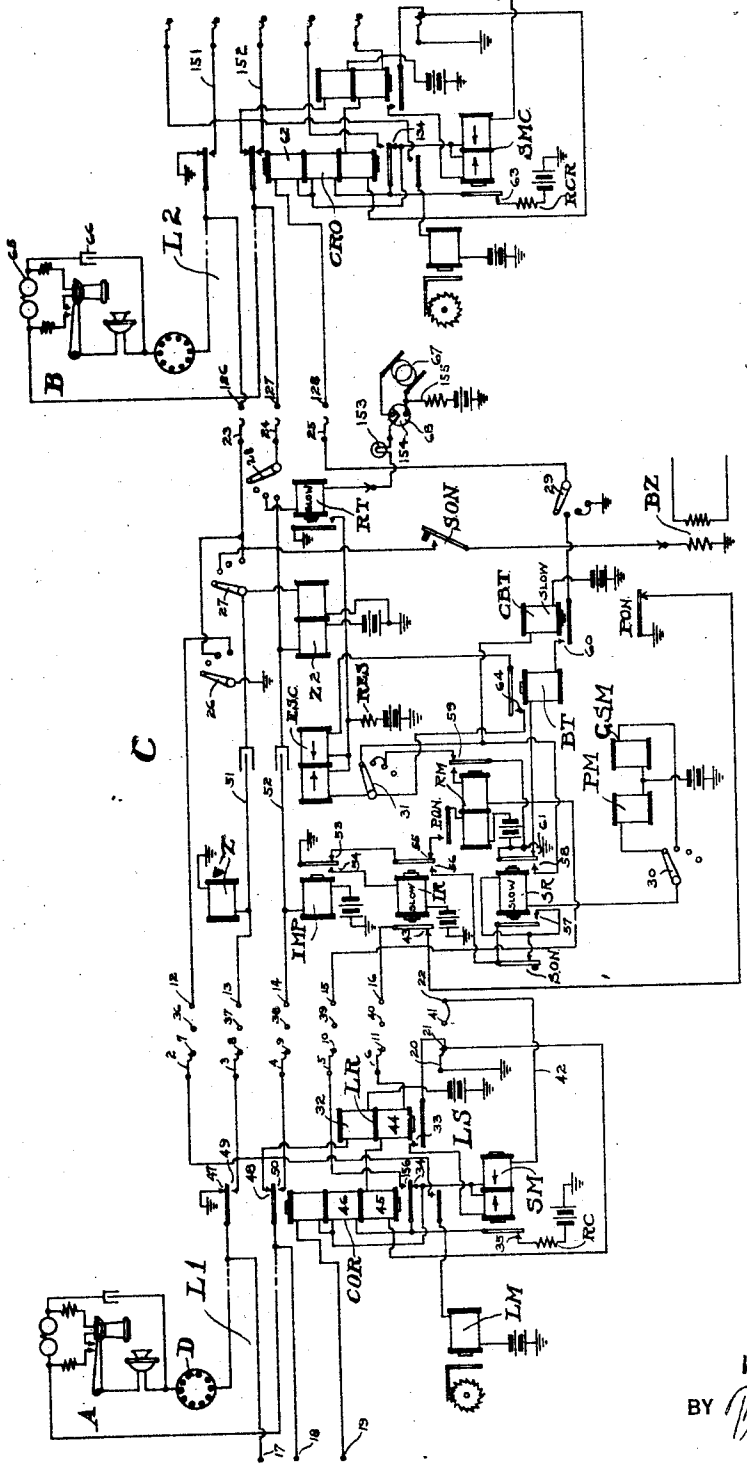
Dec. 15, 1925.

1,565,954

W. T. POWELL

TELEPHONE EXCHANGE SYSTEM

Filed Sept. 12, 1918



INVENTOR
Winfred T. Powell
BY Frank H. Slough
ATTORNEY

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UNITED STATES PATENT OFFICE.

WINFRED T. POWELL, OF ROCHESTER, NEW YORK, ASSIGNOR TO THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, OF ROCHESTER, NEW YORK, A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed September 12, 1918. Serial No. 253,696.

To all whom it may concern:

Be it known that I, WINFRED T. POWELL, a citizen of the United States, residing in Rochester, in the county of Monroe and State of New York, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a specification.

My invention relates to automatic telephone systems, in which a central source of current is employed for operating the switches and for purposes of conversation, and in which the selective switch mechanisms, employed in establishing connections between the calling and called lines, are provided in numbers proportioned to the largest number of expected co-existing conversations, there being no numerical selecting switching mechanism individual to subscribers' lines.

The general object of my invention is to provide an improved line switch, individual to each subscriber's line, capable of operating automatically to find an idle connecting circuit of the system over which connections from the calling lines may be extended to any desired called line.

It is a particular object of my invention to provide a structure in which the trunk hunting operation is accomplished very rapidly, is positively stopped when the terminals of an idle trunk circuit are encountered, and in which trunk circuits to whose test terminals normal connection has been severed, will not stop the trunk hunting operation but, will allow the switch to pass on to the terminals of the next trunk circuit.

Other objects of my invention and the invention itself will be better understood from the description of the same which follows:

Referring to the drawing accompanying this specification, at A, I show a substation of a calling line L^1, and at B, I show a called substation of a called line L^2. At LS, I show the central office equipment individual to the subscriber's line comprising the usual line relay LR, the usual cut-off relay C O R, the last-named relay, however, being specially constructed to have three windings as will be later described, the central office line apparatus also comprising a line switch having wipers 2, 3, 4, 5, 6 and 20, each adapted to traverse a bank of contact terminals, each bank comprising normal contact terminals 7, 8, 9, 10, 11 and 21, and a plurality of sets of trunk contact terminals 12, 13, 14, 15, 16 and 22.

The line switch also contains a stepping magnet S M having two windings, each when energized in the normal operation of the system neutralizes the effect of the other so that when equal current passes through both windings simultaneously the stepping magnet will be in its normal or de-energized condition. A line meter or message register is shown at L M for the calling line L^1. The multiple contact terminals 17, 18 and 19 are also extended from the line circuit of the calling line to multiple contacts of the different connector circuits having access to the line L^1.

The apparatus of the calling substation consists of the usual transmitter and receiver with associated induction coil, condenser, etc., and an automatic circuit interrupter or dial D. The apparatus of the called line L^2 is like that of the calling line, and the different elements thereof will not be specifically named or mentioned, except as they may operate when the line L^2 is seized by the connector circuit C, to function as a called line and in a manner to be later described. The connector circuit C consists of multipled contact terminals as 12, 13, 14, 15 and 16 leading to the different line switches having access of the trunk circuit C. A sufficient number of such trunk circuits will be employed to take care of the expected largest number of simultaneous connections resulting from calls incoming from the groups of lines containing the line L^1 served by the group of trunk circuits containing the connector trunk circuit C. The connector switch associated with the trunk circuit C terminates at its out-going end in switch wipers 23, 24 and 25 adapted to be moved under the control of subscriber's dial D to engage multipled terminal contacts 126, 127 and 128 of the desired subscriber's line, as will later appear.

Associated with the connector switch and connector switch trunk circuit are the usual battery feed impedance coils I M P and Z for the calling line, and Z^2 for the called line. Coil I M P is a part of the impulse

relay adapted to be controlled by the operation of the subscriber's dial to operate the other relays and magnets of the connector switch mechanism to directly control the motion of the connector switch wipers 23, 24 and 25.

In the embodiment illustrated, a side switch is illustrated having four operating positions, the side switch having a plurality of wipers 26, 27, 28, 29, 30 and 31. The side switch has an escape magnet E S C adapted to release the side switch wiper from a given position to the next advanced position upon the de-energization of the escape magnet E S C. Primary off-normal contacts for the connector switch are shown at P O N and secondary off-normal contacts for the connector switch are shown at S O N. These contacts are adapted to be operated when the connector switch mechanism is moved in a primary and secondary direction respectively. Primary and secondary stepping magnets for the switch are shown at P M and C S M adapted to move the switch in a primary and secondary direction respectively. A slow releasing interval relay I R is provided controlling the release and other functions of the switch. A busy test relay B T and a controlling relay for the busy test relay is shown at C B T. A slow releasing relay S R is provided, operating under the control of the impulse relay I M P and the interval relay I R to control the "change-over" of the switch. A source of busy tone current is illustrated at B Z and is adapted to be projected over the calling line whenever the called-for line tests busy.

To facilitate a better understanding of the invention, the operation of the system illustrated and containing an embodiment of my invention, will be now had: Assuming that the subscriber at A initiates a call by taking his receiver from the hook, through the contacts of the switch-hook at the station A, a bridge of the line conductors of the line L' will be had, completing a circuit including the operating winding 32 of the line relay L R and the central office source of current, causing the operation of the line relay and the closure of the relay contacts 33. The line switch wipers 2, 3, 4, 5, 6, and 20 are illustrated as being in their normal position to which they are always advanced upon the disestablishing of a completed connection by the said switch wipers. In this position, the wiper 20 to which ground is connected, rests upon the contact 21 to place ground upon the same, and upon the operation of the line relay contacts 33 a circuit is completed including the left-hand winding of the stepping magnet S M and the central office source of current, through the protecting resistance coil R C; the circuit being traced from the ground pole of battery, through wiper 20 and contact 21, now closed contacts 33 of the relay L R, left-hand winding of the stepping magnet S M, normal contacts 34 of the cut-off relay C O R, normal contacts 35 of the stepping magnet S M and through the protecting resistance coil R C to the negative pole of the source of current. Current from the said source flowing over the said circuit will operate the stepping magnet which will attract its armatures, the stepping magnet being arranged to advance the wipers of the line switch one step upon each retraction of its armatures, the method of doing this being well understood in the art need not be illustrated in detail. Such a stepping magnet is shown in the patent to H. G. Deitl, No. 1,147,928. The stepping magnet S M after it has fully attracted its armature will break contacts 35 serially included in the before described circuit for the left-hand winding of the stepping magnet, and the stepping magnet will immediately be again de-energized. Upon such de-energization, the armature of the stepping magnet, not shown, will be retracted and will propel the line switch wipers, one step, where they will rest in engagement with the contacts of the first trunk circuit, such contacts being shown at 36, 37, 38, 39, 40 and 41. Assuming that the said trunk circuit is busy, there will be no connection leading from ground to the test contact 40. If a trunk circuit of the group is busy, by its organization, a normal connection leading to ground and connected to its test contact such as the contact 40 for the first trunk or the contact 16 for the second trunk will be interrupted. These contacts are adapted to be successively engaged by the test wiper 6 of the line switch L S. Therefore, the wipers being in their second position, and assuming that the trunk circuit terminating in the first set of trunk contacts is busy, no circuit will be completed by the wiper 6 for the purpose of stopping the switch as will be later described. The switch will, therefore, continue to operate, the next operation being by virtue of a circuit completed for the right-hand winding of the stepping magnet S M, including normal contacts 35 of the said stepping magnet, normal contacts 34 of the cut-off relay C O R, the said right-hand winding of the stepping magnet S M, circuit conductor 42 leading therefrom and connected to all of the off-normal contacts of the switch adapted to be traversed by the wiper 20 thereof; the circuit in the second position of the switch therefor being completed through the contact 41 of the first trunk circuit, the wiper 20 to the ground pole of the source of current. Current from the said source will again ener-

gize the stepping magnet S M to cause it to attract its armature, and thereby interrupt its own circuit by breaking the contacts 35 automatically, as before described, and upon the succeeding deenergization of the stepping magnet S M, the line switch wipers will be advanced to their second operative or third position, where they will connect with contacts of the next succeeding trunk switch circuit C, which in the embodiment illustrated as has been before described, is a connector switch.

It will, of course, be apparent to those skilled in the art to which this invention appertains, that instead of connecting connector switch circuits directly to line switch contacts, the first selector and also, if desired, second selector switch circuits may be interposed between the said connector circuits and the said line switch contacts but, for the sake of simplicity in describing, such selector switch circuits and mechanisms are herein omitted.

Now, if the connector switch C were previously seized by another line switch of the group, the relay I R would have been operated and the normal contacts 43 thereof would have been broken. In such a case, the line switch of the calling line would continue to operate the circuit for the right-hand winding of the stepping magnet S M being continuous except, for its intermittently automatically operated contact 35 in its circuit controlled by the actuation of the stepping magnet itself, to advance the wipers to other trunk circuit contact sets until an idle trunk circuit is thereby located. We will assume in this description that the trunk circuit C is such an idle trunk circuit, and therefore the contacts 43 of the slow releasing relay I R will be in their normal or closed position, and therefore ground will be connected through contacts P O N of the switch, through the contacts 43 of the relay I R to the test contact 16 of the connector switch.

When the test wiper 6 of the line switch landed upon the test contact 16, therefore the before traced circuit will be continued through the very low resistance winding 44 of the line relay L R and the very low resistance winding 45 of the cut-off relay C O R and through the now closed contacts 33 of the said line relay, through the left hand winding of the stepping magnet S M through normal contacts 34 of the cut-off relay and through normal contact 35 of the stepping magnet S M and the resistance coil R C to the negative pole of the source of current. That portion of this circuit last traced leading from the junction between the two windings of the stepping magnet S M to the negative pole of the source of current, is common to both of the windings of the stepping magnet S M, and for the moment both windings are energized in parallel over this portion of the circuit, each of the windings being in separate branches leading from this portion of the circuit to the ground pole of the source of current over their respective circuits as has been before traced. Current simultaneously flowing through the two windings will retain the de-energization or non-magnetized condition of the stepping magnet core, and the armature of the stepping magnet will be retained in its normal position. The line relay L R will remain energized by virtue of the current flowing through the above traced circuit for this low resistance winding 44, which winding may be made as low as ½ ohm resistance. Thus, the contacts 33 will for the moment remain closed. The current flowing over the circuit above traced for the low resistance winding 45 of the cut-off relay C O R will now operate the cut-off relay, which will attract its armatures, switching circuits as will be described. The low resistance winding 45 may be as low as two ohms resistance. The cut-off relay having operated by virtue of the energization thereof, by the winding 45 will interrupt a shunt placed about the winding 46 of the relay C O R, and the winding 46 which is of relatively high resistance compared with the winding 45, will be included in the common part of the circuit of which the two windings of the stepping magnet are branches. This shunt about the winding 46 comprises the circuit conductors leading to, and the contacts 34 of the relay C O R which contacts are now broken. The relay C O R will be maintained energized through the connection period by current flowing through the winding 46. The contacts 47 and 48 in the circuit of the winding 32 of the line relay L R are now interrupted, and the line conductors of the line L^1 are extended through contacts 49 and 50 of the relay C O R to the line switch wipers 3 and 4 of the said line switch, which contacting with the contacts 13 and 14 of the seized idle trunk circuit C, extend the circuit of the calling line from the substation A to the talking strands 51 and 52 of the connector circuit C, to which strands connections to ground and to battery respectively are connected through impedance windings Z and I M P, respectively, the latter being a relay winding. Current will flow through these windings and over the line circuit to the calling substation instrument, and this current will cause the energization of the relay I M P which will attract its armatures, opening contacts 53 and closing contacts 54, the latter contact being in the circuit of the slow releasing relay I R which circuit also includes the source of current, and this relay I R will thereupon be operated.

The relay I R being operated, will at-

tract its armatures opening the contacts 55 and closing contacts 56 for purposes to be later described. The contacts 43 of the relay I R will now be broken interrupting the connection to ground before described as leading through P O N and through the contacts 43 to the multipled test contact 16 of the trunk circuit located upon the line switches. The interruption of this circuit opens the circuit in which the windings 44 of the line relay L R, the winding 45 of the relay C O R and the left-hand winding of the stepping magnet S M are included. The relay L R now that the circuits of both of its windings are open, will be de-energized, opening contacts 33 which contacts have been acting as locking contacts for the circuit including the winding 44, of the line relay, the winding 45 of the cut-off relay, and the left-hand winding of the stepping magnet S M. The relay C O R is now maintained energized over a circuit which may be traced from the negative pole of the source of current, through the resistance coil R C, normal contacts 35 of the stepping magnet, the winding 46 of the cut-off relay, the right-hand winding of the stepping magnet S M which is of relatively low resistance compared with the winding 46 of the relay C O R, the circuit being further traced over circuit conductor 42, contacts 22 of the line switch, wiper 20 engaging the said contact 22, and to the ground pole of battery. The relatively high resistance of the winding 46 prevents sufficient current flowing over this circuit to operate the stepping magnet S M.

The line switch apparatus is now in its fully operated connection extending condition. The subscriber at A will now variably operate the calling dial D, producing a series comprising a certain number of line circuit interruptions, the interruptions occurring at a rapid rate and each being very short, their number being in accordance with the first digit of the called line number, this being preferably accomplished in the usual way. Upon such an actuation of the dial D by the calling subscriber and the consequent rapid line circuit interruption, the impulse relay I M P in circuit with the line will be caused to vibrate its armature, closing the contacts 53 at each circuit interruption and closing its contacts 54 after each circuit interruption until the end of the series of line circuit interruptions, when the contacts 54 will again be steadily closed. During the period in which the armature of the relay I M P is thus vibrating, the slow releasing relay I R will not retract its armatures, since it is constructed in any well known manner to release its armatures only slowly, and the circuit interruption being too short to permit such release. At each re-traction of the armature of the relay I M P however a circuit will be completed, the said circuit including slow releasing relay S R and the winding of the primary stepping magnet P M for the connector switch. The magnet P M is adapted to step the connector switch wipers 23, 24 and 25 in a primary direction to select a line group, this stepping being accomplished a step at a time, one step being made for each closure of the contacts 53 of the impulse relay I M P.

The circuit for the primary stepping magnet above referred to when thus closed through the contacts 53, is traced as follows: from the ground pole of battery, through the said contacts 53, through closed contacts 56 of the relay I R, through secondary off-normal contacts S O N, now closed, the low resistance winding of the slow releasing relay S R, side switch wiper 30, first position contact therefor, the winding of the magnet P M to the negative pole of the source of current. Thus the connector switch wipers are moved in accordance with the variable operation of the subscriber's dial D, to select a group of line contacts, one set of contacts of such group being connected to terminals leading to the desired line circuit.

During the period in which the first set of circuit interruptions are made, the slow releasing relay S R being serially included in an energizing circuit which has been above described, will be energized and attract its armatures. The left-hand armature being operated will not function at this time, since its contacts 57 are shunted by the secondary off-normal contact S O N. The contacts 58, however being closed, will complete a circuit for the escape magnet E S C to energize the same, the said circuit leading from the ground pole of battery, through the said contacts 58, first position contact and wiper 31 of the side switch, the winding of the escape magnet E S C, the resistance coil R E S and thence to the negative pole of the source of current. Current from the said source flowing over the said circuit will energize the said escape magnet, which will upon a subsequent de-energization which will now occur, advance the side switch wipers to their second position, the de-energization of the escape magnet occurring when the slow releasing relay S R releases and restores the contacts 58 to their normally open position, the said contacts being included in the said escape magnet circuit. The relay S R slowly releases its armatures at the end of the dialing period at which time there is a prolonged breaking of the contacts 53 in its circuit.

After having produced the first series of circuit interruptions to select the line group in which the called line is located, the subscriber will now again operate his dial to

produce a second series of circuit interruptions, definite in number and corresponding to the second digit of the called subscriber's line number. In the embodiment of my invention illustrated, I am assuming that the called subscriber is located on a line numerically designated by a number of two digits. It is understood that in practise the called subscriber's number may contain any desired number of digits, and as before mentioned this may be provided for by interposing selector switches or their equivalent, between the connector switch and the line switch of the system illustrated. The subscriber now producing the second series of circuit interruptions, will operate the relay S R as before, but the side switch wiper 30 being in second position the secondary stepping magnet C S M will now be operated a certain number of times corresponding to the number of line circuit interruptions of the second series, the circuit for the secondary magnet C S M being the same circuit as before described for the primary magnet P M, except that the circuit leads through side switch wiper 30 and second position contacts thereof instead of first position contacts thereof.

At the end of the second series of circuit interruptions by the subscriber's dial D, the connector switch wipers 23, 24 and 25 will rest upon the contacts 126, 127 and 128 of the called line. At the end of the second series of circuit interruptions likewise, the slow releasing relay S R slowly releases its armatures in the manner previously described for the same relay at the end of the first series of circuit interruptions and the busy test function of the connector switch will now be performed. The relay S R retracting its armatures will break contacts 58 for a purpose which will now be described. In the meantime, the escape magnet is energized due to a circuit being completed by the closure of second position contacts of side switch wiper 31, the said circuit being traced as follows: from the ground pole of battery, normal contacts 59 of the release magnet R M, second position contacts and side switch wiper 31, the winding of the escape magnet E S C and the resistance coil R E S to the negative pole of the source of current, from which source current flows over the circuit to maintain the escape magnet energized.

Each time that the slow releasing relay S R was energized during each dial operation, a circuit was completed for the slow releasing relay C B T, the circuit being traced from the ground pole of battery, through the contacts 58, through the winding of the said relay C B T to the negative pole of the source of current. This circuit being completed, the relay C B T was operated to close its contacts 60 during each dialing period and for as long a time afterwards as it took the slow releasing relay S R to open the contacts 58, plus the time it takes relay C B T to release after its circuit is broken.

The operation of the relay C B T the first time was functionless, since the circuit in which the contact 60 is included was open, being connected to second position contact of side switch wiper 29, the said switch wiper at that time being in first position, but at the end of the second dialing operation the closure of the contact 60 will operate in connection with the busy test function as follows: After the opening of contacts 58 of the slow releasing relay following the second dialing operation, the slow releasing relay C B T will also commence to restore its armature. In the meantime the normal contacts 61 of the relay S R will be restored and a circuit will be completed including the contact 60 of the relay C B T, the said circuit being traced as follows; it being assumed that the called-for line is not engaged, that is, "idle" and therefore in a selectable condition. In such a condition, negative battery is connected to the test contact 128 of the called line, and when the line is non-selectable, or busy, the negative battery potential normally existing on the contact 128, will be reduced to a degree that will make it non-effective to operate the busy test relay B T in the manner which the said busy test relay is operated when connection is made with an idle line as will now be described. In such a condition the circuit for the busy test relay B T is traced from the ground pole of battery, through normal contact 61 of the relay S R, through the winding of the busy test relay B T, now closed contact 60 of the relay C B T, which has not yet restored its armature, second position contacts and side switch wiper 29, connector switch test wiper 25, line switch test contact 128 engaged by the said wiper, the winding 62 of the called-line cut-off relay C R O, the intermediate winding of the said relay and the shunting contacts 134 therefor, in multiple, normal contacts 63 of the called line stepping magnet S M C, the resistance coil R C R thereof, and to the negative pole of the source of current connected thereto. Current from the said source flowing over this circuit will energize the busy test relay B T which will attract its armature and close a circuit for the second winding of the escape magnet, which winding is thereby placed in multiple with the first winding of the escape magnet whose circuit has been previously described, the contact 64 of the magnet B T being closed, merely placing the two windings in parallel. These windings are so arranged on the core of the escape magnet that they will be differentially operating, that is, the effect of the energization of one will be to neutralize the effect of the energization produced by

the other, and when both are included in circuit as before described, the escape magnet will be de-energized. This will now be accomplished, the escape magnet will release its armature, not shown but understood, to allow the side switch wipers to escape into third position.

The third position of the side switch wiper is the ringing position, and the ringing of the called subscriber's telephone bell will now begin. In the meantime, the side switch wiper 29 moving from second to third position interrupts the circuit of the busy test magnet B T which retracts its armature, opening contact 64 in the circuit of the right-hand winding of the escape magnet E S C and the magnet E S C will again be operated by the continued flow of current from the left-hand winding. Side switch wiper 29 moved into third position, places ground upon the test brush 25 of the connector switch completing an operating circuit for the winding 62 of the cut-off relay C R O of the called line, the circuit being traced as follows: from the ground pole of battery, third position contact and side switch wiper 29, brush 25 of the connector switch, line contact 128 engaged thereby, the winding 62 of the relay C R O, contact 63 of the stepping magnet S M C and the resistance coil R C R to the negative pole of the source of current. Current from the said source will flow over this circuit and through the said winding 62 of the relay C R O, operating the relay C R O to disconnect the line relay and the source of current from the line conductors of the line L^2. The line switch of the called line being in home position, the extension 151 and 152 of the called line conductors leading to wipers of the line switch, will not complete any circuit due to the fact that the home position contacts upon which these wipers are resting, have no electrical connection. The ground applied by side switch wiper 29 on connector switch wiper 25 to the test contact 128 of the called line, also busies other multiple test contacts of the called line, not shown in the drawing but understood to be present in accordance with the usual custom.

The ringing circuit from the central office generator including the serially connected central office source of current is now connected through to the bell of the called subscriber ringing the said bell. This circuit is traced as follows: from the ground pole of battery, side switch wiper 26 and the engaged third position contact, connector switch wiper 23, line contact 126, one side of the line L^2 through condenser 66 at the substation B, the bell 65 at the said substation, the other line conductor line contact 127 of the connector switch, connector switch wiper 24, side switch wiper 28 and third position contact thereof, the winding of the slow ringing trip relay R T, signal lamp 153, and then the circuit continues alternately by two paths due to the operation of the circuit interrupter 68, the one path including the ringing generator 67 and the other path being the segment 154 of the said interrupter, the two paths being joined again and the circuit continued through resistance coil 155 to the negative pole of the source of current. Current from the ringing generator 67 intermittently applied through the interrupter 68 will intermittently ring the called subscriber's bell 65. When the called subscriber answers by removing his receiver from the hook, he thereby places a conductive bridge for the flow of direct current across the line conductors of the line L^2, and current from the central office source of current will thereupon flow through the trip relay R T to operate the said relay, which will close its contacts to shunt the left-hand winding of the escape magnet E S C, to de-energize the same.

When the escape magnet is thus de-energized, it will allow the side switch wipers to escape into fourth or conversational circuit position, whereupon the substribers will be connected through in conversational circuit, one with the other. This conversational circuit is completed by the side switch wipers 27 and 28 being in fourth position, closing the talking strands 51 and 52 and extending them to the connector switch wipers 23 and 24 already in operative engagement with the called line terminals 126 and 127.

At the time the side switch wipers reached the fourth or talking position, a circuit was closed for the calling line register L M, the said circuit being traced as follows: from the ground pole of battery, through the side switch 26 and fourth position contact thereof, passive switch contact 12, line switch wiper 2, now closed contacts of the cut-off relay C O R, the winding of the message register to the negative pole of the source of current. Current from the said source will flow over this circuit and energize the line register L M to cause it to register the completed connection. The register magnet L M will remain energized throughout the conversational period and will be restored whenever the release of the connector switch occurs.

The subscribers will now converse, and at the end of the conversational period they will retire their telephones, replacing the receivers upon the hooks and breaking the line circuits. When the calling subscriber at the substation A so breaks the circuit of the line conductors, the impulse relay I M P will be de-energized and will retract its armature, breaking its contacts 54 and closing its normal contacts 53. The breaking of the contacts 54 will cause the slow re-

leasing relay I R to release, and when this has fully retracted its armature, the release circuit of the connector switch will be established, the said circuit being traced as follows: from the ground pole of battery, through normal contacts 53 of the relay I M P, through normal contacts 55 of the slow releasing relay I R, through off-normal contacts P O N of the connector switch and the left-hand winding of the release magnet R M to the negative pole of the source of current. Current from the said source flowing over this circuit will energize the release magnet, the said release magnet when operated closing a locking circuit for itself, the said locking circuit extending through the apparatus of the calling line switch. In passing, it may be said that the right-hand winding of the release magnet is very low in resistance as compared with the winding 46 of the line cut-off relay C O R. The locking circuit is traced from the ground pole of battery, through normally open contacts of the release magnet R M, through the low resistance right-hand winding thereof, trunk contact 15 of the calling line switch, line switch wiper 5, normally open contacts 156 of the cut-off relay C O R, normally closed contacts 35 of the stepping magnet S M, the resistance coil R C to the negative pole of the source of current. Current from the said source will flow over this circuit retaining the release magnet of the connector switch operated until the subsequent breaking of this circuit as will be later described. It will be understood that preferably the contacts 34 and 156 of the cut-off relay C O R will be of the make before break type, or will be given a special adjustment to cause the contacts 34 to be closed before the contacts 156 are opened when the cut-off relay C O R is de-energized. Such adjustments are common in the art to which this invention appertains.

The locking circuit just traced being established, the low resistance right-hand winding of the release magnet R M of the connector switch will be placed in shunt with the higher resistance winding 46 of the cut-off relay C O R, and will divert current from the said high resistance winding to de-energize the relay C O R which will now retract its armatures. The retraction being completed and the normal contacts 34 of the relay C O R being closed, a short circuit including the said contacts and connecting conductors will be placed about the winding 46. Also the contacts 156 being opened will open the locking circuit for the release magnet just described, so that if the contacts P O N serially included with the left-hand winding of the release magnet have opened by the complete restoral of the connector switch mechanism to normal position, the release magnet will be de-energized. The line switch stepping magnet S M is now energized over a circuit including its normal contacts 35, the circuit being traced as follows: from the ground pole of battery, line switch wiper 20, trunk point contacts 41, 22 etc. which the said line switch wiper 20 will engage in its travel, circuit conductor 42 leading from the said multipled contacts, the right-hand winding of the stepping magnet S M, normal contacts 34 of the cut-off relay C O R, normal contacts 35 of the stepping magnet S M, through the resistance coil R C to the negative pole of the source of current. The stepping magnet S M will be intermittently operated to step the line switch wipers from position to position under the control of the contacts 35 of the said stepping magnet, and this action will continue until the line switch wiper 20 reaches a position where it will break circuit with the multipled contacts, such as 41, 22 and others not shown, which are connected to the circuit conductor 42, and there being only one contact, namely, the home position contact 21 which has no such connection, the stepping action will continue until the line switch wipers reach the said home position set of contacts, whereupon the circuit of the right-hand winding of the stepping magnet S M will be broken and the stepping will be discontinued. The connector switch mechanism having been restored to normal and the subscribers retired, the system is in its original condition of rest, the apparatus of the trunk connector circuit C may be seized by other calling lines through the operation of their line switches.

Referring back to the busy test function, if the called line had tested busy when the busy test was made in the manner previously described, busy tone current would have been sent from the busy tone source of current B Z to secondary off-normal contacts S O N, second position contact and engaged wiper 27 of the side switch, and thence over the talking strand 51 of the connector switch through the telephone of the calling subscriber, and back through the winding of the impulse relay I M P to the negative pole of the source of current. The busy tone current would thus audibly convey the information to the calling subscriber that the called line is busy, in which case he would replace his receiver upon the hook and this action would release the connector switch in the manner just described for such release, and would restore the line switch to its home point position, as has been described.

I have described the specific embodiment of my invention for the purpose of enabling those skilled in the art to understand the same, but I am aware that numerous and

extensive departures may be made from the embodiment illustrated without departing from the spirit of my invention.

What I claim is my invention is defined in the following claims:—

1. In a telephone system, the combination with a telephone line, a line switch for the said line having active and passive contacts, a line relay for the said line, a cut-off relay for the said line, a pair of normally open contacts of the said cut-off relay serially connected between a pair of the said active contacts and the talking strands of the line, separate holding and operating windings for the said cut-off relay, the said holding winding being normally short-circuited by normal contacts of the said relay, a stepping magnet adapted to step the said active contacts over successive sets of passive contacts to which are connected the terminals of trunk lines, a circuit for the said stepping magnet including a source of current and normally open contacts of the said line relay, a circuit for the said operating winding of the said cut-off relay including one of the said active contacts of the said switch and a passive contact of an idle trunk line connected thereto, the said circuit being completed when the said active contact engages the said passage contact of the idle trunk line, and a holding circuit for maintaining the energization of the said cut-off relay after the said cut-off relay has been initially energized by current through the said operating winding, the said holding circuit including a source of current and the holding winding of the said relay.

2. In a telephone system, the combination with a telephone line, a line relay for the said line normally associated therewith, a cut-off relay for dis-connecting the said line relay from the said line, a step by step switch operated under the control of the said line relay to select an idle trunk line, a holding winding for the said cut-off relay normally short-circuited by contacts thereof, and means operative when the said line switch causes a connection to be made between the said line and an idle trunk line to open the said contacts, and a source of current included in series with the said holding winding to operate the same when the said contacts are opened.

3. In a telephone system, the combination with a telephone line, adjustable terminals for the said line adapted to make connection with one of a plurality of trunk lines, a line relay for the said line, means under the control of the said line relay to operate the said adjustable terminals, a cut-off relay for the said line relay and adapted when operated to interrupt the circuit of the said line relay, a winding for the said cut-off relay normally short-circuited by contacts thereof and a circuit including the said normally short circuited winding and contacts of the said line relay and a source of current for energizing the said cut-off relay winding, and means operative when the said adjustable terminals make connection with an idle trunk line to open the said short circuiting contacts, whereby the said cut-off relay may be maintained in contact operating position to maintain the line relay circuit disconnected from the said line circuit.

4. In a telephone system, the combination with a telephone line, adjustable terminals for the said line adapted to make connection with one of a plurality of trunk lines, a line relay for the said line, means under the control of the said line relay to operate the said adjustable terminals, a cut-off relay for the said line relay and adapted when operated to interrupt the circuit of the said line relay, a winding for the said cut-off relay normally short circuited by contacts thereof and a circuit including the said normally short circuited winding and contacts of the said line relay and a source of current for energizing the said cut-off relay winding, a second winding for the said cut-off relay, a circuit for the said second winding including a source of current, and means responsive to the connection of the said adjustable terminals to an idle trunk line to close the said circuit to energize the said cut-off relay, whereby the said cut-off relay may break the said short-circuiting contacts.

5. In a telephone system, the combination with a telephone line, adjustable terminals for the said line adapted to make connection with one of a plurality of trunk lines, a line relay for the said line, means under the control of the said line relay to operate the said adjustable terminals, a cut-off relay for the said line relay and adapted when operated to interrupt the circuit of the said line relay, a winding for the said cut-off relay normally short circuited by contacts thereof and a circuit including the said normally short circuited winding and contacts of the said line relay and a source of current for energizing the said cut-off relay winding, a second winding for the said cut-off relay, a circuit for the said second winding including a source of current, means responsive to the connection of the said adjustable terminals to an idle trunk line to close the said circuit to energize the said cut-off relay, whereby the said cut-off relay may break the said short circuiting contacts, and a winding for the said line relay serially connected with the said second cut-off relay winding.

6. In a telephone system, the combination with a telephone line, a line switch

for the said line, a set of active contacts for the said line switch adapted to successively traverse sets of passive contacts, a group of trunk line terminals connected to a set of the said passive contacts which passive contacts are also multiply connected to passive line switch contacts of other lines, a stepping magnet for the said line switch having a pair of differential windings, a stepping circuit closed responsive to the connection of a subscriber's telephone instrument to the telephone line to operate the said stepping magnet, to cause the active contacts of the said line switch to traverse busy trunk line contact sets, and a circuit for the second winding closed when the said active contacts rest upon the passive contacts of an idle trunk line to neutralize the action of the first winding to stop the said switch.

7. In a telephone system, the combination with a telephone line, a line switch for the said line, a set of active contacts for the said line switch adapted to successively traverse sets of passive contacts, a group of trunk line terminals connected to a set of the said passive contacts which passive contacts are also multiply connected to passive line switch contacts of other lines, a stepping magnet for the said line switch having a pair of differential windings, a stepping circuit closed responsive to the connection of a subscriber's telephone instrument to the telephone line to operate the said stepping magnet, to cause the active contacts of the said line switch to traverse busy trunk line contact sets, a circuit for the said second winding closed when the said active contacts rest upon the passive contacts of an idle trunk line to neutralize the action of the first winding to stop the said switch, and means responsive to the connection between the said active contacts and the said idle trunk line passive contacts, to interpose a relatively high resistance coil in circuit with the first-named differential stepping magnet winding to reduce the current flow therethrough, and means located in the said idle trunk circuit responsive to the said connection to interrupt the circuit of the second-named winding.

8. In a telephone system, the combination with an automatic switch comprising passive contacts and co-operating active contacts, means outside of said switch for rendering certain of said passive contacts busy, a magnet and co-operating means for advancing said active contacts, a home set of said passive contacts upon which the said active contacts normally rest, means for initially advancing said active contacts by closing a circuit for a first winding of the said magnet, means responsive to the initial advance of the said active contacts to close a circuit through a second winding of the said magnet and open the circuit of the first winding and a circuit completed when the said active contacts engage idle passive contacts for the said first winding, a source of current for energizing the said windings, the direction of flow through said two windings being relatively reversed, whereby the said magnet is de-energized when current flows simultaneously through both windings thereof.

9. In an automatic telephone system, the combination with a connector switch, adjustable terminals therefor moved under the control of a calling substation sending device to contact with terminals of a called telephone line, normally open contacts in the circuit of a pair of the said adjustable terminals, the said circuit being the talking circuit for interconnecting the telephone lines, a magnet energized by means of a first winding to prevent the closure of the said contacts, a second differential winding for the said magnet adapted when energized to neutralize the effect of the first-named winding, and means responsive to the idle condition of the called line terminals to close a circuit for the said second differential winding to energize the same.

10. In a telephone system, the combination with a plurality of telephone lines, a group of trunk lines for the said telephone lines, line switches for the said lines, traveling switch wipers for the said line switches, one of the said wipers being a test wiper, trunk line terminals for each of said trunk lines adapted to be traversed by the said wipers, a normally connected source of potential to each trunk line contact adapted to be traversed by the said test wiper, means resident in each trunk line for removing the said source of potential to make the trunk line contacts in the different line switches busy, a controlling relay, a pair of talking circuit wipers for each of the said line switches, and circuit conductors leading therefrom through normally open contacts of said control relay to the associated telephone line terminals, a test circuit for each of the said line switches, and a holding circuit for the said control relay, the said holding circuit being local to the said line switch.

11. In a telephone system, the combination with a plurality of telephone lines, a group of trunk lines for the said telephone lines, line switches for the said lines, traveling switch wipers for the said line switches, one of the said wipers being a test wiper, trunk line terminals for each of the said trunk lines adapted to be traversed by the said test wipers, a normally connected source of potential to each trunk line contact adapted to be traversed by the said test wiper, means resident in each trunk line for

removing the said source of potential to make the trunk line contacts in the different line switches busy, a release wiper for each of the said line switches, trunk line terminals for each of the said trunk lines adapted to be traversed by the said release wiper, a control relay, a circuit conductor leading from said release wiper through normally open contacts of said control relay to a winding of said control relay, a holding circuit for the said control relay, said holding circuit being local to the said line switch, and means responsive to the disconnection of the said trunk line to place a source of potential on said release wiper to de-energize the said control relay.

12. In a telephone system, a telephone line, an automatic switch individual to said line, an operating magnet to control the movement of said automatic switch, two differentially wound operating windings for said magnet, and means controlled over the said line for initiating the operation of said magnet.

13. In a telephone system, a telephone line, an automatic switch individual to said line, circuits terminating in said switch, and an operating magnet for said switch provided with two differentially wound windings, said magnet being controlled over said telephone line to initiate the operation of said switch in seizing a circuit.

14. In a telephone system, a telephone line, an automatic switch of the advance-to-normal type individual to said telephone line, circuits terminating in said switch, an operating magnet provided with two differentially wound windings for controlling the movement of said automatic switch, and means controlled over said telephone line for initially operating said magnet.

15. In a telephone system, a telephone line, an automatic switch individual to said line, circuits terminating in said switch, a motor magnet for said switch having two differentially wound operating windings, means controlled over said line for initiating the movement of said switch to seize one of said circuits, and means controlled over said telephone line for causing said magnet to restore the switch to normal position.

16. In a telephone system, a telephone line, a substation for said telephone line, an automatic switch individual to said line, circuits terminating in said switch, a relay for controlling the operation of said switch, a motor magnet for advancing said switch under the control of said relay, a pair of contacts for said relay, and a circuit for said motor magnet having only a single pair of relay contacts therein.

17. In a telephone system, telephone lines, a plurality of automatic selective switches co-operating in the extension of one telephone line to a second telephone line, said automatic selective switches including an automatic switch individual to each telephone line, motor magnets for advancing said switches in succession, one of said motor magnets being differential, a control circuit extended from one of said telephone lines to one of said switches, and a switching relay operative when said last mentioned switch has completed its selecting operation to extend said control circuit to a second automatic switch, and means controlled over a telephone line for releasing said switches.

18. In a telephone system, an incoming line, a plurality of outgoing lines, a switch for interconnecting said lines, an impulse relay responsive to impulses over said line, a slow relay controlled by said impulse relay, a second slow relay jointly controlled by said first slow relay and said impulse relay, a primary magnet and a secondary magnet controlled successively by said impulse relay to cause said switch to seize an outgoing line, an electromagnetic device having two windings, either of which when energized will actuate said device, said device being inoperative when both of said windings are energized, said device being controlled by said second slow relay to determine the operation of each of said magnets, and a release magnet controlled by said first slow relay.

19. In a telephone system, a telephone line, a plurality of outgoing lines, a switch for interconnecting said telephone line with any of said outgoing lines, an impulse relay responsive to impulses over said line, a slow relay controlled by said impulse relay, a second slow relay controlled by said first slow relay and said impulse relay, a primary magnet and a secondary magnet controlled successively to cause said switch to seize an outgoing line, a differential change-over device controlled by said second slow relay to determine the operation of said primary and secondary magnets, a circuit for said primary magnet and said secondary magnet arranged to be completed in series with said second slow relay, and a release magnet controlled by said first slow relay.

20. In an automatic telephone system, an incoming circuit, a plurality of outgoing circuits, a switch for interconnecting said incoming circuit with any of said outgoing circuits, said switch having normally closed contacts and contacts which are closed when said switch is away from its normal position, a motor magnet for said switch having a plurality of windings, a circuit closed through one of said windings of said motor magnet and said normally closed contacts to advance said switch to an off-normal position on the initiation of a call, a circuit for the other winding closed through

said other contacts for advancing said switch therefrom to an idle circuit, means for energizing said first-mentioned winding when the idle circuit is reached, and means for releasing said switch.

21. In a telephone exchange system, an automatic switch, a differentially wound stepping magnet for operating said switch, and means for energizing the windings of said magnet to prevent further operation thereof when the switch engages terminals of an idle line.

22. In a telephone exchange system, an automatic switch, a stepping magnet for the switch having a normally inactive differential winding, a circuit for operating said magnet and means for energizing said differential winding to prevent operation of said magnet when the switch engages terminals of an idle line.

23. In an automatic switch of the character described provided with bank contacts and contact makers and operable in a single plane, and a differentially-wound motor magnet for said switch for moving said contact makers into engagement with said bank contacts.

24. An automatic switch of the character described provided with bank contacts and contact makers, a differentially-wound motor magnet for said switch for moving said contact makers into engagement with said bank contacts, and a test relay for said switch adapted to be included in series circuit with one of the differential windings of said motor magnet.

In witness whereof, I hereunto subscribe my name this 10th day of September, A. D. 1918.

WINFRED T. POWELL.