Feb. 1, 1938. R. MERCER 2,106,897

AUTOMATIC OR SEMIAUTOMATIC TELEPHONE SYSTEM

Filed Feb. 9, 1935 5 Sheets-Sheet 1

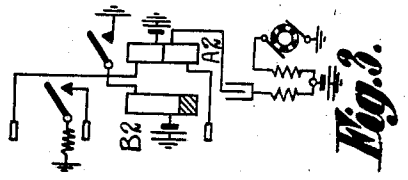

Fig. 3.

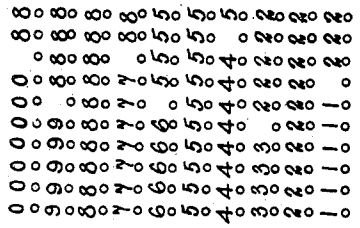

Fig. 2.

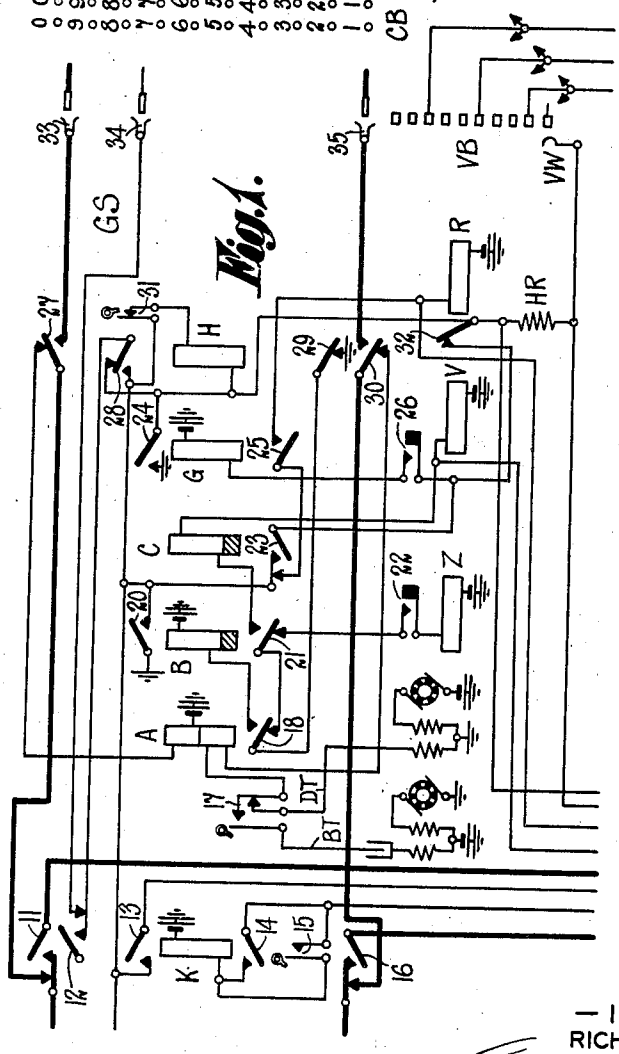

Fig. 1.

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AUTOMATIC OR SEMIAUTOMATIC TELEPHONE SYSTEM

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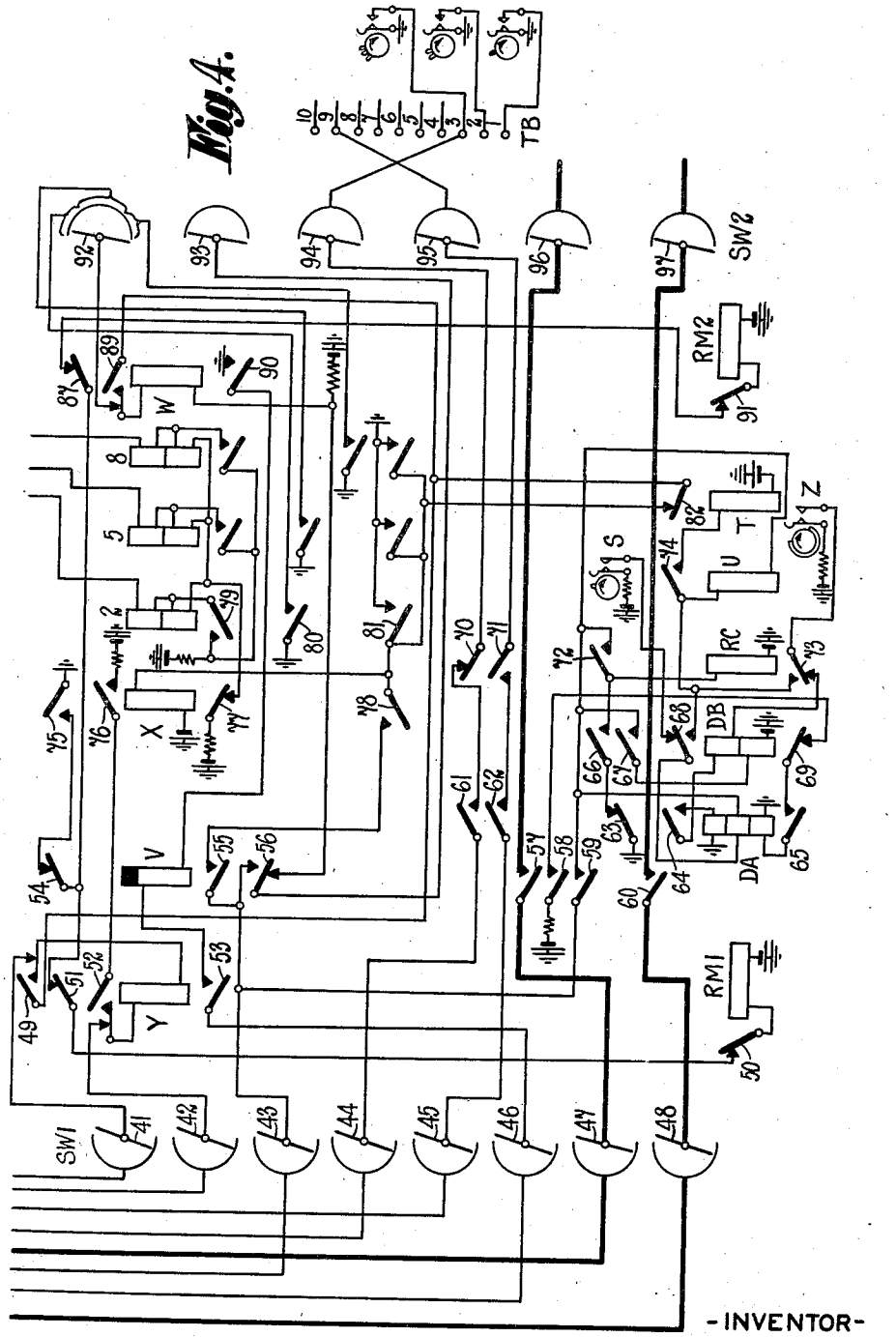
Fig. 4.



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AUTOMATIC OR SEMIAUTOMATIC TELEPHONE SYSTEM

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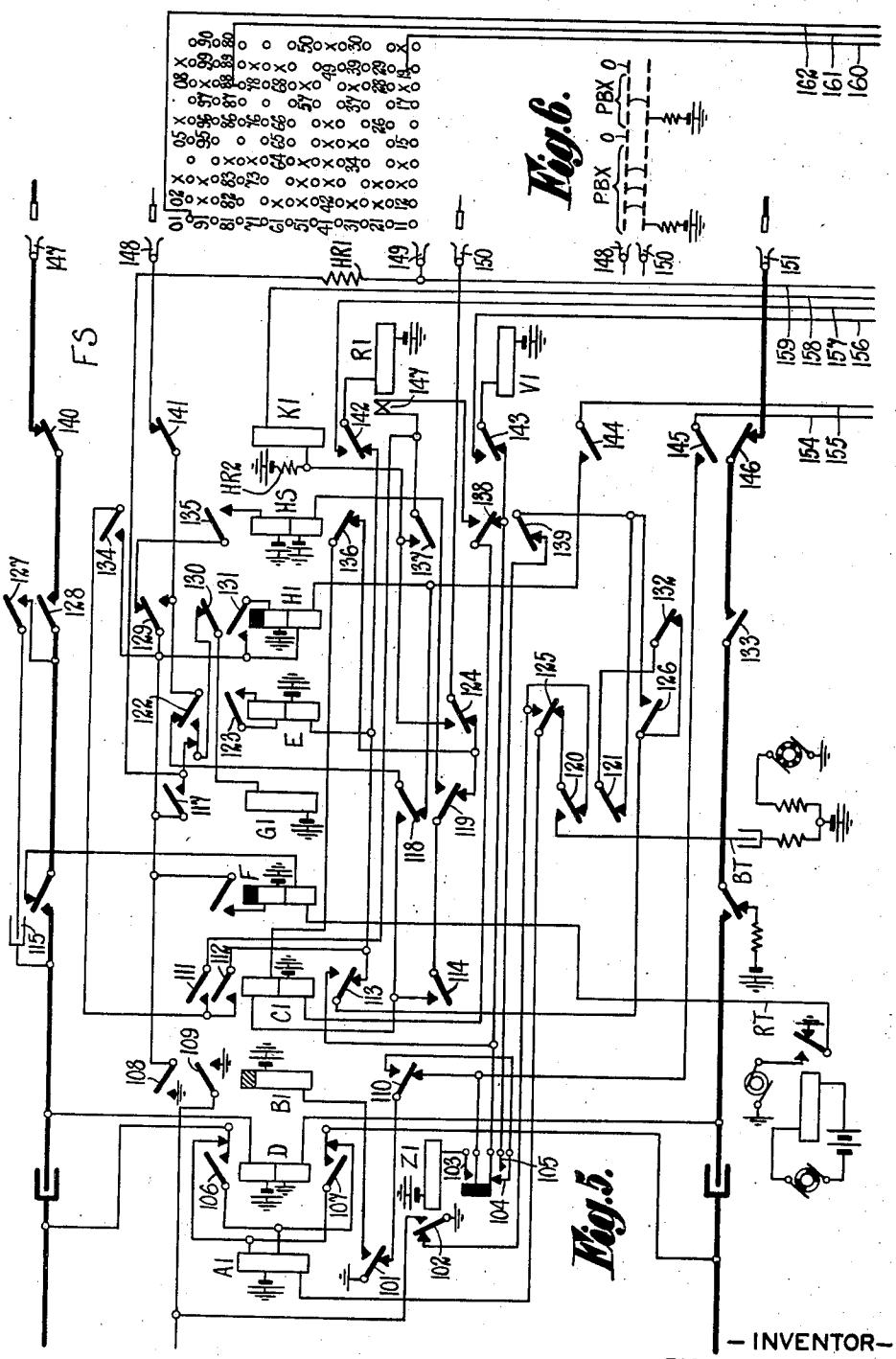

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AUTOMATIC OR SEMIAUTOMATIC TELEPHONE SYSTEM

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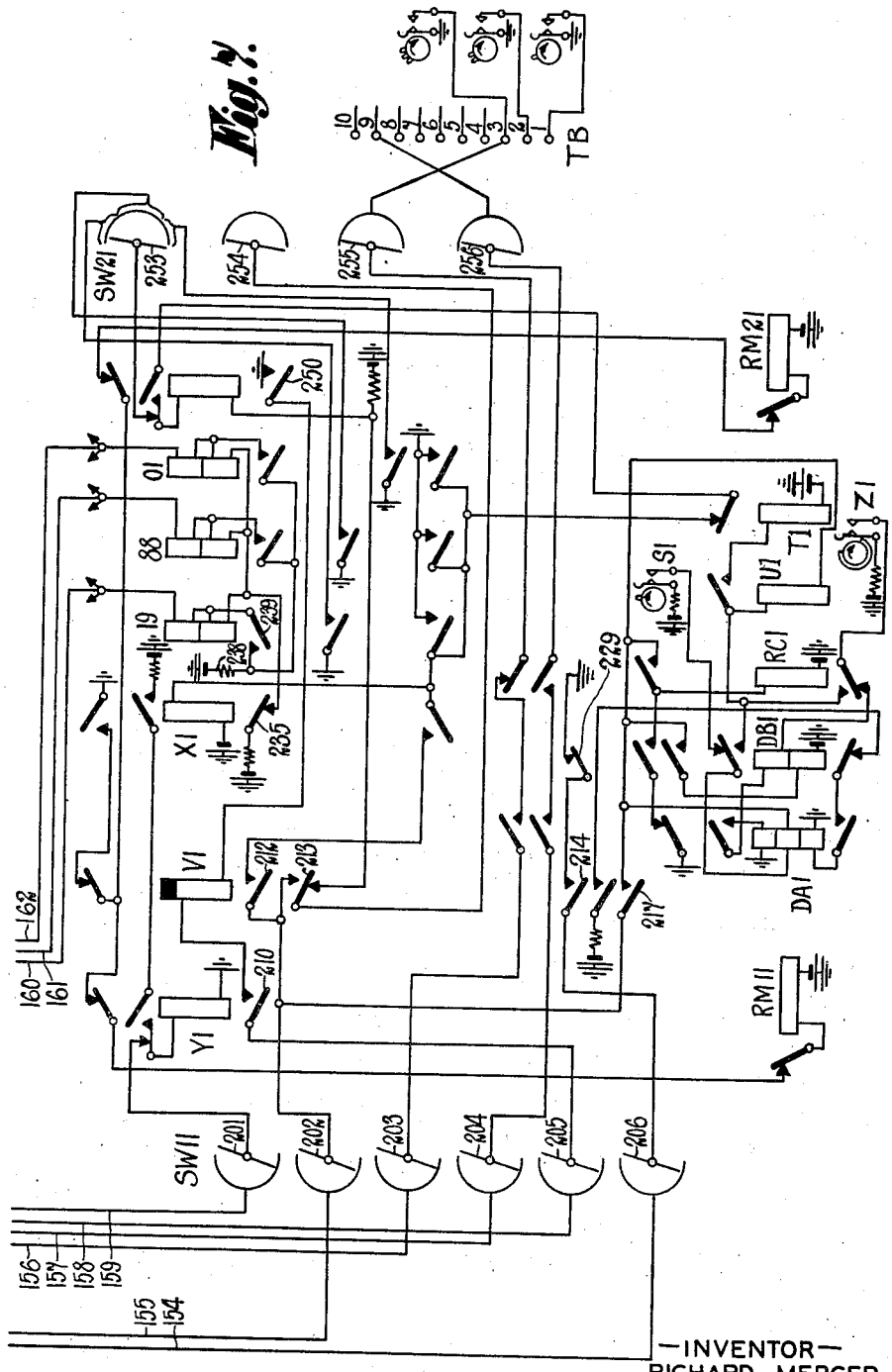
Fig. 4.



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AUTOMATIC OR SEMIAUTOMATIC TELEPHONE SYSTEM

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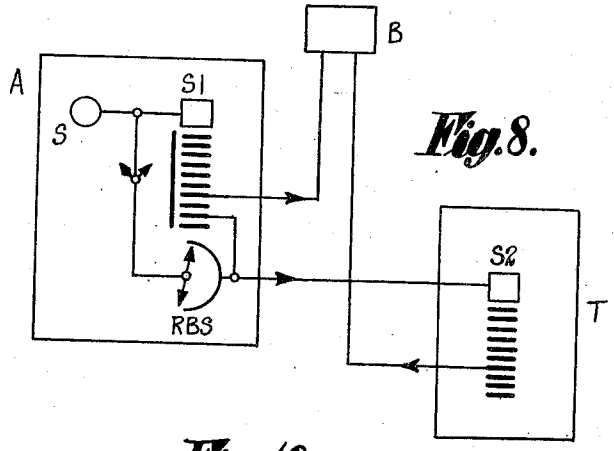


Fig. 8.

Fig. 10.

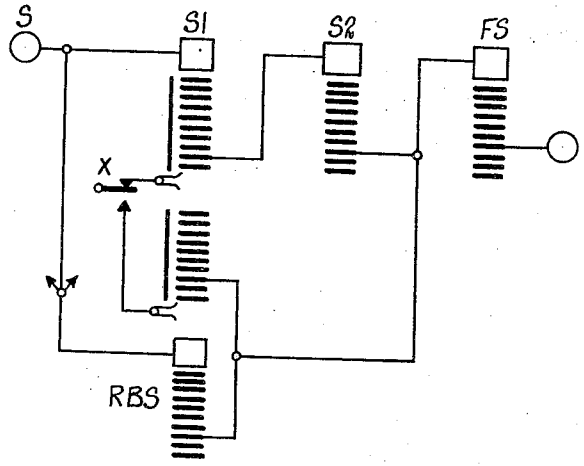
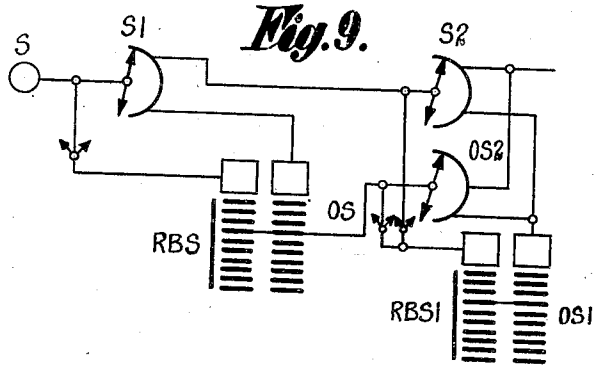


Fig. 9.



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Patented Feb. 1, 1938 2,106,897

UNITED STATES PATENT OFFICE

2,106,897

AUTOMATIC OR SEMIAUTOMATIC TELEPHONE SYSTEM

Richard Mercer, Kenton, England, assignor to Associated Electric Laboratories, Inc., Chicago, Ill., a corporation of Delaware

Application February 9, 1935, Serial No. 5,735
In Great Britain February 21, 1934

9 Claims. (Cl. 179—18)

The present invention concerns improvements in or relating to automatic or semi-automatic telephone systems.

A particular object of the invention is to effect economies in such systems by ensuring that the bank contacts of some, if not all, of the switches employed in such systems are used more efficiently.

Broadly speaking, the invention is characterized by the provision of two switches adapted to work in combination during the setting up of a connection. One switch over which the connection will be set up will be referred to as a selector switch and the other switch, which need only be used temporarily, will be referred to as an auxiliary switch.

According to the invention, the auxiliary switch differs from the selector switch in that it is either of a different type of construction or it has a different form of control, or it may have both a different type of construction and a different type of control, the auxiliary switch and the selector switch being arranged to have access to the same line or lines, or at least to the test contacts of the same line or lines, but one switch is arranged to have access to lines to which the other switch does not have access, the arrangement being such that when it is determined that the connection is to be set up over a line to which both switches have access the auxiliary switch which is first caused to select such line is arranged to control the establishment of the connection via the selector switch and the line determined by the setting of the auxiliary switch.

In order to appreciate how the auxiliary switch may differ from the selector switch, the following examples are given:

The selector switch and the auxiliary switch may have their operations initiated at different times, for instance, the auxiliary switch need not be taken into use until after the operation of the selector switch has been initiated and in certain cases when the taking into use of the auxiliary switch is dependent upon whether a certain line or lines are available or not for completing a connection the auxiliary switch may not be required at all.

The selector switch may be of the up-and-around type having access to 100 contacts or multiples thereof, while the auxiliary switch may be of the uni-selector type having motion in only a single direction or vice versa.

The selector switch may be of the crossbar type and the auxiliary switch of the uniselector or up-and-around type and vice versa.

The selector switch and the auxiliary switch may be of the same type but one could be arranged to respond to impulses from a distance and the other could be arranged to hunt automatically.

It is to be noted that the invention is intended to avoid covering the case of a selector switch and an auxiliary switch being of the same type and controlled in the same way, as it will be evident having regard to the applications of the invention referred to hereinafter that such a combination covers a very restricted field.

The invention as stated above is capable of a large number of very diverse applications, of which the following are set out by way of example:

Firstly, the invention may be applied to a group selector to enable the groups of lines to which such group selector has access to be varied in size independently of its construction or manner of operation, and for this purpose the auxiliary switch is arranged to have access only to those lines or test contacts of those lines to which the group selector has access and which cannot be selected by the normal operation of the group selector, said auxiliary switch which is first operated to select such a line being further arranged in the event of all lines in the group which can be selected by the normal control of the selector being busy to set up the connection via the group selector to the line determined by the setting of the auxiliary switch. For instance, if the group selector is of the type in which the contacts are arranged in different rows or levels, the groups of lines can be made of larger size than the capacity of a level and for this purpose the auxiliary switch takes the form of a hunting switch arranged both to hunt for a particular group as well as to hunt for an idle line in the group and conveniently can take the form of a switch having movement in a single direction only. The auxiliary switch is arranged to have access only to those contacts of a group which are not located in the row or level normally allocated to that group and is arranged to be used in the event of all the lines in the level allocated to the group required being busy to establish an overflow connection and to control the setting of the selector switch on to a contact in another row to which the line selected by the auxiliary switch is also connected. It will be clear that the auxiliary switch only requires to be used for calls to a group of lines which is larger than the normal capacity of a row or level and that it can be entirely dissociated from

the switch once the selector switch has itself established a through connection, whether on its original operation or after it has been reset.

Secondly, the invention may be applied to a final selector, whether one having access to single subscriber's lines only or one having access to groups of P. B. X. lines, or one having access both to single lines and to P. B. X. lines, and according to this feature of the invention it is possible to allow any subscriber whatever his number to have an additional line as long as there is a vacant contact anywhere on the switch. In this case the selector switch may be a final selector of any type whatever, while the auxiliary switch takes the form of a switch having access to those lines or test contacts of those lines which cannot be reached by the normal operation of the final selector, which auxiliary switch after being first controlled to select an idle line of the particular subscriber required is arranged if it is determined that the connection is to be set up over a line to which both the auxiliary switch and the final selector switch have access to control the operation of the final selector so as to set it on to the line determined by the setting of the auxiliary switch. The auxiliary switch obviously need only be operated when connection is required to a subscriber having additional lines not directly accessible in response to the dialling of his number and then only if the line or lines reached by the original setting of the selector switch are busy. The function of the auxiliary switch, in the event of there being no line free which can be reached by the original operation of the final selector switch, is to cause the final selector switch to be set on to contacts to which the line found by the auxiliary switch is connected.

It should be pointed out that in a group selector, particularly where the control of the group selector is effected directly by a subscriber's impulse sender, there may not be sufficient time for a selector switch to be reset, in which case the auxiliary switch requires to be used as an overflow connection. In a final selector the dialling operation has finished and an overflow connection through the auxiliary switch is not essential, also if a group selector is operated from a register sender it might be arranged to delay the sending of impulses until the group selector had been reset and in such cases it is only necessary for the auxiliary switch to have access to the test contacts of the lines to which the selector switch has access.

Thirdly, the invention may be applied to alternative routing, that is to say, to arrangements in which a connection can be set up over a more direct route in normal conditions and only when such connections are impossible can it be set up over a more indirect route. Usually, "alternative routing" takes the form of routing between exchanges, that is to say, calls from one exchange to another may be normally set up over a direct junction between such exchanges but if all the direct junctions between such exchanges are busy then the connection can be set up via a tandem exchange. In such arrangements the selector switch could take the form of a group selector having access to direct junction lines leading to various exchanges and also to lines leading to a tandem exchange, while the auxiliary switch could be arranged to have access only to lines leading to a tandem exchange. The auxiliary switch in this case selects an idle line to the tandem exchange so as to enable switches at the tandem exchange to be operated at the same time as the selector switch is operated. The auxiliary switch if the connection is to be sent via the tandem exchange then controls the selector switch to establish connection to the line which it has previously selected.

Fourthly, the invention may be applied to effecting a considerable reduction in the number of switches required in the main train, for instance, the number of second group selectors in a ten-thousand line exchange may be reduced to a very low figure. According to this feature of the invention the selector switch is arranged to have access both to second group selectors and to final selectors, while the auxiliary switch has access to final selectors only. If the auxiliary switch finds an idle final selector switch in the group determined by the operation of the selector switch and the second group selector switch it has selected, then the connection is set up directly between the selector switch and the final selector switch and the second selector is cut out. Obviously, this feature is equally applicable to first, second and third selectors, or in fact to selectors of three successive stages.

Fifthly, the invention may be applied to employing small capacity switches so that the selector switch takes the form of a small capacity switch, for instance, a twenty-five line uni-selector switch, while the auxiliary switch is of a much larger capacity, for instance, an up-and-around switch of 100 line capacity. The selector switch has access to the usual number of groups of lines but these groups will all be of small capacity. If there is an idle line in the group required, then the connection will be set up as regards each stage except possibly the final selector stage over a small capacity switch. If there is no idle line available then the selector switch will select an idle switch, preferably one of large capacity similar to the auxiliary switch, and having access to the same lines as the auxiliary switch, and the auxiliary switch will cause such selected switch to be stepped on to contacts previously found by the auxiliary switch so that the connection to the next group stage includes both the selector switch and a large capacity switch. As the large majority of connections will be set up over small capacity switches the number of large capacity switches required will be comparatively small.

The invention will be better understood by referring to the accompanying drawings which illustrate selected ways of carrying the invention into effect, although it will be understood that the invention is capable of application to a number of different switching layouts in which use is made or can be made of the inventive features set out in the accompanying claims.

Figs. 1, 2, 3, and 4 show the application of the invention to a one digit group selector switch of the up-and-around type, Fig. 1 showing a known group selector circuit with slight modifications, Fig. 2 illustrating the grouping arrangement, Fig. 3 showing a busy tone set connected to vacant contacts at the end of a group, and Fig. 4 an overflow link which is common to a group of selectors including that shown in Fig. 1. Figs. 5, 6, and 7 show the application of the invention to a P. B. X. final selector, Fig. 5 showing a known P. B. X. final selector circuit with slight modifications, Fig. 6 showing the manner of marking the groups of lines and Fig. 7 an overflow link which is common to a group of selectors including that shown in Fig. 5.

Fig. 8 shows a telephone network including exchanges A, B, and T with arrangements for alternative routing so that although calls from exchange A to exchange B are preferably set up over direct junctions from A to B they may be set up over indirect junctions extending via exchange T when all the direct junctions are busy.

Fig. 9 shows a switching arrangement whereby calls may in certain circumstances be set up over less than the normal number of switching stages and

Fig. 10 shows an arrangement whereby calls may in certain circumstances be set up over the normal number of switching stages but in which the switches have a capacity of considerably less than a hundred lines.

Referring to Figs. 1, 2, 3, and 4, the invention is shown applied in a diagrammatic manner to an up-and-around switch arranged to act as a group selector. It is assumed that the group selector in question is to have access to ten different groups of lines and that the traffic on the different groups varies considerably so that the following distribution of lines is that which appears most advantageous to employ, namely

Group	Lines
1st	6
2nd	18
3rd	4
4th	8
5th	15
6th	5
7th	7
8th	18
9th	5
10th	7

In Fig. 2 the manner in which the lines of each group are associated with the various contact sets is illustrated. The numbers over the small circuits, each of which represents a contact set, indicate the number of the group to which the contact set belongs. Thus it will be seen that the six lines of group 1 are arranged on the first six contacts of the first level. The first ten lines of group 2 are arranged on the second level and of the remaining eight lines of group 2, three are shown by way of example connected to the last three lines of the first level and five are shown connected to the last five lines of the third level. The four lines of group 3 are arranged on the first four contacts of the third level. The eight lines of group 4 are arranged on the first eight contacts of the fourth level. The fifteen lines of group 5 are arranged with ten on the 5th level, one on the fourth level, four on the 6th level. The manner in which the lines in the 6th, 7th, 8th, 9th and 10th groups are arranged will likewise be readily seen from Fig. 3.

The general principles of operation of the group selector are as follows. Whenever the group selector is operated to a particular level and there is an idle line in the group corresponding to the level selected then the call is set up in a perfectly straightforward manner following any known method or any method which may be evolved equivalent to the methods at present known. If there is no idle line in the group then the operation depends upon whether the group is a small group or a large group, i. e., whether the group occupies less than one level or more than one level.

If the group occupies less than one level, then special arrangements must be provided for preventing the switch hunting past that group of contacts into another group which may be located at the end of the level and selecting an idle line in that group. This may be done by providing a vacant contact to which a busy tone set, as illustrated in Fig. 3, may be connected or it may be effected by arranging that the test contacts of the lines not belonging to the group being tested are momentarily rendered busy or it may be effected by arranging to connect the test wiper circuit permanently to busy potential whenever all the lines of the group being tested are busy.

When the number of lines in a group is greater than the number of contacts available in a level then it is necessary to take into use the special auxiliary switch SW2 (Fig. 4) associated with the group selector GS. This may be taken into use only when all the contacts in the level selected in response to the dialled impulses are busy, or it may be taken into use whenever the level selected in response to the dialled impulses forms only part of the complete group of lines; in the embodiment to be described later the second alternative is used but is made dependent upon the initial line or lines in the group being busy. When taken into use the switch SW2 hunts over those lines of the group required which are located in a different level or levels from the first choice lines; the switch SW2 has therefore to hunt both for the required group and for an idle line in that group. Only if all the first choice lines, i. e., the lines in the level dialled, are busy, is it necessary to make use of the switch SW2, in which case it establishes a circuit to an idle line in the group required, whereupon the group selector GS is released and reset on to the line selected by the switch SW2. The switch SW2 is connected to the selector GS by means of switch SW1; the circuit including the switches SW1, SW2 will hereinafter be referred to as an overflow link.

If a call is to be set up necessitating the selection of an idle line in the second group, the digit 2 will be dialled and after the switch GS has responded to the two impulses the overflow link SW1, SW2 will be taken into use and while the switch GS is hunting for an idle line on the second level, the switch SW2 will hunt for an idle line among later choices which are connected to contacts on the first and third levels. If all the lines on the second level are busy and the switch SW2 finds an idle line connected, for instance, to the ninth contact on the third level, then when the switch GS has reached the eleventh step and operated the eleventh step springs the connection will be switched through to the line selected by SW2 and subsequently the switch GS will be released and will be operated first by three impulses to operate it to the third level and then by nine impulses to operate it to the ninth contact on the third level. At this instant, the overflow link SW1, SW2 is released and a through circuit is established from GS to the 39th contact set.

A description will now be given of the detailed operation of the arrangements shown in Figs. 1, 2, 3, and 4. The circuit controlling the switch GS comprising the relays A, B, C, D and H is well known, but the general operation of the switch will be described briefly so that the differences introduced by the invention will be more readily appreciated.

When the group selector GS is taken into use, relay A operates over the speaking leads and completes a circuit for relay B which operates

and at armature 20 connects earth back over test conductor to mark the switch busy. Dial tone is fed back to the calling subscriber through the lower winding of relay A from the lead DT. When the first series of impulses is dialled, relay A releases intermittently thereby repeating the impulses by way of armatures 29, 18 to relay C in series with the vertical magnet V. The vertical magnet steps the switch wipers to the level corresponding to the digit received whilst relay C operates on the first impulse and remains operated until shortly after the end of the last impulse. When the switch goes off-normal, a circuit is completed for relay G by way of off-normal springs 26 and armatures 23 and 20. Relay G operates and completes a locking circuit for itself at armature 24. Shortly after the end of the last impulse, relay C releases and completes a circuit for the rotary magnet R over armature 20, springs controlled by armature 23, and armature 25. The rotary magnet steps the switch wipers into engagement with the first contact on the third level and at the end of its stroke opens the interrupter springs 32, thereby causing relay G to release.

If the first contact in the selected level is busy, the test wiper 34 will encounter earth and relay G will be operated in a circuit extending over off-normal springs 26, interrupter springs 32, armature 28, contacts controlled by armature 12, to earth on the test wiper 34. Relay G again completes its locking circuit at armature 24 and closes a circuit of the rotary magnet which advances the wipers on to the second contact. If this contact is also busy, the same sequence of operations occurs and the wipers are stepped on to the third contact. When an idle line is found, wiper 34 will no longer encounter earth and relay H will then energize in series with relay G, which latter however is not energized in this circuit owing to the high resistance of relay H. Relay H extends the speaking leads to wipers 33 and 35 at armatures 27 and 30 and extends the incoming test conductor through to the test wiper at armature 28. Relays A and B thereupon release but before relay B releases, earth is received back over the test wiper 34 due to the operation of relays corresponding to A and B in the succeeding switch. Relay H is now held in series with relay G by earth fed back over the test wiper and when this earth is removed upon release, relay H releases and completes a circuit for the release magnet Z which extends by way of armatures 29, 18 and 21 and off-normal springs 22. It will be appreciated from the above description that when one or more of the first choice lines are idle the switch operates without any modification whatever of its normal manner of operating.

It will now be assumed that the connection is to be extended over one of a small group of lines for example group 3, but that all the lines in this group are busy. The operations which now take place are the same as those previously described except that the switch will fail to find an idle line and will continue to step until it reaches the fifth set of contacts. These contacts are connected to a busy tone set arranged in the manner shown in Fig. 3. This busy tone set is multipled to the vacant contacts following the various small groups as shown in Fig. 2. The test contact of the fifth set of contacts in the third level will therefore be disconnected when the busy tone set is not in use and, as will be seen later, will be connected to earth through a high resistance when the busy tone set is already in use. In either case, relay H will operate and connect the speaking and test leads through to the busy tone set whereupon relay A2 will operate and complete a circuit for relay B2 which in turn will connect a high resistance earth to the test contact to hold relay H operated. Busy tone is fed back over the calling line through the lower winding of relay A1 and the calling subscriber will thereupon hang up and allow the switch to restore to normal in the manner previously described.

It will now be assumed that the connection is to be extended over a large group of lines, that is, a group occupying more than one level and that in the first instance there is an idle line available in the level corresponding to the digit dialled. It will be assumed that the digit dialled is the digit 2. The operations previously described take place up to the end of the second impulse, whereupon a circuit is completed over the vertical wiper VW as follows: earth on the test wiper 34 or on armature 24, high resistance HR, vertical wiper VW, second contact in the vertical bank VB, upper low resistance and lower high resistance windings of relay 2 in series, armature 77 to resistance battery. Relay 2 operates and at armature 79 connects battery through a low resistance to the junction of its low resistance and high resistance windings to maintain it operated and to mark the second contact in the vertical bank with battery potential. At armature 81 it completes a circuit for relay X which thereupon operates and at armature 77 disconnects battery from the lower windings of relays 2, 5 and 8 so that relays 5 and 8 cannot operate at this time due to another switch in the group served by the overflow link connecting earth to the fifth or eighth contacts in the vertical bank. Relay 2 at armature 80 connects earth to those contacts in the bank engaged by wiper 92 of the switch SW2 which correspond to those contacts of the second group which are not located in the second level. Relay X at armature 75 extends earth over armatures 54 and 51 to the magnet RM1 of the rotary switch SW1 and extends earth over armatures 54 and 87 for the rotary magnet RM2 of the switch SW2. The magnet RM1 interrupts its own circuit at springs 50 and continues to operate intermittently and advance the wipers until the switch GS has been found whereupon a circuit is completed for relay Y as follows: earth on the test wiper 34 or on armature 24, bank and wiper 41, springs controlled by armature 49, winding of relay Y, springs controlled by armature 52, wiper 42 and bank contact, wiper VW and second bank contact, low resistance upper winding of relay 2, armature 79 to resistance battery. Relay Y on operating disconnects itself from wipers 41 and 42, and locks up in the following circuit: resistance battery, armatures 76 and 52, winding of relay Y, armatures 49, 82, 78 and 55 to earth on the test conductor.

Magnet RM2 similarly interrupts its own circuit at springs 91 and continues to advance the wipers of the switch SW2 until the wipers encounter an idle line in the required group, whereupon a circuit is completed for relay W as follows: earth, armature 80, bank contacts corresponding to later choice lines in group 2, wiper 92, springs controlled by armature 89, winding of relay W, resistance battery. It will be noted that the lower terminal of relay W is connected over armature 56 to wiper 93 so that the relay

can only operate if wiper 93 fails to encounter earth, that is, when it encounters an idle line. Relay W on operating completes a locking circuit for itself over armatures 89, 82 and 81. It will thus be seen that the switches SW1 and SW2 at wipers 43, 47 and 48 and wipers 93, 96 and 97 respectively serve to prepare a connection from the switch originating the call to an idle line of the second group which is not located on the second level. No further operations however take place in the common overflow link as it has been assumed that there is an idle line in the second level. When this line is found relay H energizes in the manner previously described. As there is no earth on wiper 34, relay G is not re-operated, so that the earth on wiper VW is removed whereupon relay 2 releases and opens the circuits of relays X and W at armature 81. Relay X in turn at armature 76 opens the circuit of relay Y and the overflow link is thereby restored to normal, the wipers remaining in the position to which they were set. The connection is completed by the switch GS in the manner previously described without the assistance of the common apparatus.

It will now be assumed that the connection is to be extended over a large group of lines and there is no idle line available in the level corresponding to the digit dialled but that an idle line is available to the overflow switch SW2. It will again be assumed that the digit 2 is dialled and in this case the same operations take place as previously described up to the hunting operation of the switch GS, and the overflow link is caused to operate in the manner already described in response to the initiation of the hunting movement. The switch GS continues its hunting operation but as all the lines in the second level are busy it advances to the 11th step position and operates the 11th step cam springs 15, 17, and 31. A circuit is thereupon completed for relays K and V as follows: battery, winding of relay K, cam springs 15, bank and wiper 46, armature 53, winding of relay V, armature 90 to earth, as it may be fairly assumed that the faster operating switches SW1 and SW2 will have completed their hunting operations before the switch GS has reached its 11th step position. Relay K upon operating completes a locking circuit for itself at armature 14; disconnects test wiper 34 at the contacts of armature 12; and at armatures 11, 13 and 16 transfers the incoming speaking and test leads from the switch GS to the common apparatus, while relay V at armatures 56, 57 and 60 extends these leads through to the idle line selected by the switch SW2.

The line and release relays in that switch thereupon operate and guarding earth is fed back over the test lead. Relays A and B of the switch GS release, whereupon a circuit is completed for the release magnet Z over armatures 29, 18 and 21 and off-normal springs 22. The wipers of the main switch thereupon restore to normal, and relay 2 releases due to its circuit being opened at wiper VW. Relay X, however, is maintained operated over armatures 78, 55 and 56, and relay W is maintained operated over armatures 89, 82, 78, 55 and 56 to earth fed back over the test wiper 93. Impulses dialled at any time after the operation of relay K will be effective to control the operation of the succeeding switch. The switch GS is now reset to connect with the switch selected by the switch SW2.

To facilitate the description, it will be assumed that the number of the contact corresponding to the selected line is 39. The resetting of the switch GS is effected by sending impulses from the overflow link so that in the example chosen it will be necessary to send three impulses to the vertical magnet V and nine impulses to the rotary magnet R. Appropriate connections extend from the bank contacts engaged by wipers 94 and 95 of the switch SW2 to a terminal block TB the contacts of which are wired to impulse sending cams arranged to transmit series of earth impulses corresponding in number to the number shown adjacent to the various terminals of the block TB. Three of the cams are shown in the drawings to illustrate their mode of operation, the remaining cams are arranged in an analogous manner. The terminal on the terminal block corresponding to the tens digit of the selected line is connected to the corresponding contact on the bank engaged by wiper 94 and the terminal on the terminal block corresponding to the units digit is connected to the corresponding contact on the bank engaged by wiper 95. In addition to the cams generating the various impulse series, there is a start cam which connects battery to the lead S for a short interval before the transmission of any of the impulses in the series and a stop cam which connects battery to the lead Z shortly after battery is connected to the lead S but before the first numerical impulse is sent and disconnects this battery when the last numerical impulse has been sent. When battery is next connected to the lead S, following the operation of relay V, a circuit is completed for relay DA as follows: resistance battery, lead S, armature 68, middle winding of relay DA, armatures 59 and 56, test wiper 93 to earth fed back from the succeeding switch. Relay DA thereupon operates and locks over its lower winding by way of armatures 65, 69 and 58. Shortly afterwards battery is connected to the lead Z and a circuit is thereupon completed over armature 73, the upper winding of relay DB, armature 64 and the upper winding of relay DA to earth. Relay DB operates and relay DA is held in this circuit. Relay DB locks operated over its lower winding and armatures 67 and 59 to earth on the test conductor. When the impulse sending cams come into operation a series of three impulses is sent over wiper 94, armatures 70 and 61, wiper 44 and bank contact to the vertical magnet V which thereupon raises the switch wipers three steps. When the switch moves off-normal, relay H energizes in series with relay G due to the closing of the off-normal springs 26, but no other operations take place at this time. When battery is removed from the lead Z, relay DA releases, as the circuit of its lower winding is now open at armature 69, and completes a circuit for relay RC over armatures 63 and 66. Relay RC operates, at armature 72 completes a locking circuit for itself to the test conductor and at armature 73 prepares a fresh circuit from lead Z so that when battery is next connected to lead Z a circuit is completed for the middle winding of relay DA over armatures 73 and 68 to earth on the test conductor. Relay U also energizes in parallel with the middle winding of relay DA and closes a locking circuit for itself in series with relay T. Relay T, however, being shunted by the Z lead, remains quiescent. Relay RC also opens the circuit from wiper 94 at armature 70 and closes a circuit from wiper 95 at armature 71 so that when the impulse sending cams next come into operation a series of nine impulses is transmitted over wiper 95, armatures 71 and 62, wiper

45 and bank contact to the rotary magnet R which steps the switch wipers into engagement with the ninth set of contacts in the third level. When battery is next removed from the lead Z, relay T operates in series with relay U over armature 74 to earth on the test conductor. Relay T at armature 98 opens the locking circuit of relays W and Y which thereupon release and at armatures 90 and 53 open the circuit of relays V and K which thereupon release. Relay K transfers the incoming leads back again from the common apparatus to the switch GS, and as relay H is already operated these leads are extended through to the succeeding switch connected to contact set 39. Relay K is adjusted so that armature 13 opens slightly after the springs controlled by armature 12 have closed so as to ensure continuity of holding potential on the test conductor. Relay V releases shortly after relay K and at armature 55 opens the locking circuit of relay X which in turn at armature 76 opens the locking circuit of relay Y whereupon all the common apparatus is restored to normal.

If all the lines in a large group are busy, the switch SW2 will be unable to find an idle line in the marked group so that relay W will be unable to operate. In these circumstances a busy signal will be transmitted to the calling subscriber from the lead BT via the lower winding of relay A in response to the operation of the 11th step springs 17. Relay H is prevented from operating as its circuit is opened at the 11th step springs 31. If desired, an overflow meter could be provided for the different groups for the purpose of recording the number of times that all the lines in a group are busy.

As an alternative to providing a vacant contact at the end of each small group, means could be provided in the common apparatus for indicating when all the lines in a group are busy, for example, a thermionic valve could be provided with connections extending to all the lines in a group in such manner that when they all become busy the grid potential of the valve is changed and a relay is operated in the plate circuit. An arrangement operated in this manner is described in the copending application of Taylor and Baker, 754,250, Nov. 22, 1934. The relay which is operated when all the lines in the group become busy could be arranged to connect earth back over the bank VB and wiper VW and by a suitable modification of the circuit connections cause the switch to hunt to its 11th step position, whereupon busy tone would be fed back to the calling subscriber through the lower winding of relay A. The group contact arrangement just described might be utilized to indicate that the ten lines of a large group which are on a single level are all busy and so pre-operate relays such as 2 and mark the level contact in the vertical bank to enable the overflow connection to be set up more quickly.

If there should be a level to which a group of ten lines is connected as there are no later choice lines connected to the levels, the operations would be the same as in the case of a small group of lines except that the all-trunks-busy condition would be given on the 11th step instead of from the busy tone set. Instead of the vertical wiper and the vertical bank, normal post springs could be utilized if desired. A simplified arrangement which might be employed would be to arrange for the switches SW1 and SW2 to give a permanent by-path connection for overflow calls, in which case the switch GS would not be reset, or possibly a combination may be adopted for example the resetting may be effected as long as contacts are available on the switch GS and the switches SW1 and SW2 used as a permanent by-path connection throughout the conversation if there were no contacts available on the main switch even on any level other than the level called, in which case the arrangement would have the effect of increasing the capacity of the switch group. The group selector may be of the type which is set on to the required group of lines in response to two series of impulses.

If the connection is being set up under the control of a register sender it is possible to avoid taking the speaking conductors into the overflow link as the register sender may readily be arranged to delay the transmission of the digit until the group selector has been reset. In this case it is not necessary for the auxiliary switch SW2 to have access to the line contacts of the overflow lines as it is sufficient for it to have access only to the test contacts of those lines.

If desired, the overflow link may be modified to control both its associated group selector and the switch selected in the next switching stage.

A description will now be given with reference to Figs. 5, 6 and 7 of the application of the invention to an up-and-around switch arranged to act as a final selector and having access to groups of lines leading to different private branch exchanges. A final selector of this type, which is often referred to as a P. B. X. final selector, is arranged so that when set on to the first line of a group, and this line is busy, it performs a hunting operation until it finds an idle line in the group or until it comes to the last contact in the group. The final selector is also generally arranged to have access to ordinary or individual lines which it tests in the usual manner and thereupon connects ringing current to the called line if idle or connects busy current to the calling line if the called line is busy.

A very important requirement in connection with final selectors of this type is that of allowing for expansion of the groups of lines or the conversion of an individual line to a group of lines and it is very desirable that all the contacts connected to lines leading to a particular branch exchange should be made accessible to the final selector in response to the dialling of a single number which will remain unchanged in spite of any increase in the number of lines leading to particular branch exchanges. To meet this requirement, it is generally necessary that all the lines in the group shall appear as consecutive lines in the bank of the selector. This has the serious objection that a large number of spare lines must be provided following the various groups to allow for expansion and one object of the present invention is to overcome this difficulty by arranging that the additional lines added to a group need not be consecutive with the existing lines, but can in fact be located anywhere on the switch when there is a vacant contact.

The circuit shown in Fig. 5 is a well-known circuit which has been modified by the addition of a resistance HR1, a wiper 149 and its associated contact bank together with a relay K1 and resistance R2. It will be noted that all these additions can be readily dissociated from the circuit or connected to it, thus indicating that the invention can be readily applied to P. B. X. final selectors of various types with no alteration of the fundamental circuit principles and only a comparatively few wiring connections.

A description will first be given of the operations which take place in response to the dialling of a number corresponding to an individual line. The general circuit operations are well-known and will, therefore, be described as briefly as possible so that the differences introduced by the invention will be more readily appreciated. When the switch is taken into use relay A1 operates over the speaking leads and at armature 101 completes a circuit for relay B1 which also operates and at armature 109 connects earth back over the incoming test conductor. In response to the tens digit relay A1 releases intermittently and at armature 101 repeats the impulses over armature 110, off-normal springs 104, armature 143 to the vertical magnet V1 which thereupon steps the switch wipers to the corresponding level, for example level 2. A parallel circuit extends over armature 138 to the lower winding of relay C1 which operates on the first impulse and completes a short-circuit for its upper winding over armatures 136, 119 and 114 so that it is made slow to release and thus holds operated throughout the impulse series. On the first vertical step the off-normal springs are operated and the subsequent impulses to the vertical magnet pass from armature 110 over springs 105 and armatures 139, 121, 132, 113, and 143. At the end of the impulse series, relay C releases.

When the units digit is received, relay A1 again releases intermittently and at armature 101 repeats the impulses by way of armature 110, springs 105, armatures 139, 121, 132, 113, 142 to the rotary magnet R1. The rotary magnet rotates the wipers a corresponding number of steps, for example 6, so that they now stand in engagement with the terminals of the line 26. A parallel circuit also extends to the lower winding of relay E which operates and, at armature 123, completes a short-circuit for its upper winding so that it is made slow to release and holds operated throughout the impulse series. Relay E at armature 126 places a shunt across armatures 121 and 132 and at armature 122 extends a test circuit to relay G1 as follows: battery, winding of relay G1, armatures 130, 122 and 141, test wiper 142 to the test contact of the wanted line. If this line is busy, the test contact will be connected to earth and relay G1 will thereupon operate and at armature 117 prepare a locking circuit for itself which is completed at the normally closed springs controlled by armature 122 when relay E releases shortly after the end of the impulse series. Busy current is now fed to the calling subscriber's line through the lower winding of relay A1 from the busy tone lead BT over armatures 120 and 125. On receiving the busy tone the calling subscriber will hang up his receiver whereupon relays A1, B1 and G1 will release and a circuit will be completed for the release magnet Z1 over armatures 101 and 119 and off-normal springs 103. The release magnet causes the switch wipers to restore to normal and at armature 102 connects earth to the incoming test conductor so as to mark the switch busy until the switch wipers have restored to normal.

If however the wanted line is idle the test wiper 148 will encounter battery instead of earth so that relay G1 will be unable to operate. When relay E releases a circuit is completed as follows for relay H1: battery encountered by test wiper 148, armatures 141, 122 and 118, lower winding of relay H1, armature 108, to earth. Relay H1 operates and at armature 131 completes a locking circuit for itself over its upper winding. At armatures 128 and 133 relay H1 extends ringing current to the wanted line from the lower winding of relay F and the ringing lead RT, a small portion of the ringing current being transmitted to the calling subscriber over armature 127 through a small capacity condenser 115. When the called subscriber replies, relay F operates over its lower winding in series with the called loop, holds over its upper winding and completes the talking connection. Relay D operates over both its windings in series with the called loop and at armatures 106 and 107 reverses the current flow in the calling loop for metering or supervisory purposes.

It will now be assumed that it is desired to extend connection to an idle one of a P. B. X. group of lines in which all the lines in the group are in sequence, for example, the group 42. It should be explained with reference to Fig. 6 that the first line in a P. B. X. group has the contact accessible to wiper 150 connected to resistance battery and that subsequent contacts in the group accessible to this wiper are directly connected to the corresponding contacts engaged by wiper 148 except for the last contact in the group which is left disconnected. Similarly in the case of ordinary lines O the contact accessible to wiper 150 is left disconnected. In response to the dialling of the tens and units digits, 4 and 2 respectively, the switch wipers are positioned on the second set of contacts in the fourth level in a manner similar to that already described. If the first line in the group is idle the connection is extended over this line in the manner already described. If, however, this line is busy, relay G1 operates, and as the wipers are engaging the first contacts in a P. B. X. group, wiper 150 will encounter battery, whereupon, when relay E releases, a circuit is completed over armatures 124 and 136, upper winding of relay C1, armatures 113, 122 and 141, wiper 148, to earth. Relay C1 thereupon operates and at armature 114 completes a circuit to the lower winding of relay HS over armature 119 from earth at wiper 148 over the circuit previously traced. Relay HS completes a locking circuit for itself over its upper winding at armature 135 and at armature 136 opens the initial energizing circuit of relay C1, which however is now maintained over its lower winding in the following circuit: battery, lower winding of relay C1, armatures 138, interrupter springs 147, armatures 111, 134 and 108, to earth. A circuit is also completed for the rotary magnet as follows: battery, winding of rotary magnet R1, armatures 142, 112, 134 and 108 to earth. The rotary magnet thereupon energizes, opens the circuit of relay C1 at springs 147 and advances the switch wipers into engagement with the next set of contacts. Relay E is energized over its lower winding in parallel with the rotary magnet and completes a short-circuit for its upper winding at armature 123 so that it will hold operated during the hunting movement. If the next contact in the group is also busy, wiper 148 will encounter earth so that relay G1 will remain operated and as the contact engaged by wiper 150 is directly connected to the normal test contact, wiper 150 will also encounter earth so that earth will be extended to the lower winding of relay C1 from wiper 150 over armatures 124 and 137, interrupter springs 147 and armature 138. Relay C1 again operates and at armature 112 again completes the circuit of the rotary magnet R1 which thereupon steps the switch wipers into engagement with the next set of contacts and

opens the circuit of the lower winding of relay C1 at the interrupter springs 147. This sequence of operations occurs until an idle line is found or until the last contact in the group is reached. If an idle line is found, wiper 148 will encounter battery and relay G1 will thereupon release. After a short interval, relay E releases and a circuit is completed for the lower winding of relay H1 over armatures 118 and 122, whereupon relay H1 will operate and connect up ringing current in the manner previously described. If, however, the switch continues to hunt until it reaches the last line in the group, and this line is also busy, relay G will remain operated and will lock operated over armature 117 when relay E releases. Busy tone is transmitted back to the calling subscriber over armature 120 in the manner previously described.

It will now be assumed that a call is to be made to a P. B. X. group of lines in which some of the lines of the group are located out of sequence with the first choice lines, and it will be first assumed that there is an idle line among the first choice lines. In this type of call, use is made of the wiper 149 and the bank contacts to which it has access. It should be explained that the numbers shown adjacent to the contacts of the bank associated with wiper 149 comprise the last two digits of the directory number of the various subscribers and to facilitate the description these will be taken as comprising the whole of the subscriber's number; thus, No. 11 is an ordinary or individual line; No. 12 is a P. B. X. group of three lines in sequence having no facilities for extension as contact No. 15 is already allotted to another subscriber. No. 15 is an individual line which has one further line left spare in sequence for possible extension; No. 42 is a P. B. X. group of 5 lines with possibilities of extension to lines in sequence up to 7. The subscribers having groups of lines with the later choices out of sequence are Nos. 19, 88 and 01. Subscriber No. 19 is a P. B. X. subscriber with two lines on contacts 19 and 10 respectively, and a third line on contact 28; subscriber No. 88 has a single line connected to contact 88, and a second line connected to contact 64; while subscriber No. 01 has a single line connected to contact 01, and a second line connected to contact 95. Contacts 19, 88 and 01 in the bank engaged by wiper 149 are connected to the corresponding relays 19, 88 and 01 in the common apparatus over leads 160, 161 and 162 respectively.

It will first be assumed that a connection is to be extended to the subscriber 19 and that the line connected to contact 19 is busy, but that the line connected to contact 20 is idle. The switch wipers are positioned on to the ninth set of contacts in the first level in the manner similar to that already described. As it is the first line in a P. B. X. group the wiper 150 will encounter resistance battery and as the line is busy the wiper 148 will encounter earth. Relay G1 energizes and the switch is stopped on to the next set of contacts in the manner previously described. In addition, however, the following circuit is completed to the common apparatus: earth, armatures 108 and 117, high resistance HR1, wiper 149, contact 19, conductor 160, upper low resistance winding and lower high resistance winding of relay 19 in series, armature 235 to resistance battery. Relay 19 operates and at armature 239 shunts its lower winding by the low resistance 238 so as to bring the potential of wiper 149 to substantially battery potential. Relay 19 at armature 241 completes a circuit for relay X1 which causes the switches SW21 and SW11 to operate in a similar manner to that described in connection with Fig. 4, the switch SW21 hunting over wipers 253 and 254 to find an idle line in the group 19 which does not appear in the bank of the conversational switch in sequence with the first choices, namely, Nos. 19 and 20, and the switch SW11 hunting over wiper 201 to find the conversational switch in question, namely, the switch which has battery potential connected to its conductor 159 over its wiper 149. When these are found, relays W1 and Y1 operate and prepare a circuit for relays V1 and K1 in series. Relay K1 however only energizes if there is an absence of earth on the junction point between its winding and resistance R2 and this can only occur when the wiper 150 engages an unearthed contact, that is, when it engages an idle line or when it engages the last line in the group. Since, however, it is assumed that the second contact of the group 19 is idle, relay G1 will release as wiper 148 will not encounter earth and relay H1 will operate. Due to the release of relay G1 earth is disconnected from wiper 149 and relay 19 therefore releases. Relays W1 and X1 also release and are followed by relay Y1. Relay W1 at armature 250 opens the circuit of relays K1 and V1; relay K1 is therefore only energized momentarily, while relay V1 is not energized at all as it is arranged to be slow to operate. Under these conditions it will be seen that the common apparatus is prepared for use but no actual use is made of it. In the case of a call to subscriber 88 the operations which take place if the line connected to contact 88 is idle are the same as those already described for the case of an individual line and in this case relay H1 will operate but relay G1 will not operate so that no earth will be extended over wiper 149 to the common apparatus. If, on the other hand, the line 88 is busy, relay G1 will operate, the common apparatus will be taken into use, the switches SW21 and SW11 will be set and relays V1 and K1 will thereupon be operated in series.

It will now be assumed that all the first choice lines in the desired group are busy, but that one or more idle lines exist among those lines which are not in sequence with the first choice lines. The setting of the switch FS takes place in the same manner as previously described but as all the lines directly reached in response to dialling are busy, the overflow link will be taken into use, the switches SW21 and SW11 will be set and when the wipers of the switch FS reach the last contact in the group relay K1 will operate in series with relay V1 in the following circuit: battery, resistance HR2, winding of relay K1, conductor 158, bank and wiper 205, armature 210, winding of relay V1, armature 250 to earth. Relay K1 at armatures 140, 141 and 146 disconnects the wipers 147, 148 and 151 respectively, at armatures 142 and 143 disconnects the rotary magnet R1 and vertical magnet V1 from the switch circuit and connects them to the common apparatus, at armature 144 closes a point in a circuit to the lower winding of relay H1 and at armature 145 completes a circuit to the release magnet Z1 from earth fed over conductor 154 from wiper 206 and armatures 214 and 229. The release magnet Z1 operates and causes the wipers of the switch FS to restore to normal. Relay V1 also operates in this circuit and at armatures 212 and 213 com-

pletes circuits as follows: earth at armature 108, lower winding of relay H1, contact 144, lead 155, wiper 202. The circuit then divides, part proceeding via contact 212, locking contact of relay X1 to relay X1 and battery and also a branch extends through a back contact of relay T1, locking contact of relay W1, relay W1, resistance to battery, while the other part of the circuit from wiper 202 proceeds via armature 213, wiper 254 to the cut-off relay of the wanted subscriber. Relay H1 operates in this circuit and completes a locking circuit for itself at contact 131 through its upper winding. At the same time contact 129 connects earth from wiper 108 through back contact 122, back contact 118, contact 144 to conductor 155, thereby ensuring that relays X1 and W1 are maintained operated in dependence upon earth at contact 108 and therefore in dependence upon the calling subscriber's loop circuit being closed and also effecting the operation of the cut-off relay of the called subscriber. In response to the operation of armature 217 by relay V1 the relays DA1, DB1, RC1, U1 and T1 operate in the same manner as the corresponding relays in the common apparatus associated with the group selector to control the transmission of two series of impulses over wipers 203 and 204 and conductors 156 and 157 respectively, in accordance with connections made over wipers 255 and 256 from the terminal block TB to set the switch FS on to the line selected by the switch SW21. When both series of impulses have been transmitted relays U1 and T1 operate in series and bring about the release of the common apparatus in the manner described in connection with the group selector. Relay W1 at armature 250 opens the circuit of relays K1 and V1 and these relays thereupon release. The normal conditions for ringing are now established in the final selector FS and the call is completed in the manner previously described. Similar operations take place when a connection is to be extended to subscriber No. 88 or subscriber No. 01 except that the corresponding relay No. 88 or No. 01 is energized in the common apparatus instead of the relay 19.

If all the lines both in the first choice group and in the later choice group are busy, the switches SW21 and SW11 will be set in operation as before but the switch SW21 will be unable to find an idle line in the required group so that no circuit will be completed for the relay K1. The switch SW21 will then continue to hunt until a line becomes available or until the calling subscriber restores his receiver. If desired, it could be arranged that the switch SW21 is stopped in a special position when it has found all the lines in the required group busy and the switch FS could then be arranged to restore to normal to transmit a busy signal to the calling subscriber whilst at the same time releasing the common apparatus.

Referring now to Fig. 8, this shows a subscriber's station S which is automatically connected, when a call is initiated, to an up-and-around first group selector such as S1. A rotary auxiliary switch RBS is associated in common with a group of selectors such as S1 either by means of multiple connections as shown in Fig. 8 or by means of a hunting switch. In response to the initiation of the call, the auxiliary switch RBS is automatically connected to the selected first group selector S1 and selects an idle line leading to the tandem exchange T and terminating in a group selector S2. The first series of impulses transmitted by the calling subscriber is received by the selectors S1 and S2 and causes their wipers to be stepped vertically to the corresponding level; they then hunt over this level for an idle junction to exchange B, assuming that B is the wanted exchange. If the selector S1 finds an idle direct junction the connection is completed thereover and the switches RBS and S2 are restored to common use. If, however, no direct junction is available, then the connection is completed over the junction to the tandem exchange T selected by the auxiliary switch RBS and the junction to exchange B selected by the group selector S2 at the tandem exchange T. The indirect junction selected by the switch RBS is also connected to a suitable contact set in the bank of selector S1 so that when it is known that no direct junctions to exchange B are available the selector S1 is released and is set on to the junction selected by the auxiliary switch RBS in a manner similar to that described in connection with Figs. 1–4. The switch RBS is then released and restored to common use.

It will be noted that as the indirect junctions may be connected to a different level of the selector S1 from that to which the direct junctions are connected, the indirect junctions for handling overflow calls to a plurality of different exchanges may all be connected to the same level or levels of the selector S1. In any case, all the indirect junctions will be accessible to the auxiliary switch RBS and will therefore form a single group with a resultant increase in efficiency.

If desired, and particularly if there are only one or two exchanges such as exchange B, it is possible to eliminate the selector S2 at exchange T and to send only discriminating signals over the indirect junction to cause an idle line leading to the required exchange to be selected, in which case the switch RBS need not select an idle indirect junction until after the dialling of the first digit has begun. The group selector S1 may be of the type which is set on to the required group of lines in response to two series of impulses.

Referring now to Fig. 9, S1 is an up-and-around first group selector provided with two sets of banks of 100 lines each and with a separate set of wipers for each set of banks, a switching device X being provided for switching over from one set of wipers to the other. RBS is an auxiliary switch which is preferably of the up-and-around type and is associated in common with a group of selectors such as S1 either over multiple connections as shown, or over a hunting switch.

When the subscriber at substation S lifts his receiver the group selector S1 and the auxiliary switch RBS are automatically taken into use. In response to the dialling of the first digit, which will be assumed to be the digit 2, the wipers of the selector S1 are raised to the corresponding level and then select an idle second group selector such as S2. In response to the dialling of the second digit, which will be assumed to be the digit 3, the wipers of the selector S2 are raised to the corresponding level and then select an idle final selector such as FS. The circuit is arranged so that the switch RBS responds simultaneously to the second digit so that its wipers are raised to the third level. The wipers are then rotated to select a contact corresponding to the first digit, e. g., under the control of a circuit extending over a vertical wiper of the selector S1. In the case assumed, the first and second digits are 2 and 3 respectively

so that the switch RBS will select a contact (e. g. the second) in the third level.

From the second set of banks of the selector S1, lines extend direct to final selectors; these lines are also connected to the bank of the selector RBS.

In the case of a 10,000 line exchange a direct line may extend from each contact of the lower bank to a final selector having access to a different group of one hundred lines. In practice, however, the capacity of the exchange will generally be substantially less so that for certain combinations of the first two digits two or more direct lines may be provided leading to different final selectors having access to the same group of one hundred lines particularly in cases where the corresponding final selectors carry heavy traffic, e. g., to P. B. X. groups.

It has been assumed that a direct line will be provided for every combination of the first two digits; it may be found desirable, however, not to provide a direct line for every combination of the first two digits so as to increase the number of direct lines to a group of final selectors carrying heavy traffic. It will be understood that the groups of lines in the banks of the selector RBS may be graded in well-known manner.

When the second digit has been dialled, the switch S2 hunts for an idle final selector FS in the usual manner. Simultaneously, the auxiliary switch RBS operates to select a direct line leading to a final selector having access to the same hundreds group of lines, which selector as shown is also FS but need not necessarily be so. If such a direct line is found to be idle, then a temporary connection is completed over the switch RBS to the final selector FS and the selectors S1 and S2 are released. The operation of the final selector FS may now be controlled over the temporary connection and while this is taking place the selector S1 is automatically reset under the control of the switch RBS to extend a connection over its lower bank to the final selector FS via the direct line, and when this connection has been completed the temporary connection is opened and the selector RBS is restored to common use. It will be appreciated that the selectors such as S1 may be divided into groups each having access to different final selectors so that calls will only need to be set up via selectors such as S2 when more than one call from a particular group of selectors such as S1 is being set up simultaneously to a particular hundreds group of subscribers.

It will thus be seen that connections may be set up over only two numerical selectors, namely, S1 and FS, instead of three as would otherwise be required, namely, S1, S2 and FS.

Referring now to Fig. 4, this shows an arrangement whereby speaking connections may be set up over uniselector switches which may have capacity of considerably less than 100 lines. S1 is a uniselector first group selector which may have a capacity of substantially less than 100 lines, e. g., only 25 lines; and RBS is an auxiliary switch associated in common with a group of selectors such as S1 either over a multiple connection as shown or over a hunting switch and is preferably of the up-and-around type. When the subscriber at substation S initiates a call, the uniselector S1 and the up-and-around reserve by-path selector RBS are automatically taken into use.

In response to the dialling of the first digit, the selector S1 is set to a corresponding group of lines; this may be effected by arranging that the switch RBS is set vertically in response to this digit and extends a marking circuit over its vertical wiper to the bank of the selector S1. The selector S1 then hunts for an idle line in the marked group (which may contain only two lines) leading to a selector such as S2, and if such a line is available the connection is completed thereover and the switch RBS is restored to common use. If, however, no such line is available, the switch RBS hunts for an idle uniselector, such as OS2, in a group of overflow uniselectors having their banks multipled with those of S2, whilst at the same time the uniselector S1 hunts for an overflow selector such as OS in a common group. The selectors OS are preferably of larger capacity than the selectors S1 and as shown in Fig. 4 they may be of the up-and-around type. The selector OS is then set on to the line leading to selector OS2 under the control of the auxiliary switch RBS. The connection is then completed over the selectors S1, OS and OS2, whilst the switch RBS is restored to common use. A similar overflow arrangement may be provided at the second switching stage as is illustrated in the drawings by switches RBS1 and OS1. The lines from the first selector S1 to the second selectors S2 will carry quite a large proportion of the traffic, the remainder of the traffic being routed over the overflow selectors OS and it will be appreciated from the well-known grading principle that this results in an economy in the total number of switches required. If desiired, the auxiliary switch RBS and the selector OS may also be uniselector switches.

While five important applications of the invention have been described by way of example, it will be understood that the invention is capable of other applications coming within the scope of the features mentioned. It should be specifically pointed out that the invention is not limited to up-and-around switches but is applicable also to uniselector switches and possibly to other types of switches. Similarly the invention is applicable to 200-point up-and-around switches as well as to 100-point switches.

Although the arrangements described are of particular use in systems in which connections are set up under the direct control of the calling subscriber's dial switch it will be understood that the invention is equally applicable to systems employing register controllers.

I claim:

1. In a switching system, a selector switch having its contact bank divided into separately designated contact groups, means responsive to control corresponding to the designation of a contact group for bringing said selector into association with the designated group of contacts, there being lines connected to the contacts of said selector and grouped generally in accordance with the grouping of the contacts, means for causing the selector to search over the contacts of a selected group for an idle line, means effective in the event that an idle line is found for arresting the searching operation and for causing the selector to make connection with the idle line and effective in the event that all of the lines connected to the contacts of the group are busy for arresting the operation of the selector when the end of the group is reached, certain of said groups of lines having more lines therein than there are contacts in a group, the additional overflow lines being connected to spare contacts

in other contact groups, an overflow link associated with said selector and having access to the overflow lines, means effective when the selector is brought into association with a contact group serving a group of lines containing overflow lines for operating the overflow link to make connection with the selector and to make connection with an idle overflow line of the called group, and means effective in the event that all of the non-overflow lines of the called group are busy and upon the consequent arresting of the movement of the selector at the end of the contact group for completing connection by way of the overflow link with the selected idle overflow line.

2. In a switching system, a selector switch having its contact bank divided into separately designated contact groups, means responsive to control corresponding to the designation of a contact group for bringing said selector into association with the designated group of contacts, there being lines connected to the contacts of said selector and grouped generally in accordance with the grouping of the contacts, means for causing the selector to search over the contacts of a selector group for an idle line, means effective in the event that an idle line is found for arresting the searching operation and for causing the selector to make connection with the idle line and effective in the event that all of the lines connected to the contacts in the group are busy for arresting the operation of the selector when the end of the group is reached, certain of said groups of lines having more lines therein than there are contacts in a group, the additional overflow lines being connected to spare contacts in other contact groups, an overflow link associated with said selector and having access to the overflow lines, means effective when the selector is brought into association with a contact group serving a group of lines containing overflow lines for operating the overflow link to make connection with the selector and to make connection with an idle overflow line of the called group, means effective in the event that all of the non-overflow lines of the called group are busy and upon the consequent arresting of the movement of the selector at the end of the contact group for completing connection by way of the overflow link with the selected idle overflow line, means thereafter effective for restoring the operated selector to normal position and for reoperating it under control of the overflow link to make connection with the selected overflow line, and means thereupon effective for freeing the overflow link for further use.

3. In a switching system, a group selector having access to groups of lines which may be varied in size independently of the construction and manner of operation of the group selector, whereby certain overflow lines are connected to contacts that cannot be reached in the normal operation of the selector, an auxiliary switch having access to the said overflow lines, means effective when the group selector is directed to a group containing overflow lines for causing the auxiliary switch to select an idle overflow line of the group, and means effective in the event that all the lines of the group which can be selected by the normal operation of the group selector are busy for temporarily completing the connection to the selected idle overflow line by way of the auxiliary switch; for reoperating the group selector under the control of the auxiliary switch according to the position assumed thereby to make connection with the same idle line; and for thereupon transferring the connection with the idle overflow line through the group selector.

4. In combination, a group selector having access to lines divided into groups, means for bringing said group selector into association with a group of lines and for causing it to search over the group in search of an idle line, overflow lines forming a continuation of one of the said groups, an auxiliary switch associated with said selector and having access to said overflow lines, means effective responsive to the operation of said group selector into association with the group containing the said overflow lines for causing said auxiliary switch to search for and connect with an idle overflow line, and means dependent upon said group selector finding all lines busy in the selected group for transferring the connection to the idle overflow line selected by the auxiliary selector.

5. In combination, a group selector having access to lines divided into groups, means for bringing said group selector into association with a group of lines and for causing it to search over the group in search of an idle line, overflow lines forming a continuation of one of the said groups, an auxiliary switch associated with said selector and having access to said overflow lines, means effective responsive to the operation of said group selector into association with the group containing the said overflow lines for causing said auxiliary switch to search for and connect with an idle overflow line, means dependent upon said group selector finding all lines busy in the selected group for transferring the connection to the idle overflow line selected by the auxiliary selector, said group selector having access to said overflow lines by way of spare contacts located at random in its bank, and means effective upon the finding of all of the lines in the main group busy and controlled according to the position taken up by said auxiliary switch for restoring said group selector and for reoperating it directively to make connection with the overflow line which has been connected with by the auxiliary selector.

6. In combination, a group selector having access to lines divided into groups, means for bringing said group selector into association with a group of lines and for causing it to search over the group in search of an idle line, overflow lines forming a continuation of one of the said groups, an auxiliary switch associated with said selector and having access to said overflow lines, means effective responsive to the operation of said group selector into association with the group containing the said overflow lines for causing said auxiliary switch to search for and connect with an idle overflow line, means dependent upon said group selector finding all lines busy in the selected group for transferring the connection to the idle overflow line selected by the auxiliary selector, said group selector having access to said overflow lines by way of spare contacts located at random in its bank, means effective upon the finding of all of the lines in the main group busy and controlled according to the position taken up by said auxiliary switch for restoring said group selector and for reoperating it directively to make connection with the overflow line which has been connected with by the auxiliary selector, and means thereupon effective for completing connection with the overflow line by way of the group selector and for breaking down the temporary connection set up through the auxiliary selector.

7. In a switching system, a group selector having access to lines divided into groups correspond-

ing to the physical grouping of the contacts in the bank of the selector, one of such groups of lines including overflow lines connected to contacts located in another physical group of the contact bank, an auxiliary switch associated with the group selector, means effective when the group selector is operated into association with the physical terminals of the main group having the said overflow lines located in another physical contact group for causing said auxiliary switch to assume a position corresponding to an idle one of the overflow lines, and means effective in the event that the group selector is unable to find an idle line in the physical group with which it has been brought into association for releasing the selector after it has searched over the group and for reoperating it in accordance with the idle-line position assumed by the said auxiliary switch to bring it into connection with the contact from which the idle overflow line is accessible.

8. In a switching system, a selector having access to groups of lines, some of the lines of certain groups being accessible from positions on the switch apart from the positions of the other lines of the same group, an auxiliary switch having access to the lines which are accessible from the separated positions of the switch, means effective when the switch is operated into association with a group of lines containing lines separated as to position for causing the auxiliary switch to hunt for the called group and for an idle line in the group, and means effective in the event that all of the non-separated lines in the group accessible to the switch are busy and controlled from the auxiliary switch for causing the selector to establish connection with the line selected by the auxiliary switch.

9. In combination, a switching unit including a main selector and an auxiliary selector, groups of lines accessible to said switching unit and appearing in different arrangements in the banks of said selectors, means for operating the main selector to select a group of lines and to select and seize an idle line in the group, means controlled from the main selector for causing the auxiliary selector to select a different idle line in the same group, and means controlled from the main selector depending upon its being unable to find an idle line for causing the auxiliary selector to seize the idle line it selects.

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