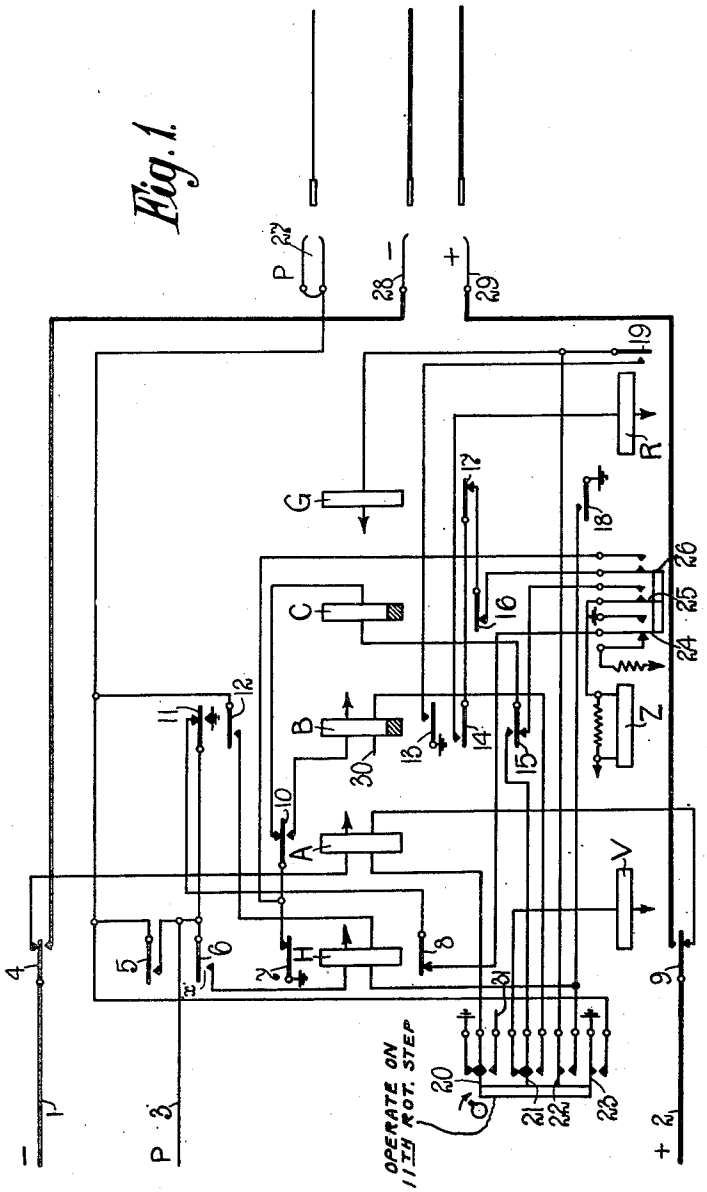
Sept. 15, 1931. W. H. PAULETT ET AL 1,823,665

TELEPHONE SYSTEM

Filed Sept. 3, 1929 7 Sheets-Sheet 1

Fig. 1.



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TELEPHONE SYSTEM

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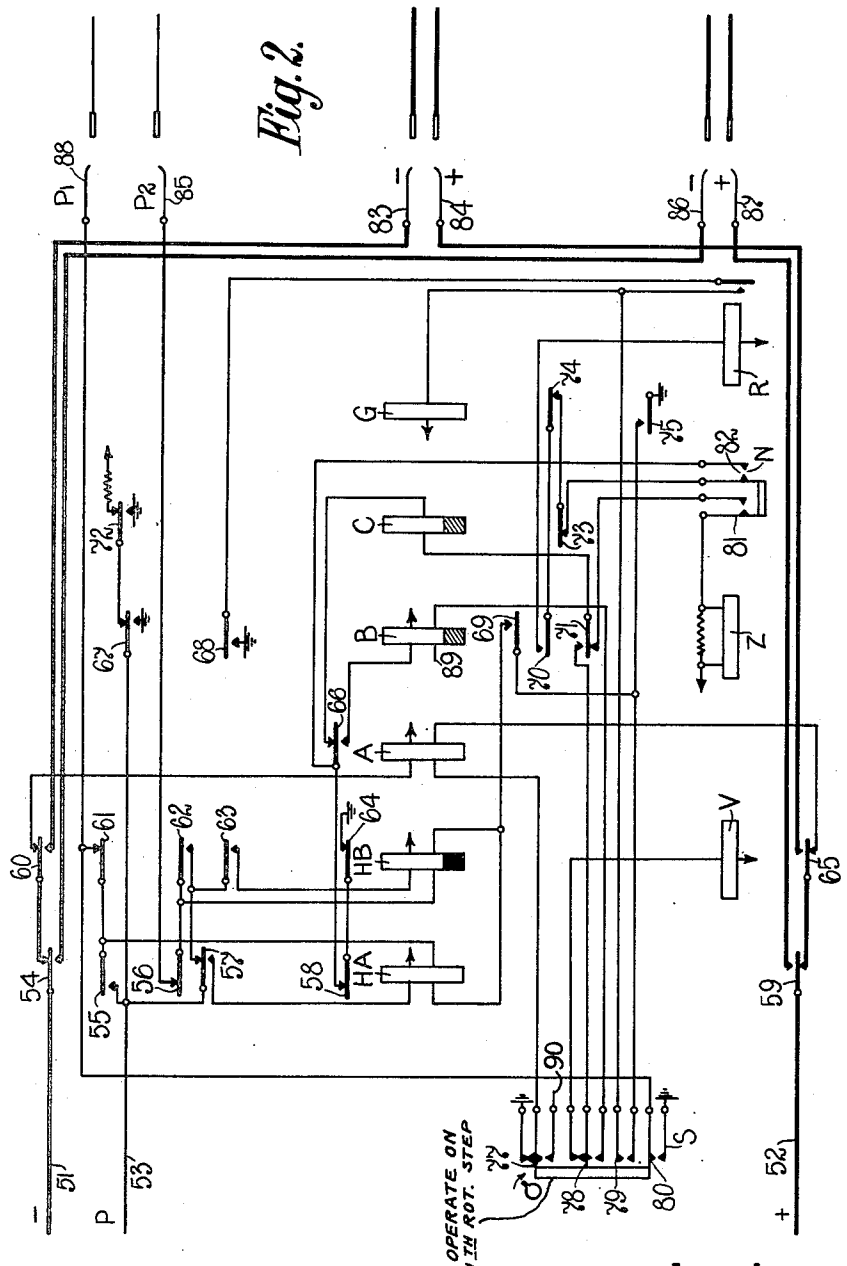
Fig. 2.



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TELEPHONE SYSTEM

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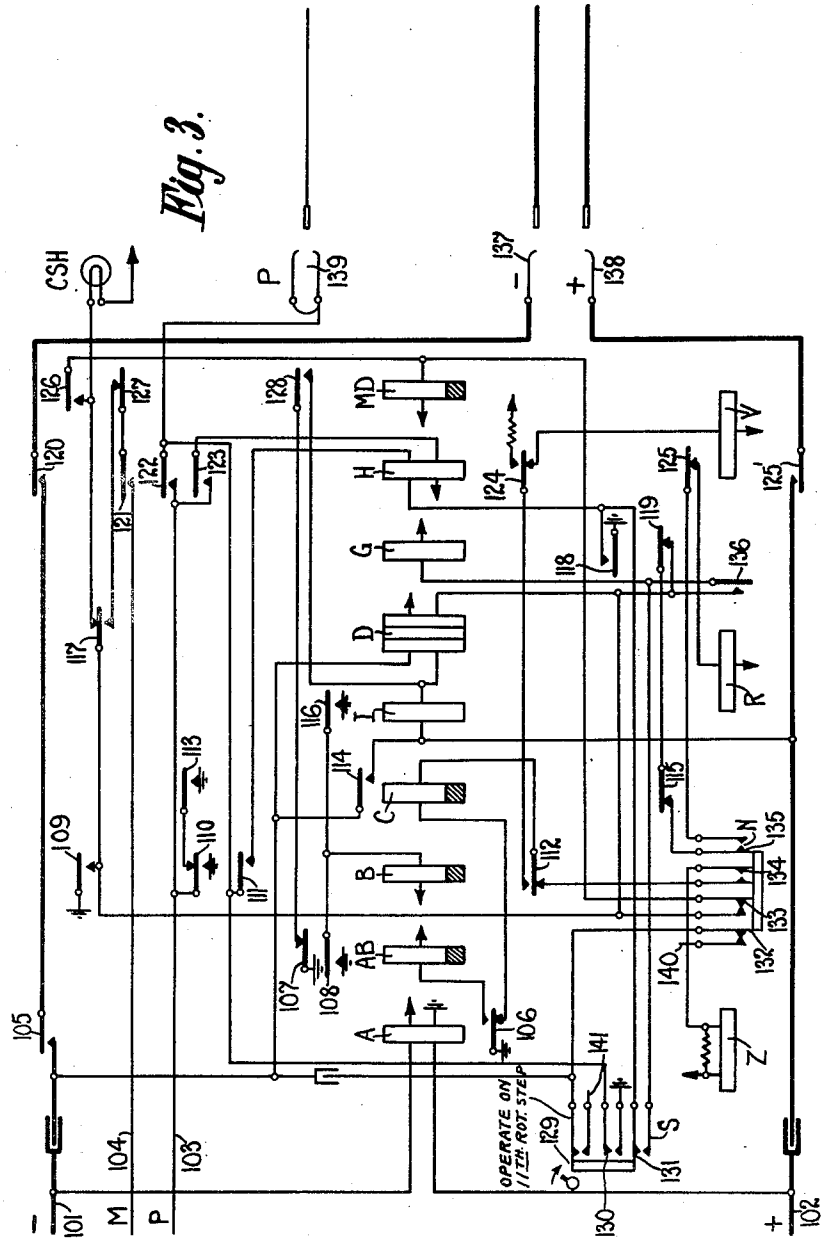
Fig. 3.



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TELEPHONE SYSTEM

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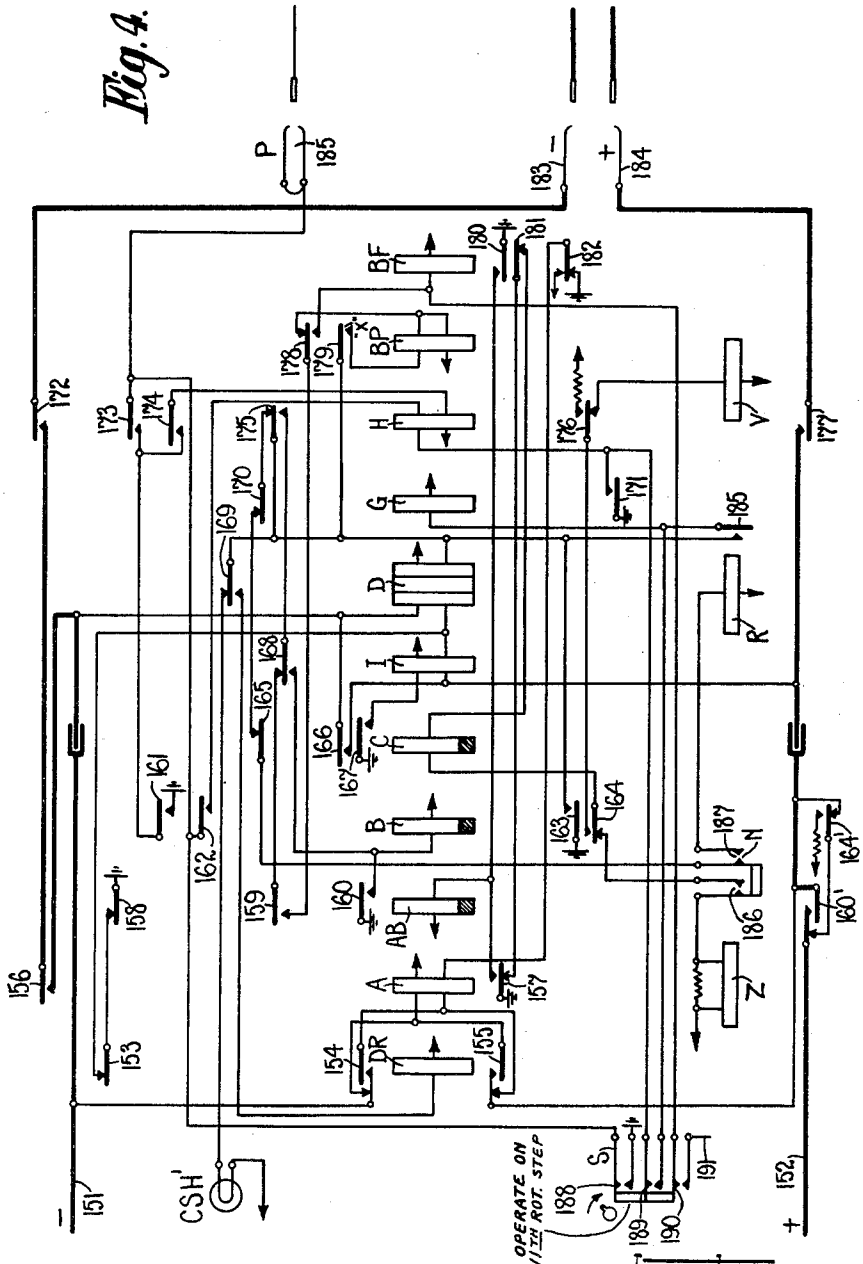
Fig. 4.



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TELEPHONE SYSTEM

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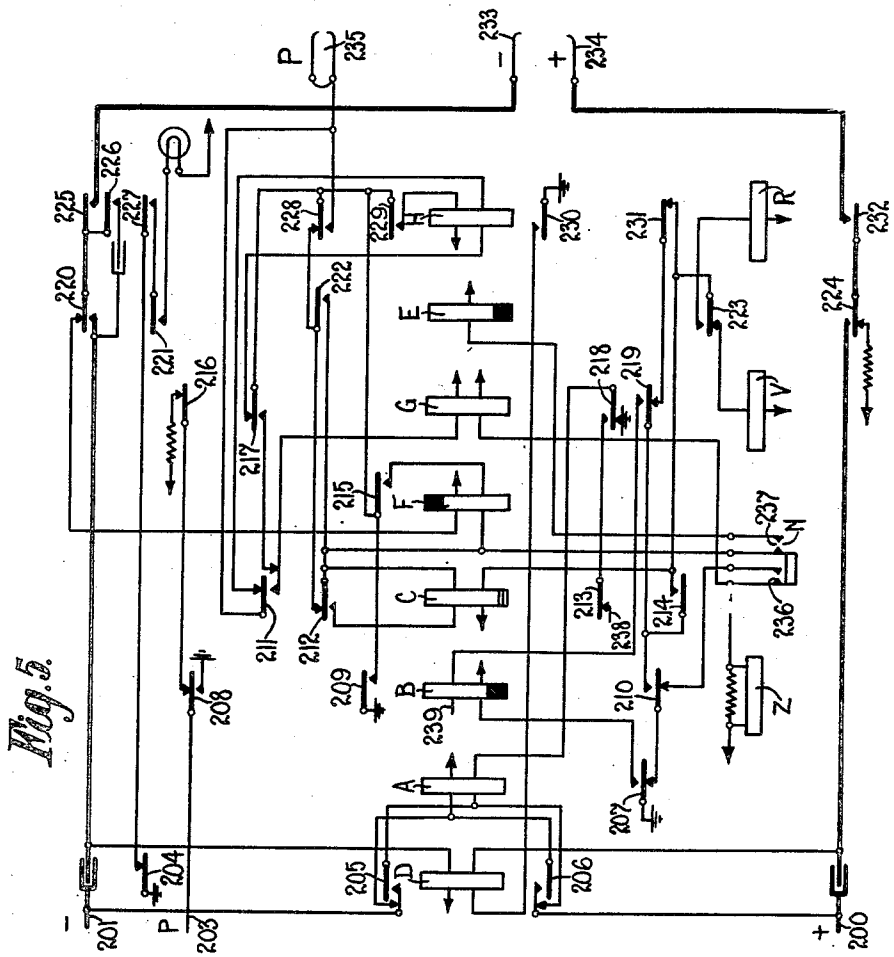

Fig. 5.

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TELEPHONE SYSTEM

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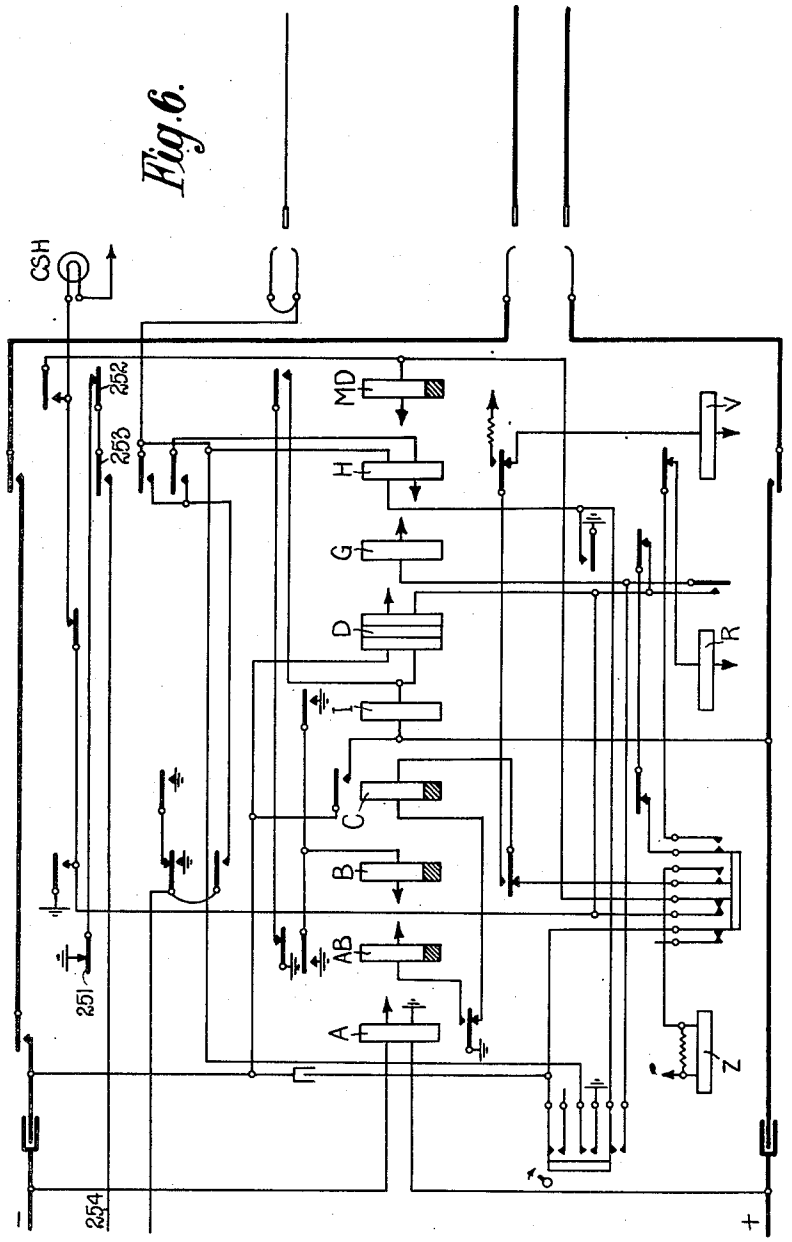
Fig. 6.



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TELEPHONE SYSTEM

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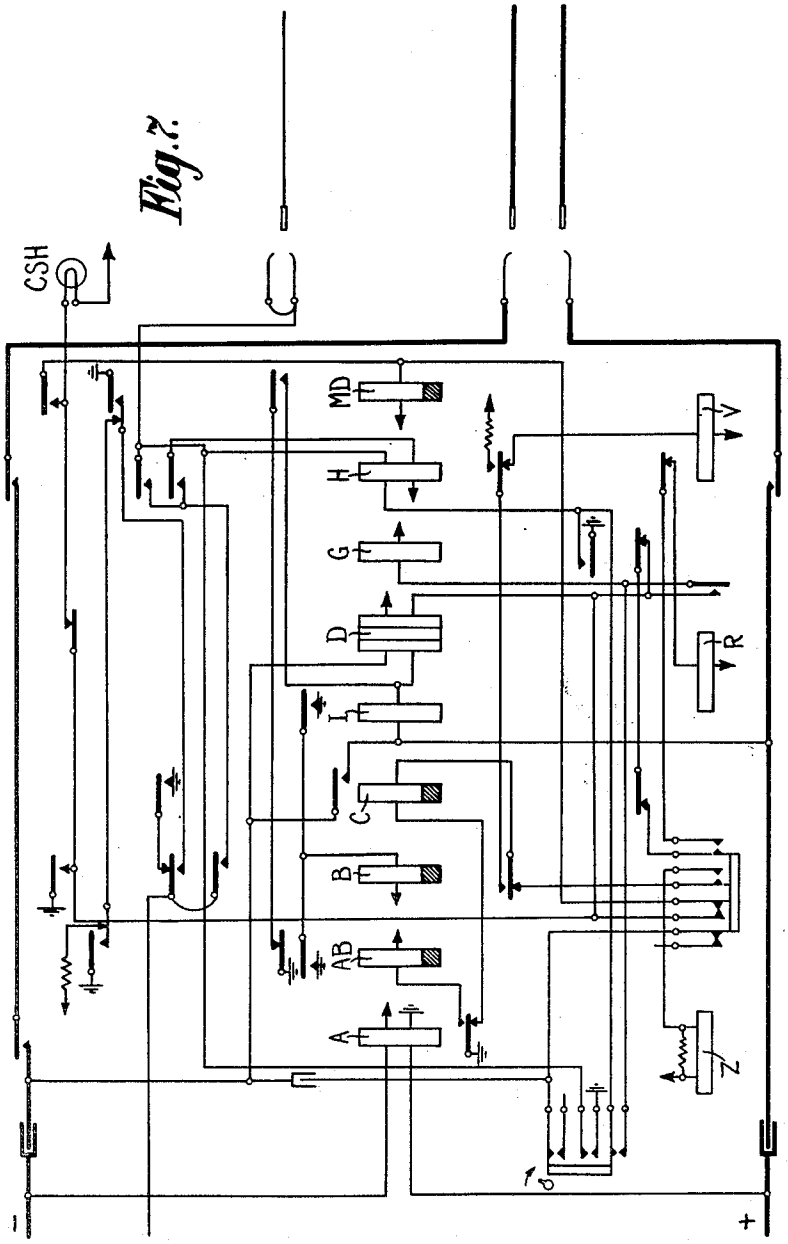
Fig. 7.



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UNITED STATES PATENT OFFICE

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TELEPHONE SYSTEM

Application filed September 3, 1929, Serial No. 390,155, and in Great Britain September 5, 1928.

The present invention relates to telephone systems and is more particularly concerned with arrangements for holding switches operated in such systems and for providing arrangements for testing whether a line is free or busy. A well-known type of telephone system employs step-by-step switches which are guarded by the application of earth potential to the test contacts, the absence of earth potential from the test contacts being employed to indicate that the switch is in a condition to be taken into use for setting up a connection.

One object of the present invention is to mark the idle condition of the switches in a more positive manner without complicating the circuit details or the construction of the switches and this is effected according to one feature of the invention by connecting one pole of battery to the associated test contact when a line is free and connecting the other pole of battery to the associated test contact when a line is busy.

In the system above referred to, unless special arrangements are made there is a possibility that a switch may be taken into use after it has been released by a calling party but before it has restored to normal. Such arrangements are readily provided according to another feature of the invention by which the switches are adapted to be maintained in operated position by the application of potential to a holding conductor whilst they are marked busy due to the presence of the holding potential and also due to the absence of special idle potential so that a switch may be released by the removal of the holding potential without rendering it available for use until idle potential is restored.

According to a further feature of the invention a holding conductor which is adapted to maintain a plurality of switches operated extends over the test wipers of the switches, potential different from that used for holding being employed to designate an idle line.

The invention will be better understood from the following description of several methods of carrying it into effect which should be taken in conjunction with the accompanying drawings. It will be understood that the particular arrangements shown and described are given by way of example only and that the invention is not limited to these precise arrangements.

Referring now to the drawings, these show in the usual manner circuits of automatic switches according to the invention for use in various circumstances. All the switches are assumed to be of the well-known vertical and rotary type having their contacts arranged in rows.

Fig. 1 represents an intermediate group selector, that is to say one in which all bridges across the line are cut out and a straight-through connection obtained when the switch has been completely set. This switch may be taken into use either from a lineswitch or from a selector which may be of similar type or may be of the battery feeding type.

Fig. 2 indicates a similar switch provided however with two sets of wipers and corresponding bank contacts and arranged for simultaneous hunting over both banks so that testing of two lines takes place at the same time.

Fig. 3 is a first selector with transmission bridges for supplying feed current to the calling party and giving operator hold facilities. This switch is accessible from a subscriber's lineswitch.

Fig. 4 is an incoming selector accessible over a two-conductor trunk line.

Fig. 5 is a final selector or connector which connects directly with a wanted party's line and supplies ringing current and subsequently battery feed to the wanted line.

Fig. 6 shows a first selector substantially similar to Fig. 3 except that it is arranged for metering at the end of the conversation rather than upon the reply of the called party.

Fig. 7 is a first selector similarly arranged for metering at the end of a conversation, but in this case by a booster impulse over the test lead instead of by connection of potential to a separate metering lead.

The operation of the various switches will

now be considered in detail. Referring first to Fig. 1, when the switch is seized by the completion of a loop across conductors 1 and 2, a circuit is completed for line relay A which thereupon operates and at armature 10 completes a circuit for the upper winding of relay B. Relay B at armature 11 removes the normal battery connection to test lead 3 which is supplied over off-normal springs 24 and armature 8 and its back contact. This battery potential, which is applied through a comparatively high resistance, is necessary to mark the switch idle and permit it to be taken into use from a preceding selector. In case the switch is seized from a subscriber's lineswitch which is arranged to hunt for absence of earth as is more usually the practice it will be necessary for earth to be applied to conductor 3 by the operation of armature 11 as is shown in the drawings, and in this case the battery connection is superfluous. The switch may however be wired as shown in which case it will operate in either set of circumstances without change. Relay B moreover at armatures 12, 13 and 14 prepares circuits for relay H, relay G and rotary magnet R respectively, and at armature 15 opens a point in the release magnet circuit and prepares the impulsing circuit for the vertical magnet V.

When the next series of impulses is transmitted, relay A will de-energize intermittently and on each deenergization will complete a circuit from earth, armature 7 and its back contact, armature 10 and its back contact, winding of relay C, armature 15 and its front contact, cam springs 21, winding of vertical magnet V to battery. The vertical magnet is accordingly energized intermittently and operates to raise the wipers 27—29 a corresponding number of steps. Relay C which is slow to release remains energized throughout the impulse series and at armature 16 opens a point in the rotary magnet circuit. At the end of the series of impulses relay C de-energizes and a circuit is then completed for the rotary magnet from earth, armature 7 and its back contact, off-normal springs 26, back contact and armature 16, back contact and armature 17, armature 14 and its front contact, winding of magnet R to battery. Wipers 27—29 are accordingly advanced one step to engage the first set of contacts in the level chosen and the magnet also operates the springs 19 thereby completing a circuit for relay G. Relay G at armature 18 prepares a testing circuit for relay H and at armature 17 opens the circuit of the rotary magnet so that this magnet de-energizes and opens the circuit of relay G. In case the line which the wipers are now engaging is free, wiper 27 will encounter battery and a circuit will then be completed to cause the operation of relay H. If the line is in use, however, there will be earth on the associated test contact or in case the test lead should be broken the contact will be dead and in either case it will be impossible for relay H to operate. Accordingly as soon as relay G de-energizes, a circuit is again completed for the rotary magnet and the same cycle of operations takes place, the wipers being advanced a further step. This continues until a free line is encountered, whereupon relay H energizes over its lower winding and at its lightly-tensioned armature 6 completes a locking circuit for itself over the upper winding to earth at armature 11. Relay H moreover at armatures 4 and 9 disconnects relay A and switches the speaking leads through to wipers 28 and 29, at armature 5 extends test conductor 3 to wiper 27 to busy the seized line, at armature 7 opens a point in the circuit of relay B and also of the rotary magnet and at armature 8 opens a point in the guarding circuit the utility of which will be more fully appreciated subsequently. Relay B is sufficiently slow to ensure that earth shall be maintained on the test conductor until it is fed back from the switch just taken into use. It may be pointed out that the provision of a make spring connected to earth for off-normal spring 24 is only necessary in the case in which the switch is accessible from a rotary lineswitch which is arranged to hunt for absence of earth in the usual manner. In case the switch were accessible from a selector of similar type the front contact of armature 11 could be omitted and also the make contact of off-normal spring 24 and in this event it would also be possible to dispense with armature 8 which is only inserted to prevent relay H being permanently locked up to the earth on the operated off-normal spring 24.

In case the switch should be unable to find a free line it would be advanced to the eleventh rotary position and cam springs 20—23 would then be operated. Thereupon at springs 20 busy tone and flash battery are connected up over lead 31 to the lower winding of relay A, at spring 21 a circuit is completed from the busy hold lead 30 for the lower winding of relay B to maintain this relay energized while relay A is de-energized during the battery period, at spring 22 a circuit is completed for maintaining relay G energized so as to prevent any further operation of the rotary magnet and at spring 23 earth is applied to test wiper 27 to operate an overflow meter which may be common to a number of switches.

The release of the switch is brought about by the removal of earth from the test conductor whereupon relay H is de-energized and at armature 7 completes a circuit for the release magnet Z in series with relay C which accordingly operates though without useful effect at this time. It will be noted that the switch is not rendered available for re-seizure until it has reached its normal position whereupon battery is re-applied at off-normal spring 24

and the circuit of the release magnet is opened at springs 25.

Referring now to Fig. 2, the circuits of the switch there shown are similar except that the switch is provided with two sets of wipers arranged for simultaneous hunting. Moreover the guarding circuit is slightly different in that the battery potential indicating the idle condition is applied over a back contact of relay C and accordingly the switch is not available for use until a short interval after the operation of the release magnet.

The various circuit changes which take place during the operation of the switch will be traced through briefly. When the switch is seized by the completion of a loop across conductors 51 and 52, relay A operates and at armature 66 completes a circuit for relay B which thereupon at armature 67 removes idle potential and applies guarding potential to the test conductor 53, at armature 68 prepares a circuit for relay G at armature 69 prepares circuits for relays HA and HB and at armatures 70 and 71 prepares circuits for the rotary magnet R and vertical magnet V respectively. When the next series of impulses is transmitted, relay A de-energizes intermittently and sends a corresponding number of pulses to the vertical magnet which operates to raise the wipers 83—88 to the desired level. Relay C is energized in series with the vertical magnet throughout the train of impulses and at armature 73 maintains the circuit of the rotary magnet open. When relay C de-energizes, however, magnet R is energized to rotate the wipers one step into engagement with the first set of bank contacts and at springs 76 to complete a circuit for relay G. This relay at armature 74 opens the circuit of the rotary magnet thus causing it to open contacts 76 and at armature 75 completes the test circuit for relays HA and HB. If test wipers 85 and 88 both fail to encounter battery due to the associated lines being busy or out of order, neither of these relays can operate and on the de-energization of relay G the rotary magnet is again energized to advance the wipers another step. If wiper 88 now encounters battery while wiper 85 encounters earth relay HB will be short-circuited but a circuit will be completed from battery on wiper 88 over bank contact and armature 61, lower winding of relay HA, front contact and armature 69, front contact and armature 75 to earth. Relay HA upon operating in this circuit, at armatures 54 and 59 switches leads 51 and 52 through to wipers 86 and 87, at armature 55 feeds earth forward to wiper 88 to busy the seized line, at armature 56 disconnects wipers 85, at armature 57 completes a locking circuit for itself over its upper winding and at armature 58 opens a point in the circuits of the release and rotary magnets. In case wiper 85 had encountered battery while wiper 88 had encountered earth, relay HB would have operated and at armature 60—65 would have produced similar changes to those produced by relay HA. In case wipers 85 and 88 both encountered battery both relays HA and HB would have commenced to operate but owing to the fact that relay HB is provided with a copper slug which makes it slightly slow to energize relay HA energizes first and at armature 56 opens the circuit of relay HB. By this means a definite choice is given when two idle lines are encountered simultaneously, and this arrangement is very desirable in case grading is employed between the various groups of switches. If the switch had been unable to find a free line in either bank, it would have been advanced to the eleventh position and the cam springs 77—80 would then have been operated. Thereupon at springs 77 busy tone and flash battery are connected up over lead 90 to the lower winding of relay A, at springs 78 a circuit is completed for the lower winding of relay B from the busy hold lead 89 to maintain this relay during the flash battery period, at springs 79 a locking circuit is completed for relay G to prevent any further operation of the rotary magnet and at springs 80 earth is fed forward to test wiper 88 to operate a suitable overflow meter. The release of the switch takes place when earth is removed from the test conductor whereupon relay HA or HB as the case may be will de-energize and complete a circuit extending from earth, back contact and armature 64, armature 58 and its back contact, armature 66 and its back contact, winding of relay C, armature 71 and its back contact, off-normal springs 81, winding of release magnet Z to battery. Magnet Z and relay C operate in series in this circuit, the former restoring the switch shaft and wipers in the usual manner and the latter at armature 72 applying earth to the test conductor 53 in place of battery so as to prevent seizure of the switch at that time. When the switch has completely restored, off-normal springs 81 will open and relay C will commence to release so that after a short interval battery will be replaced on test conductor 53 and the switch will be available for further seizure.

Referring now to Fig. 3, this shows a battery feeding first selector which is assumed to be accessible from a rotary lineswitch of the type which hunts for absence of earth so that it is unnecessary to provide a battery connection to the test conductor to indicate that the switch is in condition to be seized. This switch is also provided with arrangements for metering over a fourth wire when the called party replies. When the switch is taken into use, relay A is energized over leads 101 and 102 and the calling loop and at armature 105 prepares a circuit for repeating impulses to succeeding switches and at armature 106 completes a circuit for relay AB. The latter re-

lay upon operating, at armature 107 opens a point in the operator hold circuit which will be more fully described subsequently and at armature 108 completes a circuit for relay B. Relay B thereupon at armature 109 completes a circuit over armature 117 and its bank contact for the supervisory lamp CSH and over off-normal spring 133 for relay MD and prepares a number of other circuits, at armature 110 applies earth to the test conductor 103 to maintain the lineswitch operated, at armature 111 prepares a circuit for relay H and at armature 112 opens a point in the circuit of the release magnet Z and prepares a circuit for the vertical magnet V. Relay MD completes a locking circuit for itself at armature 126, at armature 127 opens a point in the metering circuit and at armature 128 closes a point in the operator hold circuit for relay I. Moreover at this time dial tone from lead 140 is connected up over off-normal springs 132 to conductor 101 to indicate to the calling party that he may now operate his dial switch.

When the first series of impulses is transmitted, relay A de-energizes intermittently, thereupon at armature 106 transmitting a corresponding number of pulses to the vertical magnet V which accordingly operates to raise the wipers 137—139 a corresponding number of steps. Relay C which is slow to release is energized in series with the vertical magnet throughout the impulse series and at armature 115 opens a point in the circuit of the rotary magnet, another point being closed at springs 135 as soon as the switch goes off-normal. At the end of the vertical movement relay C de-energizes and a circuit is then completed from earth, armature 109 and its front contact, back contact and armature 119, armature 115 and its back contact, off-normal springs 135, armature 125 and its back contact, winding of rotary magnet B to battery. Magnet B accordingly advances the wipers 137—139 into engagement with the first set of bank contacts and at springs 136 completes a circuit for relay G which thereupon at armature 119 opens the circuit of the rotary magnet and at armature 118 completes a testing circuit for the upper winding of relay H to test wiper 139. If the line now connected with is busy or out of order as indicated by the absence of battery on the test contact, relay H will be unable to energize and when relay C de-energizes due to the release of rotary magnet R, the circuit of this magnet will be again completed and it will operate to advance the wipers a further step. When a free line is encountered, battery picked up by wiper 139 will be extended over armature 111 and its front contact, upper winding of relay H, front contact and armature 118 to earth. Relay H upon operating at this time, at armatures 120 and 125′ connects the speaking leads through to wipers 137 and 138, at armature 121 closes a point in the metering circuit, at armature 122 feeds earth forward to wiper 139 to busy the seized line, at armature 123 completes a locking circuit for itself over its lower winding, at armature 124 disconnects the vertical magnet and substitutes a connection to battery through a resistance and at armature 125 opens a point in the circuit of the rotary magnet to prevent any further operation of this magnet. A loop is now completed across wipers 137 and 138 which extends as follows: wiper 137, armature 120 and its front contact, armature 105 and its front contact, left-hand winding of polarized relay D, winding of relay I, front contact and armature 125′, wiper 138 and this loop serves to prepare the succeeding switch for operation in the usual manner.

When the next series of impulses is transmitted, relay A pulses as before and at armature 105 intermittently opens the loop circuit just traced so as to produce operation of the succeeding switch in the usual manner. Moreover at armature 106 a circuit is completed intermittently for relay C which therefore energizes and at armature 114 short-circuits relays I and D so as to give a better impulsing circuit. Succeeding trains of impulses are transmitted in the same way to set the various switches and if the called party's line is idle at this time it is connected with and his bell is rung. When he replies by removing his receiver, current flow over the speaking conductors is reversed at the final selector switch and this serves to effect the operation of polarized relay D which accordingly at armature 117 extinguishes lamp CSH and opens the locking circuit of relay MD and also closes another point in the metering circuit. Relay MD is slow to release and de-energizes after a short interval thereupon at armature 127 extending earth on armature 109 to the metering lead 104 to effect the operation of the calling party's meter.

The subscribers may now converse as desired and when they have finished they will replace their receivers. If the called party replaces his receiver first, relay D will de-energize and again complete a circuit for the lamp CSH which accordingly serves to indicate when the called party is being held by the calling party. When the calling party replaces his receiver, relay A de-energizes and at armature 105 opens the loop extending to the succeeding switches so as to cause their release in the usual manner and at armature 106 opens the circuit of relay AB and completes the circuit of relay C. Relay AB on de-energizing after a short interval opens the circuit of relay B which thereupon at armature 110 connects up armature 113 which is at this time in operated position. Relay B also at armature 112 completes a circuit for release magnet Z in series with

relay C and the magnet operates to release the switch. Earth is maintained on test conductor 103 until restoration is complete and the circuit of magnet Z and relay C is accordingly opened at off-normal springs 134.

In case the switch should be unable to find a free line in the selected level, it would be advanced to the eleventh rotary position thus causing the operation of the cam springs. Thereupon at springs 129 busy tone over lead 141 is connected to lead 101 to inform the calling party that he cannot obtain his connection, at springs 130 earth is connected to test wiper 139 to operate an overflow meter and at springs 131 a locking circuit is completed for relay G to prevent any further operation of the rotary magnet. Release is effected when the calling party replaces his receiver whereupon relay A de-energizes with the result previously described. There is no necessity in this case for connecting up busy flash battery since the switch shown is only accessible from a subscriber's lineswitch and not from an operator's position. If connection is extended to an operator's position in which case it is desirable that the operator should control the release of the connection no battery reversal will take place and consequently since relay D does not operate relay MD will remain operated and no metering will be effected. Furthermore the connections at the operator's position will be such that battery is applied to the lower speaking lead as well as to the upper speaking lead. Consequently when the calling party replaces his receiver at the end of the conversation and relays A and AB de-energize, a circuit is completed from earth, armature 107 and its back contact, armature 128 and its front contact, winding of relay I to battery on the lower speaking lead. Consequently relay I is maintained energized and at armature 116 provides an alternative circuit for relay B so that release cannot take place until battery is removed from the lower speaking lead when the operator takes down the connection.

Referring now to Fig. 4, this shows an incoming selector, that is to say, a selector which is adapted to be seized over a two-wire junction so that in this case it is clearly impossible for the switch to feed back battery on the test conductor in order to indicate its idle condition. The arrangement adopted is that in the bank of the switch having access to the outgoing and of the trunk line a permanent battery connection is made to the associated test contact so that if the trunk line is free this battery connection will be effective. If, however, the line is in use earth will be connected to the test contact in the usual manner, and this will have the effect of rendering the battery connection ineffective. When the switch shown in Fig. 4 is seized by the connection of a loop across the speaking conductors 151 and 152, line relay A is energized and at armature 156 prepares the outgoing loop and at armature 157 completes a circuit for relay AB. This relay at armature 158 opens a point in the operator hold circuit for relay I, at armature 159 completes a point in the circuit for repeating busy flash, at armature 160 energizes relay B and at armature 160′ connects the lower speaking lead through independently of armature 164′. Relay B upon energizing at this time, at armature 161 prepares the holding circuit for relay H, at armature 162 prepares a test circuit for this relay, at armature 163 prepares a number of circuits and lights the supervisory lamp CSH, and at armature 164 prepares the impulsing circuit. When the next series of impulses is transmitted, relay A de-energizes intermittently and on each de-energization completes a circuit at armature 157 extending over armature 181 and its back contract, winding of relay C, armature 164 and its front contact, armature 176 and its back contact, winding of vertical magnet V to battery, so that magnet V operates to step wipers 183—185 to the required level. Relay C being slow to release remains energized throughout the train of impulses and at armature 165 opens a point in the rotary magnet circuit, at armature 166 short-circuits relays I and D and at armature 167 completes a circuit for the upper winding of relay I which accordingly operates but without effect at this time. When relay C de-energizes at the end of the train of impulses, the circuit of the rotary magnet is completed from earth, armature 163 and its front contact, armature 175 and its back contact, armature 170 and its back contact, back contact and armature 165, off-normal springs 187, winding of magnet R to battery. The rotary magnet operates to step the wipers into engagement with the first set of bank contacts and closes its springs 185 thereby completing a circuit for relay G which at armature 170 opens the circuit of magnet R and at armature 170 opens the circuit of magnet R and at armature 171 completes a testing circuit for the upper winding of relay H. Relay H is not operated unless the test wiper 185 picks up battery indicating that the line is idle and if this does not occur, when relay G again de-energizes owing to the opening of its circuit at springs 185 it again completes a circuit for the rotary magnet R so that the wipers are advanced a further step. When an idle line is reached, relay H is operated from battery picked up by the test wiper and at armatures 172 and 177 switches the speaking leads through to wipers 183 and 184, at armature 173 connects earth to test wiper 185, at armature 174 locks itself up over its lower winding, at armature 175 opens the rotary magnet circuit and prepares a circuit for relay BP and at armature

176 disconnects the vertical magnet. A loop including relays I and D is now placed across wipers 183 and 184 and accordingly the switch which has now been taken into use is prepared for operation in the usual manner. When the next series of impulses is received, relay A responds as before and repeats the impulses at armature 156. Relay C is again energized and at armature 166 short-circuits relays I and D to improve the impulsing while at the same time maintaining relay I operated at armature 167 and subsequent series 1 of impulses are repeated in the same way. The arrangement whereby relay I is maintained saturated also reduces the impedance when relays I and D are subsequently re-inserted in the loop and this overcomes any tendency for the line relay of the distant switch to de-energize momentarily and give a false impulse. When the connection has been completely set up and the wanted party replies, the current flow over the speaking conductors is reversed at the final selector and is then in such a direction as to operate relay D. This relay accordingly at armature 169 opens the circuit of the supervisory lamp CSH' and completes the circuit of relay DR which at armature 153 opens a further point in the operator's hold circuit and at armatures 154 and 155 reverses the connections of relay A to conductors 151 and 152 thus repeating back the supervisory signal.

At the end of the conversation when the wanted party replaces his receiver relay D is again de-energized and connects up the lamp CSH' the prolonged lighting of which accordingly indicates that the called party is being held. When the calling party replaces his receiver, relay A de-energizes and releases relay AB at armature 157 and at armature 156 opens the loop to the succeeding switches so as to effect their release in the usual manner. Relay AB opens the circuit of relay B and when relay B has de-energized the circuit of the release magnet is completed as follows: earth, armature 157 and its back contact, armature 181 and its back contact, winding of relay C, armature 164 and its back contact, off-normal springs 186, winding of magnet Z to battery. The release magnet operates to restore the switch to normal and relay C is also energized though without any particular effect in this case.

If the switch had been unable to find a free line in the selected level it would have been advanced to the eleventh position, thereupon operating the cam springs. At springs 188 earth is connected to test wiper 185 to operate an overflow meter connected to the eleventh contact, at springs 189 a locking circuit is completed for relay G so as to prevent any further operation of the rotary magnet and at springs 190 interrupted earth over lead 191 is connected to relay BF which accordingly energizes and de-energizes intermittently. Thereupon at armature 182 battery is connected up to the lower winding of relay A in place of the normal earth connection, at armature 181 the impulsing circuit is opened to prevent impulses being transmitted to the vertical magnet on the de-energization of relay A and at armature 180 an alternative circuit is completed for relay AB to prevent this relay de-energizing on the release of relay A. Consequently the usual busy flash battery conditions are connected back over the trunk line to operate a flashing signal at an operator's position or to control a battery feeding switch by which busy tone will be connected back to the calling party. In case a busy condition is encountered beyond the switch shown in Fig. 4, battery and earth intermittently will be applied to the lower speaking conductor. During the application of battery, relay I is de-energized and a circuit is then completed as follows: battery, lower winding of relay BP, back contact and armature 178, front contact and armature 159, back contact and armature 168, front contact and armature 175, front contact and armature 163 to earth. Relay BP is a two-step relay and at this time operates only its light armature 179 thereby preparing a locking circuit for itself. On the termination of the battery period, relay I again energizes thereby at armature 168 removing the short-circuit from the upper winding of relay BP which thereupon energizes fully and at armature 178 prepares a circuit for relay BF. When relay I next de-energizes the circuit previously traced will be extended to relay BF which will accordingly energize with the results previously described. Relay I will now continue to operate in synchronism with the busy flash pulses and relay BF will pulse similarly thereby repeating the busy signal back to the calling party.

In case the connection is extended to an operator's position, it is desirable that the operator should have control of the release as was described in connection with Fig. 3. In this case no reversal will take place and consequently relays D and DR will not be operated but as long as the connection remains set up battery will be connected to the lower speaking conductor. When the calling party replaces his receiver, relays A and AB will be de-energized and a circuit will then be completed from earth, armature 158 and its back contact, armature 153 and its back contact, lower winding of relay I to battery connected to the lower speaking conductor so that relay I will remain operated and at armature 168 will complete an alternative circuit for relay B so that the connection remains held up. Moreover owing to the fact that relay B is now energized while relay

AB is de-energized, the battery connection to the lower speaking conductor is repeated back over front contact and armature 164′ and normally closed springs controlled by armature 160′ to lead 152 to hold up the preceding switches.

Referring now to Fig. 5, this represents a final selector or connector switch, that is to say one which is adapted to connect with a wanted line and does not perform any hunting operation. This switch is assumed to be accessible over selectors modified according to the invention, for instance, as shown in any of Figs. 1–4. When the switch is taken into use by the completion of a loop across conductors 201 and 202, line relay A is operated and at armature 207 completes a circuit for the lower winding of relay B. Relay B upon operating, at armature 208 removes the normal battery connection from test lead 203 and replaces it by earth, at armature 209 prepares circuits for relays E, F and H and at armature 210 disconnects the release magnet Z and prepares the circuit of the vertical magnet V. When the next series of impulses is transmitted, relay A de-energizes intermittently in accordance therewith and on each de-energization completes a circuit from earth, armature 207 and its back contact, armature 210 and its front contact, armature 219 and its back contact, armature 231 and its back contact, lower winding of relay C to battery and in parallel therewith armature 223 and its back contact, winding of vertical magnet V to battery. The vertical magnet is operated in the usual manner to raise wipers 233—235 to the required level and relay C is also operated and since at armature 212 it short-circuits its upper winding it is rendered slow to release and thus remains energized throughout the train of impulses. At armature 211 it prepares a circuit for relay G which is not yet operative, at armature 213 it opens a point in the busy flash circuit and at armature 214 shunts armature 219 and 231 though this also is without effect at this stage. On the termination of this series of impulses, relay C de-energizes and a circuit is then completed as follows: earth, armature 209 and its front contact, armature 228 and its back contact, back contact and armature 212, off-normal springs 237, winding of relay E to battery. Relay E upon energizing at this time, at armature 222 completes a locking circuit for itself independent of relay C and at armature 223 connects up the rotary magnet R in place of the vertical magnet V. When the final series of impulses is transmitted, relay C is energized over the same circuit as before and impulses are transmitted to the rotary magnet R which accordingly steps the wipers into engagement with the contacts associated with the wanted line. The upper winding of relay G is now connected to test wiper 235 so that if busy contacts are passed over during the rotary movement relay G will be energized. This however produces no detrimental effect since the busy circuit is held open at armature 213 and the impulsing circuit is maintained intact at armature 214.

Suppose in the first instance that the wanted line is busy when it is connected with; in this case wiper 235 will encounter earth and therefore relay G will be operated when the wipers come to rest. Accordingly when relay C de-energizes, a locking circuit is completed for the upper winding of relay G over the normally closed springs controlled by armature 211 and at armature 218 busy flash battery is connected to the lower winding of relay A, while at armature 219 a circuit is completed for the upper winding of relay B to the busy hold lead 239 when relay A de-energizes during the battery periods. Accordingly the usual busy signal is repeated back to the calling party who will realize that he cannot obtain his connection and therefore replaces his receiver. When this is done relay A de-energizes and accordingly during the next earth period of the busy flash, relay B de-energizes also. On the de-energization of relay B the release magnet circuit is completed from earth, armature 207 and its back contact, armature 210 and its back contact, off-normal springs 236, release magnet Z to battery and in parallel thereto, lower winding of relay G to battery. Relay G is accordingly maintained energized until the switch has reached normal position and at armature 216 removes the battery connection indicating the idle condition so as to ensure that the switch shall not be again taken into use until it has fully restored.

Assume now that the wanted party's line is idle when it is connected with; in this case when the rotary movement terminates wiper 235 will not encounter earth and relay G will be de-energized. A circuit is then completed from earth, armature 209 and its front contact, armature 217 and its back contact, lower winding of relay H, back contact and armature 211, test wiper 235, cut-off relay and magnet of the called party's lineswitch to battery. The cut-off relay and relay H energize in series in this circuit and the latter at armature 229 completes a locking circuit for itself over its upper winding. Relay H moreover at armatures 225 and 232 connects up wipers 233 and 234, at armature 226 closes a circuit for giving ringing tone to the calling party, at armature 227 prepares a circuit for the supervisory lamp, at armature 228 applies direct earth to test wiper 235 and opens the circuit of relay E, at armature 230 connects earth to the lower winding of the back bridge relay D and at armature 231 opens the impulsing circuit to prevent any further operation of the rotary magnet in case the subscriber should dial again. Re-

lay E is slow to release and when it falls away it connects the ringing generator to the wanted line at armatures 220 and 224 in series with the upper winding of ringing trip relay F. This slight delay is desirable to ensure that ringing current shall not be connected up until the wanted line has been cleared of its normal battery and earth connections by the operation of the cut-off relay so that premature tripping shall not occur. The wanted party's bell is now rung and when he replies by removing his receiver the direct current bridge thus completed across the line serves to operate relay F which thereupon at armature 215 completes a locking circuit over its lower winding in series with relay E. This latter relay is therefore again operated and at armatures 220 and 224 cuts off the ringing current and completes the speaking connection. Back bridge relay D is now operated over the called party's loop and at armatures 205 and 206 reverses the connections of line relay A to conductors 201 and 202 for metering or supervisory purposes. When the called party replaces his receiver at the end of the conversation, relay D again de-energizes and reverses the current flow over the speaking conductors back to its original direction and at armature 204 completes a circuit for the supervisory lamp the prolonged lighting of which indicates that the called party is being held because the calling party has not hung up. When the calling party replaces his receiver, release takes place in the manner previously described, relay G being operated in parallel with the release magnet to ensure that the switch is not marked as selectable until it has properly restored to normal.

Referring now to Fig. 6, this as already mentioned is substantially identical with Fig. 3 but is arranged to give metering at the end of the conversation rather than on the reply of the called party. This arrangement is preferable in some circumstances for instance where there is a possibility of a local call being broken down in favour of a long distance call. Fig. 6 also differs slightly from Fig. 3 as regards the holding circuit of relay H in that the B relay contact has been included in the circuit of the holding winding instead of that of the energizing winding. The full operation of the switch will not therefore be traced through in detail, but it will suffice to point out that relay MD is again operated when relay B energizes and locks up dependent upon relay D. When the called party replies, relay D operates and opens the circuit of relay MD whereupon it releases but no metering circuit is completed. When the calling party replaces his receiver, relay A de-energizes and opens the circuit of relay AB which de-energizes also after a short interval. Relay AB opens the circuit of relay B but since relay B is slow to release there is a short time during which relay AB is de-energized and relay B energized. Relay H it will be noted is dependent upon relay B. Accordingly a circuit is now completed from earth, back contact and armature 251, back contact and armature 252, armature 253 and its front contact to the metering lead 254. This circuit is maintained until armature 253 restores on the de-energization of relay H following the release of relay B. Relay C is energized during the release operation as before and applies earth to the test conductor for guarding purposes. It will be noted that in case no reply is obtained or if the call is extended to an operator, relay MD will be maintained energized and accordingly will not commence to release until relay B has fallen away at which time the circuit of relay H will be opened so that the metering circuit cannot be completed.

Fig. 7 is similar to Fig. 6 except that metering is effected by the connection of booster battery to the test conductor instead of by earth potential to a separate metering lead and that the H relay contacts in the metering circuit are unnecessary as the test conductor extends over contacts of relay B. The operation, however, is substantially similar, booster battery being connected up during the time that relay B is falling away. Moreover as in the previous case if the call is unsuccessful or has been extended to an operator, relay MD will not commence to release until relay B is de-energized and thus it will not be possible for the metering circuit to be completed.

The arrangement shown in Figs. 6 and 7 whereby the locking winding of relay H, which extends to battery, is connected to the test lead over contacts of relay B overcomes a possible disadvantage in that if this winding is connected direct, then when the holding earth is removed to effect release, the battery which is applied until relay H falls away is similar except as regards its resistance to the idle potential and might therefore in particularly unfavorable circumstances cause faulty operation. In view, however, of the extremely short release time of relay H this possibility is extremely remote. The difficulty such as it is can also be overcome by arranging that in Fig. 1 for instance, the front contact of armature 5 is connected directly to earth instead of the test conductor 3, thereby producing successive release of a train of switches in a forward direction.

What we claim is:—

1. In a telephone system, an automatic hunting switch having an incoming test conductor, means in said switch for normally connecting one pole of battery to said test conductor to apply an idle potential, means for seizing said switch if idle, and means in said switch responsive to said seizure for disconnecting said one pole of battery from said conductor and for connecting the opposite

pole of battery to said conductor to mark said switch busy with a busy potential.

2. In a telephone system, an automatic hunting switch having an incoming test conductor, means in said switch for normally connecting one pole of battery to said test conductor to apply an idle potential, means for seizing said switch if idle, means in said switch responsive to said seizure for disconnecting said one pole of battery from said conductor and for connecting the opposite pole of battery to said conductor to mark said switch busy with a busy potential, means for operating said switch to extend a connection, means for connecting the opposite pole of battery to said conductor over the established connection to maintain said switch in operated position and busy, means for removing said opposite pole of battery from said conductor to release said switch and remove said busy condition, means whereby said switch is unselectable due to the absence of said idle potential during its release, and means whereby said switch is again selectable responsive to the complete restoration of said switch and the connection of said idle potential to said conductor.

3. In a telephone system, an automatic hunting switch having an incoming test conductor, means in said switch for normally connecting one pole of battery to said test conductor to apply an idle potential, means for seizing said switch if idle, means in said switch responsive to said seizure for disconnecting said one pole of battery from said conductor and for connecting the opposite pole of battery to said conductor to mark said switch busy with a busy potential, a test wiper for said switch, means for operating said switch and wiper to extend a connection, means for disconnecting said opposite pole of battery from said conductor responsive to the establishment of said connection, and means for connecting the opposite pole of battery to said conductor by way of said test wiper to maintain said switch busy and in operated position.

4. In a telephone system, an automatic switch having line wipers and a test wiper, trunk lines each having line contacts and test contacts accessible to said line and test wipers, means for operating said wipers over said contacts to hunt for an idle one of said trunk lines, a relay in said switch for connecting the talking conductors of said switch with said line wipers, means in said switch for connecting one terminal of the winding of said relay to said test wiper during the hunting operation, and means in said switch for connecting a source of potential to the other terminal of said winding each time the test wiper engages a different test contact.

5. In a connector switch for completing connections to called lines, means for selecting and operating said switch to extend a connection to one of said lines, a busy relay operated in case said switch extends a connection to a busy line to indicate the busy condition thereof, means for releasing said switch, means for again operating said relay during the release of said switch, and means controlled by the operation of said relay for making said switch unselectable until the switch is fully restored to its normal position.

6. In a telephone system, a calling line, an automatic switch, means responsive to a call by the calling line for seizing said switch, a first relay in said switch having two circuits, a slow relay in said switch energized responsive to the seizure of said switch for energizing said first relay over the first of said circuits, means controlled by the energization of said first relay for marking said switch busy, an operator's position, means for operating said switch to extend the connection from the calling line to said operator's position, means responsive to the calling subscriber replacing his receiver for deenergizing said slow relay, and a third relay in said switch energized responsive to the deenergization of said slow relay for maintaining said first relay energized over the second of said circuits in order to maintain said switch busy.

7. A telephone system as claimed in claim 1 in which off-normal contacts in said switch are included in the means for normally connecting said idle potential to said test conductor.

8. A telephone system as claimed in claim 1, including outgoing trunk lines accessible to said switch and having test contacts normally connected to said idle potential, a test wiper in said switch having access to said test contacts, means for operating said switch and test wiper to connect with one of said trunk lines, and means in said switch for applying the opposite pole of battery to the test contact of the connected trunk line over said test wiper to mark such trunk line busy.

9. In a telephone system as claimed in claim 1 including a test wiper in said switch, a driving magnet in said switch for operating said wiper in its hunting movement, and a circuit for operating said driving magnet completed independently of said test wiper as long as said test wiper encounters busy potentials during the hunting operation.

10. In a telephone system as claimed in claim 1 including line wipers and a test wiper for said switch, a relay in said switch for connecting the talking conductors of said switch to said line wipers, and a circuit for energizing said relay including said test wiper.

11. In a telephone system as claimed in claim 1 including two relays in said switch, means for energizing the first of said relays for connecting the opposite pole of battery to

said conductor to apply a guarding potential thereto only as long as said switch is in use, means for deenergizing said first relay and for releasing said switch, and means for energizing the second of said relays to apply said guarding potential to said conductor during the release of said switch.

12. In a telephone system as claimed in claim 1 including two relays in said switch, means for energizing the first of said relays for connecting the opposite pole of battery to said conductor to apply a guarding potential thereto only as long as said switch is in use, means for deenergizing said first relay, means responsive thereto for releasing said switch and for energizing the second relay, means controlled by the energization of said second relay for applying said guarding potential to said conductor during the release of said switch, and means whereby the energization of either of said relays disconnects said idle potential from said conductor.

13. In a telephone system as claimed in claim 3 in which when release is initiated the opposite pole of battery extending by way of said test wiper is removed, means for releasing said switch and preceding switches responsive thereto, and means whereby when said switch is fully restored said idle potential is connected to said test conductor to render said switch available for use in other connections.

14. In a telephone system as claimed in claim 4 including a magnet for driving the switch in its hunting operation and a second relay for connecting said source to said other terminal of said winding each time the test wiper engages a different test contact, an energizing circuit for said second relay, and means controlled by said magnet for intermittently closing said circuit on each operation of said magnet.

15. In a telephone system as claimed in claim 4 including a magnet for driving the switch in its hunting operation and a second relay for connecting said source to said other terminal of said winding each time the test wiper engages a different test contact, an energizing circuit for said second relay, means controlled by said magnet for intermittently closing said circuit on each operation of said magnet, an energizing circuit for said magnet, and means controlled by each energization of said second relay for opening said magnet circuit.

16. In a telephone system as claimed in claim 4 including a magnet for driving the switch in its hunting operation and a second relay for connecting said source to said other terminal of said winding each time the test wiper engages a different test contact, an energizing circuit for said second relay, means controlled by said magnet for intermittently closing said circuit on each operation of said magnet, an energizing circuit for said magnet, means controlled by each energization of said second relay for opening said magnet circuit, a set of springs in said switch, means for operating said springs in case said wipers are operated beyond said contacts when all said trunk lines are busy, and a locking circuit for said second relay completed responsive to the operation of said springs for preventing further operation of said wipers.

17. In a telephone system as claimed in claims 4, including a test conductor in said switch, means for energizing said relay over a circuit including said test wiper, said winding, and said source of potential, and a locking circuit including said test conductor completed for said relay responsive to its energization.

18. In a telephone system as claimed in claim 4 including a driving magnet in said switch for controlling the hunting operation, a driving circuit for operating said magnet, means for energizing said relay over a circuit including said test wiper, said winding, and said source of potential, and means controlled by the energization of the said relay for opening the driving circuit of said magnet.

19. In a telephone system, a calling line, an automatic switch, means responsive to a call by the calling subscriber for seizing said switch, a first relay in said switch having two circuits, a slow relay in said switch energized responsive to the seizure of said switch for energizing the said first relay over the first of said circuits, means controlled by the energization of said first relay for marking said switch busy, automatic switches, an automatic subscriber's line, means responsive to a call by the calling subscriber for operating said switch and automatic switches to complete a connection to said automatic subscriber's line, a third relay in said switch, a loop circuit including both talking conductors of said switch for energizing said third relay when a connection is extended to said automatic subscriber's line over said automatic switches, an operator's position, means for operating said switch to extend the connection from the calling line to said operator's position, means responsive to the calling subscriber replacing his receiver for deenergizing said slow relay, a circuit including only one of the speaking conductors of said switch for energizing said third relay, and means controlled by the energization of said third relay for maintaining said first relay energized over the second of said circuits in order to maintain said switch busy.

20. In a telephone system as claimed in claim 6 wherein the energization of said third relay and the maintained energization of said first relay prevents the release of said switch by the calling subscriber.

21. In a telephone system as claimed in claim 1 including means for operating said switch in a primary directive movement, a relay in said switch energized during the primary movement and deenergized thereafter to initiate the secondary movement of said switch, means for releasing said switch, and means responsive thereto for energizing said relay to connect said opposite pole of battery to said conductor during the release of said switch.

In testimony whereof we have signed our names at Liverpool, England, this 20th day of July, 1929.

WILLIAM HENRY PAULETT.
CHARLES GILLINGS.