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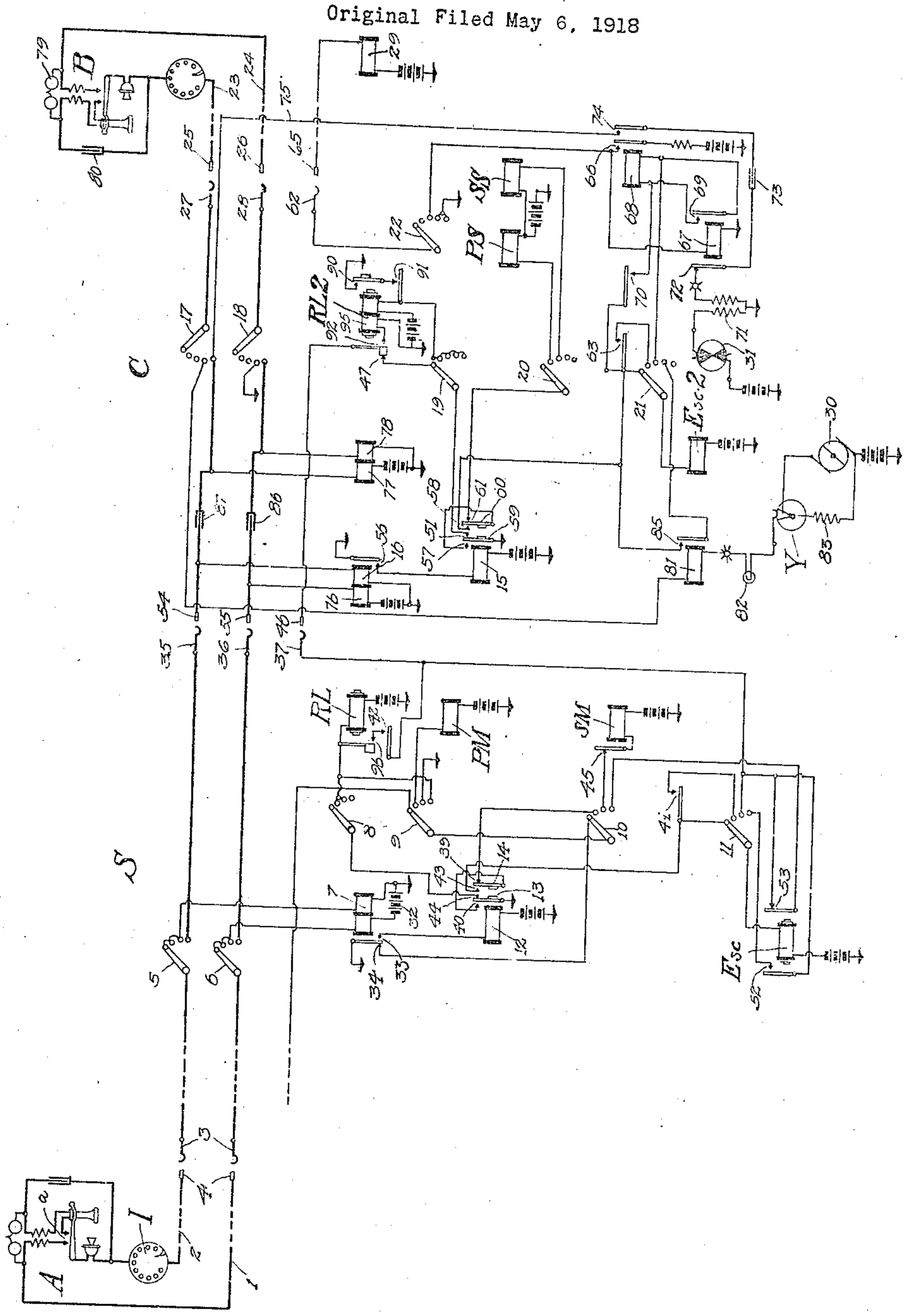
TELEPHONE SWITCHING SYSTEM

Original Filed May 6, 1918



INVENTOR

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UNITED STATES PATENT OFFICE.

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TELEPHONE SWITCHING SYSTEM.

Application filed May 6, 1918. Serial No. 232,963.

To all whom it may concern:

Be it known that I, FRANK M. SLOUGH, a citizen of the United States, and residing at Rochester, in the county of Monroe and State of New York, have invented certain new and useful Improvements in Telephone Switching Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to telephone switching systems, and more particularly to a form of telephone switching system particularly applicable to subscriber or so-called automatic telephone systems, in which the central office line interconnecting apparatus is controlled by current impulses delivered over the two sides of the line in series, and acting through the medium of the so-called fast and slow relays to control the selector and connector switches of the exchange.

It has been the common practice to have these fast and slow relays responsive, respectively, to interruptions of the line circuit and to a series of such interruptions. The well-known type of subscriber operated switch for example, has a controlling relay which sends a current impulse to a primary switch operating magnet at each interruption of the line circuit. At the same time impulses are sent to a slow relay which energizes at the first impulse and retains its armature in its operated position during a series of impulses. At the end of the series of impulses, the slow relay retracts its armature thereby completing a circuit, whereby the switch wipers are stepped ordinarily by a secondary operating magnet to automatically select an idle line of a group first selected by the primary switch operating magnet.

The above refers more particularly to what are known as selector switches, and in the operation of connector switches a similar organism is used to control a so-called side switch, the side switch being advanced after a series of impulses to local connector switch circuits to suitably control the secondary movement of the connector switch in preparation for the next series of impulses to move the secondary switch wipers to a line connecting position.

In the system of my invention I propose to accomplish the switching function, whereby the selector switch is controlled in its primary or secondary movements, or whereby connector switches are controlled in their primary and secondary movements by the use of a single relay of unitary structure having two armatures, the one of which is responsive to the short impulses of current passing through the winding of the relay, and the other of which can only operate on a current impulse continuing for a predetermined length of time. Such a relay as is described and claimed in my application, Serial No. 135,636, filed December 7, 1916, is capable of such a use. Other relays which may be made to perform in a way suitable to the requirements of the present invention are the Ghegan type of relays which are very commonly used in the art of telegraphy, according to the well-known Ghegan two-way repeater system.

It is an object of my invention to simplify the wiring and operation of selector and connector switches of automatic exchanges by the use of such a relay to control their operation to simplify the wiring, the space occupied, and to make the operation more positive.

Other objects of my invention and the invention itself will be apparent as the description thereof progresses.

Referring to the drawing accompanying this specification, at A, I show a calling substation instrument having a subscriber's switch *a*, the usual talking apparatus illustrated in the conventional way, and a conventional representation of a subscriber's line circuit interrupter, or commutator of the usual type, the circuit of the line being extended to the central office switching apparatus by line conductors 1 and 2. Certain parts of the central office switching apparatus as are not necessary to a full understanding of my invention are omitted as, for instance, the line finder switch mechanism containing the switch wipers 3, and line contacts 4. It is understood that these switch wipers and contacts will be brought into association in any desired manner. 7 is the impulse relay by means of which the actuating impulses are transmitted to the stepping magnets of the first selector switch, with which it is associated.

If the present invention were employed in a semi-automatic instead of a full automatic system, the stepping relay 7 would be

operated by the central operator's sending device instead of impulses transmitted from the calling subscriber's station. The side switch employed in illustrating the present invention is of such a nature that it moves its wipers upon the energization of its actuating magnet. A side switch operating in such a manner is disclosed in an application of Oscar F. Forsberg, Serial No. 6302, filed Feby. 5th, 1915, Patent No. 1,252,420, January 8, 1918. The side switch herein disclosed is moved from position 1 to position 2 upon the first energization of its controlling escape magnet, from position 2 to position 3 upon the second energization thereof and from position 3 to position 4 upon the third energization of its escape magnet. A fifth position for the side switch wiper is provided in the case of the side switch used in the connector circuit, whereas the side switch used in connection with the selector circuit herein illustrated has only four positions.

In connection with the selector switch of my invention, at PM I show a primary stepping magnet therefor, adapted to step the selector switch wipers from contact level to contact level under the control of the substation interrupter shown at I. At SM is shown a secondary stepping magnet for the selector switch and which magnet is adapted to step the selector switch wipers from one set of contacts to another in a given level to which they have been previously directed under the control of the subscriber's interrupter I by the primary magnet PM. The secondary magnet SM, automatically produces its own circuit interruptions whereby the stepping action is automatically continued. A release magnet for the selector switch is shown at RL, adapted when operated by a prolonged impulse of current to restore the selector switch mechanism to its normal un-operated position. At *Esc* is shown an escape magnet adapted upon its energization to move the side switch wipers 5, 6, 8, 9, 10 and 11, from one position to the next succeeding position. At 12 is shown a relay having two armatures, each of which is adapted to be operated in a distinct manner, the first armature 13 being responsive to short and long current impulses as used in systems of the type described, and the second armature 14 being only responsive when the current impulse through the winding of the relay has been continued for a certain predetermined length of time.

The apparatus of the connector C is in general very much like the apparatus of the selector S, the two-armature relay being shown at 15, the release magnet at RL^2, the impulse relay at 16, the primary stepping magnet at PS, and the secondary stepping magnet at SS in the connector switch. The secondary stepping magnet operates under the control of the subscriber's dial or the circuit interrupter I just as is the case with the primary stepping magnet, and does not operate automatically as is the case with the stepping magnet of the selector switch. The escape magnet controlling the operation of the side switch wipers 17, 18, 19, 20, 21 and 22 is shown at Esc^2. The called subscriber's telephone is shown at B, and is connected by line conductors 23 and 24 to the connector switch contacts, such as 25 and 26 at the central office. The connector switch wipers shown in the drawing adapted to cooperate with these connector switch contacts are shown at 27 and 28. At 29 is shown a magnet individual to the calling subscriber's line. At 30 is shown a ringing generator and adapted to be connected through the circuits of the connector switch, to the called subscriber's line at a suitable point in the operation of the circuit. A busy signal interrupter is shown at 31.

The operation of the above-mentioned apparatus and other apparatus not mentioned, will be made clear from a description of the operation of the circuits involved when a connection is established between the calling subscriber's station A and the called subscriber's station B. Upon the subscriber at A making a call, we will assume that the calling line has been by suitable means, such as by interconnection of the wipers 3 and the contacts 4, extended to the side switch wipers 5 and 6 of the selector switch S. A circuit is thereby completed including the subscriber's impulse relay 7, and the central office source of current 32, which current flowing through the windings of the impulse relay and over the telephone line to the subscriber's instrument, will cause the impulse relay 7 to attract its armature which closes contacts 33 and opens contacts 34. The closing of the contacts 33 causes the operation of the relay 12 by the central office source of current thereby included in its circuit, and the relay 12 will thereupon attract its armatures 13 and 14 one after the other in the order mentioned, the armature 13 being a quickly responsive armature and the armature 14 being, as has been mentioned, a slow acting armature. After these armatures are operated, a circuit is completed including the central office source of current for the escape magnet *Esc* which operates to advance the switch wipers 5, 6, 8, 9, 10 and 11 from position 1 to position 2, in which position the primary stepping magnet PM is functioned to operate to advance the selector switch wipers 35, 36 and 37 in the primary direction of movement. The subscriber thereupon operating his circuit interrupter I, shown conventionally in the drawing as a dial interrupter to break and make the circuit of the line thereby de-energizes and energizes the im-

pulse relay 7 a predetermined number of times which may be a variable number depending upon the will of the subscriber. Upon the first breaking of the line circuit and the consequent first de-energization of the impulse relay 7, the contacts 33 in the circuit of the two-armature relay 12 will be opened, and the contacts 34 momentarily closed. The side switch wiper 10 being in second position however, the closing of the contacts 34 at this time will be functionless. The opening of the contacts 33, however, for a very brief interval will cause the armatures 13 and 14 to be momentarily restored to their normal position.

Following the brief de-energization of the relay 7, by the first breaking of the line circuit by the subscriber's circuit interrupter I, there will be a momentary closure of the line circuit by the continued operation of the subscriber's interrupter I, during which momentary closure the fast armature 13 of the relay 12 will be operated, but the time of closure will not be long enough to permit the closure of the armature 14, so that momentarily there will be a circuit completed including the normally opened contacts 40 of the armature 13 and the normally closed contacts 39 of the armature 14, the circuit also including the second position contacts of the side switch wiper 10 and the second position contacts of the side switch wiper 9, together with the primary stepping magnet PM and the central office source of current. Current from the said source momentarily flowing over this circuit, will cause a momentary actuation of the primary stepping magnet PM to advance the wipers 35, 36 and 37 of the selector switch S, one step.

Following the first actuation of the primary stepping magnet PM, the off-normal contacts 41 and 42 of the selector switch S will be closed to condition the selector switch release magnet RL, and to condition the escape magnet *Esc* respectively for operation. The subscriber may make only the single interruption of the line circuit to select the first level of selector switch contacts, or, the circuit interruptions may continue until more than one circuit interruption has been made. In this description we will assume that a plurality of circuit interruptions are made in rapid succession, so that between the circuit interruptions there will be short energizations of the two-armature relay 12 under the control of the impulse relay 7, and that at each energization by the circuit which has been traced the primary stepping magnet PM will be actuated to advance the selector switch wipers a step. None of the energizations except the last one, however, will continue long enough to cause the operation of the second armature 14 of the relay 12. Upon the last energization which is prolonged, however, the armature 14 will be operated, causing the escape magnet to be again actuated. The circuit for the escape magnet at this time includes the central office source of current, the winding of the escape magnet, the second position contacts of the side switch wiper 11, the off-normal contacts 41 of the selector switch and the normally opened contacts 43 and 40 of the two armatures of the relay 12 which are now closed. The escape magnet being again actuated will cause all of the side switch wipers of the first selector switch to be advanced into their third position. At this time it will be noted that the release magnet RL is caused to be very slow acting, so that it will only operate on a prolonged flow of current and on such short closures of this circuit as may be caused by the short interruptions of the line circuit under the control of the subscriber as previously described, will not cause it to operate even though at such times its circuit may be completed through the momentary closure of the contacts 44 of the relay 12.

When the side switch wipers 9 and 10 attain their third position as described, a circuit is closed for the secondary stepping magnet SM including its own normal contacts 45, the central office source of current and the third position contacts of the switch wipers 9 and 10, so that the switch wipers reaching the third position as has been described, the secondary stepping magnet will operate, and breaking its own circuit will automatically release which will close its circuit, and the actuation continuing it will intermittently be actuated and released a number of times until the selector switch wipers 35, 36 and 37 have made contact with a non-busy connector switch circuit. This is determined when the selector switch wiper 37 encounters a contact which is connected to the ground pole of the central office source of current under the control of apparatus in the idle connector circuit, the presence or absence of such a ground indicating the idle or busy condition of the associated connector circuit.

We will assume that the connector circuit C is such an idle connector circuit. The contact 46 is connected to ground to indicate such an idle condition through normal contacts 47 of the release magnet RL^2, and through the first position contacts of the connector side switch wiper 19 and normal contacts 51 of the special two-armature relay 15 of the connector switch. Ground thus applied to the contacts 46 will be extended to the selector switch wiper 37 and through the third position contacts of the side switch wiper 11 of the selector switch, through the escape magnet *Esc* to the negative pole of the central office source

of current. Current from this source flowing through the escape magnet will actuate the same to attract its armatures, closing contacts 52 and opening the contacts 53, and in addition will allow the side switch wipers 5, 6, 8, 9, 10 and 11 to be advanced into their fourth or last operative positions. When so advanced, connection is made between the talking conductors 1 and 2 of the calling line and the selector switch wipers 35 and 36, the connection extending through the fourth position contacts of selector side switch wipers 5 and 6. At the same time the selector impulse relay 7 is disconnected from the line circuit, since its connection therewith is only possible through the first three positions of the last-named side switch wipers. The relay 12, as well as the relay 7 will be de-energized restoring its armatures to normal position. The stepping magnet for the selector switch is also left out of operative circuit due to the fact that this circuit includes only third position contacts of the side switch wiper 10 which is now advanced to its fourth position.

Means are provided consisting in part of the contacts 52 of the escape magnet to provide for the continued closure of its circuit during the last-named operation for a brief interval, or until the associated apparatus involved has attained its full operated position. Thus, the escape magnet E*sc* may have its circuit continued through the fourth position of the said switch wiper 11, through its normally opened contacts 52, and through the selector switch contacts 37 and 46, the normal contacts 47 of the connector release magnet RL^2, first position contacts of the connector side switch wiper 19, and normal contacts 51 of the connector switch two-armature relay 15. As soon as the line circuit, however, is extended to the selector switch wipers 35 and 36 as has been described, the circuit will be still further extended through the said wipers, and through contacts 54 and 55 to the windings of the connector switch impulse relay 16, which corresponds in its functions much to the impulse relay 7 of the selector switch. Current from the central office source will flow through the windings of the impulse relay 16 and over the line circuit of the calling line to energize the relay 16, attracting its armatures and closing its contacts 56, which being closed cause the operation of the two-armature relay 15. The two-armature relay 15 is constructed and operates in the same manner as the two-armature relay 12 whose operation has been described, the relay 15 attracting its armatures will interrupt the connection to ground which has been described as being established through the contacts 51 of the relay 15, and which caused the operation of the selector switch escape magnet E*sc*. The escape magnet E*sc* will thereupon be restored to normal.

At this stage of the operation all of the magnets of the selector switch are de-energized, and the selector side switch wipers are in fourth or ultimate position. The operation of the two-armature relay 15 at this time is sufficiently long continued after the first series of impulses have been sent by the subscriber and before the second series of impulses have been sent by the subscriber, to permit the operation of both armatures of the relay 15, which will thereupon close their respective contacts 57 for the fast armature, and 58 for the slow armature. The closure of these contacts will complete a circuit from the ground pole of battery through its contacts, through the first position contacts of the side switch wiper 21 of the connector switch and the escape magnet Esc^2 to the negative pole of battery, thus causing the operation of the last-named escape magnet. The connector escape magnet Esc^2 being operated, will cause the side switch wipers 17, 18, 19, 20, 21 and 22 to advance from their first or normal position of rest to their second position which is their first operative position. In this second position the circuit extending back to the contact 46 of the selector switch is still further broken by the opening of the first position contacts of the side switch wiper 19.

The subscriber now operating his interrupter I for the second time, will send a second series of impulses of a predetermined known number to vibrate the fast armature 59 of the two-armature relay 15, the slow armature 60 thereof during the sending of these impulses remaining in its normal position. Upon the first interruption of the line circuit by the subscriber, the slow operating armature 60 instantly returns to its normal position, where it remains throughout the sending of the following current impulses. Then upon each detraction of the fast armature 59, a circuit is completed through the second position contacts of the side switch wiper 20 for the primary stepping magnet PS of the connector switch, the circuit including the winding of the primary stepping magnet, the central office source of current, the second position contacts of side switch wiper 20, normal contacts 61 of the slow operating armature 60 of the two-armature relay, and normally opened contacts 57 of the rapid operating armature 59 of the relay 15. Each operation of the armature 59 closing the contacts 57, causes the primary stepping magnet PS to advance the connector switch wipers 27, 28 and 62 from one level to another level of connector switch contact banks.

It may be seen that at the time through normal contacts 51 of the vibrating armature 59, that the circuit of the release mag-

net RL^2 is closed for very brief intervals, but this release magnet is made so that it is slow operating, that is, sluggish of movement, and it will not respond to impulses of such short duration as would be caused by the rapid intermittent closures of the contacts 51 at this time.

At the end of the first series of impulses, the connector switch wipers will have been advanced a certain number of steps depending upon the variable or predetermined operation of the subscriber's instrument interrupter, and the operation by the subscriber ending, the last impulse will be continued by a prolonged impulse lasting until the next operation of the subscriber's circuit interrupter I. Upon this prolonged impulse, the slow acting armature will be also attracted, and a circuit will be completed including the second position contacts of the side switch wiper 21 for the escape magnet Esc^2 of the connector switch, said circuit including normally opened contacts 57 and 58 of the relay 15, off-normal contacts 63, the said second position contacts of the side switch wiper 21, the winding of the escape magnet Esc^2, and the central office source of current, which source will cause the operation of the said escape magnet to cause the side switch wipers 17, 18, 19, 20, 21 and 22 to be advanced into their third position. When the side switch wiper 20 is advanced into third position, the secondary stepping magnet SS is substituted into the circuit for the primary stepping magnet PS.

The subscriber again operating his circuit interrupter, will cause the immediate retraction of the armature 60 where it will remain throughout the following series of impulses, and the armature 59 will be vibrated with the impulses as before described, to cause at this time the operation of the stepping secondary magnet SS in the same manner as before described for the primary stepping magnet PS. The secondary stepping magnet SS being intermittently actuated, will step the connector switch wipers 27, 28 and 62 from one set of line contacts to another set of line contacts in the level previously selected. When the subscriber predetermined number of impulses in this series has been sent, the connector switch wipers will be resting upon the line contacts 25, 26 and 65 of the called-for line. The last subscriber sent impulse will be a prolonged or continued impulse, so that both armatures of the relay 15 will be again operated, the slow acting armature 60 responding only after a short period of time.

If the called-for line is not busy, this fact will be indicated by the presence or absence of a direct connection to the ground pole of battery leading to the contact 65 of the called for line. Otherwise there would only be connected to this contact 65, the negative pole of the source of current leading to its contact 65, through the winding of the local line magnet 29 for the calling line. For the moment we will consider that the called-for line is busy and that in a manner which will be later described in detail, the ground pole of the source of current has been previously connected to the contact 65 of the called-for line. The connector switch wiper 62 making contact with this grounded contact 65, will thereupon extend its ground connection to the point 66 in the circuit indicated in the drawing, thereby completing a short circuit about the winding of the relay 67, known as the test relay, to prevent its operation. This relay 67 will be thereby prevented from establishing a short circuit about the winding 68, by the operation of the contact 69 of the relay 67 and the contact 69 therefore remaining open, the relay 68 will remain unshunted by the said contacts.

A circuit is completed for the relay 68 upon the full operation of the slow acting armature 60 of the relay 15, the circuit being traced from the ground pole of battery through the normally opened contacts 57 and 58 of the relay 15, through the now closed secondary off-normal contacts 70 of the connector switch, through the winding of the relay 68, through the third position contacts of the side switch wiper 21, and through the winding of the escape magnet Esc^2 to the negative pole of the source of current. The winding of the relay 68 is of a very high resistance containing a large number of turns of very fine wire, so that the current flowing over this circuit will be limited in value to prevent the operation of the escape magnet Esc^2, which requires a relatively large amount of current to operate. The high resistance relay 68, however, by virtue of its adjustment and large number of turns, will be operated to apply the busy-tone signal to the calling line conductors. The busy-tone signal is produced by the interrupter 31 and the central office source of current through the said interrupter and a winding of the induction coil 71. The current flowing through the said winding will induce a current in the secondary winding of the induction coil 71, the induced current flowing from the ground pole of the source of current, through the said secondary winding, normal contacts 72 of the relay 67, the condenser 73, now closed contacts 74 of the relay 68, circuit conductor 75 which is connected to the line conductor 2 of the calling line, through the selector switch contacts 35—54 and fourth position contacts of the selector side switch wiper 5 and the associated line finder contacts 3—4, the circuit being completed through the subscriber's telephone and returning through the line conductor 1, which is extended through the line finder contacts 4—3, fourth

position contacts of the selector side switch wiper 6, selector switch contacts 36—55, returning to ground through the windings 76 and 78 of the relay 16 and the battery feed coil 78. This current flowing over the calling subscriber's line and through his instrument, will produce a characteristic tone in the calling subscriber's receiver, known as the busy-tone. The calling subscriber hearing this tone will know that the called-for line is busy and replaces his receiver upon the hook, restoring the interconnecting apparatus to normal position, the manner of release of the switches and connections involved being later described in this narrative.

Assuming now that the called-for line is not busy, there will be no ground connected to the contact 65 of the called-for line and current from the central office source of current will flow through the local magnet 29 of the called line, through the connector switch contacts 62—65 and through the third position contacts of side switch wiper 22, and through the relay 67 to operate the relay 67 and energize the local line magnet 29. The operation of the magnet 29 is to dissociate the calling, or line finder apparatus, from the circuit of the line in any suitable manner, such dissociation being well understood. The operation of the relay 67 will produce a short circuit about the relay 68 by virtue of the shunting contact 69, now closed, and the operation of the relay 68 will be prevented. The escape magnet Esc^2, will now be operated over a circuit including the central office source of current, the third position contacts of the side switch wiper 21, the contact 69 of the relay 67, the off-normal contacts 70 of the connector switch, and the now closed contacts 58 and 57 of the two-armature relay 15. Current from the said source will operate the escape magnet Esc^2, to cause it to advance the connector side switch wipers 17 to 22 inclusive, into their fourth position. The side switch wiper 22 connects the ground pole of the source of current to the contacts 65 of the called-line through the connector switch wiper 62, thus to produce the busy condition of the contacts 65 which are understood to be multipled to like contacts 65 of other connector switches, this being well understood in the art. The presence of this ground will prevent the intrusion of other calling lines into the connection.

The side switch wiper 20 advancing into its fourth position, will dissociate the secondary stepping magnet SS from its operative circuit relation with the stepping contacts 57 of the two-armature relay 15. The connector side switch wipers 17 and 18 in their fourth position, complete a circuit for the ringing generator 30, the said circuit including the signal bell 79 of the called-for line subscriber. This circuit is traced as follows. From the ground pole of battery through the fourth position contacts of the side switch wiper 18, through the now closed connector switch contacts 28—26, the line conductor 24 of the called line, signal bell 79, condenser 80, the line conductor 23, connector switch contacts 27—25, fourth position contacts of the side switch wiper 17, the winding of the ringing trip relay 81, the resistance lamp 82, the circuit being alternately completed by the rotation of the interrupter Y to the negative pole of the source of current, through the resistance coil 83, or depending upon the position of the rotating interrupter Y, through the ringing generator 30, to the negative pole of the source of current. The ringing generator 30 will project ringing current over the line intermittently until the called-for subscriber responds. Upon the response of the called-for subscriber, current from the central office source of direct current will flow over the circuit through the responding subscriber's transmitter and through the trip relay 81, to cause the operation of the said trip relay. This trip relay thereupon closes its contacts 85, which will complete a circuit for the escape magnet Esc^2, this circuit being traced from the negative pole of the source of current through the winding of the escape magnet, the fourth position contacts of the connector side switch wiper 21, the now closed contacts 85 of the trip relay 81 and now closed contacts 57 and 58 of the two-armature relay 15, to the ground pole of the source of current. Current from this source will operate the escape magnet Esc^2, to cause the connector side switch wipers 17—22, inclusive, to advance from their fourth to fifth, or ultimate operative position. In this ultimate operative position, the side switch wipers 17 and 18 will complete a talking circuit extending between the talking conductors 1 and 2 of the calling line to the talking conductors 23—24 of the called line, so that the subscribers may now converse, talking battery being supplied for the calling line through the windings of the relay 16, and for the called line through the windings of the battery feed coil 78, the talking circuit extending through condensers 86 and 87.

By the opening of the fourth position contacts of the side switch wipers 17 and 18, the ringing circuit is interrupted. The side switch wiper 22 passing from fourth to fifth position continues the connection to ground to the test contact 65 of the called line. The circuit of the escape magnet is interrupted by the passing of the side switch wiper 21 from position 4 to position 5. The subscribers now being in conversational circuit will converse, and upon retiring, the calling subscriber will open the

circuit of his line by opening the contact *a* at his instrument, thereby releasing the serially connected relay 16 which will open its contacts 56 in the circuit of the two-armature relay 15. This causes the disconnection to take place, and the release of the selector and connector switches, and circuits and apparatus involved. The two armatures of the relay 15 will be restored to normal, and a circuit will be completed through contacts 51 of the relay 15 for the release magnet RL^2 of the connector switch. The circuit of the release magnet RL^2 being established for a sufficiently long and predetermined period, the sluggish release magnet RL^2 will have time to operate its armatures to cause the release of the selector switch, together with its associated side switch wipers and line connecting wipers, the means for doing this being well known and understood in the art to which this invention appertains.

The operation of the release magnet RL^2 is continued until all of the apparatus is fully restored to normal by virtue of the locking circuit, consisting of contacts 90 of the release magnet which are closed upon its operation and off-normal contacts 91 in this locking circuit. The contacts 91 are arranged to be opened only when all of the apparatus has been restored to normal position, so that the release magnet RL^2, until this occurs, causes the release mechanism to remain fully actuated. At the same time the release magnet RL for the selector switch is operated, the circuit for operating the release magnet RL of the selector switch being traced from the ground pole of battery through the second winding 95, now closed contacts 92 of the connector switch release magnet RL^2, selector switch contacts 37–46, normally closed contacts 53 of the escape magnet *Esc* of the selector switch, fourth position contacts of selector side switch wipers 9 and 10, and the winding of the selector release magnet RL to the negative pole of the source of current. This release magnet is also slow acting, but the circuit being continued it will operate and having operated will close a locking circuit for the winding of this release magnet including contacts 96 of the magnet RL, off-normal contacts 42 of the selector switch, the circuit leading therefrom directly through the selector switch contacts 37—46, and now made contacts 92 of the connector switch, release magnet, through the winding 95 thereof, to the ground pole of battery. The off-normal contacts 42 of the selector switch are adapted to be opened only when all of the rest of the apparatus of the selector switch has been restored to its normal position, the actuation of the release magnet RL causing such restoral in any well known manner. The function of the serially included winding 95 of the connector switch release magnet is to provide for the continued operation of this magnet insuring continued closure of the contacts 92 in the circuit of selector switch release magnet switch, until the selector switch mechanism as well as the connector switch mechanism has been restored to normal. Thus, a positive restoral of all of the apparatus of the connector and selector switches is provided. When the side switch wipers 9 and 10 of the selector switch have been restored to normal position, a circuit is provided for the disconnect apparatus of the finder switch not shown extended from the ground pole of battery through normal contacts 34 of the selector impulse relay 7, and first position contacts of the side switch wipers 9 and 10 to the finder switch release magnet not shown but well understood in the art.

What I claim is:—

1. In a telephone system, a line, an automatic switch accessible to said line, and means for controlling the said switch by impulses delivered over the two sides of the said line in series, said means comprising a two-armature relay, one of the said armatures being responsive to all of the impulses of a series, a second armature for the said relay responsive only to the final impulse of the series, and steering means for the said switch controlled jointly by the said first and second armatures.

2. In a telephone system, a line, an automatic switch accessible to said line, switch wipers for the said switch, controlling means for the said switch wipers, means for controlling the movements of the said switch by impulses delivered over the two sides of the said line in series, said means including a relay having a plurality of armatures, one of the said armatures being responsive to all of the impulses of a series, another of the said armatures being responsive only to the final impulse of the series, said controlling means being under the joint control of the said armatures.

3. In a telephone system, an automatic switch having primary and secondary operating magnets and a release magnet, a relay having an armature for directively controlling said operating magnets, a second armature for the said relay for controlling the "change over" from one operating magnet to the other, and means operative under the joint control of both of the said armatures to close and energize the circuit for the said release magnet.

4. In a telephone system, a subscriber's line, an automatic switch having primary and secondary operating movements, and release means, means for extending said line to said switch, a relay for the said switch having a plurality of armatures, one

of the said armatures controlling the operating movements of the said switch, a second armature controlling the "change over" from one operating movement to the other, the first armature being responsive to short and prolonged impulses of current, and the second armature being responsive to only prolonged impulses of current, and means at the substation for producing short impulses and prolonged impulses of current, whereby the connection to another line may be established by the said switch.

5. In a telephone system, a subscriber's line, an automatic switch having primary and secondary operating movements, and release means, means for extending said line to said switch, a relay for the said switch having a plurality of armatures, one of the said armatures controlling the operating movements of the said switch, a second armature controlling the "change over" from one operating movement to the other, the first armature being responsive to short and prolonged impulses of current, and the second armature being responsive to only prolonged impulses of current, means at the substation for producing short impulses and prolonged impulses of current, whereby the connection to another line may be established by the said switch, and releasing means for the said switch under the control of one of the said armatures, the said releasing means being operative only on a prolonged current flow and irresponsive to short impulses of current, whereby connection to the other line may be disestablished.

6. In a machine switching telephone system, the combination with a selector, a stepping relay associated therewith, a sender for operating the same, a release circuit for the said selector, a primary stepping circuit controlled by an armature of the said relay, a secondary stepping circuit, a slow acting armature for the said relay adapted to shift the control of the said first named armature from the primary stepping circuit to the secondary stepping circuit whereby the said first-named armature will on a first series of impulses control the stepping of the said selector in a primary direction, and at the end of the said series of impulses will be adapted to control the stepping of said selector in a secondary direction.

7. In a switch system for interconnecting lines, a current source, a switch for performing operations of different characters, a controlling relay for controlling the amount of an operation performed by the said switch, a primary circuit for enabling the switch to perform one operation, a secondary circuit for enabling the switch to perform another operation, a change over circuit for transferring the action of the said controlling relay from the primary circuit to the secondary circuit, a change-over electromagnet in the change-over circuit, a plurality of armatures for the said controlling relay, a front contact of one armature and a back contact of another armature adapted to be included in said primary and secondary circuits to operate the said switch, and front contacts of both armatures adapted to be included in the said change-over circuit to operate the said change-over electromagnet.

8. In an automatic telephone system, the combination with a selector switch and a connector switch, means to cause the selector switch to assume a connector selecting position, a release magnet for the said selector switch to cause it to be restored to its normal position, means to cause the said connector switch to assume a line selecting position, a release magnet to restore the said connector switch to its normal position, and a releasing circuit for the said selector switch release magnet including its winding and normally opened contact thereof, an off-normal contact of the said selector switch, a selector switch wiper, an associated connector switch contact and a normally opened contact of the said connector switch release magnet, a winding thereof, and a source of current whereby the said connector switch release magnet and the said selector switch release magnet will both remain energized until the said selector switch has been released.

9. In a telephone system, a telephone line, an automatic switch accessible to said line, means for controlling said switch by impulses delivered over the two sides of said line in series, said means including a single electromagnetic device having armatures, one of said armatures being responsive to individual impulses of the series, and the other being responsive at the close of the series of impulses, and a circuit controlling device for said switch controlled jointly by said armatures.

10. In a telephone system, lines divided into groups, an automatic switch having motion in one plane to select groups, and motion in a plane at right angles thereto to find a line in a selected group, means including a relay for controlling the operation of said switch a single energizing winding for said relay, means responsive to impulses over the two sides of a line circuit in series for energizing said winding, means for rapidly interrupting said line circuit to generate impulses, means whereby one of said armatures responds to said interruptions, and means for maintaining the other of said armatures in a stationary position during the transmission of said impulses.

11. In a telephone system, an incoming line, outgoing lines, a two motion switch for interconnecting said incoming line with any of said outgoing lines, a relay responsive to

impulses transmitted over said incoming line, said relay having contacts and two armatures operated out of synchronism to control the same, a magnet for controlling the movements of said switch, and a circuit for said magnet extending serially through contacts controlled by said armatures.

12. In a telephone system, an incoming line, outgoing lines, a two motion switch for interconnecting said incoming line with any of said outgoing lines, a relay having two sets of contacts controlled over said incoming line, one set of contacts being operated in response to each impulse of a series, and the other set of contacts being operated in response to the last impulse of a series, a magnet for controlling the movements of said switch, and a circuit for said magnet extending serially through contacts controlled by said armatures.

13. In a telephone system, an incoming line, a plurality of outgoing lines, a switch for extending said incoming line to any of said outgoing lines, a relay responsive to impulses transmitted over said incoming line, said relay having armatures operating out of synchronism, primary and secondary operating devices for said switch, a circuit controlling mechanism for causing the operation of said devices in proper sequence, releasing mechanism for said switch, and circuits for said devices, and mechanisms controlled at the armatures of said relay.

14. In an automatic telephone system, two subscribers' stations, an automatic mechanism for establishing connection between the same involving a calling station and an impulse transmitter, and means for establishing said connection by impulses from said transmitter, a generator circuit normally disconnected from connected stations, a relay responsive to interruptions in the line circuit, said relay having fast and slow operating armatures, a circuit controlling device for connecting said generator circuit into the connected line circuit, and an operating circuit for said circuit controlling device controlled jointly at the armatures of said relay.

15. In a telephone system, in combination with a connector switch, a relay for controlling the operation of the said switch, said relay having a plurality of armatures in multiple magnetic circuits, a single winding only for the said relay to energize the said multiple magnetic circuits, a circuit comprising a source of current and a circuit interrupter for the said winding, means responsive to the operation of the said circuit interrupter to transmit a series of current impulses through the winding of the said relay, and circuit connections under the control of the said two armatures adapted to operate the connector switch in a primary manner upon a first operation of the said circuit interrupter and in a secondary manner upon a second operation of the said circuit interrupter.

16. In a telephone system, in combination with a connector switch, a double armature relay for controlling the said switch in primary and secondary movements, a single energizing winding for the said relay, a circuit for the said winding comprising a source of current and a circuit interrupter, means responsive to the operation of the said circuit interrupter to transmit a series of current impulses through the winding of the said relay, one of the said armatures being responsive to vibrate substantially in unison with the said current impulses and the other armature being responsive only to the last current impulse of the series.

17. In a telephone system, in combination with a connector switch, a double armature relay for controlling the said switch in primary and secondary movements, a single energizing winding for the said relay, a circuit for the said winding comprising a source of current and a circuit interrupter, means responsive to the operation of the said circuit interrupter to transmit a series of current impulses through the winding of the said relay, one of the said armatures being responsive to vibrate substantially in unison with the said current impulses and the other armature being responsive only to the last current impulse of the series, the said vibrating first armature controlling the extent of movement of the said connector switch and the other armature controlling the character of switch movement.

18. In a telephone system, an automatic switch having a primary movement to select groups and a secondary movement to find a line in a selected group, means including a relay for controlling the operation of the said switch, said relay having a pair of armatures, the operation of one of the said armatures being sluggish as compared with the operation of the other armature, the first armature controlling the extent of primary and the extent of secondary movement and the other armature operating between the said primary and the said secondary switch movements to shift the control of the first armature over the said switch so as to cause it upon a subsequent operation to move in a secondary manner.

19. In an automatic telephone system, the combination with a connector switch for making connection with a desired called telephone line, a primary magnet, a secondary magnet, a controlling relay for the said switch, said relay having a pair of armatures, a calling line adapted to be associated with the said relay to control the said connector switch, a commutator for

the said calling line adapted to produce successive series of calling line interruptions, one of the said armatures being responsive to each following circuit closure after each circuit interruption, the other of the said armatures being responsive only to the final prolonged closure after each series of interruptions, and to the act of associating the said calling line with the said relay, a distributor switch adapted to operate under the control of the said relay at each operation of the said other armature, said primary and said secondary magnets being adapted to operate the connector switch in a primary and a secondary manner respectively, each under the successive control of the said first armature, and circuit connections whereby the control of the said first armature over the primary magnet is secured by a first operation of the said distributor switch, and whereby the control of the said first armature is shifted from the said primary magnet to the secondary magnet upon a second operation of the said distributor switch.

20. In a telephone exchange system, an incoming line, a switch for extending said line, primary and secondary stepping magnets for operating said switch, an escape magnet for controlling the operation of said secondary stepping magnet, and a relay connected to said incoming line, said relay having contacts in the circuits of said primary and escape magnets, the contact in the circuit of said escape magnet being closed upon energization of said relay.

In witness whereof, I hereunto subscribe my name this 12th day of April, A. D. 1918.

FRANK M. SLOUGH.