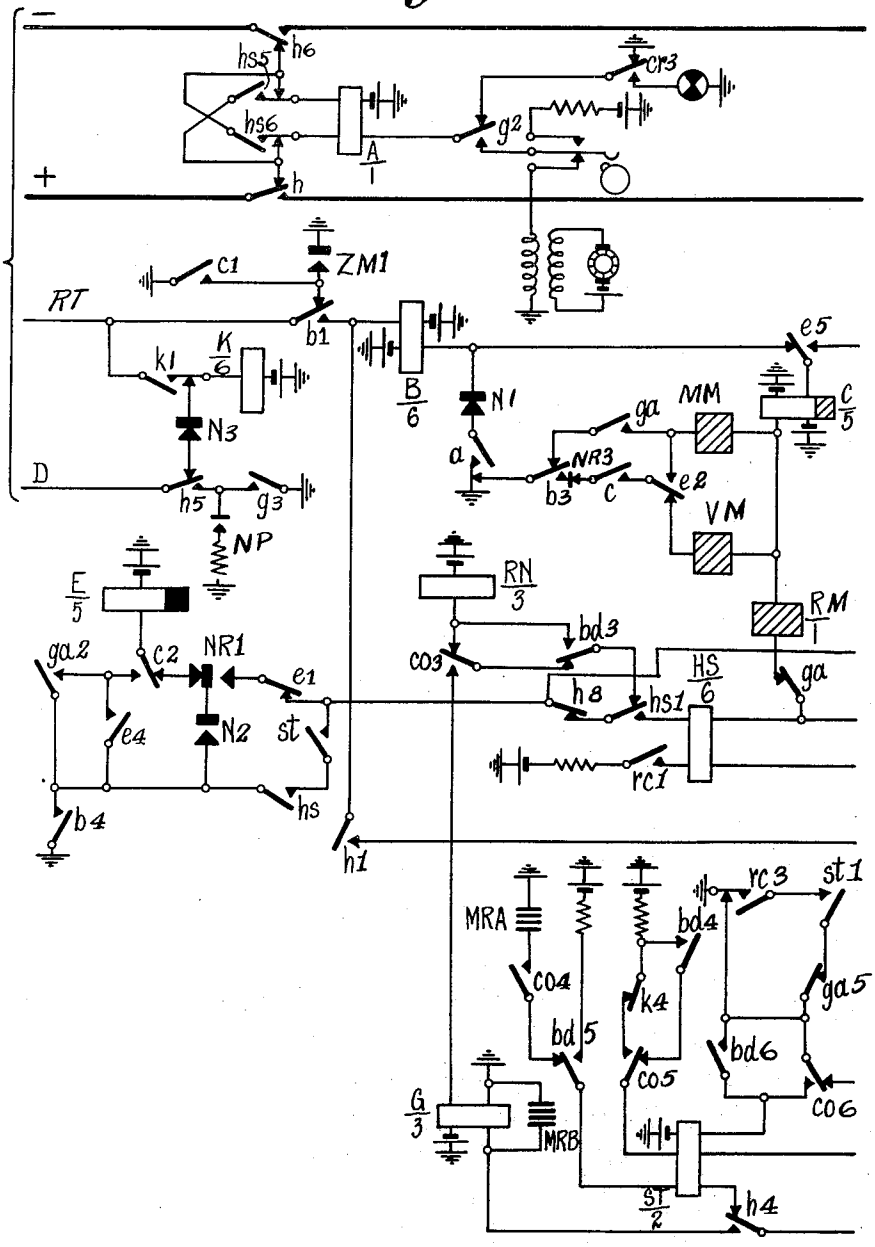
May 1, 1934. F. T. BELAS ET AL 1,956,610

TELEPHONE SYSTEM

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Fig. 1.



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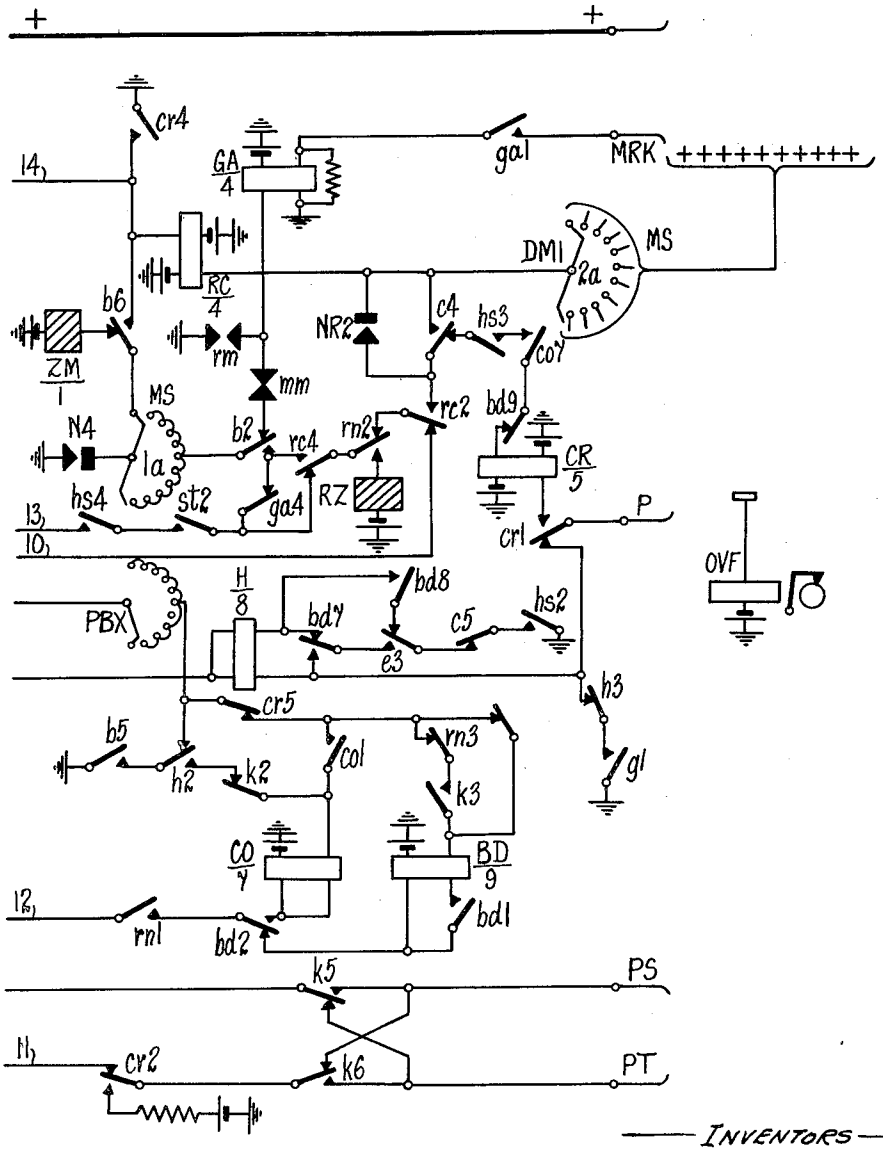
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TELEPHONE SYSTEM

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Fig. 2.



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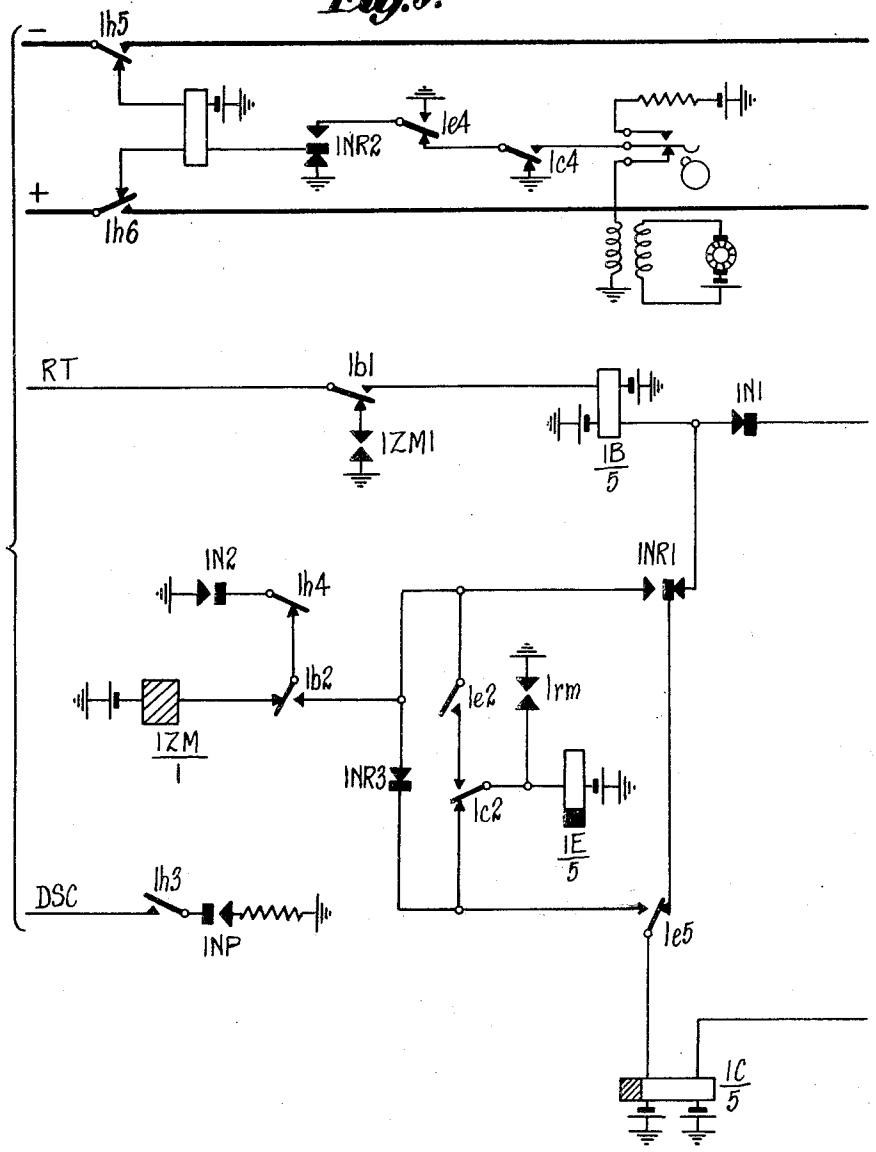
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TELEPHONE SYSTEM

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Fig. 3.



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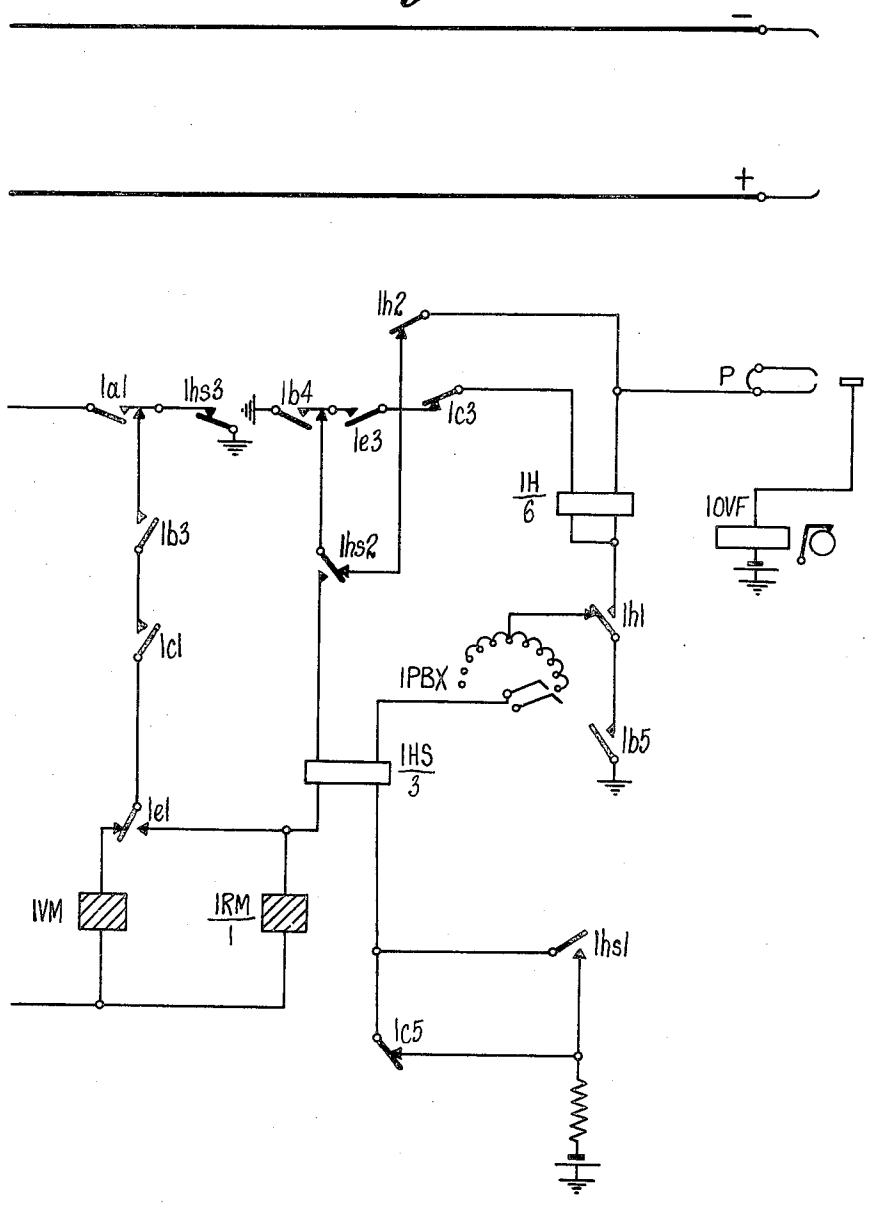
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TELEPHONE SYSTEM

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Fig. 4.



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Patented May 1, 1934 1,956,610

UNITED STATES PATENT OFFICE

1,956,610

TELEPHONE SYSTEM

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Application October 26, 1932, Serial No. 639,540
In Great Britain November 6, 1931

14 Claims. (Cl. 179—18)

The present invention relates to telephone systems in general and is more particularly concerned with the provision of arrangement whereby certain calls have preference over others. The object is to provide improved arrangements for permitting certain types of calls to be interrupted in favour of more privileged calls.

According to one feature of the invention for use in a telephone system an automatic switch is adapted to select a group of lines and to hunt over the selected group a predetermined number of times to find a line in a selectable condition.

According to another feature of the invention for use in a telephone system an automatic switch is adapted to perform a plurality of hunting operations successively over the same group of lines, the testing circuit being modified for each hunting operation.

According to a further feature of the invention for use in a telephone system having facilities for differently valued calls an automatic switch is adapted to hunt for an idle one of a group of lines and if all the lines are busy to perform hunting operations over the same group for a line engaged on a connection of inferior value and, if no such line is found, to perform a final hunting operation for a line engaged on a connection of equal value.

The invention will be better understood from the following description of one method of carrying it into effect when taken in conjunction with the accompanying drawings comprising Figs. 1, 2, 3 and 4 which should be arranged side by side in pairs to form two complete switch circuits.

Before entering into the detailed circuit operations a brief reference will first be made to a trunking layout in which the switches shown can be employed. For this purpose it may be assumed that the switches are located in a toll exchange in a large town and are accessible from different classes of operators in the toll exchange. The area also includes exchanges in the town itself (which will be referred to as "local exchanges") and exchanges on the outskirts of the town (which will be referred to as "suburban exchanges"). The suburban exchanges may possibly be manual exchanges, and calls from these exchanges are handled by an operator at the suburban exchange, in addition to the operator at the toll exchange. The three types of calls to be considered in the description which follows are namely:—

(1) Calls between a subscriber at a suburban exchange and a subscriber at a local exchange which will be referred to as "local calls".

(2) Calls between a subscriber at one suburban exchange and a subscriber at another suburban exchange which will be referred to as "suburban" calls.

(3) Calls between a subscriber at a suburban exchange and a subscriber in a different area which will be referred to as "toll" calls.

These three types of calls are all extended through the toll exchange and are handled by separate operators who will be referred to as "local" operators, "suburban" operators and "toll" operators respectively.

With the circuit shown the suburban operators take precedence over the local operator, while the toll operators take precedence over both. The three classes of operators have access to a plurality of common groups of junctions each group extending from the toll exchange to a corresponding suburban exchange. Suburban and toll operators have access to these groups of junctions over switches similar to that shown in Figs. 1 and 2, while the local operators have access to the same junctions over switches similar to that shown in Figs. 3 and 4. The circuit of the switch shown in Figs. 1 and 2 is arranged so that suburban operators can break down a connection set up over a junction line by a local operator (i. e. break down a connection of inferior value), while a toll operator can break down connections set up over junctions by both local and suburban operators. Moreover, the suburban operators and toll operators are provided with facilities whereby they may camp on a connection of equal value, in case all the junctions in the group selected are already in use by similar operators.

It will be noted that these switches are arranged to be held in their operated position by potential fed forward, and it is consequently particularly advantageous to break down the connection at the outgoing end of the junction since otherwise it would be possible for the junction to be held while it was not in use. A further advantage is that it permits connections to be broken down where the terminating exchange is the manual exchange without requiring any special circuits at the exchange. Both types of switches are provided with what is known as a P. B. X. bank arc, which comprises in effect a miniature bank and wiper, and enables several groups of junctions to be provided in a single level. The speaking leads and test leads are multipled in the banks of both types of switches while in

addition the switch shown in Figs. 1 and 2 is provided with two additional wipers PS and PT, to provide facilities for breaking down inferior connections and camping on connections of equal value.

The following table shows the different test conditions encountered by the wipers of this switch during the hunting operation:—

Different test conditions encountered

Condition of junction	Potential encountered by wiper		
	P.	PS.	PT.
(1) Idle	Battery		
(2) Engaged by local operator	Earth		
(3) Engaged by suburban operator.	Earth	Earth	
(4) Engaged by suburban operator and camped on by another suburban operator.	Earth	Booster	
(5) Engaged by toll operator	Earth		Earth.
(6) Engaged by toll operator and camped on by another toll operator.	Earth		Booster.

A brief description will first be given of the operation of the switch shown in Figs. 1 and 2 when it is taken into use over a group selector by a suburban operator. When the switch is seized over the bracketed conductors extending from the left-hand side of Fig. 1 relay A operates over the negative and positive conductors and at its armature *a*1 closes circuits for relays B and C in parallel. Relay B operates and locks by way of its armature *b*1 and the upper winding, to earth extended forward over the release trunk conductor RT from the preceding switch. Relay C in operating performs no important circuit operations at this stage.

Upon the reception of the first series of impulses relay A is operated in synchronism and at each de-energization completes the following circuit for energizing the vertical magnet VM in series with the low resistance left-hand winding of relay C: earth at armature *a*1, operated armature *b*3, rotary springs NR3, operated armature *c*3, armature *e*2, vertical magnet VM and winding of relay C to battery. In this manner the vertical magnet is energized to raise the shaft and wipers to the desired level corresponding to the number of impulses in the series, and at the conclusion of the first vertical step, the off-normal springs operate, thereby at springs N1 opening the initial energizing circuit for relays B and C, at springs N3 disconnecting relay K from the discriminating lead DSC and at springs N4, Fig. 2, closing a circuit for relay RC over its upper winding.

Although the initial circuit is opened to relay C it should be explained that the relay remains held during the impulsing period owing to the inclusion of its left-hand winding in the magnet circuit and by reason of the copper slug surrounding its core.

At the conclusion of the train of impulses the wipers will be standing opposite the required level, and as relay A is now held operated for an extended period, relay C releases after a short interval and at armature *c*2, Fig. 1, closes a circuit for relay E which operates to change over the impulsing circuit from the vertical magnet VM to the driving magnet MM of a single motion marking switch MS. Relay E in operating at armature *e*5 closes a circuit for relay C from earth over wiper 1*a* of the switch MS, Fig. 2, and relay C in turn transfers the holding circuit for relay E to the control of its own armature *e*4.

The next series of impulses are therefore received on the driving magnet MM in series with the low resistance winding of relay C, and the digit is registered by the positioning of the wipers of the switch MS into engagement with an appropriate set of bank contacts.

As will be seen from Fig. 2 the bank 2*a* of the switch MS is wired in numerical order to the bank of the two motion switch engaged by wiper MRK, and further all the contacts in this bank are multipled vertically, so that the single motion switch can control the initial setting of the two motion switch over any of its levels. Such an arrangement is particularly desirable since the switch may be required to make a number of hunting movements over the same level and therefore some means of definitely marking the group position must be provided.

When the wiper 1*a* of the switch MS leaves its resting position, the holding circuit previously traced for relays RC and C is opened, but as the latter relay is again energized in the magnet circuit, it remains held throughout the impulsing period and in turn at armature *c*4 maintains a holding circuit for relay RC over its lower winding to earth over the bank multipling and wiper 1*a* of the switch MS.

At the conclusion of the second train of impulses relay A is again held operated and upon the release of relay C, the holding circuit is opened to relay RC at armature *c*4, and the following circuit is now complete to the rotary magnet RM by means of which the wipers are advanced into engagement with the first set of contacts in the level selected: earth at the off-normal springs N4, armatures *b*2, *ga*4, *rc*4, *rn*2, *rc*2, conductor 10, winding of the rotary magnet RM in series with the low resistance left-hand winding of relay C to battery. During the first rotary step the rotary off-normal springs NR1 to NR3 are operated but are without immediate effect at this time. At the end of the magnet stroke, the associated springs *rm*, Fig. 2, close and complete a circuit for operating relay GA over its left-hand winding. Relay GA at armature *ga*4, same figure, opens the circuit to the rotary magnet RM and at armature *ga*1 connects its right-hand winding circuit with the testing wiper MRK.

If it is assumed that the first set of contacts are other than those marked by battery over wiper 2*a* of the single motion switch MS, there will be no circuit for holding relay GA and consequently when the rotary magnet springs *rm* again open owing to the de-energization of the magnet, relay GA releases to enable the rotary magnet to make a still further step to position the wipers on the second set of contacts, and this action will continue automatically until the marked set of contacts corresponding to the first junction in the group selected is found. Relay C which is energized in series with the rotary magnet remains held throughout the hunting period, and in turn maintains a holding circuit for relay E, Fig. 1. When the marked position is found by wiper MRK, relay GA will operate at the end of the magnet stroke over its left-hand winding as previously explained, and under these circumstances a holding circuit is provided over its right-hand winding to battery in series with the lower winding of relay RC which also operates. Relay RC at armatures *rc*2 and *rc*4, Fig. 2, opens the driving circuit previously traced to the rotary magnet, and provides a locking circuit for

itself to earth over the bank commoning and wiper 1*a* of the switch MS. The locking circuit to relay RC is also effective in short circuiting relay GA, which thereupon releases to enable the switch to continue its hunting movement over the group of junctions selected. It should be mentioned at this point that in addition to the usual wipers shown extending from the right-hand side of Fig. 2, the switch is also provided with a miniature wiper and ten bank arc containing 100 contact points in all, which are wiped over during the normal operation of the switch. In the drawings one level only of this bank has been shown designated PBX in Fig. 2, and the circuit arrangements are such that all contacts corresponding to a particular group of junctions are connected together and led to earth by way of the resting armatures *h*2 and *b*5 in the manner shown in the drawings. Preferably the bank in question will comprise a substantially semi-circular metal plate into which rows of contact pins are screwed to provide the necessary wiper connections, and accordingly when it becomes necessary to disconnect a particular contact such as for marking the end of a group of junctions this may be effected by unscrewing the actual contact pin from the plate thereby leaving a vacant space. When the wipers of the switch ride into engagement with the bank contacts therefore the miniature wiper referred to will also ride into its bank, and if the position finally selected corresponds to a group of junctions, the operation of relay RC is effective in energizing relay HS, Fig. 1, over its lower winding, to prepare for the subsequent hunting operation over the group of junctions selected. Relay HS moreover at armatures *hs*5 and *hs*6, Fig. 1, reverses the direction of battery to the calling circuit to suspend the sending of the next digit, in case the switch is used in conjunction with a register translator.

It will also be appreciated that the operation of relays GA, RC and HS is substantially simultaneous, and consequently upon the release of relay C after its slow period, and during the slow releasing period of relay E, the following testing circuit is completed to the switching relay H, Fig. 2, to enable the condition of the first junction in the group selected to be ascertained: earth at the operated armature *hs*2, Fig. 2, armatures *c*5, *e*3 and *bd*7, both windings of relay H in series, armature *cr*1 to the testing wiper P and bank contact.

If it is assumed for the purpose of the description that the first junction is already in use, the testing wiper P will encounter earth on the bank contact which short-circuits the switching relay H against operation, and when relay E finally releases after its slow period the following driving circuit is again completed to the rotary magnet to enable the wipers to be moved to the next set of contacts. Earth at the operated armature *b*4, Fig. 1, off-normal springs N2, normal rotary springs NR1, armatures *e*1, *h*8 and *hs*1, upper low resistance winding of relay HS in series with the rotary magnet RM and low resistance winding of relay C to battery. Relay C is operated in this circuit to prepare for the operation of relay E, while relay HS remains held over its upper winding while the miniature wiper PBX is passing from contact to contact.

At the conclusion of the magnet stroke the springs *rm* close and cause the operation of relay GA in the manner already described, and the latter at armature *ga*2, Fig. 1, causes the operation of relay E to break the magnet circuit. Relay C which was operated in series with the magnet now released and in turn opens the holding circuit to relay E, and during the slow release period of the latter the circuit is again prepared to the switching relay H to enable the second trunk of the group to be tested.

Hunting over the selected group of junctions is therefore slightly slower than the initial finding operation, and this is necessary to enable a testing circuit to be completed to relay H for each step of the wipers.

The lower testing wipers PS and PT may be neglected at this stage since they are disconnected, and their function in the selection of junctions which are already engaged will be fully described later.

In the manner described the switch will continue to hunt over the group of junctions selected until an idle one is found, as indicated by the presence of battery on the test contact P, under which circumstances the switching relay H is then operated over both its windings in series, and locked for the remainder of the connection over its lower low resistance winding, to earth extended forward on the release trunk conductor RT from the preceding switch. By this means the junction selected is guarded, that is to say, the resistance of the lower winding of relay H is sufficiently low to short-circuit the idle marking battery to such an extent as to prevent another switch from cutting through on to the same junction. Relay H moreover at armature *h*2, Fig. 2, opens the circuit at relay HS since further hunting is not required, at armature *h*4 extends the right-hand winding of relay G over conductor 11, and armatures *cr*2 and *k*6 to wiper PS, to indicate to other hunting switches that the junction selected is engaged by a suburban operator.

It will be noticed that the right-hand winding of relay G is short-circuited by a metal rectifier MRB, connected up in such sense as to prevent the operation of relay G on this winding from the normal current flow, but enables the relay to be operated when booster battery is applied to the test contact from another switch. The specific function of this arrangement will be more fully appreciated as the description proceeds.

Relay H also at armatures *h*6 and *h*7, Fig. 1, extends the negative and positive speaking conductors by way of the wipers and bank contacts of the switch to the junction selected. This operation releases relay A, but as already explained relay B remains held over its upper winding from earth extended forward on the release trunk conductor RT.

If, however, all the junctions in the group selected are in use, the wipers will be stepped on to a spare set of contacts at the end of the group which are unwired, while similarly the miniature wiper PBX will be moved out of engagement with the bank commoning so that relay HS releases. Consequently upon the release of relays C and E after their slow period, the following circuit is completed for operating relay RN: from earth at armature *b*4, Fig. 1, off-normal springs N2, normal rotary springs NR1, armatures *e*1, *h*8, *hs*1, *db*3 and *co*3, winding of relay RN to battery. Relay RN at armature *rn*2, Fig. 2, opens the circuit of relay RC, and completes a circuit to the rotary release magnet RZ which is effective in restoring the wipers to their rotary home position. Upon the release of relay RC the two-step relay BD, Fig. 2, is par-

tially operated over the following circuit: earth, at the resting armature *rc*3, Fig. 1, armature *co*6, conductor 12, armatures *rn*1 and *bd*2, left-hand winding of relay BD to battery. Relay BD closes its light armature *bd*1 only in this circuit, and this condition obtains until the wipers come into their rotary normal position where the normal rotary springs NR1 release, thereby opening the circuit of relay RN which releases and removes the short circuit from the windings of relay BD to enable that relay to operate fully over both its windings in series to earth at the operated armature *b*5. Relay BD in operating suitably modifies the connections to wipers PS and PT to enable the switch to search again over the selected group of junctions for the first one engaged on a local connection, which will be indicated by the absence of earth or booster battery potential on the contacts encountered by wipers PS and PT. For this purpose it will be seen that relay BD in operating at armatures *bd*4 and *bd*5 connects battery potential by way of the centre winding and also the lower winding of relay ST to the testing wipers PS and PT, while furthermore at armature *bd*6 relay ST is initially operated over its upper winding. It will be understood that while in the present case the testing circuit is altered after every hunting operation, the invention is not limited thereto and the switch may perform a second hunting operation with the same testing conditions.

The following table shows the conditions which in the present case bring about the cessation of the various hunting operations:

Hunting operations when controlled by a suburban operator

	Hunting operation continues until the following potentials are absent on the contacts engaged by the following wipers.		
	P	PS	PT
1st hunt (for an idle line).	Earth		
2nd hunt (for a line engaged on a local call).	Earth	or Earth and booster.	and Earth and booster.
3rd hunt (for a line engaged on a suburban call but not camped on by another suburban operator)	Earth	or Booster	and Earth and booster.

The switch is now prepared for the second hunting operation, but before this can take place it is necessary to position the wipers by a finding operation into engagement with the first junction of the group selected, that is, that one marked over wiper 2*a* of the single motion switch MS. Consequently when relay NR releases after the wipers resume their normal rotary position, the circuit previously traced is again completed to the rotary magnet which thereupon interacts with relay GA until the marked position is found, when relay RC re-operates and locks and again closes a circuit for relay HS from earth over the miniature bank arc PBX. Relay RC moreover at armature *rc*3 opens the initial energizing circuit to the upper winding of relay ST, and if it be assumed that the first junction of the group is engaged on a connection which is other than local, one of the wipers PS or PT must encounter earth or booster battery potential, which serves to hold relay ST over its middle or lower winding until such time as its upper winding is reconnected by the release of relay GA. A different circuit is now completed to the rotary magnet in order that the wipers may be advanced into engagement with the second junction of the group which may be traced from earth at the off-normal springs N4, wiper 1*a* and bank commoning of the switch MS, operated armature *b*2, armatures *ga*4, *st*2 and *hs*4, conductor 13, armature *h*8 and *hs*1, low resistance winding of relay HS in series with the rotary magnet RM and low resistance winding of relay C to battery. At the conclusion of the magnet stroke the springs *rm* close and re-operate relay GA, which at armature *ga*4 interrupts the magnet circuit and at armature *ga*5 opens the circuit to the upper winding of relay ST so that this relay again becomes dependent upon the potentials picked up by wipers PS and PT.

If it is further assumed that the second junction is engaged on a connection which is other than local, relay ST will remain held over one of its windings, and the driving circuit to the rotary magnet will continue. Relay C is held continuously during the hunting operation and in turn maintains the holding circuit for relay E.

Assuming now that the third junction encountered is engaged on a local connection, when relay GA operates at the conclusion of the magnet stroke there will be no circuit over the wipers PS and PT for holding relay ST, which thereupon releases and at armature *st*2, Fig. 2, disconnects the circuit to the rotary magnet. After a short interval the series relay C falls away and during the slow release period of relay E which is controlled thereby, direct earth is extended over the following circuit to wiper P to break down the local connection: earth, contacts *hs*3, *c*5, *e*3, *bd*7, *cr*1, wiper P. The application of direct earth to wiper P has the effect of short-circuiting the low resistance holding winding of the switching relay in the local switch, such as shown in Figs. 3 and 4 so that it falls away, and causes a busy flash signal to be given to the local operator to inform her that the junction has been taken for a suburban connection. The release of the switching relay in the local switch removes the guarding earth potential from the contact engaged by wiper P, and when relay E in the switch in question restores, the following circuit is completed for operating the switching relay H: earth at the operated armature *hs*2, armatures *c*5, *e*3 and *bd*8, both windings of relay H in series, armature *cr*1, to battery on the contact encountered by the P wiper from the junction circuit. Relay H in operating in the manner already described extends the speaking leads through to the junction and the suburban operator will now inform the subscriber at the suburban exchange that his connection has been interrupted to enable an urgent long distance call to be completed. The calling operator then sends a ringing signal over the junction to recall the operator at the suburban exchange who is instructed to transfer the incoming end of the junction to the subscriber required on the suburban call. It will be appreciated that if during the second hunting operation the wipers are positioned on to a line which has in the meantime become idle, the switch will seize this line since neither wiper PS nor PT will be marked by earth or booster battery potential.

If, however, none of the junctions in the group selected are engaged on a local call, the wipers will be stepped to the spare position where the circuit to the lower winding of relay HS is opened and it releases to cut off the driving circuit to the rotary magnet, and after a slow releasing

period of relays C and E, relay RN is re-operated. Relay RN at armature *rn*2, Fig. 2, opens the circuit of relay RC and completes a circuit to the rotary release magnet RZ to restore the wipers to the level, and also causes the partial operation of the two-step relay CO over its left-hand winding so that the relay closes its light armature *co*1. When the wipers reach their rotary home position the rotary normal springs are restored thereby re-operating relay E and causing the release of relay NR so that the short circuit is now removed from the left-hand winding of relay CO which now operates fully and locks over both its windings in series to earth at armature *b*5. Relay CO opens the circuit of relay BD, and suitably modifies the connections to the testing wipers PS and PT to enable the switch to make a further search for a junction engaged to a suburban call, but not already camped on by another suburban operator. That is to say, the hunting operation will continue until the wiper PS fails to encounter booster battery at the same time as wiper PT fails to encounter earth or booster battery. For this purpose relay CO in operating at armature *co*5 connects the centre winding of relay ST to battery and at armature *co*4 connects the lower winding of relay ST to earth by way of a metal rectifier MRA, connected up in such sense as to oppose the normal battery flow thereby rendering the relay responsive only to booster battery over its lower winding. Moreover at armature *co*6 relay ST is initially operated over its upper winding. The switch is now prepared for its third hunting operation over the same level and before this can take place it is necessary that the switch shall perform the preliminary finding operation to locate its wipers at the commencement of the group of junctions selected. Consequently when relay RN releases with relay RC normal, the rotary magnet is caused to interact with relay GA in the manner already described until the marked position is found. Relay C operates continuously during the finding period and in turn maintains relays E.

When the marked position is found relay RC operates and locks and again closes a circuit for relay HS from earth over the miniature bank arc PBX. Relay RC moreover at armature *rc*3 opens the initial energizing circuit to the upper winding of relay ST and if it be assumed that the first junction in the group is engaged by a toll operator or camped on by a suburban operator, one of the wipers PS or PT will encounter a holding potential and relay ST remains held over its middle or lower winding until such time as its upper winding is re-connected by the release of relay GA. In this manner the driving circuit is maintained to the rotary magnet which is further energized to cause the wipers to take another step, and this action will continue automatically until the desired connection is encountered.

When the desired connection is encountered relay GA operates at the conclusion of the magnet stroke and as there is now no circuit for holding relay ST it releases and at armature *st*2 cuts off the driving circuit to the magnet. After a short interval relay C releases and during the slow releasing period of relay E, relay CR is operated from earth at the off-normal springs N4, wiper 1*a* and bank commoning of the switch MS, armatures *b*2, *rc*4, *rn*2, *rc*2, *c*4, *hs*3, *co*7 and *bd*9, left-hand winding of relay CR to battery. Relay CR at armature *cr*1 completes a locking circuit for itself over its right-hand winding to earth over wiper P from the busy connection, and at armature *cr*4, same figure, connects earth to conductor 14 to re-operate relay C and hold relay RC. Relay C in turn holds relay E before it has time to release from its previous disconnection, in order to provide a circuit for the operation of the switching relay H when the junction selected becomes free. Relay CR moreover at armature *cr*5 opens the circuit of relay CO, and at armature *cr*3, Fig. 1, connects intermittent earth to the lower winding of relay A in order to provide a flashing lamp signal at the suburban operator's position to inform her that the switch has camped on a suburban connection. Furthermore at armature *cr*2, Fig. 2, booster battery by way of a resistance is connected to wiper PS and bank contact, to mark the junction as camped on by a suburban operator, and in addition this battery will find a circuit by way of the bank multiple to operate relay G in the camped on switch. Relay G at armature *g*3 extends earth over the discriminating lead DSC to bring up a lamp signal at the first suburban operator's position, to inform her that another operator is waiting and it is therefore desirable to release the junction as soon as possible. When this is done earth is removed from the contacts encountered by wiper P so that relay CR in the switch shown releases and in turn opens the circuit of relay C, and consequently during the slow releasing period of relay E the switching relay H is operated over both its windings in series to enable the switch to immediately seize the junction. Relay H in operating holds over its lower low resistance winding to guard the junction selected, and also re-operates relay CO over both its winding in series for a purpose which will be fully described later. Relay CR in releasing cuts off the flashing signal to the operator and at armature *cr*2 replaces the booster battery on the wiper PS with earth from the right-hand winding of relay G to mark the junction as engaged on a suburban call.

If, however, all the lines in the selected group are unavailable owing to their being camped on by other suburban operators and engaged by toll operators, the wipers of the switch will thereupon be rotated to the spare position where relay HS releases and upon the release of relays C and E, relay G is then operated over its left-hand winding. The operation of relay G with H normal, at armature *g*2 causes a busy flash signal to be extended over the lower winding of relay A to notify the suburban operator that the connection is unsuccessful, and that a further call must now be set up. It should also be explained that the spare contact encountered by wiper P at the end of each group of junctions is connected to an overflow meter, designated in the drawings OVF, provided for the purpose of registering all unsuccessful calls and is operated from earth connected up by way of armature *g*1 when relay H is in its normal position.

When the switch is taken into use by a toll operator relays A, B and C are operated in the manner already described and in addition relay K is operated from earth extended forward over the discriminating lead DSC. Relay K in operating locks by way of its armature *k*1 for the remainder of the connection to earth on the release trunk conductor RT, and at other armatures not specifically mentioned at this time, suitably modifies the circuit connections to enable the switch to satisfy the requirements of the toll operator. As regards the circuit operation it may be stated that the first two hunting operations take place in the manner previously described,

and when relay CO operates after the switch has unsuccessfully hunted for the second time, relay BD does not release but remains held in an alterative circuit provided over the operated armature *k*3. During the third hunting operation the switch will hunt for a junction engaged on a suburban connection irrespective of whether it has been camped on by another suburban operator or not. For this purpose relays CO and K are operated together so that the middle winding of relay ST becomes disconnected, and therefor the relay is rendered inoperative to "busy" potentials and "camped on" potentials picked up by wiper PS during the hunting operation.

In order that the switch shall not stop on a toll connection, battery is connected by way of the lower winding of relay ST to the testing wiper PT, and so long as this wiper encounters earth or booster battery potentials, corresponding to the "busy" and "camped on" markings of toll connections then it will be seen that relay ST remains operated and therefore hunting continues. The following table shows the condition which brings about the cessation of the hunting movement:

Hunting operations when controlled by toll operator

	Hunting operation continues until the following potentials are absent on the contacts engaged by the following wipers				
	P		PS	PT	
1st hunt (for an idle line).	Earth				
2nd hunt (for a line engaged on a local call).	Earth	or	Earth and booster	Earth and booster.	
3rd hunt (for a line engaged on a suburban call).	Earth	or		Earth and booster.	
4th hunt (for a line engaged on a toll call but not camped on by another toll operator).	Earth	or		Booster.	

It should also be mentioned that relays C and E are held operated continuously during the hunting period. When wiper PT fails to encounter either earth of booster battery potential indicating that the junction is in use on other than a toll connection relay ST will release to open the driving circuit to the magnet, and upon the release of relay C and during the slow release period of relay E, direct earth is connected to wiper P over the circuit previously traced to break down the suburban connection. Under these circumstances the connection of earth to wiper P has the effect of short-circuiting the lower holding winding of the switching relay H in the suburban switch which releases, and brings about the operation of relay G in the switch under consideration over its left-hand winding. Relay CO remains held during the transmission period of armature *h*2. Relay G connects busy flash and tone to the lower winding of relay A in order to signal the suburban operator that the junction has been taken for a toll connection.

When the suburban connection is released, guarding earth is removed from the test contacts encountered by wiper P, and when relay E of the switch in question releases relay H will then energize over both its windings in series in the manner already described to seize the junction. Relay H moreover at armature *h*4 extends earth to the testing wiper PT to mark the junction in the multiple as engaged on a toll connection.

If the suburban connection has been camped on by another suburban operator, relay CR in the camping switch will remain held to the toll connection which has previously broken down the suburban connection.

If, however, all the junctions in the group selected are engaged on toll calls the wipers of the switch will be stepped to the spare position, where relay HS releases and relay RN is energized to complete the rotary release circuit. Relay RN at armature *rn*3 releases relay BD and the switch is now prepared for its fourth hunting operation. On the fourth hunt the switch is required to select the first available junction in the group which is engaged on a toll call, but not camped on by another toll operator, and for this purpose the testing wiper PT is connected to earth in series with the lower winding of relay ST and the metal rectifier MRA, connected up in such sense as to enable relay ST to be operated over its winding from booster battery only, that is, the "camp on" marking potential of another toll operator.

With these connections the hunting operation of the switch will continue until wiper PT fails to encounter booster battery potential, whereupon relay ST releases and disconnects the circuit to the magnet, but as relay BD has been released meanwhile the breakdown circuit is not effective, and upon the release of relay C the camp on relay CR operates and locks over wiper P to the busy connection in the manner already described. Relay CR in operating connects intermittent earth to the lower winding of relay A to signal the calling toll operator that the switch has camped on a busy connection, while at armature *cr*2 booster battery potential is connected to wiper PT and bank contact to mark the busy junction as camped on by a toll operator. The booster battery marking potential also finds a circuit by way of the bank multiple for operating relay G of the first toll operator's switch, which contacts busy flash to the lower winding to relay A to produce a flashing signal at the operator's position, thus informing her that another toll operator is waiting and it is therefore desirable to release her connection as early as possible.

If, however, all the junctions in the group selected are already camped on by other toll operators, the switch will be stepped to the spare position where relay HS is released, and a circuit is then completed for operating relay G over its left-hand winding to connect busy tone and flash to the lower winding of relay A thereby signalling to the calling toll operator that the connection is unsuccessful. Direct earth is also connected to the test wiper P under these conditions to bring about the operation of the overflow meter OVF connected to the spare contact which registers the overflow calls for traffic record purposes.

Certain of the junctions, preferably the last in any particular group may if desired be provided with amplifier switching facilities, that is to say, these junctions will be provided with auxiliary equipment whereby a call may, if it is deemed necessary, be extended by way of an amplifier. When it is known that a certain class of call requires amplification, the calling operator will obtain access to the amplifier junctions by dialling a special number, which has the effect of positioning the wipers of the single motion marker switch MS into an intermediate position in the group, that is, in engagement with the first amplifying junction. By this means the switch will be caused to hunt over the sub group

of amplifying junctions only, and will be unable to select any of the earlier junctions in the group which are not provided with the required facility.

When an amplifier junction is taken into use and amplification is required on the particular call being served, the operator may by the operation of a key at her position cause booster battery to be extended over the release trunk conductor to operate an amplifier switching relay (not shown) connected between the test conductor engaged by wiper P and the outgoing end of the junction. This relay disconnects the calling circuit from the junction and diverts it to the amplifier position where it brings up a calling signal in front of the amplifier operator. The calling operator now speaks to the amplifier operator over the switch and requests her to make the necessary connections, which consists of inserting an amplifier in the junction line. Under these conditions the circuit set up by the calling operator over the switch will be used for supervisory signals only which are relayed from the amplifier equipment, since the amplifier operator will have direct access to the junction over plugs and jacks. Certain of the junctions may also be arranged for ring down clearing, and as this feature necessitates a slight change in the operation of the switch to meet the different supervisory conditions required, all such junctions are conveniently located on the same level of the switch where normal post springs are arranged to be operated to effect the circuit changes.

Considering now the circuit operation in conjunction with the drawings, it will be seen that when this level is called, the normal post springs NP, Fig. 1, are operated, and when the switch cuts through as indicated by the operation of relay H, resistance earth is connected to the discriminating lead DSC, thereby operating a changeover relay at the operator's position which bridges a ring-off relay across the junction line and removes the normal supervisory bridge. In series with the changeover relay at the operator's position is a marginal relay which does not operate on the resistance earth. When, however, the junction becomes camped on by another switch, the latter connects booster battery over wiper PT in the manner already described to operate relay G in the switch of the first connection, which connects direct earth to the discriminating lead DSC. The marginal relay at the first operator's position thereupon operates and provides a signal to the effect that another operator is waiting for the junction. The operators' positions (not shown) are arranged to respond to busy flash and reverse battery signals and are therefore suitable for calling to automatic exchanges or for providing a busy flash signal if all the junctions are engaged.

Upon the release of the connection when the calling operator clears, the circuit over the negative and positive conductors is disconnected and earth is removed from the release trunk conductor RT. Relays A and B therefore release and the restoring circuit is completed for the single motion marking switch MS which may be traced from: earth at the operated off-normal springs N4, Fig. 2, wiper 1*a* in engagement with the bank commoning, armature *b*2, driving magnet interrupter springs *mm*, left-hand winding of relay GA to battery. Relay GA at armature *ga*3 energizes the driving magnet MM and interaction takes place between the two until the wipers arrive at their home position. Relay C re-operates in series with the driving magnet MM and holds continuously during the homing operation, and at armature *c*1 re-applies earth to the release trunk conductor RT to guard the switch against selection during this period. When the wipers of the switch MS arrive in the home position wiper 1*a* leaves the bank commoning so that the driving circuit to the magnet MM is terminated, and a circuit is immediately completed for the release magnet ZM which brings about the full release of the two motion switch wipers to their normal position. When this is done the off-normal springs are restored and at springs N4 the circuit to the release magnet is opened.

In order to still further guard the switch against selection during its release operation, the release magnet ZM is provided with a pair of springs designated ZM1, Fig. 1, arranged upon operation to connect guarding earth to the release trunk conductor RT.

If the utmost availability of the junction is desired the "breakdown" and "camp on" facilities could if necessary be vested in a reserving operator who would be provided with a complete multiple of all the junctions. Under these circumstances the switches would be considerably simplified and adapted to return a busy signal when all junctions proved busy.

Access to the reserving operators' positions could be made over a different level of the preceding group selector by releasing the original connection and dialling another digit.

By means of suitable lamp signals the reserving operators would be able to supervise the exact nature of the call over each junction, and could therefore, with the aid of plugs and jacks or similar switching means adjust the traffic in a fully flexible manner.

A description will now be given of the local operator's switch shown in Figs. 3 and 4, which has access to the same groups of junctions as the suburban and toll operator's switch already described, but is not provided with breakdown or camp on facilities. Generally the mode of operation will be readily apparent from a knowledge of the previous switch, and the description which follows will therefore be directed more particularly to the main switching features and no attempt will be made to trace detailed circuits.

Referring now to the drawings when the switch is taken into use by a local operator, relay 1A operates over the negative and positive conductors and in turn operates relay 1B which locks for the remainder of the connection to earth on the release trunk conductor RT. Relay 1C is also operated on the operation of relay 1A and in conjunction with relay 1B prepares the circuit to the vertical magnet 1VM. Upon the reception of the first series of impulses relay 1A is operated in synchronism and at each de-energization completes the circuit for energizing the vertical magnet 1VM in series with a low resistance winding of relay 1C. In this manner the shaft and wipers are raised to the desired level, and at the conclusion of the first vertical step the off-normal springs 1N1 and 1N2 are operated, thereby at one set of springs opening the initial energizing circuit to relay 1C, which however remains held during the impulsing period over its other winding in series with the vertical magnet.

At the conclusion of the train of impulses the wipers will be standing opposite the required level and as relay 1A is now held operated for an extended period relay 1C releases after a short interval and operates relay 1E to change over the

impulsing circuit from the vertical magnet to the rotary magnet 1RM. Relay 1E in turn re-operates relay 1C and each relay then becomes locked over an armature on the other. The next series of impulses are therefore received on the rotary magnet 1RM and are effective in setting the wipers into engagement with the first junction of the desired group. During the first rotary step the normal rotary springs 1NR1 to 1NR3 are operated and although the initial energizing circuit to 1C is opened the relay again remains held, this time in series with the rotary magnet 1RM.

In addition to the usual switch wipers negative, positive and private the switch is adapted to carry a miniature wiper and bank arc of the type already described, for the purpose of determining the number of junctions in each group. In the drawings one level only of the miniature bank is shown designated 1PBX, and the wiring is such that all contacts corresponding to a particular junction group are connected together and extended to earth over the operated armature of relay 1B5. A spare position is left unwired at the end of each group to signal the termination of the hunting operation.

At the conclusion of the second series of impulses relay 1A will again become operated for an extended period so that relay 1C is released after a short interval, and during the slow releasing period of relay 1E a testing circuit is completed to relay 1H over both its windings in series to the wiper P. A circuit is also complete for operating relay 1HS over the miniature bank arc 1PBX whereupon the relay then locks in a circuit controlled by relays 1H and 1B.

If it is assumed for the purpose of the description that the first junction in the group is already in use, wiper P will encounter guarding earth which short-circuits relay 1H against operation, and upon the release of relay 1E after its slow period the rotary magnet 1RM is again energized by way of normally closed springs controlled by armature 1e3 to advance the wipers into engagement with the second junction of the group. It will be noticed that relay 1HS is held operated while the miniature wiper is stepping from contact to contact by the inclusion of its low resistance left-hand winding in series with the rotary magnet circuit. At the conclusion of the magnet stroke the associated springs 1*rm* will close and complete a circuit for operating relay 1E, which thereupon locks by way of its own armature and in armature on relay 1C which is also re-operated in series with the rotary magnet. Relay 1E at 1e3 opens the driving circuit to the magnet and upon the release of relay 1C and during the slow release period of relay 1E which is controlled thereby, a circuit is again completed to relay 1H to enable it to test the condition of the second junction line.

If it is further assumed that the second junction line is also in use, relay 1H will be unable to operate owing to the presence of the guarding earth on the test contacts, and upon the release of relay 1E the rotary magnet is enabled to take another step, and this action will continue automatically until a free junction is found, or alternatively until the wipers are moved into the spare position at the end of the group.

When an idle junction is found wiper P will encounter battery on the test contact which serves to operate relay 1H over both its windings in series so that the relay then locks over its right-hand winding which is sufficiently low in resistance to guard the junction line selected. Relay 1H moreover drops relay 1HS to terminate the hunting operation, and also switches through the negative and positive calling lines to the junction selected. If, however, all the junctions in the groups selected prove busy the wipers of the switch will be rotated into the spare position where the miniature wiper 1PBX will leave the bank commoning, and consequently relay 1HS drops away to terminate the hunting motion.

For the purpose of registering all such overflow calls a meter designated 1OVF is connected to the P contact of the spare position, and when relay 1HS releases with relay 1H normal, direct earth is connected to the P wiper to operate the overflow meter. In addition, when relay 1E releases after its slow period relay 1C is re-operated over its left-hand winding and connects busy flash and tone to the lower winding of relay 1A, to signal the local operator that the call is unsuccessful. This condition it will be noted is identical to that set up when a local operator's connection is broken down by a surburban or toll operator, under which circumstances the switching relay 1H is forcibly released and the busy signal immediately becomes operative.

When the switch is set by dialling to the level assigned to junctions having ring-down clearing, the normal post springs 1NP are operated, and in consequence when the switch cuts through a resistance earth is projected over the discriminating leads DSC, for the purpose of suitably modifying the supervisory arrangements at the operator's position in the manner suggested in the previous description.

Upon the release of the connection when the local operator clears down, the circuit over the negative and positive conductors is opened and at the same time earth is removed from the release trunk conductor RT so that relays 1A and 1B are restored. Relay 1B drops the switching relay 1H and a circuit is then complete to the release magnet 1ZM which brings about the full release of the shaft and wipers to the normal position. In order that the switch shall be definitely guarded against re-seizure until it is fully restored to normal, the release magnet 1ZM is provided with a pair of springs 1ZM1, arranged upon operation to replace guarding earth on the release trunk conductor RT during the release condition.

It will be understood that while the invention has been shown as applied to a telephone system employing operators to set up calls, it is not limited thereto and it will be apparent to those skilled in the art that various modifications may be made without departing from the spirit of the invention. For instance the switch shown in Figs. 1 and 2 may be seized from a register sender and will perform a plurality of hunting operations according to the location of the sender with respect to the toll exchange. It is also possible that the switch may be seized by a subscriber's loop in which case the subscriber would have to delay dialling between digits until the switch had found an outlet. For this purpose it would be necessary for a tone to be transmitted back to the subscriber when the switch has found an outlet, the tone indicating that the subscriber may dial the next digit.

We claim:

1. In a telephone system, groups of lines, an automatic numerical switch, two means of access to said switch, means for operating said switch over either means of access to select a group of

lines, and means for operating said switch to hunt over the selected group a predetermined number of times dependent upon the means of access said switch is operated over to find a line in a selectable condition in case all of said lines of the selected group are busy.

2. In a telephone system, groups of lines, an automatic numerical switch adapted to be taken into use in two classes of calls, means for operating said switch to select a group of lines, means for operating said switch to hunt over the selected group to find a line marked in a particular manner, and means for marking in different manners the two classes of calls.

3. In a telephone system, groups of lines, an automatic switch, means for moving said switch in response to a series of impulses from a normal position to a sub-normal position and subsequently to hunt over a group of lines, means for restoring said switch to the subnormal position in case said switch fails to find a line in said group marked in a particular manner, and means for reoperating said switch in a second hunting operation over the same group of lines to hunt for a line in the group marked in a different manner.

4. In a telephone system, an automatic switch, means for operating said switch to perform a plurality of hunting operations successively over the same group of lines in case said lines are busy, a testing circuit in said switch, and means for modifying the testing circuit after each successive hunting operation.

5. In a telephone system, groups of contacts, means for marking said contacts in different manners, an automatic switch, means for operating said switch to hunt over a group of contacts for a contact marked in a particular manner, and means for reoperating said switch if no such contact is available to hunt over the same group of contacts for a contact marked in a different manner.

6. In a telephone system having facilities for establishing differently valued calls, an automatic switch, means for operating said switch to hunt for an idle one of a group of lines, and means for reoperating said switch if all the lines are unavailable to perform a second hunting operation for a line engaged on a connection of inferior value.

7. In a telephone system having facilities for establishing differently valued calls, an automatic switch, means for operating said switch to hunt over a group of lines for one engaged on a connection of an inferior value, and means for reoperating said switch if such line is not available to perform a further hunting operation over the same group for a line engaged on a connection of equal value.

8. In a telephone system having facilities for establishing differently valued calls, an automatic switch, means for operating said switch to hunt for an idle one of a group of lines, means for reoperating said switch if all the lines are busy to perform a second hunting operation over the same group for a line engaged on a connection of inferior value, and means for reoperating said switch if no such line is found to perform a final hunting operation for a line engaged on a connection of equal value.

9. In a telephone system, lines, automatic switches, means for operating certain of said switches to extend connections of different values over a single group of said lines and to mark the selected lines differently according to the value of the connection, means for operating one of said switches to select the first available line of the lowest available value by hunting successively over the group of lines, said switch testing on each successive hunting operation for an available line of progressively higher value.

10. An automatic switch as claimed in claim 6 including means responsive to an inferior line being found for terminating the hunting operation, means in said switch for connecting with the line in said inferior value connection, and means responsive thereto for breaking down the connection of inferior value.

11. An automatic switch as claimed in claim 8 including means for terminating the hunting operation when a line of equal value is found, and means for completing a connection with the engaged line only when the said line is released from the previous connection.

12. In a telephone system, automatic switches, two means of access for taking each of said switches into use, a group of lines, means for operating said switches to extend connections of different values over said group of lines in accordance with the means of access said switches are taken into use over, means for breaking down a busy connection in case all of said lines are busy in connections of one value and for seizing the selected line to establish a connection of a higher value in case one of said switches is taken into use over the first means of access, and means for breaking down a busy connection in case all said lines are busy in connections of said one value, for breaking down a connection of a higher value in case all said lines are busy in connections of said higher value, and for seizing the selected line to establish a connection of a still higher value in case one of said switches is taken into use over the second means of access.

13. An automatic switch as claimed in claim 9 including a marker switch operated by dialled impulses to mark a group of lines, and means for operating the switch to hunt for the marked group in each of its successive hunting operations.

14. In a telephone system, automatic switches, two means of access for taking each of said switches into use, a group of lines, means for operating said switches to extend connections of different values over said group of lines in accordance with the means of access said switches are taken into use over, means for breaking down a busy connection in case all of said lines are busy in connections of one value and for seizing the selected line to establish a connection of a higher value in case one of said switches is taken into use over the first means of access, means for breaking down a busy connection in case all said lines are busy in connections of said one value, for breaking down a connection of a higher value in case all said lines are busy in connections of said higher value, and for seizing the selected line to establish a connection of a still higher value in case one of said switches is taken into use over the second means of access, a test wiper and a switching relay in each of said switches, and means for applying a potential over the test wiper of a switch to shunt the switching relay in the switch engaging the line in the connection to be broken down.

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