig. 1. It may be here noted that these contacts are actuated whenever magnet O¹ is energized, regardless of which of the stacks a¹, a², etc., is selected for operation. Contacts shown at 161 are always closed when magnet O¹ is energized and contact 163 is removed from engagement with contact 162 and into engagement with contact 164. When the contacts of stack a¹ were actuated, a circuit was completed for relay 201 which may be traced from battery, through the winding of this relay, armature 252 and back contact of relay 205, lowermost pair of contacts of stack a¹, thence over the third line conductor 137 and through the winding of cutoff relay 111, causing the operation of both relays. Relay 111, in operating, interrupts the circuit for line relay 110, the armature of which falls back, removing ground from the start circuit 115 and restoring ground to commutator contact 114 corresponding to line 1. When contacts 162 and 163 were opened, due to the energization of magnet O¹, the circuit for shift relay SR¹ was interrupted and contact made between 163 and 164 which caused the circuit to be extended through contacts 163^b and 164^b to the winding of shift relay SR², associated with the next selecting group relay B. The deenergization of the line relay 110 interrupted the holding circuit for relay 101 which fell off. When relay 201 became energized, it completed a circuit for relay 202 which may be traced from battery, through one winding of relay 202, armature 212 and front contact of relay 201, conductor 113, contacts of the middle pair of stack a¹, conductor 138, over line conductor L¹, through the substation apparatus, back over line conductor L², conductor 139, the upper pair of contacts in stack a¹, conductor 214, armature 215 and front contact of relay 201, through the other winding of relay 202, back to battery. Thus, relay 202 is bridged directly across the calling subscriber's line.

As previously explained, when the commutator brush 113 engaged the contact of the calling

line, ground was absent and magnet M did not pull up. This also interrupted the circuit of relay 102, but as relay 102 is slow-to-release, it did not drop off before ground was applied to the contact engaged by brush 113 due to the deenergization of line relay 110. Relay 101 having become deenergized, a circuit is now provided from battery through the winding of magnet M, armature 117 and back contact of relay 105, armature 118 and front contact of relay 102, armature 124 and its back contact to the brush 113 and thence to ground, through the armatures of the line relays of non-calling lines. This circuit operates in the same manner as one previously described and magnet M repeatedly energizes and deenergizes until brush 113 arrives at its normal position which is not connected to ground.

When the circuit for shift relay SR¹ was interrupted, it opened the circuit for shift magnet S¹ which in turn permitted the opening of contacts 46a in the circuit of operating magnet O¹. However, a holding circuit for magnet O¹ has been closed in the meantime, which extends through contacts 161, conductor 140 and armature 216 and front contact of relay 201. A circuit now exists for relay 204 which extends from battery, through the winding of 204, contacts 165 and 166, controlled by shift relays SR⁴ and SR², respectively, conductor 218, contact and armature 219 of relay 201, conductor 220, armature 251 and contact of relay 212 and back contact and armature 221 of relay 211. A source of dial tone "Dial tone" is now connected to the calling subscriber's line, through the armatures and back contacts of relay 212, back contacts and armatures of relay 211, armatures and back contacts of relay 210, to the heavily-shaded conductors which are included in the talking circuit and extend to the calling parties' station. The calling subscriber, upon hearing the dial tone, will know that the apparatus is ready to receive the dial impulses.

On the assumption that subscriber on line 1 is calling the subscriber on line 10, he will actuate his dial to open the line circuit ten times, thus causing battery feed relay 202 to be deenergized ten times. Relay 202, at its armature 225 and front contact completed a circuit by way of armature 226 and front contact of relay 204, through the winding of relay 104. Relay 104 in turn completed a circuit from battery, through the winding of relay 105, front contact and armature 140 of relay 104 to ground, through off-normal contact 123 which is now closed. Relay 105, in operating, closed a locking circuit for its winding which extends from armature 140 to ground, through contact and armature 141 of relay 105. At each interruption of the substation circuit by the dial, relay 202 will be deenergized, thus interrupting the circuit of relay 104 which will in turn be deenergized. Each time armature 142 of relay 104 falls back, it completes a circuit for motor magnet M as follows: from battery, through the winding of magnet M, conductor 116, armature 117 and front contact of relay 105 and armature 142, back to battery. Thus, motor magnet M will be energized ten times and will step the selecting mechanism to its 10th position corresponding to the tenth line which is the line to which the connection is desired. The operation of motor magnet M, as just described, rotates the shaft 16 having the four sets of cams fixed therewith. The tenth cam in each of the four selecting group relays will be in operative position. The cam, however, which will actually

function, will be determined by which of the magnets O¹, O², O³ or O⁴ are actuated. In the present case, the magnet O³ of selecting group relay C will be actuated as follows: At the end of the selecting impulses, relay 104 remains energized maintaining a circuit from battery, through the resistance 143, contact and armature of relay 104, winding of relay 106 and off-normal contact 123 which is now closed. The continued flow of current through resistance 143 causes relay 106 to become energized. A circuit had previously been provided for shift relay SR³ from battery, through the winding of this relay, conductor 144, armature 230 and front contact of relay 204 and front contact and armature 141 of relay 105. Relay SR³ closed the circuit for shift magnet S³ which shifted plate 10^c and closed contacts 46^c in the same manner as connected with selecting group relay A. Thus, when relay 106 attracted its armature, it closed a circuit through the winding of magnet O³, contacts 46^c, conductor 145, armature 146 and front contact of relay 106, causing plate 10^c of selecting group relay C to be tilted, thus actuating the tenth contact stack c¹⁰. When magnet O³ attracted its armature, it closed a locking circuit for itself from battery, through its winding contacts 161^c, contact 231 of relay 211, thence over conductors 147 and 140, back to battery, through armature 216 and front contact of relay 201. Whenever the test or lowermost pair of contacts of one of the stacks of selecting group relay C are closed, a circuit is completed from battery through the winding of relay 206, conductor 232 to all of the lowermost springs of selecting relay C. In the present case, this circuit is continued through the resting spring of the lowermost pair of stack c¹⁰, thence over conductor 148 and through the cut-off relay 149 of line 10. This causes relay 206 to operate. A circuit is also completed at this time for test relay 210 which extends from battery, through both windings of this relay, through normal contacts of relay 211, conductor 233, armature 234 of relay 205, conductor 232 and thence to ground, through cutoff relay 149 as in the circuit traced above. The flow of current through relays 206 and 210 to relay 149 causes the latter relay to operate. If the line is idle, relay 210 is energized.

When relay 210 becomes energized, it completes a circuit from battery through the winding of relay 211, armature 240 and front contact of relay 210, conductor 233, armature 234 and back contact of relay 205 and thence to ground through the winding of cutoff relay 149. Relay 210, in operating, closes a locking circuit for itself which extends from battery, through its winding, armature 241 and front contact, contacts 242 of ringing cutoff relay 208, armature 243 and back contact of relay 205, armature 244 and back contact of relay 207 and thence to ground through armature 221 and front contact of relay 211. Relay 211, when it attracts its armature, completes a locking circuit for itself which extends from battery, through its winding, armature 245 and its front contact, conductor 233, armature 234 of relay 205, conductor 232 and thence to ground, through the winding of cutoff relay 149. Thus, relay 211 is now locked up in a circuit controlled solely by relay 205 and the contacts of the selecting relay C.

When relay 206 operated, it closed a circuit from battery, through the winding of busy tone relay 212 which in turn closed one point in the circuit from the source of busy tone BT. If relay

210 had not operated, the circuit from busy tone BT would have been extended through back contacts and armatures of relay 211 and back contacts and armatures of relay 210 to the heavily-shaded conductors which extend to the calling line. However, on the assumption that the called line is idle, relay 210 is energized and cuts off the source of busy tone BT in an obvious manner. Had the called line been busy, the high resistance winding of relay 210 would have been in parallel with the low resistance winding of relay 211 of the other link, in which case, relay 210 would not have received sufficient current to attract its armatures.

Assuming that the line is idle, relay 210 pulls up and completes a circuit from battery, through the winding of ringing interrupter relay 209, through contact and armature of relay 210 to interrupter INT. Relay 209 in attracting its armature 235, connects the source of ringing tone RT to the calling line. Through its armature 236, it connects one side of the source of ringing energy 237 to a heavily-shaded conductor extending to the called line and at armature 239 it connects the other side of the source of ringing energy, through resistance 238 to the other heavily-shaded conductor extending to the called line. The ringing current from source 237 flows through the winding of ringing cutoff relay 208, armature 236 and front contact of interrupter relay 209, armature 246 and front contact of relay 211, contacts of stack c^{10} of selecting relay C, thence out over one side of line 10, through the substation apparatus on line 10, back over the other side of the line, through the companion contacts of c^{10} of selecting relay C, armature 247 and front contact of relay 211, armature 239 and resistance 238, back to the source of current.

When the called party answers, the increased flow of current through the winding of relay 208 causes it to attract its armature, interrupting the circuit through contacts 242, thus breaking the locking circuit for relay 210 which thereupon returns to its normal position. If the called party answers during a silent period, relay 207 will be energized causing ringing current to be cut off in an obvious manner. When relay 209 falls back, following the response of the called subscriber, battery feed relay 207 is bridged across the called line and, due to the decreased resistance of the line, it attracts its armatures. At its armature 248, it closes a path in parallel with armature 234 of relay 205 in the holding circuit of relay 211. Thus, the circuit of relay 211 is now controlled in part at the substation of the called line. The subscribers are now connected for conversation.

Upon the cessation of the selecting impulses sent by the calling subscriber, relay magnet O^3 was energized which caused relay 206 to become energized in series with cutoff relay 149 as previously described. Relay 206 in turn completed a circuit for relay 212. Relay 204, which has been maintained energized in a circuit including a back contact and armature 251 of relay 212 now becomes deenergized and at its armature 226, interrupts the circuit for the relay 104. Relay 104 in retracting its armatures, interrupts the holding circuit for relay 105 causing its armature to be retracted. The circuit is now completed from battery through the winding of motor magnet M, armature 117 and back contact of relay 105, armature 118 and front contact of relay 102, armature 124 and its resting contact brush 113 and contact 114 engaged thereby to ground through the back contact and ar-

mature of the called line. Thus, electromagnet M is energized and steps the selecting mechanism around, in a manner previously described, until brush 113 engages a contact 114 which is not grounded. If at this time no other line is calling, the selecting mechanism will return to its normal position.

After the conversation has been terminated, the subscribers will replace their receivers upon the switch hooks which will open the respective line circuits. The opening of the line circuit of the subscriber on line 1 interrupts the circuit for battery feed relay 202 and it retracts its armatures. The opening of the hook switch on line 10 interrupts the circuit for battery relay 207 which becomes deenergized. At this time, relay 201 is held up in series with the cutoff relay 111 of line 1 and relay 206 is in similar manner energized in series with cutoff relay 149 of line 10. A circuit is now completed from battery, through the winding of relay 205, armature and back contact of relay 203, armature 249 and front contact of relay 201 to ground, through armature 262 and front contact of relay 212. Relay 205 attracts its armature 234 which opens the holding circuit for relay 211 as armature 248 of relay 207 had previously fallen back. Relay 211 thereupon becomes deenergized and at its armature 221, interrupts the circuit for relay 205 which likewise falls back. When relay 205 attracted its armature 252, it interrupted the circuit for relay 201 which became deenergized and at its armature 216, removed the ground from conductor 140 through which magnet O^1 was locked up.

When magnet O^3 was first operated, its locking circuit included the ground at armature 219 of relay 201 but when relay 211 became energized, a substitute locking circuit for magnet O^3 was provided through armature 250 of relay 211 so long as this relay remained energized. Upon the falling back of relays 211 and 201, the selecting relay magnets O^1 and O^3 both become deenergized as the lead from the normally closed contacts of relay 201 is open at this time at the back contact of armature 253 of slow release relay 205.

As previously explained, the selecting group relay A is the answering end of one link, while the selecting relay C is the terminating end of said link. This connecting circuit has been designated as link 1. In exactly the same manner, the originating end of link 2 terminates in selecting group relay B and terminates in selecting relay D. Of course, it is to be understood that more than two pairs of relays A, C or B, D may be provided so that more than two links are available for the ten lines. Also, the number of lines in the group may be considerably increased without departing in any way from the mode of operation herein described.

If a call is initiated by another line while line 1 and line 10 are connected by link 1, the selecting circuit will function in exactly the same manner in connection with link 2, as above described in connection with link 1. Should a second line call, the start wire 115 will be grounded through the line relay of the calling line which will actuate relay 103 and the other relays as above described. But as the plate 10 of selecting relay A is maintained in operated position, due to the continued energization of magnet O^1 , contact 163 will be separated from its lower associated contact 162 and in engagement with its upper contact 164. Thus, instead of shift relay

SR¹ being operated, as above described, conductor 123 will be extended over conductor 150, then through the resting contacts 123^b and 164^b at the right in selecting relay B and through the winding of relay SR² to battery. Thus, if a second call is initiated, relay SR² will operate causing the operation of shift magnet S² which in turn will cause the energization of magnet O² of selecting relay B.

It is obvious, from the above description, that the selecting mechanism comprising the commutator shaft, magnet M and the controlling circuits therefor, are common to the several link circuits which may be provided and are at all times in normal position, except when actually employed in establishing a connection.

Should a subscriber call a busy line and neglect to replace his receiver upon its hook, the selecting mechanism will return to its normal position as soon as the connection has been established. It will be recalled that relay 206 was energized in series with the cutoff relay 149 of the called line as soon as the power magnet O³ was energized. Relay 212 then was actuated and, thus, would interrupt the circuit for relay 204. Relay 204 in turn interrupted the circuit of relay 104 causing relay 105 to fall back, completing the previously traced circuit for the motor magnet M, through the armature 117 and its back contact, armature 118 and its front contact and interrupter armature 124 of the stepping magnet. Thus, the selector will be stepped around until the contact of another calling line is engaged or until it reaches normal position.

Should a second subscriber call before the first calling subscriber has completed his connection, it will have no effect on the apparatus until the power magnet O³ or O⁴, at the terminating end of the link employed, has operated responsive to the dial impulses sent by the first calling subscriber, at which time relay 206 operates in series with the cutoff relay of the called line. Upon connection being made to a calling line, relays 104 and 105 of the control mechanism are maintained energized until after the selecting impulses are sent by the calling subscriber. Thus, although the line last calling will have placed ground on start lead 115, it will have no effect as the circuit for magnet M will be open at the armature 117 and back contact of relay 105 and no operation will take place. As soon, however, as the magnet O³ or O⁴ of the terminating selecting relay has actuated, relay 206 will operate, causing relays 204, 104 and 105 to fall off and the selector will again start its operation as above described.

In the present disclosure, the operation of applicant's connecting mechanism has been illustrated in a system having but a single group of lines. However, the mechanism and principles of operation herein disclosed may readily be adapted to systems having a plurality of line groups or to large exchange systems in which several stages of selection are required.

The relay and selecting mechanism herein disclosed will be found to operate in a satisfactory manner and they represent a structure which applicant, at present, considers a preferred embodiment of his invention. It is obvious, however, that many modifications may be made in the details of both the structure and the operating circuits. The invention should, therefore, be limited only by the scope of the appended claims.

Having thus described my invention, what I

claim as new and desire to secure by Letters Patent of the United States is:

1. In a line connecting apparatus, a relay including more than two contact sets, an electromagnet and an armature therefor, common to said contact sets and an electromagnetically operated selective means for operatively associating said armature with a single desired one of said contact sets, whereby the said desired contact set will be actuated to the exclusion of all other said contact sets by energization of said electromagnet.

2. In a line connecting apparatus, a relay including a plurality of contact sets, a plurality of displaceable arms for said relay, one for each set of contacts, an electromagnet, an armature for said electromagnet arranged to displace the said arms toward said contacts upon actuation thereof, a shaft rotatably mounted adjacent to said arms, cams spirally positioned on said shaft, there being a cam for each arm, said cams being arranged to successively shift the said arms one after another into registry with their respective contact sets upon rotation of said shaft and electromagnetic means for rotating said shaft to operatively associate an arm with a desired contact set whereby the contacts of said desired set will be actuated to the exclusion of all others as a result of the energization of the electromagnet of said relay.

3. In a line connecting apparatus, a relay including a plurality of contact sets, a plurality of displaceable arms, one for each of said contact sets, a rotatable shaft adjacent to said arms, means carried by said shaft, arranged to selectively shift said arms into registry with their respective contact sets incident to rotation of said shaft, electromagnetic means for rotating said shaft, an operating electromagnet for said relay, an armature for said magnet arranged to actuate said plurality of arms by energization of said operating magnet, whereby the contacts of the selected contact set are actuated.

4. In a line connecting apparatus, a relay including a plurality of contact sets arranged in a row, there being a plurality of pairs of related contacts in each set, a plurality of displaceable arms, one for each said contact set, a rotatable shaft adjacent to said arms, cams spirally arranged on said shaft, one for each of said arms, said cams being arranged to selectively shift said arms into registry with their respective contact sets incident to rotation of said shaft, means for rotating said shaft, an operating electromagnet for said relay, and an armature for said magnet arranged to displace said plurality of arms by energization of said operating magnet, whereby the contacts of the selected contact set are actuated.

5. In a line connecting apparatus, a plurality of relays, each including a plurality of contact sets, an electromagnet and an armature therefor, individual to each relay, each electromagnet and its armature being common to the contact sets of a relay, an electromagnetically actuated selective means common to said relays for operatively associating an armature with a desired one of said contact sets, whereby the contacts of said desired set will be actuated to the exclusion of all other sets as a result of the energization of the electromagnet of the corresponding relay.

6. In a line connecting apparatus, a plurality of relays, each including a plurality of contact sets, an electromagnet and an armature therefor, individual to each relay, each electromagnet

and its armature being common to the contact sets of a relay, an electromagnetically operated selective means for operatively associating an armature with a single desired one of said contact sets, whereby the contacts of said desired set will be actuated upon energization of the electromagnet of the corresponding relay, means for retaining the contacts of said set in actuated position and means permitting the contemporaneous operation of said selective means to select a desired contact set in another of said relays.

7. In a line connecting apparatus, a plurality of relays, each relay including a plurality of contact sets, a plurality of arms for each relay, one for each set of contacts, electromagnets, one for each relay, an armature for each electromagnet common to the arms of the corresponding relay and arranged to displace said arms toward their respective contact sets upon actuation thereof, a shaft, an electromagnet for actuating said shaft and means carried by said shaft arranged to selectively shift said arms into operative relation to their respective contact sets, whereby the contacts of a desired set will be actuated as a result of the energization of the electromagnet of the corresponding relay.

8. In a line connecting apparatus, a plurality of relays, each relay including a plurality of contact sets, a plurality of displaceable arms for each relay, one for each set of contacts, electromagnets, one for each relay, an armature for each electromagnet common to the arms of the corresponding relay, arranged to displace said arms upon actuation thereof, a shaft rotatably mounted adjacent to said arms, electromagnetic means for rotating said shaft and means carried by said shaft, effective incident to actuation thereof, for selectively shifting said arms into operative relation to their respective contact sets whereby the contacts of a desired set may be actuated as a result of the energization of the electromagnet of the corresponding relay.

9. In a line connecting apparatus, a plurality of relays, each relay including a plurality of contact sets, a plurality of displaceable arms for each relay, one for each set of contacts, electromagnets, one for each relay, an armature for each electromagnet common to the arms of the corresponding relay, a shaft rotatably mounted adjacent to said arms, electromagnetic means for rotating said shaft and means carried by said shaft arranged to selectively shift the arms into operative relation to their respective contact sets upon rotation of said shaft, whereby the contacts of a desired set may be actuated by energization of the electromagnet of the corresponding relay.

10. In a line connecting apparatus, a plurality of relays, each relay including a plurality of contact sets, a plurality of arms for each relay, one for each set of contacts, electromagnets, one for each relay, an armature for each electromagnet common to the arms of the corresponding relay and arranged to displace said arms upon actuation thereof, a shaft, an electromagnet for actuating said shaft, means carried by said shaft arranged to selectively shift said arms into operative relation to their respective contact sets, whereby the contacts of a desired set may be actuated upon energization of the electromagnet of the corresponding relay, means for returning said shaft to normal position and means for retaining the actuated contact set in actuated position.

11. In a line connecting apparatus, a plurality

of relays, each relay including a plurality of contact sets, a plurality of displaceable arms for each relay, one for each set of contacts, electromagnets, one for each relay, an armature for each electromagnet common to the arms of the corresponding relay, a shaft rotatably mounted adjacent to said arms, electromagnetic means for rotating said shaft, means carried by said shaft arranged to selectively shift the said arms into operative relation to their respective contact sets upon rotation of said shaft, whereby the contacts of a desired set may be actuated upon energization of the electromagnet of the corresponding relay, means for returning said shaft to normal position and means for retaining the actuated contact set in actuated position.

12. In a line connecting apparatus, a plurality of relays, each relay including a plurality of contact sets, a plurality of arms for each relay, one for each set of contacts, electromagnets, one for each relay, an armature for each electromagnet common to the arms of the corresponding relay and arranged to displace said arms upon actuation thereof, a shaft, an electromagnet for actuating said shaft, means carried by said shaft arranged to selectively shift said arms into operative relation to their respective contact sets, whereby the contacts of a desired set may be actuated upon energization of the electromagnet of the corresponding relay, means for retaining the contacts of the actuated set in actuated position and means permitting the contemporaneous operation of said shaft to select a desired contact set in another of said relays.

13. In a line connecting apparatus, a plurality of relays, each relay including a plurality of contact sets, a plurality of displaceable arms for each relay, one for each set of contacts, electromagnets, one for each relay, an armature for each electromagnet common to the arms of the corresponding relay, arranged to displace said arms upon actuation thereof, a shaft rotatably mounted adjacent to said arms, electromagnetic means for rotating said shaft, means carried by said shaft, effective incident to rotation thereof, for selectively shifting said arms into operative relation to their respective contact sets whereby the contacts of a desired set will be actuated upon energization of the electromagnet of the corresponding relay, interengaging means on said arms and contact sets for retaining the arm of an actuated contact set in shifted position and means permitting the contemporaneous operation of said shaft to select a desired contact set in another of said relays.

14. In a line connecting apparatus, a relay, including a plurality of contact sets, an electromagnet for said relay, an armature for said electromagnet, displaceable arms, one for each contact set, carried by said armature, a shaft mounted adjacent to said arms, means for actuating said shaft, and means carried by said shaft arranged to selectively shift one of said arms into registry with a desired contact set upon actuation of said shaft, so that the contacts of said desired set will be actuated incident to energization of said electromagnet.

15. In a line connecting apparatus, a relay, including a plurality of contact sets, an electromagnet for said relay, an armature for said electromagnet, a plurality of displaceable arms carried by said armature, one for each contact set, a shaft rotatably mounted adjacent to said arms, means for rotating said shaft, a group of cams spirally positioned on said shaft, there be-

ing a cam for each arm, said cams being arranged to selectively shift the said arms into operative relation to their respective contact sets upon rotation of said shaft, whereby the contacts of a desired set will be actuated upon energization of said electromagnet.

16. In a line connecting apparatus, a plurality of relays, each relay including a plurality of contact sets, electromagnets, one for each relay, an armature for each electromagnet, a plurality of displaceable arms carried by each armature, one for each contact set of a relay, a shaft, means for actuating said shaft and means carried by said shaft arranged upon actuation thereof, to selectively shift said arms into operative relation to their respective contact sets, whereby the contacts of a desired set will be actuated upon energization of the electromagnet of the corresponding relay.

17. In a telephone system, a link circuit, relays, one at each end of said link circuit, in which said link circuit terminates, a plurality of contact sets in each relay, subscribers' lines terminating in the respective contact sets of each of said relays, a single actuating magnet for each relay, selecting mechanism, means actuated responsive to the initiation of a call on one of said lines for causing said selecting mechanism to associate the single contact set of the relay at the answering end of said link circuit in which said calling line terminates with the corresponding actuating magnet for operation thereby, and means responsive to substation control for actuating said selecting mechanism to associate the single contact set of the relay at the other end of said link circuit in which the wanted line terminates with the actuating magnet of said other relay for operation thereby.

18. In a telephone system, a plurality of link circuits, relays, one at each end of each of said link circuits in which said link circuits respectively terminate, a plurality of contact sets in each relay, lines terminating in said contact sets, a single actuating magnet for each relay, selecting mechanism, means actuated responsive to an incoming call on one of said lines for causing said selecting mechanism to associate the contact set of the relay at the answering end of one of said link circuits in which said calling line terminates with the corresponding actuating magnet for operation thereby, and means responsive to substation control for actuating said selecting mechanism to associate the contact set of the relay at the other end of said link circuit in which the desired outgoing line terminates with the actuating magnet of said other relay for operation thereby.

19. In a telephone system, a plurality of link circuits, relays, one at each end of each of said link circuits in which said link circuits respectively terminate, a plurality of contact sets in each relay, lines terminating in said contact sets, a single actuating magnet for each relay, selecting mechanism, means actuated responsive to an incoming call on one of said lines for causing said selecting mechanism to associate the contact set of the relay at the answering end of one of said link circuits in which said calling line terminates with the corresponding actuating magnet for operation thereby, means responsive to substation control for actuating said selecting mechanism to associate the contact set of the relay at the other end of said link circuit in which the desired outgoing line terminates with the actuating magnet of said other relay for operation

thereby, and means for thereupon freeing said selecting mechanism for use in establishing a connection from another incoming line to an outgoing line through another link circuit and its terminating relays.

20. In a telephone system, a plurality of link circuits, relays, one at each end of each of said link circuits in which said link circuits respectively terminate, a plurality of contact sets in each relay, subscribers' lines terminating in said contact sets, a single actuating magnet for each relay, selecting mechanism, means actuated responsive to the initiation of a call on one of said lines for causing said selecting mechanism to associate the contact set of the relay at the answering end of one of said link circuits in which said calling line terminates with the corresponding actuating magnet for operation thereby, means responsive to substation control for actuating said selecting mechanism to associate the contact set of the relay at the other end of said link circuit in which the wanted line terminates with the actuating magnet of said other relay for operation thereby, and means for thereupon freeing said selecting mechanism for use in establishing a connection from another calling line to another called line through another link circuit and its terminating relays.

21. In a telephone system, a plurality of link circuits, relays, one at each end of each of said link circuits in which said link circuits respectively terminate, a plurality of contact sets in each relay, subscribers' lines terminating in the respective contact sets of each of said relays, a single actuating magnet for each relay, selecting mechanism, means actuated responsive to the initiation of a call on one of said lines for causing said selecting mechanism to associate the contact set of the relay at the answering end of one of said link circuits in which said calling line terminates with the corresponding actuating magnet for operation thereby, means responsive to substation control for actuating said selecting mechanism to associate the contact set of the relay at the other end of said link circuit in which the wanted line terminates with the actuating magnet of said other relay for operation thereby, and means for thereupon freeing said selecting mechanism for use in establishing a connection from another calling to another called line through another link circuit and its associated relays.

22. In a telephone system, a plurality of link circuits, relays, one at each end of each of said link circuits in which said link circuits respectively terminate, a plurality of contact sets in each relay, subscribers' lines terminating in the respective contact sets of each of said relays, a single actuating magnet for each relay, a single selecting mechanism common to said relays, means actuated responsive to the initiation of a call on one of said lines for causing said selecting mechanism to mechanically associate the contact set of the relay at the answering end of one of said link circuits in which said calling line terminates with the corresponding actuating magnet for operation thereby, means responsive to substation control for actuating said selecting mechanism to mechanically associate a contact set of the relay at the other end of said link circuit in which the wanted line terminates with the actuating magnet of said other relay for operation thereby, and means for thereupon freeing said selecting mechanism for use in establishing a connection from another calling line

to another called line through another link circuit and its terminating relays.

23. In a telephone system, relays, each having a plurality of contact sets and a common actuating magnet, subscribers' lines terminating in said contact sets, control mechanism, effective upon initiation of a call on one of said lines to associate a contact set of one of said relays in the contacts of which the calling line terminates with its respective actuating magnet for operation thereby, and responsive to sub-station control for associating a contact set of one of said relays in which the wanted line terminates, with its actuating magnet for operation thereby and link circuit means for inter-connecting the actuated contact sets.

24. In a circuit controlling apparatus, pairs of contact springs arranged, respectively, in cooperatively engageable relation, a plurality of displaceable arms, one for each pair of springs, a selecting device adjustably mounted adjacent to said arms, means for operating said device, means on said device, effective upon actuation thereof, for selectively displacing said arms into registry with their respective pairs of springs, an actuating member common to said arms, and an electromagnet for operating said actuating member, said actuating member being arranged, upon actuation thereof by said electromagnet, to move a displaced arm into operative engagement with a pair of springs whereby a desired pair of springs may be brought into operative relation by the energization of said electromagnet.

25. In a circuit controlling apparatus, pairs of contact springs arranged, respectively, in cooperatively engageable relation, a plurality of displaceable arms, one for each pair of springs, a selecting device adjustably mounted adjacent to said arms, means for operating said device, means carried by said device, effective upon actuation thereof, for displacing said arms, one by one, into registry with their respective pairs of springs, an actuating member common to said arms, and an electromagnet for operating said actuating member, said actuating member being arranged, upon actuation thereof by said electromagnet, to move a displaced arm into operative engagement with a pair of springs whereby a desired pair of springs may be brought into operative relation by the energization of said electromagnet.

26. In a circuit controlling apparatus, pairs of contact springs arranged, respectively, in cooperatively engageable relation, a plurality of displaceable arms, one for each pair of springs, a selecting device adjustably mounted adjacent to said arms, means for operating said device, means on said device, effective upon actuation thereof, for selectively displacing said arms in one direction into registry with their respective pairs of springs, an actuating member common to said arms, and an electromagnet for operating said actuating member, said actuating member being arranged, upon actuation thereof by said electromagnet, to move a displaced arm in a different direction into operative engagement with a pair of springs whereby a desired pair of springs may be brought into operative relation by the energization of said electromagnet.

27. In a circuit controlling apparatus, pairs of contact springs arranged, respectively, in cooperatively engageable relation, a plurality of displaceable arms, one for each pair of springs, a shaft adjustably mounted adjacent to said arms, cams on said shaft, effective upon actuation

thereof, for selectively and successively displacing said arms into registry with their respective pairs of springs, an actuating member common to said arms, and an electromagnet for operating said actuating member, said actuating member being arranged, upon actuation thereof by said electromagnet, to move a displaced arm into operative engagement with a pair of springs whereby a desired pair of springs may be brought into operative relation by the energization of said electromagnet.

28. In a circuit controlling apparatus, pairs of contact springs arranged, respectively, in cooperatively engageable relation, a plurality of displaceable arms, one for each pair of springs, a shaft rotatably mounted adjacent to said arms, means for rotating said shaft, means on said shaft, effective upon actuation thereof, for selectively displacing said arms in one direction into registry with their respective pairs of springs, an actuating member common to said arms, and an electromagnet for operating said actuating member, said actuating member being arranged, upon actuation thereof by said electromagnet, to move a displaced arm in a transverse direction into operative engagement with a pair of springs whereby a desired pair of springs may be brought into operative relation by the energization of said electromagnet.

29. In a circuit controlling apparatus, pairs of contact springs arranged, respectively, in cooperatively engageable relation, a plurality of displaceable arms, one for each pair of springs, a shaft rotatably mounted adjacent to said arms, means for rotating said shaft, cams on said shaft, effective upon rotation thereof, for selectively displacing said arms into alignment with their respective pairs of springs, an actuating member common to said arms, and an electromagnet for operating said actuating member, said actuating member being arranged, upon actuation thereof by said electromagnet, to move a displaced arm into operative engagement with a pair of springs whereby a desired pair of springs may be brought into operative relation by the energization of said electromagnet.

30. In a circuit controlling apparatus, pairs of contact springs arranged, respectively, in cooperatively engageable relation, a plurality of displaceable arms, one for each pair of springs, a shaft mounted adjacent to said arms, means for actuating said shaft, means on said shaft, effective upon actuation thereof, for selectively displacing said arms in one plane into registry with the respective pairs of springs, an actuating member common to said arms, and an electromagnet for operating said actuating member, said actuating member being arranged, upon actuation thereof by said electromagnet, to move a displaced arm in an intersecting plane into operative engagement with a pair of springs whereby a desired pair of springs may be brought into operative relation by the energization of said electromagnet.

31. In a circuit controlling apparatus, pairs of contact springs arranged, respectively, in cooperatively engageable relation, a plurality of displaceable arms, one for each pair of springs, a shaft rotatably mounted adjacent to said arms, means for rotating said shaft, cams on said shaft, effective upon rotation thereof, for selectively displacing said arms one by one in one plane into registry with their respective pairs of springs, an actuating member common to said arms, and an electromagnet for operating said actuating

member, said actuating member being arranged, upon actuation thereof by said electromagnet, to move a displaced arm in an intersecting plane into operative engagement with a pair of springs whereby a desired pair of springs may be brought into operative relation by the energization of said electromagnet.

32. In a telephone system, a plurality of relays, a plurality of contact sets in each relay, lines terminating respectively in said contact sets of each of said relays, an actuating magnet for each relay, selecting mechanism common to said relays and means actuated responsive to the initiation of a call on one of said lines for causing said selecting mechanism to associate the single contact set of an idle one of said relays in which said calling line terminates with the corresponding actuating magnet for operation thereby.

33. In a telephone system, a plurality of relays, a plurality of contact sets in each relay, subscribers' lines terminating in the respective contact sets of each of said relays, an actuating magnet for each relay, selecting mechanism, control means actuated, responsive to the initiation of a call on one of said lines, for causing said selecting mechanism to associate the single contact set of one of said relays in which the calling line terminates with the corresponding actuating magnet for operation thereby, and means responsive to the initiation of a call on another of said lines for actuating said selecting mechanism to associate the single contact set of another relay in which the second calling line terminates with the actuating magnet of said other relay for operation thereby.

34. In a telephone system, a plurality of relays, a plurality of contact sets in each relay, lines terminating respectively in contact sets of each of said relays, an actuating magnet for each relay, selecting mechanism common to said relays, means actuated responsive to the initiation of a call on one of said lines for causing said selecting mechanism to associate the contact set of an idle relay in which said calling line terminates with the corresponding actuating magnet for operation thereby, means for thereupon freeing said selecting mechanism and means responsive to the initiation of a call on another of said lines for actuating said selecting mechanism to associate the single contact set of another of said relays in which the second calling line terminates with the actuating magnet of said other relay for operation thereby.

35. In a telephone system, relays, a plurality of contact sets in each relay, lines terminating respectively in contact sets of each of said relays, an actuating magnet for each relay, means actuated responsive to the initiation of a call on one of said lines for associating the contact set of an idle relay in which said calling line terminates with the corresponding magnet for operation thereby, said means being actuated in response to the initiation of a call on another of said lines for associating the contact set of a now idle relay in which the second calling line terminates with the corresponding magnet for operation thereby.

36. In a telephone system, relays, a plurality of contact sets in each relay, subscribers' lines terminating in the respective contact sets of each of said relays, an actuating magnet for each relay, selecting mechanism common to said relays, means actuated responsive to the initiation of a call on one of said lines for associating one of said relays with the calling line, means re-

sponsive to substation control for actuating said selecting mechanism to associate the contact set of the said one of said relays in which a wanted subscriber's line terminates with the actuating magnet of the said relay for operation thereby, and means for thereupon freeing said selecting mechanism for use in establishing a connection from another calling line to another called line through another of said relays.

37. In a telephone system, relays, a plurality of contact sets in each relay, subscribers' lines terminating in the respective contact sets of each of said relays, an actuating magnet for each relay, selecting mechanism common to said relays, means actuated responsive to the initiation of a call on one of said lines for associating one of said relays with the calling line, means controlled over said line for actuating said selecting mechanism to associate the contact set of the said one of said relays in which the wanted subscriber's line terminates with the actuating magnet of the said relay for operation thereby, means for thereupon freeing said selecting mechanism, and means for associating a second one of said relays with a second calling line, said selecting mechanism being now controllable over said second calling line to actuate said selecting mechanism to associate the contact set of said second one of said relays in which the second wanted subscriber's line terminates with the actuating magnet of said second one of said relays for operation thereby.

38. In a telephone system, relays, a plurality of contact sets for each relay, each set comprising pairs of contact springs arranged, respectively, in cooperatively engageable relation, a plurality of displaceable arms, one for each pair of springs, a selecting device adjustably mounted adjacent to said arms, means for selectively moving said device, shift means on said device, effective upon movement thereof, for selectively displacing said arms one by one in one plane into registry with their respective pairs of springs, an actuating member common to said arms, and an electromagnet for operating said actuating member, said actuating member being arranged, upon actuation thereof by said electromagnet, to move a displaced arm in an intersecting plane into operative engagement with a pair of springs whereby the springs of a desired pair may be brought into operative relation by the energization of said electromagnet.

39. In a line connecting apparatus as set forth in claim 1, said means including laterally displaceable arms mounted on and carried by said armature, one for each of said contact sets; any one of said sets of contacts being rendered actuable by said armature, incidental to energization of said electromagnet, responsive to lateral displacement of the associated arm; and means for laterally displacing the arm corresponding to any desired contact set.

40. In a line connecting apparatus as set forth in claim 1, said means including arms pivotally mounted on and carried by said armature, one for each of said contact sets; any one of said sets of contacts being rendered actuable by said armature, incidental to energization of said electromagnet, responsive to rotation of the associated arm about its pivot; and means for rotating the arm corresponding to any desired contact set.

41. In a line connecting apparatus as set forth in claim 1, said contact sets being arranged in

a row along said armature, but not directly actuable thereby when the armature moves incidental to energization of said electromagnet, said armature having a row of arms adjustably mounted thereon for movement therewith and corresponding respectively to said contact sets, each arm having a normal position in which it does not engage and operate its corresponding

contact set when the armature is moved by said electromagnet, each arm having a position of adjustment in which it contacts and actuates its corresponding contact set when moved by the armature, and means for moving any desired one of said arms from its said normal position to its said position of adjustment.

GEORGE R. EATON.