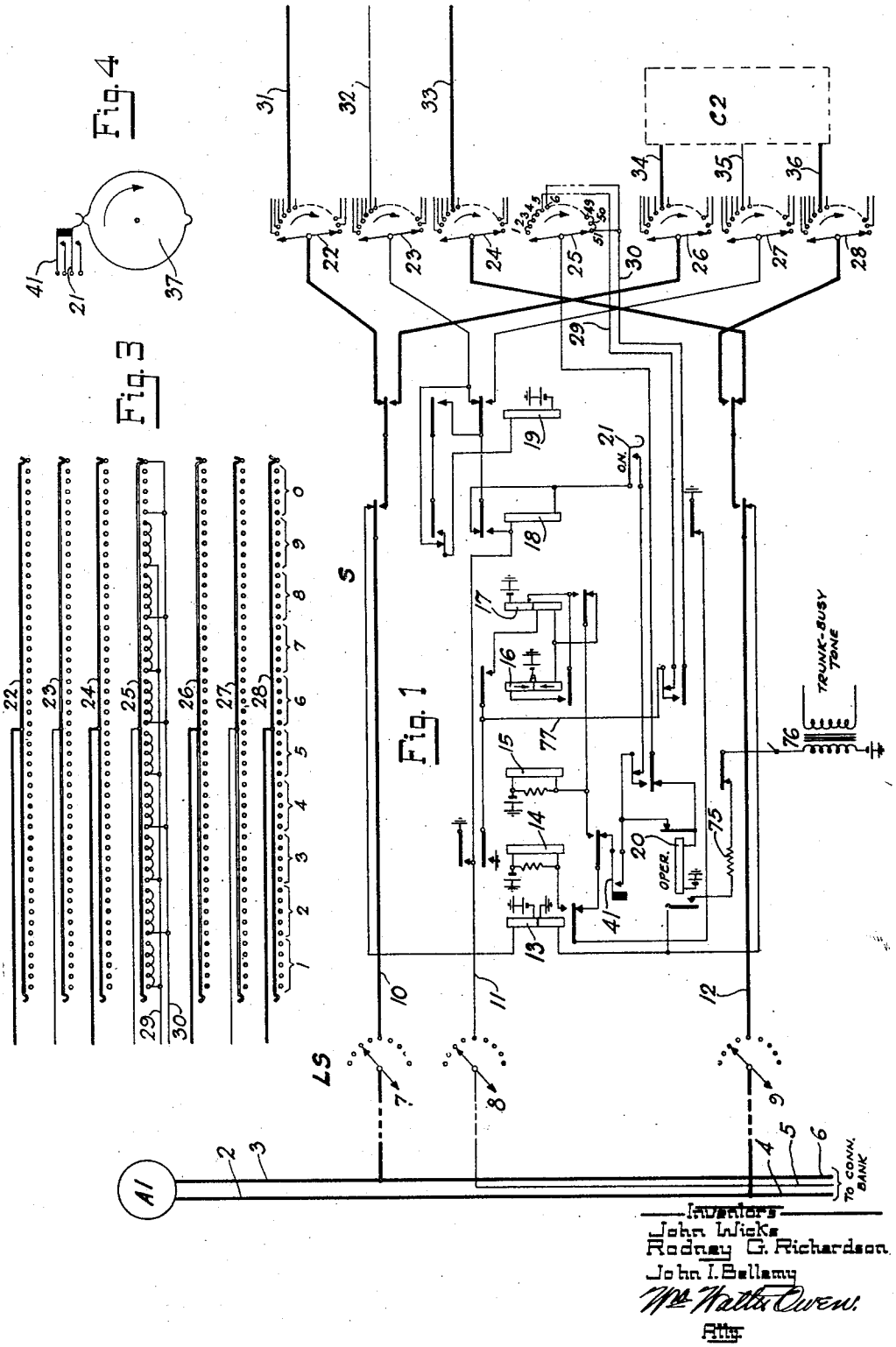
March 28, 1933. J. WICKS ET AL 1,903,207

TELEPHONE SYSTEM

Original Filed March 2, 1931 2 Sheets-Sheet 1



Inventors
John Wicks
Rodney G. Richardson
John I. Bellamy
By McWatters & Owen
Attys

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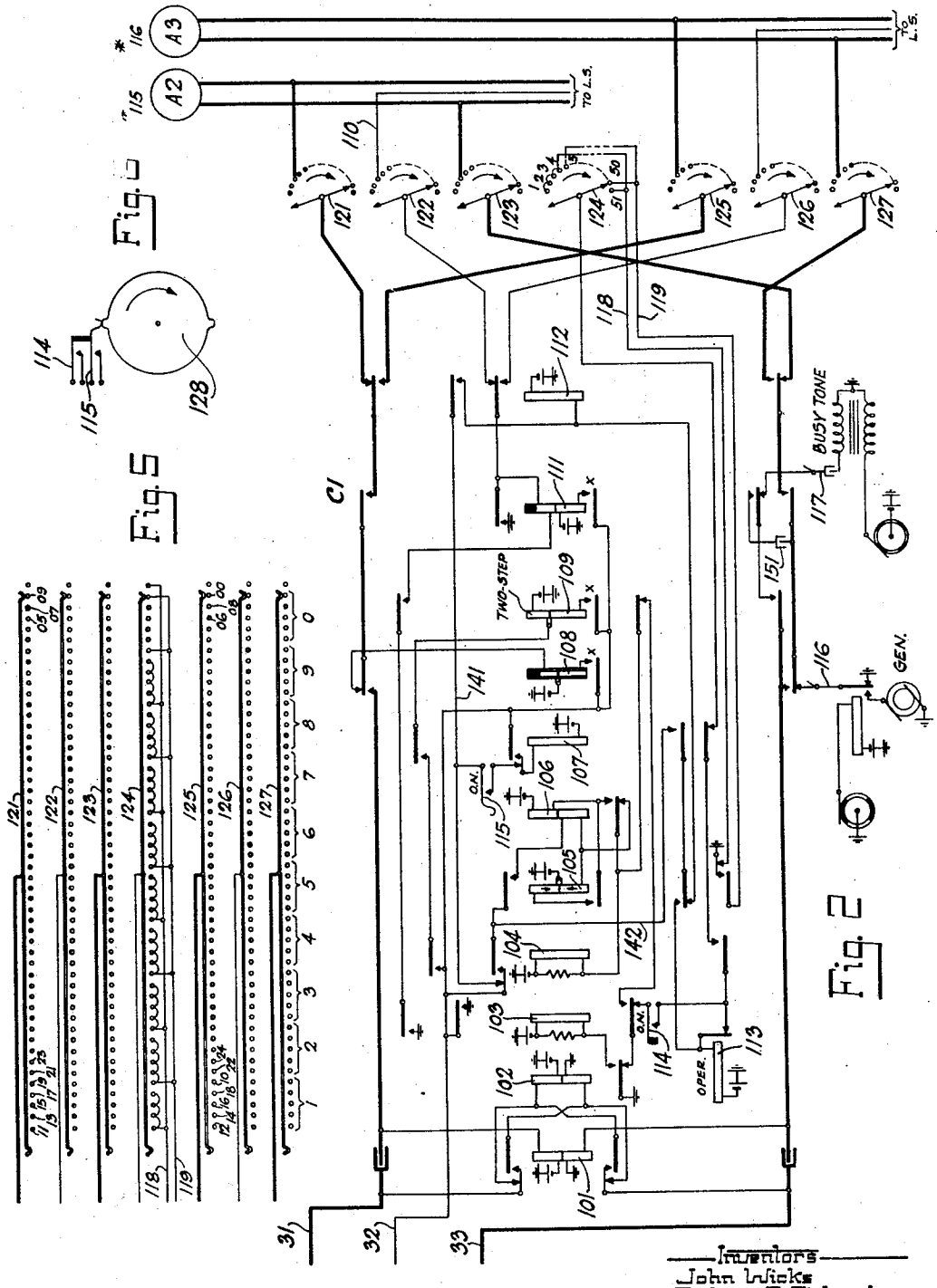

Fig. 2

Fig. 3

Fig. 5

Inventors
John Wicks
Rodney G. Richardson
John I. Ballamy
Wm. Watts Ousley
Atty.

Patented Mar. 28, 1933

1,903,207

UNITED STATES PATENT OFFICE

JOHN WICKS, OF OAK PARK, RODNEY G. RICHARDSON, OF CHICAGO, AND JOHN I. BELLAMY, OF BROOKFIELD, ILLINOIS, ASSIGNORS, BY MESNE ASSIGNMENTS, TO ASSOCIATED ELECTRIC LABORATORIES, INC., OF CHICAGO, ILLINOIS, A CORPORATION OF DELAWARE

TELEPHONE SYSTEM

Application filed March 2, 1931, Serial No. 519,310. Renewed June 10, 1932.

The present invention relates to telephone systems in general, being concerned more particularly with automatic telephone systems; and the main object is the production of a new and improved automatic telephone system in which the switches which respond to the controlling impulses to set up the telephone connections are of simple construction, having only a rotary movement, and are positioned in accordance with the received impulses and restored to normal position, by the same operating magnet.

According to one feature of the invention, each switch is provided with a directing wiper and cooperating contacts, connected up in groups corresponding to the groups of lines accessible to the switch; and it is a further feature that counting means is provided for controlling the connections to the directing wipers so as to control the advance of the switch while impulses of a digit are being received, but the counting means is arranged to be operated by the first impulse and restored by the second so that it is used over and over, and does not need to have as many positions as there are impulses in the digit of highest value.

In order to render it unnecessary to provide a register having a separate setting for each different value that a digit may have, the groups of contacts in the bank of the directing wiper which correspond to the odd-numbered line groups are connected to one conductor, while the groups of bank contacts corresponding to the even-number line groups are connected to another conductor, and the driving potential is supplied alternately to these two conductors as the counting means operates and restores during the receipt of impulses of a digit, the switch being operated through the directing wiper to keep step with the received impulses.

It is a special feature of the arrangement just mentioned that the full time occurring between the beginning of one impulse of a digit and the beginning of the next succeeding impulse of a digit is available for driving the wipers of a switch across a group of contacts, and that no harm results in case the switch completes the movement responsive to a given impulse before the next impulse arrives.

It is a further feature of the invention that the counting means for responding to the impulses of a digit comprises a pair of relays which are operated successively responsive to each odd-numbered impulse of a digit and are deenergized successively responsive to each even-numbered impulse of a digit.

According to a further feature of the invention, the trunk-hunting operation of a selector is automatically stopped by the closing of a local holding circuit for the operating magnet; a trunk-busy tone is sent back to the calling line; and the selector is prevented from responding further to dialling impulses, all responsive to the wipers of a selector being driven beyond the last contacts of a selected group when all trunks in a selected group are found to be busy.

A further feature of the arrangement is that the number of steps a switch must take to pass over a group of line terminals is halved by the provision of two sets of wipers in place of one, together with a wiper switching relay and suitable circuits for operating it. In the case of the selector, the wiper-switching relay is operated automatically over the test wiper of the normally connected wiper set to substitute the alternate set of wipers in case the trunk line encountered by the normally-connected set is busy.

A feature of the final selectors or connectors used in the present system is that the circuits associated with the pair of counting relays of a connector are automatically altered upon the positioning of the wipers of the connector in accordance with the tens digit, so that the same pair of counting relays responds during the units digit, and alternately operates the stepping magnet and the wiper-switching relay, whereby the switch is advanced one step for each odd-numbered impulse received and the wiper-switching relay in energized when each even-numbered impulse is received. By this coordination of the operations of the stepping magnet and of the wiper-switching relay, a connection may be extended to any one of the ten lines of a selected group, although the

wipers of the switch are advanced a maximum of five steps responsive to the final digit of a number. A special feature of the arrangement for advancing the wipers of the connector in response to the impulses of the final digit is that the length of an impulse delivered to the operating magnet is independent of the length of the received impulses, being merely dependent upon the elapsed time between the beginning of one impulse and the beginning of the next succeeding one.

A further feature relates to the circuit arrangements for testing a called line and for signalling the calling subscriber so as to inform him whether the called line is busy or idle. According to this arrangement, a circuit is always completed for sending back busy-tone current to the calling line when the called line has been selected. At the same time, a test circuit is closed for operating a seizing relay in case the called line is idle. If this seizing relay is able to operate, it opens the busy-tone connection and applies a ringing tone to the calling line to indicate that the called line is idle and is being signalled. A special feature of this arrangement is that a calling subscriber may wait in case a line is busy and have his connection automatically completed to the line when it becomes idle.

There are additional objects and features of the invention, but they are, for the most part, incidental to the objects and features above stated. These additional objects and features will be understood best upon a further perusal of the specification in connection with the accompanying drawings comprising Figs. 1 to 6.

Referring now to the accompanying drawings, they show, by means of the usual circuit diagrams, a sufficient amount of apparatus in a telephone system embodying the features of the present invention to enable the invention to be understood. Figs. 1 and 2 are circuit drawings showing how connections may be set up from a calling substation A1 of the automatic telephone system by way of the lineswitch LS, the selector S, and the connector C1, to either of the substations A2 and A3; Fig. 3 shows the arrangement of the contacts in the banks of wipers 22 to 28 of the selector S, Fig. 1; Fig. 4 shows how the off-normal springs 21 and 41 of the selector S are controlled by the cam 37; Fig. 5, similar to Fig. 3, shows the arrangement of the contacts if wipers 121 to 127 of the connector C1; and Fig. 6 shows how the off-normal springs 114 and 115 of the connector C1 are controlled by the cam 128.

General description

The telephone exchange illustrated is assumed to have a capacity of one thousand lines. These lines are divided into ten groups of one hundred lines each. Each line terminates at the exchange in a rotary lineswitch, such as the rotary lineswitch LS in which the line of substation A1, Fig. 1, terminates. The rotary lineswitches used are assumed to be of the standard type shown in Figs. 48 and 49 and described in the matter beginning at the top of page 51 of Automatic Telephony, by Arthur Bessey Smith and Wilson Lee Campbell, second, edition, published by the McGraw-Hill Book Company, Inc., New York, 1921. The banks of the rotary lineswitches are multipled together in groups, and trunks lead from the banks of the lineswitches to selectors such as S, there being about one hundred selectors provided to take care of the probable maximum number of simultaneous calls.

The selectors

The mechanism of the selectors may be the same as the mechanism of the lineswitches shown and described in the portion of Automatic Telephony above referred to, except that the number of wipers is increased to seven, as shown, and the number of contact sets is increased to fifty-one sets, seven contacts in each set. Each selector wiper is double-ended as in the case of the lineswitch, and one end of the set of wipers of a selector rests on the fifty-first set of bank contacts, as indicated in Figs. 1 and 3. A cam 37, Fig. 4, is secured on the same shaft with the wipers and is arranged to be rotated as the wipers are driven around. The cam 37 has two projections, one of which always raises the springs 21 and 41 from their contacts when one end of the wipers is on the fifty-first set of bank contacts.

The first fifty contact sets in the banks of a selector constitute ten groups, each group of bank contacts corresponding to a different one of the ten groups into which the lines of the exchange are divided. The division of the bank contact sets into ten groups is indicated by the ten brackets shown below the contact sets in Fig. 3 and numbered 1 to 0. The wipers of the selector S are divided into two sets, with the wiper 25 common to both sets. Wipers 22 to 24 comprise the first set, and wipers 26 to 28 comprise the second set. Each set includes two line wipers and a test wiper.

The wiper 25 is a directing wiper. It is controlled through its contacts by impulses delivered alternately over conductors 29 and 30 during the dialling of a digit, and in a manner to be pointed out hereinafter, in order to position the wipers on the first set of bank contacts of the group corresponding to the digit transmitted to the selector from the dial on the calling line.

The conductors leading from the contact sets of the selectors extend to the connectors, such as the connectors C1, Fig. 2, and C2, Fig. 1, there being about one hundred connectors.

divided into ten groups of about ten connectors each, each connector group corresponding to a different first digit dialled by a calling subscriber. The banks of the selectors are multipled together, so that the connectors are accessible to each of the selectors. It may be pointed out that the multiple is not carried straight through all of the selectors in case there are more than ten connectors in some groups, but the multiple is suitably divided in such a case to take care of the additional connectors, as is well known.

Each off-normal position of the wipers of the selector corresponds to two trunks, one trunk for each set of wipers. For example, when the wipers of the selector are standing on the fifth set of bank contacts, wipers 22 to 24 are in engagement with the trunk line comprising conductors 31 to 33 and extending to the connector C1, Fig. 2. At the same time, the wipers 26 to 28 are in engagement with the trunk line comprising conductors 34 to 36 and extending to the connector C2, which is shown only as a dotted rectangle because it is similar to the connector C1 shown in detail in Fig. 2.

Since there are two trunk lines accessible from each off-normal position of the selector, the wiper-switching relay 19 is provided to selectively control the connection of either set of wipers to the selector to the exclusion of the other set. The wiper-switching relay 19 is operated automatically in the course of testing for idle trunk lines, in a manner to be hereinafter explained in detail.

The connectors

The connectors are similar to the selectors. Each connector has seven wipers, which comprise two sets of wipers, three wipers a set, with a common directing wiper. The connector C1, Fig. 2, for example, has two sets of wipers 121 to 123, and 125 to 127, with directing wiper 124 common to both sets. There are 51 sets of bank contacts, grouped as shown in Fig. 5, with the wipers normally standing on the fiftieth set. Whereas each selector has a single directed movement to select a group, and a trunk-hunting movement to select an idle trunk leading to a connector, each connector has two directed movements, a primary movement to select a group of ten lines, and a secondary movement to select the desired line in the group of ten. During the primary movement, the connector, like the selector, is controlled by its directing wiper to advance the wipers into association with a different group of contact sets for each impulse of a received digit.

At the end of the tens digit, the wipers of the connector are standing on the contact set preceding the first contact set of the group corresponding to the digit. Then, responsive to the impulses of the units digit, the operating magnet of the connector advances the wipers over the contacts of the selected group, advancing them one step responsive to each odd-numbered impulse. Each connector is provided with a wiper-switching relay, such as relay 112 of the connector C1, Fig. 2. This wiper-switching relay is in a deenergized condition at the end of each odd-numbered impulse in a units digit, and it is in an energized condition at the end of each even-numbered received impulse. Accordingly, the connector associates itself successively with all ten of the lines of a selected group responsive to the dialling of the digit having the maximum number of impulses therein; from which it follows that when a digit of any lower value is received as the final digit, the connector is stepped into association with the corresponding line of the group.

Each connector is provided with a cam such as the cam 128, Fig. 6, of the connector C1. The cam 128 is provided with two projections, one of which is always in engagement with the tip of off-normal spring 115 when the wipers of the connector are in normal position. In this way, springs 115 and 114 are normally maintained disengaged from their respective associated contacts.

Detailed description

The invention having been explained generally, a detail description of the operation of the apparatus shown will now be given. For this purpose it will be assumed that the subscriber at substation A1, Fig. 1, desires to converse with the subscriber at A2, Fig. 2, whose number is 115, as indicated in Fig. 2.

Call from substation A1 to substation A2

When the receiver is removed at substation A1, the lineswitch LS operates in the usual manner responsive to current-flow over the line conductors 2 and 3. It will be assumed that the lineswitch LS rotates its wipers into engagement with the trunk line comprising conductors 10 and 12 and extending to the selector S, and takes this trunk line for use. When this occurs, line relay 13 of the selector S, which is connected to conductors 10 and 12 through contacts of switching relay 18, operates over conductors 2 and 3 of the calling line and closes a circuit for release relay 14 through contacts of relay 18. Relay 14 thereupon operates and prepares a circuit for series relay 15 at its lower armature, at the same time placing ground potential on release-trunk conductor 11 at its upper armature. The ground potential on release-trunk conductor 11 serves to maintain the selector S guarded against seizure by other lineswitches, and it maintains the lineswitch LS operated in the usual manner.

When ground potential is placed on release-trunk conductor 11, a circuit is closed for relays 18 and 19 in series, by way of the inner upper armature of relay 18, inner up-

per armature, normal, of relay 19, and the contacts controlled by the middle upper armature of relay 18. Relays 18 and 19, both having a relatively high resistance and both having a reasonably strong spring tension, do not operate in series with one another.

When the first digit 1 is dialled, line relay 13 deenergizes once, momentarily, responsive to its circuit being momentarily opened at the usual calling device (not shown) at substation A1. When it falls back, line relay 13 opens the circuit of release relay 14 and closes a circuit through the contacts of relay 14 for series relay 15. At this point attention may be called to the resistance element shunted around the winding of relay 14. Because of this shunt, the self-induced current of relay 14 flows through the associated resistance and maintains the relay energized during any momentary interruption of its circuit. It will be noted, moreover, that there is a similar resistance shunted around the winding of relay 15. This resistance has a similar purpose.

When the circuit of relay 15 is momentarily closed, as above mentioned, the relay operates; and, because the self-induced current of the relay has a local path through the associated resistance, the relay remains operated throughout a series of momentary impulses delivered thereto during the dialling of a digit of a higher value than the digit 1.

At the same time that the single impulse corresponding to the digit 1 is delivered to series relay 15, a multiple circuit exists through contacts of relay 17 for the lower winding of the differential relay 16. When this circuit is closed, relay 16 operates and closes a locking circuit for its lower winding. This locking circuit includes the lower winding of relay 17 and armatures of relays 16 and 14. No current flows through the locking circuit, however, as long as the initial circuit of the lower winding of relay 16 remains closed, as the actuating potential is the same as the locking potential. But, as soon as the impulse is terminated, current flows through the lower winding of relay 17 in series with the lower winding of relay 16, whereupon relay 17 operates. Relay 16, of course, remains operated.

As will now be explained, relays 16 and 17 are so arranged that relay 16 is operated at the beginning of each odd-numbered impulse of a series; relay 17 is operated at the end of each odd-numbered impulse; relay 16 is restored at the beginning of each even-numbered impulse; and relay 17 is restored at the end of each even-numbered impulse:

If it be assumed for the moment that the digit being received has a higher value than 1, then a second impulse will be delivered before relay 15 has time to fall back. The second impulse results in the restoration of relay 16 because current flows through the operated armature of relay 17, and through the inner lower armature of relay 16 to the upper winding of relay 16. Relay 16 promptly restores because of the differential action of the upper winding with respect to the lower winding. In order to secure a quick restoring action of relay 16, the upper winding may be made considerably more powerful than the lower winding. When relay 16 lets go responsive to current flow in its upper winding, it opens the circuit of the upper winding at its inner lower contacts, and it opens the locking circuit of the lower windings of relays 16 and 17 at its upper contacts, preventing relay 16 from reoperating when the inner lower contacts open. The upper winding of relay 17 holds the relay operated until the second impulse subsides, whereupon relay 17 falls back.

Since relays 16 and 17 are both in a deenergized condition at the end of the second impulse, the above-described operations of these relays are repeated responsive to the third and fourth impulses, and again for as many pairs of impulses as may be received. The condition of relays 16 and 17 at the end of any digit depends upon whether the digit consists of an odd-number of impulses or an even number. If the number of received impulses is odd, relays 16 and 17 are both in an operated condition at the end of the series of impulses, but they are both deenergized at the end of an even series of impulses.

Returning now to the point at which relay 15 responded to the impulse comprising the digit 1, it will be noted that relay 15 connects up the directing wiper 25 of the selector to the operating magnet 20. Accordingly, upon the energization of relay 16, also responsive to the impulse comprising the digit 1, the placing of ground potential on the fifty-first contact in the bank of wiper 25 at the lower armature of relay 16 closes a circuit through the said fifty-first contact in its bank and wiper 25, lower armature of relay 15 and associated contact, and the self-interrupting contacts of operating magnet 20 to the winding of the magnet. As a result of the closing of this circuit, the magnet 20 operates and drives the wipers 22 to 28 in the direction indicated by the arrows. The wipers take only one step at this time because the circuit of magnet 20 is opened as soon as wiper 25 leaves the fifty-first set of contacts and engages the first set of bank contacts. This is because there is no ground potential on conductor 29, which is connected to the first five contacts in the bank of wiper 25.

Accordingly, since the digit dialled by the calling subscriber is the digit 1, and has only single impulse, conductor 30 remains grounded through the contacts of relay 16, and conductor 29 does not become grounded; with the result that the wipers 22 to 28 of the selector remain on the first contact set until

series relay 15 falls back to start the trunk-hunting operation. However, in order that the operation of the selector S responsive to the dialling of a digit of any value be understood, the operations involved when the first digit dialled is 0 (having ten impulses) instead of 1 will now be described:

It was explained above how the magnet 20 is operated through test wiper 25 responsive to the ground potential placed on conductor 30 by relay 16 to drive the wipers from the fifty-first set of bank contacts into engagement with the first set upon the receipt of the first impulse. Now, when the second impulse is received, in the present assumed case, relay 16 falls back and transfers the ground potential from conductor 30 to conductor 29. Since conductor 29 is connected to the first five contacts in the bank of wiper 25, and, since wiper 25 is standing on the first of the bank contacts, a circuit is closed through wiper 25 for the operating magnet 20, by way of the contacts of relay 15, causing magnet 20 to operate in a buzzer-like manner to advance the wipers over the contacts until wiper 25 leaves the fifth bank contact and stands upon the sixth contact, which is connected to conductor 30, as may be seen in Figs. 1 and 3. Assuming that the impulses are generated by the calling device at the usual rate of about ten impulses a second, about one-tenth of a second elapses between the beginning of any one impulse and the beginning of the next succeeding impulse. Accordingly, the selector S is allowed about one-tenth of a second to advance over five contacts, the minimum allowable rate of advance of the wipers of the selector being about fifty steps a second. This speed is easily attained with this mechanism, as a rotary lineswitch ordinarily attains a speed of about eighty steps a second.

When the third impulse is received at the selector, and relay 16 operates again and transfers the ground potential from conductor 29 to conductor 30, ground potential is placed on the sixth-to-tenth contacts in the bank of wiper 25, as may be seen in Fig. 3. Accordingly, magnet 20 is operated through wiper 25 to advance the wipers of the selector until wiper 25 passes over the grounded sixth-to-tenth contacts in its bank and arrives upon the now-ungrounded eleventh contact.

As the impulses continue to arrive, and relay 16 continues to be operated by the odd-numbered impulses and restored by the even-numbered impulses, the step-by-step advance of the selector continues. The conductor 29 is grounded at the beginning of the fourth impulse, the third group of contacts in the bank of wiper 25 is grounded, whereupon the wipers of the selector are rotated to the first contact set in the fourth group; when conductor 30 is grounded at the beginning of the fifth impulse, the fourth group of contacts in the bank of wiper 25 is grounded, whereupon the wipers of the selector are advanced to the first contact set in the fifth group; the wipers are advanced to the sixth group responsive to the sixth impulse; are advanced to the seventh group responsive to the seventh impulse; are advanced to the eighth group responsive to the eight impulse; and are advanced to the ninth group responsive to the ninth impulse when ground is again placed on conductor 30; and are advanced to the tenth group responsive to the tenth impulse when ground potential is again placed on conductor 29 responsive to the fifth restoration of relay 16 of the selector.

It will be noted that the forty seventh to fiftieth contacts in the bank of wiper 25 have no conductors connected thereto. This will be understood when it is remembered that the wipers are not required to be driven across the contacts of the tenth group under the control of the common directing wiper or test wiper 25. The forty-sixth contact, however, is connected to conductor 30 to enable a busy tone to be returned (in a manner hereinafter explained) in case all trunks in the ninth group are busy when the digit 9 is dialled.

The positioning of the wipers of the selector in accordance with the digit 0, the digit of highest value, having been explained, the positioning of the wipers of the selector in accordance with any digit of lower value will be understood.

Returning now to the point at which the wipers 22 to 28 of the selector are driven from in engagement with the normal set of bank contacts, the fifty-first set, and into engagement with the first set of bank contacts, responsive to the operation of relay 16 when the single impulse of the first digit is received, it will be recalled that relays 16 and 17 remain operated because no further impulses are received. Accordingly the wipers 22 to 28 remain in engagement with the first contact set in the switch bank, which is also the first contact set in the first trunk group.

After a slight interval, relay 15 falls back when the self-induced circulating current traversing its winding in series with the associated resistance element becomes sufficiently attenuated. Upon falling back, relay 15 disconnects the directing wiper from operating magnet 20 at its lower armature and extends the circuit of magnet 20 through the off-normal spring 21 and by way of the inner upper armature of the switching relay 18 to one of the test wipers, 23 or 27, depending upon whether relay 19 is energized or deenergized. The operation occurring now depends upon whether the first trunk line accessible to wipers 22 to 24 is busy or idle, as will now be pointed out.

It will be noted that wiper-switching relay 19 is normally connected to test wiper

23 by way of contacts of switching relay 18. Accordingly, relay 19 is free to energize and deenergize during the primary movement of the switch, depending upon whether the trunk lines encountered by wiper 23 during the primary movement are busy or idle. When wiper 23 arrives on the first contact in its bank, relay 17 is connected to the said wiper through contacts of relay 18. A busy trunk line is marked by ground potential on its release-trunk conductor. Therefore, if the trunk line on which wipers 22 to 24 are standing is busy, relay 19 operates and disconnects wipers 22 to 24 substituting wipers 26 to 28. Relay 19, however, remains in connection with test wiper 23. Under this condition, test wiper 27 of the lower set is the one to which the motor magnet 20 is extended upon the falling back of relay 15. The further operation accordingly depends upon whether the first trunk line accessible to wipers 26 to 28 is busy or idle. If this trunk line is busy, test wiper 27 encounters a ground potential on the release-trunk conductor thereof, closing a circuit through the inner upper armature of the operated relay 19, inner upper armature, normal, of relay 18, off-normal spring 21, and contacts of relay 15, for the operating magnet 20. Operating magnet 20 accordingly operates the wipers 22 to 28 in a buzzerlike manner in search of an idle trunk line.

Upon the first additional step of the wipers 22 to 28, two new trunk lines are encountered by the two regular wiper sets of the selector. If either of these trunk lines is idle, no further rotation of the wipers of the selector takes place. For example, if the trunk line encountered by wipers 22 to 24 is idle, relay 19 falls back immediately upon the second contact set being reached, thereby transferring the motor magnet 20 from wiper 27 to wiper 23. Accordingly, there is no circuit completed for operating motor magnet 20, and the energization of switching relay 18 takes place.

Assuming, however, that the trunk line encountered by wipers 22 to 24 on the second step of the switch is busy, relay 19 remains energized through test wiper 23. In this case, motor magnet 20 remains connected to test wiper 27. Then, if the trunk line terminating in the contacts on which wipers 26 to 28 now stand is busy, motor magnet 20 is again operated. If, on the other hand, this trunk line is idle, the motor magnet is not operated and the switching relay 18 operates.

In order that the operation of the connector C1, Fig. 2, may be explained, it will be assumed that both trunk lines accessible to the selector by way of its second set of bank contacts are busy, in which case the rotary movement of the selector continues, owing to magnet 20 being operated through test wiper 27. It will be assumed further that no idle trunk line is found until the wipers 22 to 28 have been driven into engagement with the fifth and last set of bank contacts in the first trunk group, and that the trunk line accessible by way of wipers 22 to 24 and comprising conductors 31 to 33 is idle. In this case, relay 19 falls back as soon as the fifth bank-contact set is reached, and no further operation of magnet 20 takes place. At this point, switching relay 18, which has been maintained short circuited heretofore by the application of ground potential to the motor-magnet circuit, now energizes from ground potential on the grounded release-trunk conductor 11, through off-normal contacts 21, contacts of relay 15, self-interrupting contacts of operating magnet 20, and the winding of operating magnet 20 to battery. Operating magnet 20 does not operatively energize in series with relay 18 because of the relatively high resistance of the said relay. When relay 18 operates, it opens a point in the test circuit at the resting contact of its inner upper armature; disconnects the deenergized wiper-switching relay 19 from wiper 23 at the contacts controlled by its middle upper armature; at its inner lower armature it disconnects ground potential from the armature of line relay 13 so as to prevent a premature releasing operation; it connects wiper 23 to the incoming release-trunk conductor 11 at its inner upper armature thereby seizing the trunk line and making it busy; and at its upper and lower armatures it disconnects the incoming talking conductors 10 and 12 from the windings of line relay 13 and extends them by way of the upper and lower armatures, normal, of wiper-switching relay 19, wipers 22 and 24, and conductors 31 and 33 to the conductor C1.

In the connector C1, line relay 102, which is bridged across the conductors 31 and 33 in series with the exchange battery and through contacts of back-bridge relay 101, now operates over the calling line and through wipers 22 and 24. Upon operating, line relay 102 closes an operating circuit for the associated release relay 103. Release relay 103 operates and prepares the switch for operation at its lower armature, and it places ground potential on release-trunk conductor 32 at its inner upper armature. The application of ground potential to conductor 32 maintains the conductor 32 marked busy and it maintains a holding circuit for the lineswitch LS and the selector S after the slow-acting release relay 14 of the selector S has fallen back responsive to the opening of its circuit at the contacts of relays 18 and 13.

When the calling subscriber dials the second digit 1 (the tens digit) in the desired number, line relay 102 falls back once momentarily, opening the circuit of relay 103

and closing a circuit for the shunted series relay 104. Relays 103 and 104, like relays 14 and 15 of the selector S, are shunted so as to render them sufficiently slow-acting to remain operated throughout a series of impulses.

When the single impulse is delivered to relay 104, a branch circuit exists through contacts of relay 106 for the lower winding of relay 105. Accordingly, relays 105 and 104 operate at about the same time. Relay 105 completes a locking circuit for itself at its inner upper contacts through the lower winding of relay 106. This locking circuit includes release-trunk conductor 32, grounded at the upper contacts of relay 103, and the inner upper armature of the now-operated series relay 104. Current does not flow through the locking circuit of relay 105 as long as the initial circuit remains intact, as the operating potential and locking potential are both ground potential. As soon as the impulse is over, relay 106 operates in series with relay 105, and shifts the operating circuit directly to its own upper winding, and through the inner lower contacts of relay 105 to the upper winding of relay 105.

By comparing the circuits of relays 105 and 106 with the circuits of relays 16 and 17, it will be noted that relays 105 and 106 have the arrangement hereinbefore described in connection with relays 16 and 17. Therefore, in case a series of impulses is being received, as it is when the digit has a value higher than 1, relay 105 falls back at the beginning of the second impulse because of the differential action of its two windings, but relay 106 does not fall back until the end of the second impulse, as it is held operated by its upper winding.

As the impulses of a series continue to come in, relay 105 operates at the beginning of each odd-numbered impulse and falls back at the beginning of each even-numbered impulse; while relay 106 operates at the end of each odd-numbered impulse and falls back at the end of each even-numbered impulse, all as described in connection with relays 16 and 17.

Now, when relay 105 operates at the beginning of the impulse constituting the digit 1, it shifts ground potential from conductor 118 to conductor 119 at its lower armature. The placing of ground potential on conductor 119 results in ground potential being applied to the fiftieth contact in the bank of directing wiper 124, which is the contact on which wiper 124 is normally standing. Ground potential is accordingly encountered by wiper 124, closing a circuit through the lower contacts of relay 107, lower contacts of the operated relay 104, self-interrupting contacts of magnet 113, and the winding of magnet 113 to battery. Accordingly, magnet 113 operates in the usual buzzer-like manner to advance the wipers 121 to 127. Only one step is taken by the wipers at this time, as when wiper 154 comes into engagement with its fifty-first contact it encounters no ground potential, as ground potential is removed from conductor 118 as long as relay 105 is in operated condition. The wipers are accordingly stopped with one end thereof on the fifty-first set of bank contacts, while the opposite end of the wipers is within one step of the first set of contacts in the switch bank. Therefore, the wipers are in position to be advanced onto the first set of contacts in their bank responsive to the first impulse in the units digit.

At this point, attention may be called to the difference in the wiring of the banks of the directing wipers of the selector S and the connector C1. The wipers 22 to 28 of the selector, as has been pointed out hereinbefore, normally stand on the fifty-first contact set and are arranged so that they advance a single step upon the receipt of the first impulse of a digit and thereby engage the first set of contacts in the bank. The wipers of the connector C1, on the other hand, are normally standing on the fiftieth set of bank contacts and are advanced to the fifty-first set of bank contacts upon the receipt of the first impulse of a digit, and are not advanced to the first contact in the bank until an additional impulse is received. This difference, of course, resides in the different functions of the two switches: the selector receives only a single digit and automatically hunts for a trunk line in the group corresponding to the digit received, while the connector receives two digits, and it is so arranged that, when the final digit is received, it makes connection with the line corresponding to the final digit and lying within the group selected in accordance with the pre-final, or tens digit.

Aside from the different normal positions of the wipers, as above discussed, the connector C1 responds to the first digit received thereby in the same manner as explained hereinbefore in connection with the selector S, always coming to rest within one step of the first set of contacts in the group indicated by the tens digit. For example, when the first impulse of the tens digit is received, the ground potential is shifted from conductor 118 to conductor 119 upon the energization of relay 105, advancing the wipers from the fiftieth set of contacts to the fifty-first set; when the second impulse of the digit is received, ground potential is shifted from conductor 119 to conductor 118 by the deenergization of relay 105, advancing the wipers of the switch, through the control of directing wiper 124, to the fifth set of bank contacts, or to within one step of the first contact set in the second group, when the third impulse is received, ground potential is again shifted from conductor 118 to conductor 119, whereupon the

wipers 121 to 127 are advanced under the control of wiper 124 from the fifth contact set to the tenth contact set or to within one step of the first set of contacts in the group corresponding to the digit 3; etc. In the present case, however, only one impulse is received; the wipers are resting on the fifty-first contact set; and relays 105 and 106 are both in an energized condition at the termination of this impulse.

After a slight interval, relay 104 falls back and disconnects directly wiper 124 from the operating magnet at its lower armature. Relay 104 also opens the locking circuit of relays 105 and 106 at its inner upper armature, at the same time closing a circuit for relay 107. When this occurs, relays 105 and 106 both fall back preparatory to reoperating during the units digit. Changeover relay 107 now operates in a circuit from the grounded conductor 32, through off-normal spring 115 and its associated contact. Relay 107, upon operating, locks itself to conductor 32 at its inner-upper armature. At its lower armature relay 107 disassociates magnet 113 from the directing wiper 124; it prepares a circuit for the two-strap relay 109 at its upper armature; and at its middle-lower armature it prepares a circuit for operating wiper-switching relay 112 and magnet 113 alternately during the receipt of the impulses of the units digit. Accordingly, by the operation of change-over relay 107, the circuits of the connector C1 have been suitably altered to enable the connector to respond properly to the final digit in the number.

When the units digit 5 is dialled, line relay 102 deenergizes five times momentarily, as its circuit is interrupted five times at the calling device on the calling line. Each time it falls back, line relay 102 sends an impulse through the contacts of release relay 103 and by way of the lower contacts of relay 109 to the series relay 104, as before. Relay 104 accordingly operates at the beginning of the units digit and remains operated throughout the series of impulses. Relays 105 and 106 having been restored at the end of the tens digit, as above pointed out, relay 105 is operated in a circuit which includes its lower winding in multiple with the winding of relay 104 when the first impulse of the units digit is received. Relay 105 disconnects the wiper-switching relay 112 at its middle lower armature and connects up operating magnet 113. Accordingly, operating magnet 113 now operates in a circuit from ground by way of the grounded release-trunk conductor 32, inner upper armature of relay 104, conductor 142, inner lower contacts of relay 107, and the middle lower armature of the operated relay 105 to magnet 113. Magnet 113 is thus energized preparatory to advancing the wipers 121 to 127 upon its subsequent denergization. Relay 105 also closes its locking circuit to conductor 132 at its upper armature, which locking circuit includes the lower winding of relay 106 as hereinbefore pointed out, and it also connects up its upper winding at its inner lower armature.

As a further result of the energization of series relay 104 at the beginning of the units digit, a circuit is closed at the upper contacts of relay 104 and through the upper contacts of changeover relay 107 for the upper winding of the two-step relay 109. The upper winding of relay 109 is relatively inefficient. As a result, the relay now operates only its sensitive inner lower contacts, labeled "X". These sensitive contacts close a locking circuit for the two windings of the relay in series. No current flows over this locking circiut for the time being however, because the initial circuit for the relay is still established.

When the first impulse of the units digit subsides and relay 102 reoperates, relay 106 operates in series with relay 105 and transfers the operating circuit to its own upper winding and to the upper winding of relay 105.

When the second impulse of the units digit is received, and line relay 102 falls back again, line relay 102 closes a circuit through contacts of the operated relay 103, through the lower contacts of relay 109, and through the armature of the operated relay 106 for the upper winding of relay 106. At the same time, the upper winding of relay 105 is energized in multiple with the upper winding of relay 106, through the inner lower contacts of relay 105. With both of its windings energized, the differential relay 105 restores, opening the locking circuit through the lower windings of relays 105 and 106 at its upper armature, and disconnecting its neutralizing upper winding at its inner lower armature. Relay 106 remains operated through its upper winding until the termination of the second impulse, whereupon it falls back and again prepares a circuit for the lower winding of relay 105.

Upon the falling back of relay 105 at the beginning of the second impulse, as above pointed out, the circuit of operating magnet 113 is opened at the middle lower armature of relay 105, and the circuit of wiper-switching relay 112 is closed instead. When this occurs, magnet 113 falls back and advances the wipers 121—127 onto the first set of contacts in the first group. Relay 112 operates and prepares a locking circuit for itself at its middle upper armature, which circuit is not closed for the time being, as conductor 141 is disconnected from the grounded conductor 32 at the contacts of the operated relay 104. At its remaining armatures, wiper-switching relay 112 disconnects wiper 121—123 and connects up wipers 125—127.

From the above description, it will be seen that operating magnet 113 was energized at the beginning of the first impulse and respon-

sive to the operation of relay 105, and that it remained energized until the beginning of the second impulse, when its circuit was opened upon the denergization of relay 105; and it will be seen that the wiper-switching relay 112 was energized at the beginning of the second impulse so as to disconnect the normal set of wipers and to connect up the alternate set.

As the succeeding impulses of the units digit 5 continue to arrive, the operation is as follows:

Relay 105 operates at the beginning of the third impulse and disconnects wiper-switching relay 112, substituting magnet 113, whereupon relay 112 falls back and magnet 113 energizes; when differential relay 105 falls back at the beginning of the fourth impulse, magnet 113 is disconnected and relay 112 is again connected up, whereupon relay 112 operates and performs its wiper-switching operation, and magnet 113 falls back and advances the wipers to the second set of bank contacts; and when relay 105 is operated for the third time during the digit, responsive to the beginning of the fifth impulse, it disconnects wiper-switching relay 112 and connects up magnet 113, whereupon relay 112 falls back and magnet 113 operates preparatory to advancing the wipers from the second set of contacts to the third set of contacts in the first group. Relay 106 operates in the usual manner at the end of the third impulse, and relays 105 and 106 both remain energized for the time being, as no more impulses come in.

After a slight interval, the shunted series relay 104 falls back, as no further impulses are received. When it falls back, relay 104 removes ground potential from conductor 142 at its upper armature, thereby opening the circuit of operating magnet 113 and opening the locking circuit for the lower windings of relays 105 and 106, whereupon magnet 113 falls back and, in so doing, advances the wipers 121—127 from the second set of bank contacts in the first group to the third set of bank contacts. Relay 104, at the normally closed contacts controlled by its inner upper armature, also replaces ground potential on conductor 141 so as to close a locking circuit for relay 112 in case this relay is energized at the end of the digit. In the present case, the digit being odd, relay 112 is not in an energized condition, and its locking circuit is therefore not closed. When relay 105 falls back responsive to the opening of its locking circuit at the inner upper armature of relay 104, it closes a point in the circuit of relay 112, but relay 112 does not energize because ground potential is removed from its actuating conductor 142 by the same armature of relay 104 which opens the locking circuit of relays 105 and 106.

When the initial circuit for the upper winding of the two-step changeover relay 109 is opened at the upper armature of series relay 104, current starts to flow through the locking circuit of relay 109, which includes conductor 32, the lightly-adjusted, first-step, inner lower armature and contact of the relay, and the two windings of the relay in series. The lower winding of the relay is an efficient winding, with the result that the relay now operates fully. At its inner lower armature, relay 109 disconnects series relay 104 and relays 105 and 106 from the impulse circuit so as to prevent further operation of relays 104 to 106 in case the calling subscriber should inadvertently dial an additional digit. At its lower armature, relay 109 connects up the common busy-tone lead 117 to the lower talking conductor through contacts of switching relay 111, and at its upper armature, it applies ground potential to the test winding of switching relay 111, through the upper contacts of release relay 103, so as to enable relay 111 to test the called line and determine its busy or idle condition.

It will be recalled that the wipers 121 to 127 have been advanced three steps during the dialling of the units digit, and that wiper-switching relay 112 is in normal position, as shown in the drawings. Accordingly, wipers 121—123 are now standing upon the set of bank contacts to which the line of substation A2 is connected.

The called line busy

Assuming that the called line is in use, there is a ground potential upon the test conductor thereof, to which connection is made by test wiper 122, by way of the contact upon which it is now standing. With ground potential thus encountered by wiper 122, switching relay 111 does not operate, as both terminals of its test winding are connected to the same potential. Under this condition, the connection with the busy-tone lead 117 is not broken and the busy-tone is accordingly returned automatically through contacts of relay 111 and through the lower contacts of relay 109 to the lower talking conductor, and is accordingly heard by the calling subscriber.

Upon hearing the busy tone, indicative of the busy condition of the called line, the calling subscriber understands that the called line is in use. He may accordingly replace his receiver, resulting in the release of the operated switches in a manner to be explained hereinafter.

Calling subscriber waits for busy line to become idle

In case he desires to do so, the calling subscriber may wait for the busy line to become idle. In case he does this, the circuits remain in the condition shown until such time as the called line becomes idle, at which time the switching relay 111 operates to remove the

busy tone and complete the connection in a manner to be hereinafter explained.

Desired line idle when called

It will now be assumed that the line of substation A2 is idle when called. Under this condition, the appplication of ground potential to the left-hand terminal of the upper winding of relay 111 results in the closure of a circuit through the upper winding of relay 111, inner upper armature, normal, of relay 112, test wiper 122, the third contact in its bank, and by way of test conductor 110 of the called line, to battery through the cut-off winding of the associated lineswitch (not shown). The cut-off winding of the lineswitch associated with the called line now operates through the upper winding of relay 111 and disconnects the associated line relay, thereby clearing the called line for the application of ringing current and for talking.

In the connector C1, relay 111 is energized sufficiently by the current flow through the low-resistance upper winding to operate its sensitive inner lower armature to complete a locking circuit for the relay through its lower winding. When this locking circuit is completed, relay 111 operates fully. Upon so doing, it applies ground potential directly to conductor 110 of the called line at its inner upper armature, short circuiting its upper winding; disconnects the busy-tone lead 117 from the lower talking conductor at its inner lower armature; and at its upper and lower armature connects up the line wipers 121 and 123, thereby starting the application of ringing current to the called line. It is to be noted that a copper collar is provided on the upper end of relay 111, indicated by the solid-black upper portion of the relay. This copper collar slows up the operation of relay 111 somewhat, thereby providing additional time for the cut-off relay of the called lineswitch to operate and clear the line before the ringing circuit is established.

Ringing current is applied from the ringing conductor 16, which is alternately grounded and connected to the live pole of the associated grounded generator, and it passes to one conductor of the called line by way of the lower armatures of relays 111 and 112, and by way of wiper 123 and the bank contact on which it is now standing. The return path for the ringing current is by way of the upper conductor of the called line, the third contact in its bank and wiper 121, and the upper contacts of relays 112, 111, and 108, to battery by way of the upper winding of ring-cut-off relay 108. Relay 108, being a standard ring-cut-off relay, does not operate as long as the receiver is not removed at the called substation, because of the inclusion of the usual condenser in the circuit of the ringer at the called substation. The small-capacity condenser 151 permits a sufficient amount of the interrupted ringing current to pass back to the calling telephone by way of the lower talking conductor to provide intermittent buzzing tone in the calling receiver to inform the calling subscriber of the ringing operation.

The called subscriber responds

When the called subscriber responds to the ringing of his bell by removing his receiver, ring-cut-off relay 108 operates as a result of the placing of a direct-current bridge across the conductors of the called line. When it does so, its sensitive inner lower armature closes a locking circuit for the relay through its lower winding. At its upper and lower armatures, relay 108 opens the ringing circuit and completes the talking circuit. When this occurs, back-bridge relay 101 supplies talking current to the called line and it is operated thereover. Upon operating, back-bridge relay 101 reverses the connections between the incoming conductors 31 and 33 and line relay 102, thereby reversing the current flow over the calling line. This reversing operation is, of course, a standard provision, and may be employed for giving supervision to calling operators, and for operating meters, and the like. The two subscribers may now converse with each other as desired.

The release of the established connection

After the conversation has taken place, the two subscribers are expected to replace their receivers. When the receiver is replaced at substation A2, back-bridge relay 101 falls back, whereupon the current-flow over the incoming conductors 31 to 33 is reversed back to its normal direction, but no other circuit change takes place in the connector.

The release of the connector C1

When the subscriber at substation A1 replaces his receiver and opens the talking bridge across his line, line relay 102 of the connector C1 falls back. After an interval, the shunted release relay 103 falls back and removes ground potential from release-trunk conductor 32 at its inner upper armature. When this occurs, the locked relays 107, 108, 109, and 111 fall back, and relay 111 disconnects the wipers 121—123.

At its lower armature, relay 103 closes the restoring circuit for the connector through the off-normal spring 114 and its associated contact and the self-interrupting contacts of the operating magnet 113. Accordingly, magnet 113 operates in a buzzer-like manner in this circuit and advances the wipers 121 to 127 of the connector C1 to the normal position shown in the drawings. When this position is reached, one of the lugs on the cam 128, Fig. 6, engages the tip of spring 115, moving springs 115 and 114 away from their associated contacts. Spring 114 breaks the

circuit of operating magnet 113, enabling the connector C1 to remain in its normal position.

The release of the selector S

As a further result of the removal of ground potential from release-trunk conductor 32 of the connector C1, the switching relay (not shown) of the lineswitch LS falls back because there is no longer ground potential on conductor 11, and switching relay 18 of the selector S falls back. Upon falling back, relay 18 closes a circuit at its inner lower armature through the armature of relay 13, lower armature of relay 14, off-normal spring 41 and its associated contact, and the self-interrupting contacts associated with magnet 20, to the said magnet. Magnet 20 accordingly operates in a buzzer-like manner to advance the wipers 22 to 28 to the normal position shown in the drawings, whereupon the circuit of magnet 20 is opened at off-normal spring 41 by the cam 37, Fig. 4, one of whose lugs engages spring 21 to open both sets of off-normal contacts.

The entire connection is now released and the apparatus involved therein is in readiness to be employed in subsequent connections.

Call from substation A1 to substation A3

In order to explain how a connection is set up through wipers 125 to 127 of the connector C1, it will be assumed that the subscriber at substation A1 desires to converse with the subscriber at substation A3, whose number is 116. The last digit of the number being an even digit, the line of substation A3 is reached through the alternate set of wipers of the connector C1 as shown.

When the receiver is removed at substation A1, the lineswitch LS operates to seize an idle selector, the selector S, for example. The selector S is accordingly prepared for operation in the hereinbefore manner, and it responds to the dialling of the first digit 1 as hereinbefore described. It will be assumed in the present case, as before, that the selector S seizes the trunk line comprising conductors 31—33 and leading to the connector C1, Fig. 2. When this occurs, the line and release relays, 102 and 103, of the connector C1 are operated as hereinbefore described to prepare the connector for operation.

When the second digit 1 is dialled, series relay 104 responds in the usual manner, and relays 105 and 106 operate to control the stepping operation of the connector C1 so as to cause the wipers to be advanced one step as hereinbefore mentioned so that the wipers now stand on the fifty-first set of bank contacts, or within one step of the first set of bank contacts. Relays 105 and 106 automatically release at the end of the digit, when relay 104 falls back; and changeover relay 107 is operated through the off-normal spring 115 and its associated contact.

When the unit digit 6 is dialled, six impulses are delivered by line relay 102 and through the contacts of release relay 103 to relays 104 and 106. Relays 105 and 106 are operated by the first, third, and fifth of the impulses, and they are restored by the second, fourth, and sixth of the impulses. Operating magnet 113 is energized each time relay 105 is operated, and the magnet is accordingly operated and released three times to advance the wipers 121 to 127 three steps. Since the relays 105 and 106 are deenergized by the sixth impulse, wiper-switching relay 112 is energized through the contacts of relay 105 at the end of the digit. The energizing circuit for relay 112 is as follows: from ground by way of the grounded release-trunk conductor 32, inner upper armature of series relay 104, inner lower armature of changeover relay 107, inner lower armature, normal, of relay 105, and through the winding of relay 112 to battery.

Now, when series relay 104 falls back at the end of the impulse series, it opens the initial circuit of relay 112 when it removes ground potential from conductor 142 at its inner upper armature; but, through the make-before-break contacts controlled by the upper armature, it closes a locking circuit for relay 112 over conductor 141 and through the middle upper armature of relay 112 before it breaks the initial energizing circuit. Relay 112 is accordingly locked in an operated condition, and the wipers 125, 126, and 127 remain substituted for wipers 121, 122, and 123. The two-step changeover relay 109, having been energized through its first step at the beginning of tens digit, energizes through its second step in the hereinbefore-described manner at the end of the units digit. It makes an application of busy-tone current to the lower talking conductor at its lower armature, and at its upper armature it applies ground potential to the left-hand terminal of the upper winding of relay 111. At this time, with relay 112 energized, the busy test is performed through test wiper 126 of the lower set. If the test conductor of the line of substation A3 is grounded, relay 111 does not operate, and the busy tone continues to be sent back to the calling telephone to indicate this condition. If, on the other hand, the line is idle, relay 111 operates through the cut-off relay (not shown) of the lineswitch associated with the called line of substation A3. When it operates, relay 111 disconnects the busy-tone conductor 117 and substitutes ring-back tone from the ringing lead 116 through the small condenser 151, and it connects up the wipers 125 and 127 in the ringing circuit.

The subsequent operations are the same as

described hereinbefore. It may be pointed out that wiper-switching relay 112 releases responsive to the removal of ground potential from release-trunk conductor 32 and at the same time that relays 107 to 109 and 111 release.

Additional explanation

It may be pointed out that the sensitive inner lower armature of relay 111 is adjusted with a sufficient degree of stiffness to prevent its operation responsive to the current-flow through the upper winding of the relay in case another connector is testing a called line at the same time. In this way, if two connectors come to rest upon the contacts of the same called line at the same instant, the current flow from the cut-off winding of the lineswitch individual to the called line is divided through the test windings of both connectors, and neither connector can seize the line. This provision is especially valuable in case two or more connectors are standing upon a busy called line waiting for it to become idle. If relay 111 and the similar relays in the other connectors were adjusted sensitive enough to operate on a small fraction of the current that can be obtained through the cut-off winding of a called lineswitch, two or more connectors would be likely to seize the called line at the same time. This, however, is prevented by the above-mentioned adjustment of relay 111.

Using the alternate wiper set of the selector S

Referring now again to the selector S, it will be recalled that wiper-switching relay 19 is operated during the trunk-hunting movement of the selector as long as the trunk lines encountered by wipers 22 to 24 are busy. Now, assume that the digit 1 has been dialled and that the wipers of the selector S are being driven over the first group of bank contacts in search of an idle trunk. If the first eight trunk lines in the group are busy, the wipers 22 to 28 are driven onto the ninth and tenth trunk lines, extending to the connectors C1 and C2, Figs. 2 and 1. If the connector C1 is busy at this time, relay 19 remains operated over test wiper 23 and release-trunk conductor 22, maintaining the wipers 26 to 28 connected up. In this case, if the connector C2 is idle, there is no ground potential on release-trunk conductor 35 thereof, and no ground potential is therefore encountered by test wiper 27. In this case, switching relay 18 of the selector is no longer short circuited and it operates in its previously-traced circuit including motor magnet 20. Upon operating, relay 18 at its inner upper armature extends the incoming release-trunk conductor 11 by way of the inner upper armature of the operated wiper-switching relay 19, and through test wiper 27 to release-trunk conductor 35 of the connector C2; it opens a point in the restoring circuit at its inner lower armature; and at its upper and lower armatures it disconnects the incoming conductors 10 and 12 from the windings of line relay 13, and extends them by way of the upper and lower armatures of the operated relay 19, and through wipers 26 and 28, to the corresponding conductors 34 and 35 leading to the connector C2. As a further result of its operation, relay 18 completes a locking circuit for wiper-stitching relay 19 at its middle upper armature, at the same time disconnecting relay 19 from test wiper 22. The locking circuit for relay 19, of course, includes the switched-through release-trunk conductor of the connection now established to the connector C2, which conductor is grounded for the time being at the upper contacts of the shunted release relay 14. Ground potential is, of course, returned over release-trunk conductor 35 from the connector C2 before the shunted release relay 14 has had time to fall back responsive to the operation of relay 18. Relay 19 falls back at the same time that relay 18 does, responsive to the subsequent removal of ground potential from conductor 35 at the connector C2.

All trunks busy in selected group

The operations occurring when the selector S is unable to find an idle trunk in a selected group will now be explained. It will be recalled that relays 16 and 17 are both in an energized condition or both in a deenergized condition at the end of the dialling of a digit, depending upon whether the digit is an odd digit or an even digit. If the digit is odd, relays 17 and 18 are energized, in which case conductor 30 is grounded and conductor 29 is ungrounded, while the reverse condition is true in case the digit dialled is an even digit. In any event, the wipers 22 to 28 of the selector are advanced by wiper 25 during the dialling of the digit until wiper 25 (see Fig. 3) is in engagement with a contact connected to the ungrounded one of the conductors 29 and 30. The completion of the primary or group-selecting movements of the selector is finished, of course, before series relay 15 falls back shortly following the end of the digit. When relay 15 falls back, in addition to connecting magnet 20 to the test circuit including the inner upper armatures of relays 18 and 19 and off-normal contacts 21, relay 15 at its inner lower armature and associated resting contact, connects magnet 20 directly to the directing wiper 25. This, however, is without effect as long as the wipers of the selector are not driven beyond the selected group of bank contacts. If the wipers are driven beyond the selected group of bank contacts, however, wiper 25 encounters a bank contact of the next succeeding group, which is grounded by way of conductor 20

or conductor 30, depending upon whether the digit dialled was odd or even. When wiper 25 encounters this grounded contact, magnet 20 is operated through the resting contact and inner lower armature of relay 15 and through wiper 25. Upon operating, magnet 20 opens the test circuit at its self-interrupting contacts thereby preventing the energization of relay 18 in case the first trunk line in the next group is idle. It will be apparent that no further advance of the wipers of the selector can take place as long as magnet 20 is continuously energized through wiper 25. In this way, the selector S is prevented from seizing the first idle trunk line in the next succeeding trunk group. It will be understood, of course, that a wrong number would result if this precaution were not taken. In order to inform the calling subscriber of the busy condition of all the trunks in the selected group, the operating magnet 20 is arranged to connect a source of trunk-busy tone to the lower talking conductor at its left-hand contacts. The circuit of the trunk-busy tone is from the left-hand winding of the transformer 76 through the lower contacts of relay 15, resistance 75, and through the left-hand contacts of operating magnet 20 to the lower talking conductor. The calling subscriber is informed of the busy condition of the trunk group when he hears the tone from the transformer 76. He is expected to replace his receiver and release the selector S and the calling lineswitch.

In case a calling subscriber should disregard the trunk-busy tone and proceed to dial the remaining digits in the desired number, the delivery of impulses to relays 15 to 17 by line relay 13 would destroy the established all-trunks-busy condition in the selector S and cause the wipers of the selector to be driven into engagement with an idle trunk line in an unwanted group, if line relay 13 were permitted to follow the additional digits. Line relay 13, however, is prevented from following the additional digit as will now be pointed out. It will be noted that a circuit now exists through the lower winding or relay 13, left-hand contacts of magnet 20, resistance 75, lower contacts of relay 15, and the left-hand winding of transformer 76 to battery. Accordingly, the lower winding of relay 13 is maintained energized in this local circuit each time its circuit is momentarily interrupted at the contacts of the calling device on the calling line, thus preventing relay 13 from responding to the interruptions in constituting the subsequent digits. The resistance 75 in this circuit serves two purposes: (1) it limits the flow of trunk-busy tone, thereby preventing an uncomfortably loud tone from being heard at the calling telephone; and (2) it limits the current flow in the local circuit of the lower winding of line relay 13 to a relatively small value so that line relay 13 will release a short time after the receiver is replaced on the calling line, but it will not release when its circuit is opened only momentarily as it is during the dialling of the additional digits.

It is to be noted that the above-traced local circuit for the lower winding of line relay 13 is not closed during the regular primary or group-selecting movement of the selector S, because series relay 15 is operated during such movement, maintaining the local circuit open at its lower armature. It is true, of course, that the local circuit of the lower winding of line relay 13 is closed momentarily each time magnet 20 operates during the regular trunk-hunting movement of the selector, but this is without any particular effect at the selector S. The calling subscriber of course hears a series of short buzzes from the trunk-busy-tone transformer 76, but the subscribers soon learn that this is part of the regular, normal operation of the system.

When the calling subscriber replaces his receiver after receiving the trunk-busy tone from transformer 76, and in the manner above pointed out, the regular circuit of line relay 13 over the two conductors of the calling line in series is opened, leaving the local circuit of the lower winding of line relay 13 established through contacts of magnet 20 and the relatively high resistance 75. Owing to the small amount of current that can flow in this circuit, relay 13 shortly falls back, opening the circuit of the shunted release-relay 14, and closing the circuit of series relay 15. Relays 15 and 16 respond, opening the circuit magnet 20. Release relay 14 falls back after a slight interval. When it does so, it opens the circuit of relay 15 at its inner lower armature, and it removes ground potential from conductor 77 at its inner upper armature, permitting relays 16 and 17 to fall back if they are energized at this time. With conductor 77 ungrounded, there is no ground potential on either conductor 29 or conductor 30; accordingly, the restoring operation is not interfered with. When relay 14 falls back, it also completes the regular restoring circuit at its inner lower armature, which circuit includes off-normal spring 41 and the self-interrupting contacts of magnet 20. Magnet 20 thereupon operates in a buzzer-like manner to drive the wipers 22 to 28 to their normal positions, whereupon the restoring circuit is opened at off-normal spring 41.

What is claimed is:

1. In combination, an automatic switch, groups of lines terminating in the bank of said switch, and means responsive to each impulse of successive impulses transmitted to said switch for initiating an automatic

hunting movement which drives the switch over a group of lines.

2. In combination, an automatic switch, groups of lines terminating in the bank thereof, said switch being arranged to respond to a series of impulses and being of a fast-operating type so that it will move over a group of lines during an impulse cycle, and means responsive to each impulse of a series and independent of the end of such impulse for driving said switch into association with the next succeeding group of lines.

3. In an automatic switch having a free-hunting movement to select any desired one of a plurality of groups of contacts in the bank thereof, marking means responsive to each received impulse for making an altered group marking in the bank of said switch, and means responsive to each group marking and independent of any further marking for driving said switch to a contact group depending jointly upon the effected marking and upon the previous position of said switch.

4. In an automatic switch having access to bank contacts arranged in groups, a control relay in said switch, means for operating and releasing said relay repeatedly a number of times depending upon the value of a received digit, and means effective each time said relay is operated and each time said relay is restored for advancing said switch into association with the next succeeding group of contacts.

5. In combination, an automatic switch arranged to be set into a position corresponding to the value of a received digit, counting relays arranged to respond to the received impulses of a digit, means for repeatedly operating and restoring said counting relays during the receipt of the digit, and means controlled by the operations and restorations of said counting relays for positioning said automatic switch in accordance with the value of the received digit.

6. In an automatic switch, wipers each having a row of contacts over which it is arranged to be driven, said contacts being divided into groups, one of said wipers being a directing wiper, means for operating the wipers of said switch responsive to operating potential encountered by said directing wiper, and means for operating said switch to any desired extent by alternately placing operating potential on the even-numbered and odd-numbered groups of contacts in the bank of said directing wiper.

7. In an automatic switch, a group of wipers each arranged to be driven over a separate row of bank contacts, said bank contacts being arranged in groups, one of said wipers being a directing wiper, an operating magnet for driving said wipers responsive to potential supplied thereto through said directing wiper, means in said switch responsive to a series of impulses, said means being arranged to place an operating potential on the even-numbered contact groups in the bank of said directing wiper responsive to each odd-numbered impulse received, said means being responsive to each even-numbered impulse received for placing said operating potential on the odd-numbered contact groups in the bank of said directing wiper, said operating magnet being effective in each case to drive the wipers of said switch as long as said directing wiper encounters operating potential.

8. In an automatic switch arranged to receive series of impulses, wipers having separate rows of companion bank contacts arranged in groups, said wipers having a normal position, a relay, circuit arrangements for operating said relay responsive to the first-received impulse of a series, circuit arrangements responsive to the said operation of said relay for driving the wipers from normal position into association with the first group of bank contacts, and circuit arrangements for restoring said relay responsive to the second received impulse, the said driving means of the switch being responsive to the said restoration of said relay to drive the wipers of the switch into association with the second group of bank contacts.

9. In an automatic switch as claimed in claim 8, the said circuit arrangements associated with said relay being effective to reoperate said relay responsive to each succeeding odd-numbered impulse in a series and to restore the relay responsive to each succeeding even-numbered impulse in a series, and the said driving means being effective responsive to each succeeding operation and restoration of said relay to drive the wipers of the switch into association with the next succeeding group of bank contacts.

10. In combination, lines divided into groups, an automatic switch having access to all of said groups of lines, said switch being arranged to receive a series of impulses corresponding in number to any desired one of said groups of lines, said switch having wipers and companion groups of contacts through which connection may be made to any one of said lines, driving means for said switch responsive to the first-received impulse for driving said wipers into association with the first group of bank contacts before the second impulse is received, said driving means being also responsive to the beginning of each succeeding impulse for driving the wipers over all the contacts in the group with which it is associated and into association with the next group of contacts before an additional impulse is received.

11. In a trunking system, lines divided into groups, an automatic trunking switch having corresponding groups of bank contacts to

which said lines are connected, wipers co-operating with said bank contacts, a directing wiper arranged to guide said switch into association with a desired group of lines, a test wiper arranged to guide said switch into association with an idle line in a desired group, said switch being arranged to receive a series of impulses indicative of the group with which connection is desired, a self-interrupting driving magnet in said switch, a series relay in said switch arranged to be operated responsive to the first impulse of a series and to remain operated throughout the series of impulses, contacts on said series relay for connecting said self-interrupting driving magnet to said directing wiper during the receipt of a series of impulses so that the magnet may be controlled through said directing wiper to drive the wipers into association with the group corresponding to the received series of impulses, the said contacts on the series relay being effective when the said relay falls back at the end of a series of impulses for substituting said test wiper for said directing wiper so as to enable the driving magnet to be operated to associate the wipers of said switch with an idle line in the selected group.

12. In a selector switch, a group of wipers including a directing wiper, an operating magnet having self-interrupting contacts, said switch being arranged to receive a series of impulses indicative of a desired setting thereof, a relay in said switch arranged to be operated at the beginning of the series of impulses and to be restored at the end of the impulse series, and means controlled by said relay for connecting said operating magnet to said directing wiper through said self-interrupting contacts when the relay operates at the beginning of a series of impulses, and to connect said directing wiper and said magnet together independent of said self-interrupting contacts when the relay falls back at the end of a series of impulses.

13. In combination, a bank of contacts arranged in groups, each group comprising a plurality of sets of contacts, a set of wipers arranged to be driven over said contact sets successively, an operating magnet, means for operating said magnet intermittently to drive said wipers over said contact until a desired group of bank contacts has been reached, additional means for operating said magnet intermittently to drive said wipers over the contacts in a selected group to bring the wipers into association with an idle contact set, and means effective in case the wipers are driven beyond the last set of contacts in a selected group for maintaining said operating magnet energized continuously in order to prevent further advance of the wipers.

14. In a trunking switch having wipers arranged to be driven over a bank of contacts, said contacts being divided into contact groups, one of said wipers being a directing wiper, said switch being arranged to receive a series of impulses indicative of a group of contacts, a series relay arranged to be operated during the receipt of the series of impulses and to be restored at the end, means responsive to the impulses of said series for placing operating potential on certain groups of contacts in the bank of said directing wiper, circuit arrangements effective while said series relay is operated for advancing the wipers of said selector switch as long as the said directing wiper encounters said operating potential, additional circuit arrangements effective after said series relay falls back for causing the advance of said wipers independent of said directing wiper, and circuit arrangement depending upon said series relay being in a restored condition for preventing the advance of said wipers responsive to said directing wiper encountering said operating potential.

15. In combination, a selector having access to a plurality of groups of lines, a line conductor incoming to said selector, a quick-acting line relay arranged to respond to directing impulses delivered thereto over said line conductor to set said selector on a group of lines, means for testing the line of a selected group and for seizing an idle one of them, and means effective in case no idle line is found for rendering said line relay slow acting to prevent it from responding to subsequent directing impulses.

16. In combination, a selector arranged to be controlled from a calling line and having access to a group of lines, a motor magnet, and means for intermittently operating it to advance said selector over said lines, means effective in case said selector is unable to find an idle line in said group for reoperating said motor magnet, and means controlled by said motor magnet for sending a busy indication back to the calling line while it is reoperated.

17. In a telephone system, a single-motion automatic switch having access to groups of lines, a motor magnet for advancing said switch, means for transmitting two series of impulses to said switch, circuit arrangements for operating said motor magnet a plurality of times for each impulse of the first series of impulses except the first, and circuit arrangements effective during the record series of impulses for operating said motor magnet only a single step for each pair of impulses received.

18. In a telephone system, an automatic switch having access to a group of subscribers' lines, said switch having two sets of wipers through which connections are made to subscribers' lines and a wiper-switching relay for selecting wiper sets, a motor magnet arranged to advance said wipers, said switch being arranged to receive impulses

comprising a digit indicative of a desired one of said lines, means independent of said wiper-switching relay responsive to the impulses of a received digit for operating said motor magnet once for each pair of impulses received, and means depending upon whether the received digit contains an even number of impulses or an odd number of impulses for operating said wiper-switching relay or for permitting it to remain normal.

19. In a telephone system, an automatic switch having access to a group of subscribers' lines, said switch being arranged to receive impulses constituting a digit indicative of a desired line, said switch having two wiper sets and a wiper-switching relay for controlling the connecting up of either set of wipers to the exclusion of the other, a motor magnet for operating said switch, and means effective during the receipt of the impulses of a digit and independent of said magnet and said relay for operating said motor magnet and said wiper-switching relay responsive to respective alternate impulses.

20. In combination, an automatic switch having a primary movement to select a group of contacts and having a secondary movement to select a particular contact in a selected group, a group of counting relays, means for operating said counting relays a plurality of times during the receipt of the impulses of the digit indicative of the desired group of contacts, means operative coincident with the operations of said counting relays for positioning said automatic switch upon the desired group of contacts, means for automatically releasing said counting relays in case they are operated at the end of a group-indicating digit, said counting relays being responsive in a similar manner to the impulses of a digit indicating the desired contact in the selected group, the said operating means of the switch being responsive to the last-named operations of said counting relays to position the switch on the desired set of bank contacts.

21. In combination, an automatic switch having incoming talking conductors, said switch having access to a group of lines, means for positioning said switch on a desired line responsive to directive impulses received over one of said incoming conductors and for applying busy tone current to one of said incoming conductors, and means automatically effective dependent upon the called line being idle for stopping the application of busy-tone current and for seizing the called line.

22. In a telephone system, an automatic switch having access to a group of lines, means for setting up a connection from a calling line to said automatic switch and for positioning said switch upon the contacts of a desired line responsive to received directive impulses, means effective independent of the busy or idle condition of the called line for transmitting a busy indication back to the calling line, and means dependent upon the called line being idle for substituting an idle indication for the busy indication.

23. In an automatic switch having an incoming conductor and having access to a group of subscribers' lines, a test relay in said switch for testing called lines, means responsive to directive impulses received over said incoming conductor for positioning said switch on the contacts of the desired line, means thereupon effective for closing a busy-tone connection to said incoming conductor and for rendering said busy-test relay able to test the called line, and contacts controlled by said busy-test relay and dependent upon said busy-test relay finding the called line idle for opening said busy-tone connection.

24. In combination, an automatic switch having access to a group of lines, means for positioning said switch on a desired line, means thereupon effective independent of the busy or idle condition of the called line to close a test circuit for testing the called line and for maintaining said test circuit intact indefinitely in case the called line is busy, and means controlled over said test circuit responsive to the called line becoming idle for completing a connection to the called line.

25. In combination, an automatic switch having groups of lines terminating in the banks thereof, a pair of impulse-responding relays, means for operating and restoring said relays responsive to alternate impulses of a series, and means including said relays and responsive to each impulse of a received series for driving said switch into association with a new group of lines.

26. In an automatic switch having access to bank contacts arranged in groups, a control relay in said switch, means for operating said switch responsive to one impulse of a received series and for restoring it responsive to the next succeeding impulse, means controlled by said relay for making a group marking in the bank of said switch when it operates and for making a different group marking in the bank of said switch when it is restored, and means responsive to each of said markings for advancing said switch into association with the next succeeding group of contacts.

27. In an automatic switch having access to bank contacts aranged in groups, a marking conductor associated with the contacts in each odd-numbered group and another marking conductor associated with the contacts in each even-numbered group, means for applying marking potential to said marking conductors alternately, and means effective each time said marking potential is applied and

dependent upon the continued application of said marking potential for driving said switch over an entire group of contacts.

28. In combination, an automatic switch having groups of lines terminating in the bank thereof, said switch being arranged to respond to a series of impulses and being of a fast-operating type so that it will move over a group of lines during an impulse cycle, and means in said switch responsive to each impulse of a series for initiating a driving operation to drive said switch into association with the next succeeding group of lines, said means being effective to continue the said driving operation once it has commenced and independent of any further external control until the next succeeding group of lines has been reached.

29. In a telephone system, an automatic switch having access to a group of lines, an operating magnet for said switch, means for controlling said operating magnet to drive the switch into association with a desired group of lines, and means responsive to a series of impulses indicative of a desired line in the desired group for operating said motor magnet only a single step for each pair of impulses.

30. In a telephone system, an automatic switch having access to subscribers' lines divided into groups, said switch being arranged to receive a series of impulses indicating a desired group and to receive a further series indicative of a desired line in the desired group, a motor magnet in said switch and means for operating it responsive to the first series of impulses to bring the switch into association with the desired group of lines, said switch having two wiper sets and a wiper-switching relay for controlling the connecting up of either set of wipers to the exclusion of the other, and means effective during the receipt of the final series of impulses for operating said motor magnet and said wiper-switching relay responsive to respective alternate impulses.

31. In a telephone system, an automatic switch having access to subscribers' lines divided into groups, said switch being arranged to receive a series of impulses indicating a desired group and to receive a further series indicative of a desired line in the desired group, a motor magnet in said switch and means for operating it responsive to the first series of impulses to bring the switch into association with the desired group of lines, said switch having two wiper sets and a wiper-switching relay for controlling the connecting up of either set of wipers to the exclusion of the other, means effective during the final impulse series for operating said operating magnet only once for each successive pair of impulses, and means for securing the operation of said wiper-switching relay following the final impulse or not, depending upon whether the number of impulses is even or odd.

32. In combination, an automatic switch responsive to a series of impulses, said switch having a magnet for advancing it to an extent depending upon the number of impulses in a received series, two operating conductors for said switch, means for repeating received impulses over said operating conductors alternately, and means including a wiper of said switch for associating said operating magnet with said operating conductors alternately, whereby the switch is driven to the desired extent.

33. In combination, an automatic switch having an operating magnet for driving it into a desired position, a pair of operating conductors, means for placing an operating potential on one of said operating conductors and for shifting the operating potential to the other of said conductors each time a new impulse in a received series is received, and means including a wiper of said switch for associating the operating magnet with said operating conductors alternately, whereby the switch is driven into the desired position.

34. In combination, an automatic switch having an operating magnet, a pair of operating conductors over which said magnet is arranged to be operated alternately, means responsive to each odd-numbered impulse of a series for applying operating potential to the first of said operating conductors and for maintaining it applied until the next impulse arrives, and means responsive to each even-numbered impulse of a series for applying operating potential to the other operating conductor and for maintaining it applied until the next impulse arrives.

35. In combination, an automatic switch arranged to be positioned responsive to a series of incoming impulses, an operating magnet for positioning said switch, and a pair of translating relays responsive to each impulse received at the line relay to deliver an impulse to said operating magnet of the approximate length of a complete incoming-impulse cycle of the line relay.

In witness whereof we hereunto subscribe our names this 27th day of February, 1931.

JOHN WICKS.
RODNEY G. RICHARDSON.
JOHN I. BELLAMY.