

Feb. 13, 1940.

R. TAYLOR ET AL

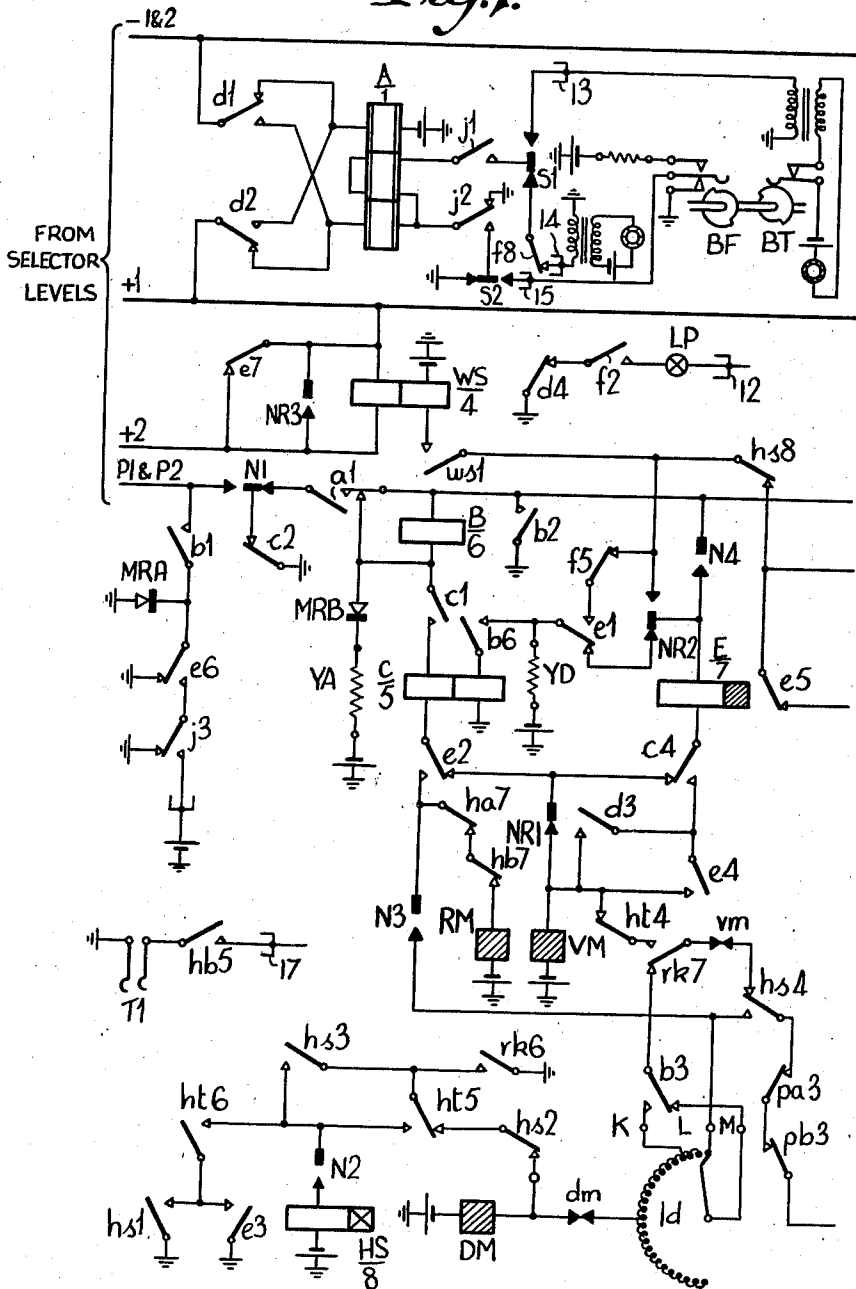
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TELEPHONE SYSTEM

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4 Sheets-Sheet 1

Fig. 1.



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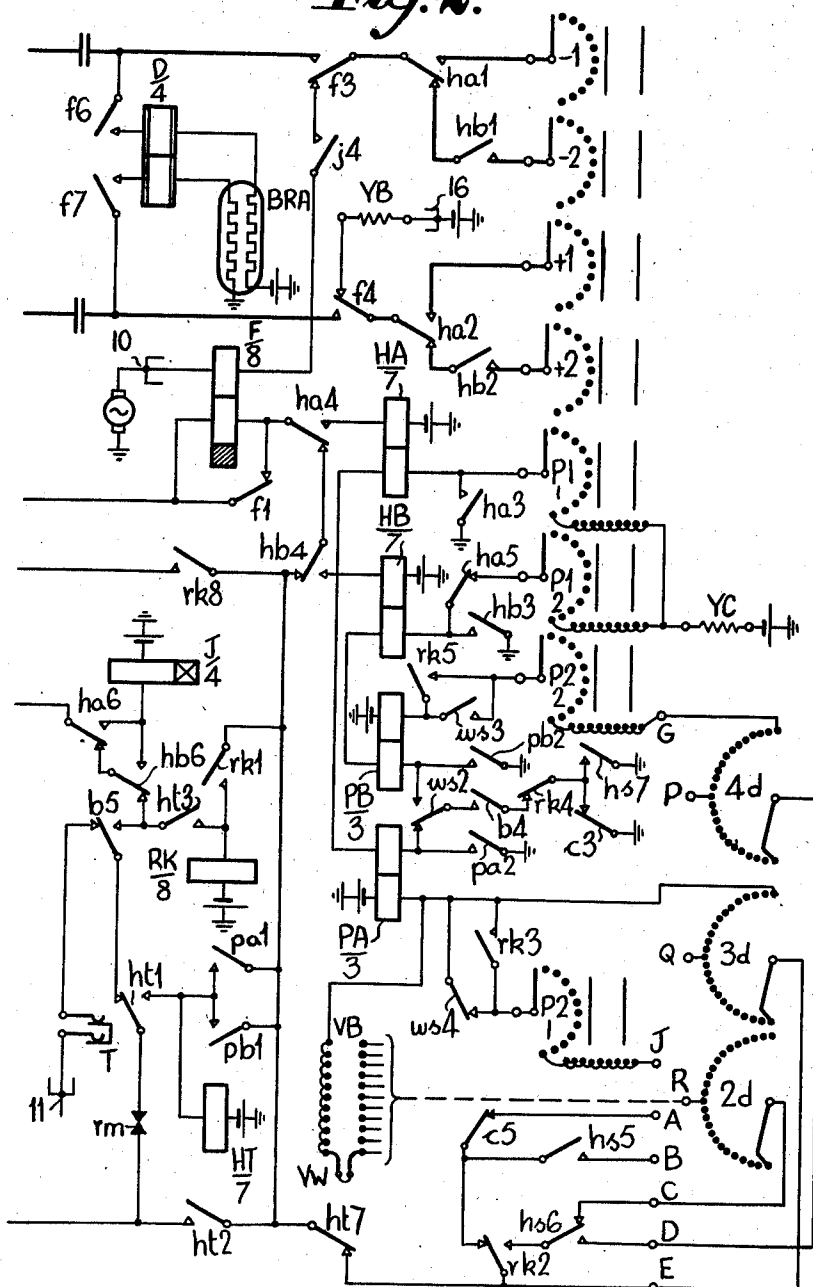
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4 Sheets-Sheet 2

Fig. 2.



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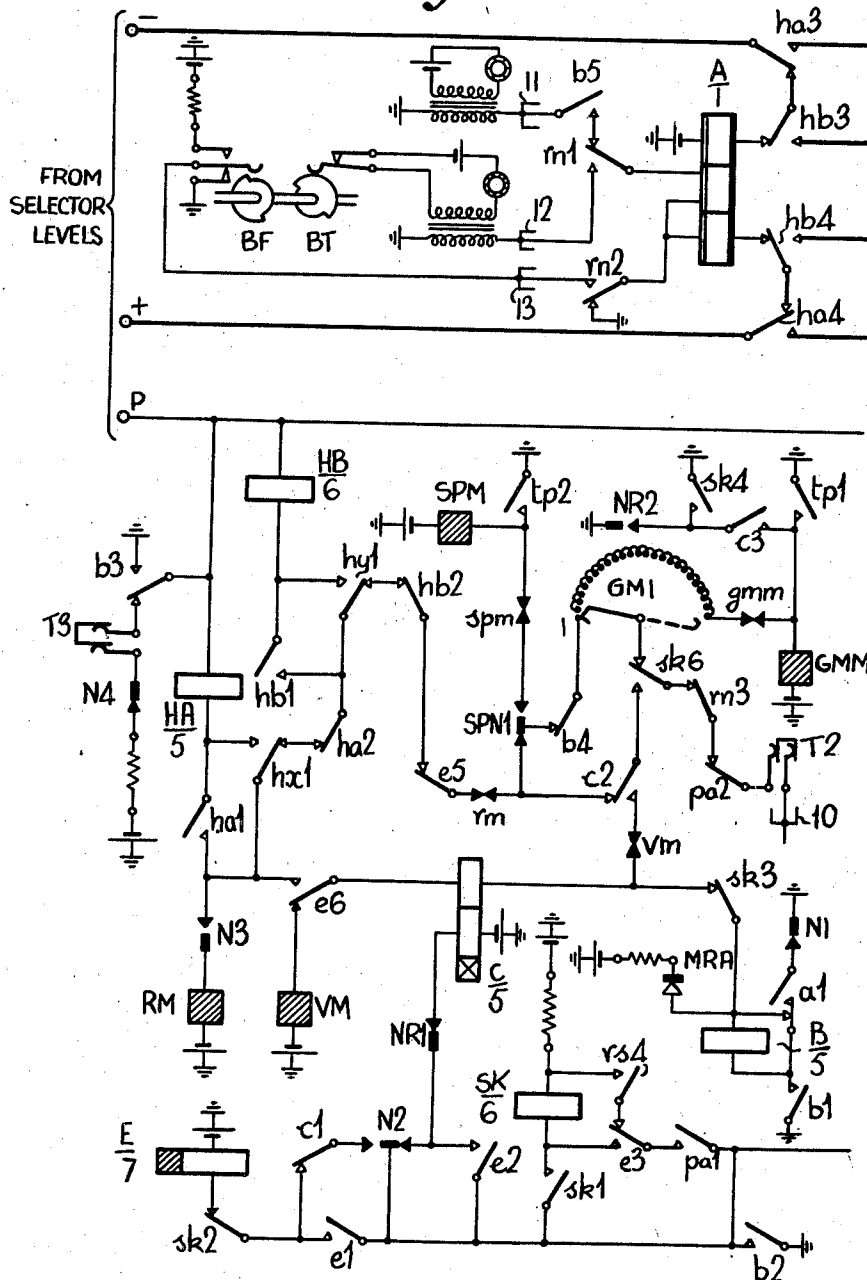
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TELEPHONE SYSTEM

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4 Sheets-Sheet 3

Fig. 3.



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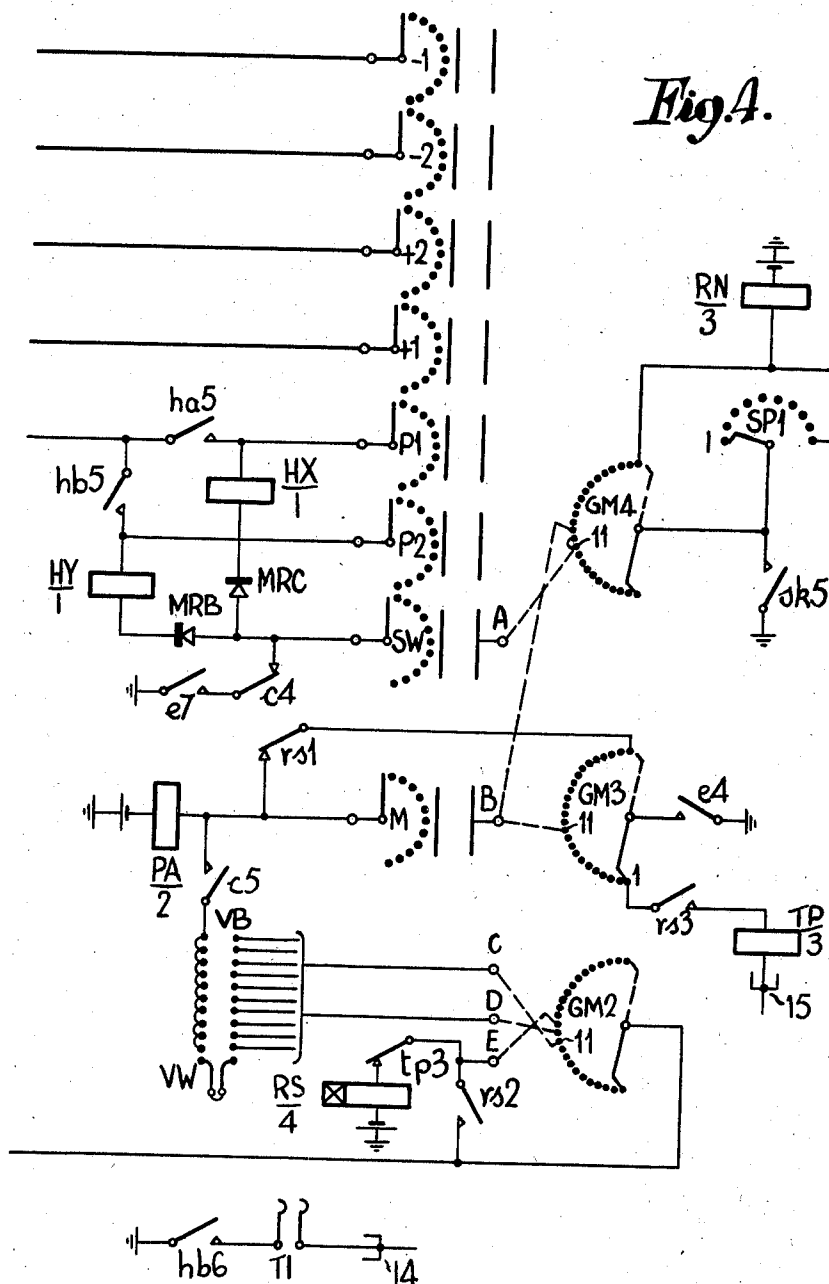
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TELEPHONE SYSTEM

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4 Sheets-Sheet 4



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2,190,140

TELEPHONE SYSTEM

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6 Claims. (Cl. 179—18)

The present invention relates to telephone systems and while particularly concerned with systems employing final selector or two digit group selector switches of the up and around or two-motion type is also applicable to group selectors of other kinds and constructions.

Arrangements have already been suggested whereby after the setting operation a switch is adapted to hunt for an idle line in a group. In case the group overflows on to other levels due to all lines in the first level having been found busy a further level is hunted over which is reached as a result of a level hunting operation. With this arrangement it was necessary to group the lines in a special manner for instance, outlets on a level for any one group had to be successive and in case a group required more than one level the overflow outlets of the group had to be accommodated on the first and subsequent successive outlets of the further level required. In order to cater for extension, one or more spare outlets were allotted at the end of each group but if it was desired to extend a group above the predetermined maximum it was necessary to make a somewhat complicated change to the switch or even to remove the group to another switch with a consequent alteration of the exchange number allocated to the group. One of the objects of the invention is therefore to provide an improved switch which permits of the utilisation of spare outlets in any position on any level when it is desired to extend a group.

According to one feature of the invention an auxiliary switch preferably of the uniselector type is associated with a final selector or group selector switch and is arranged after the final selector or group selector has tested a line or group of lines and found them to be busy to control the selector so that it hunts to find another line or lines of the group first tested under the control of the uniselector distinct from the previous arrangements in which resetting of the switch was effected by impulsing.

According to another feature of the invention a switch provided with two or more sets of wipers is arranged initially to test a group of lines accessible to one set of wipers only as determined by the route over which the switch was taken into use but is arranged in testing over other lines of the group to test over either set of wipers according to the position of the additional lines of the group.

According to a third feature of the invention the switch when the wipers are passing over

contacts is operated by a self-interrupted circuit except when it is passing over outlets in the group being tested.

According to a fourth feature of the invention after the switch has hunted over the first section of the group it is adapted to simultaneously test outlets accessible to two or more sets of wipers.

According to yet a fifth feature of the invention single lines, adjacent lines forming a single group and lines of a group having a plurality of sections with one or more lines of the group in each section are adapted to be tested repeatedly. The invention being particularly applicable up and around switches can be controlled by a uniselector so as to repeatedly test a group of lines.

These and other features of the invention will be better understood from the following description of two methods of carrying it into effect, reference being had to Figs. 1 and 2 and Figs. 3 and 4, which should be arranged side by side to form circuit diagrams of a 200 outlet P. B. X. final selector and of a 200 outlet group selector respectively. Both switches are of the longitudinal and rotary type and employ two magnet mechanisms of the type disclosed in Patent No. 2,028,689, granted January 21, 1936, to R. N. Saxby, while each switch has associated with it an auxiliary uniselector.

Referring now to Figs. 1 and 2 it will first be assumed that an auxiliary uniselector is not fitted in which case the switch is arranged to perform the functions of a standard 200 outlet final selector with facilities for P. B. X. groups up to 10 lines on both hundreds of the 200 total outlets. This is effected by strapping terminals K, L and M and terminals G, J and E together and by making the following cross connections to the odd and even hundreds banks P₂₁ and P₂₂ as follows:

Terminal A to the first line in each P. B. X. group and terminal B to all other lines in each P. B. X. group except the last.

It will also be assumed first of all that the switch is taken into use over the odd hundreds set of conductors negative 1, positive 1 and P₁ in which case the operation does not involve the energisation of the wiper switching relay WS.

When the speaking leads are looped relay A operates and brings up relay B which thereupon at armature b₁ extends a guard earth on to the incoming P₁ conductor and at armature b₂ operates relay C over its right hand winding in series with resistance YD. Relay C in operat-

ing at armature *c1* prepares the impulsing circuit via its left hand low resistance winding to the vertical magnet VM, the magnet being, however, non-operative in series with the winding of relay B.

On reception of the first train of setting pulses relay A responds and each time it releases a circuit is completed to energise the magnet VM as follows: earth, armatures *b2*, *a1* and *c1*, left hand winding of relay C, armature *e2*, contacts NR1, magnet VM to battery and accordingly the switch wipers are raised to the level corresponding to the digit dialled. During the impulse train relay B is intermittently short circuited at armature *a1*, but this relay remains operated due to the slugging effect of the short circuiting. The presence of the metal rectifier MRB in the energising circuit of relay B prevents the slowing down of the magnet operation which would otherwise result by the direct connection of the comparatively low value non-inductive resistance in parallel with its winding.

It will be readily understood that neither the vertical magnet nor relay C will hold operated in series with relay B and moreover the inductance of the latter relay is such that it has no appreciable effect on the magnet performance.

On the first vertical step the off normal springs N are mechanically operated and at contacts N4 extend an earth from armature *b2* to short circuit the right hand winding of relay C to enable the relay to hold satisfactorily during impulsing also to enable it to release when impulsing ceases.

At the end of the train of impulses relays A and B remain steadily operated and after a short period relay C releases whereupon relay E is operated in series with the magnet VM and at armature *e2* it transfers the impulsing circuit to the rotary magnet RM and at armature *e1* removes the earth shunt from the right hand winding of relay C thereby enabling it to re-operate.

The second digit is similarly repeated by relay A through the winding of relay C to the rotary magnet RM which accordingly advances the wipers into engagement with the required line. On the first rotary step the rotary off normal springs NR are mechanically operated and at contacts NR2 again short circuit the right hand winding of relay C.

At the end of the digit relay C releases after a short interval and at armature *c4* opens the circuit of relay E which, due to its slug, commences to release slowly. At armature *c3* an earth is now extended over armatures *rk4*, *b4* and *ws2*, and the upper winding of relay PA in series with the lower winding of relay HA on to the odd hundreds group test wiper P1 and assuming that the wipers have been positioned into engagement with the first line of a P. B. X group the odd hundreds test wiper P2 will encounter an earth by way of the strapping between the bank contact on which it is resting and terminal A, armatures *c5*, *rk2*, *ht1*, *hb4*, *ha4*, *f1* and *b2* whereupon relay PA will be operated over its lower winding. Relay PA in operating at armature *pa1* operates relay HT from the same earth and this relay thereupon locks over armature *ht1*, contacts *rm* and armature *ht2*. Relay HT in operating completes an operating circuit for relay HS from earth over armatures *e3* and *ht6* and operated off normal contacts N2 and at armature *ht7* it disconnects the operating circuit for relay PA.

If the first line of the P. B. X group is engaged wiper P1 will encounter an earth or disconnection thus preventing the operation of relay HA whilst relay PA will release. On the release of relay PA an energising circuit is completed for the rotary magnet RM as follows:—earth by armatures *b2*, *f1*, *ha4*, *hb4*, *ht2*, *ph3*, *pa3*, *hs4*, off normal contacts N3, armatures *ha1* and *hb1*, magnet RM to battery and accordingly the wipers are advanced to the next position while at the same time the opening of the rotary magnet interrupter contacts *rm* opens the holding circuit of relay HT. Relay HT thereupon releases and at armature *ht2* disconnects the magnet energising circuit while at armature *ht7* it extends earth to terminals A and B by way of armatures *rk2*, *c5* and *hs5*. The cross connection from terminal A is now ineffective since the wipers have been stepped off the first line of the group but the earth is now extended over terminal B and cross connection to the intermediate lines of the group in the P2 bank and it thereupon re-energises relay PA over its lower winding.

Relay PA in operating again operates relay HT which as before locks and prepares the magnet energising circuit and disconnects the lower winding of relay PA. Should the P1 wiper again encounter a busy outlet relay HA will not operate and relay PA will release as before, whereupon the rotary magnet is again energised and the cycle of operations continues until the switch reaches a free outlet in the group or alternatively the switch will rotate to the 11th position.

Relay E will have released after its slow release period at some instant during the rotary search and in so doing it re-operates relay C on its right hand winding by removing the short circuit therefrom while it disconnects the impulsing circuit for the rotary magnet at armature *e2* to prevent its energisation in case the subscriber's dial is accidentally operated. Relay HS is provided with a slug to enable it to hold operated during the interaction between relays HT, PA and the rotary magnet.

As soon as wiper P1 encounters a free outlet in the group which is indicated by a battery potential extended from the cut-off relay of one of the subscribers in the group, relay PA will remain held on its upper winding when its lower winding is disconnected by armature *ht7* while relay HA will operate.

Relay HA in operating at armature *ha4* locks over its upper winding to the earth via armatures *f1* and *b2*, at armatures *ha1* and *ha2* connects up wipers +1 and -1, at armature *ha3* it extends an earth over the P1 wiper to guard the selected outlet and to operate the called subscriber's cut-off relay; at armature *ha4* it disconnects the holding circuit for relay HT and at armature *ha7* it disconnects the magnet driving circuit. Relay HT in releasing opens the holding circuit of relay HS which releases after a short interval and thereupon completes an operating circuit for relay J as follows: earth, armature *b2*, contacts N4 and NR2, armatures *hs5*, *e5* and *ha5*, winding of relay J to battery, and this relay in operating at armature *j4* thereupon applies ringing current over common conductor 13 through the winding of relay F onto the selected line, the ringing current finding a return path by way of resistance YB to the ringing return battery connected to common lead 16. At armatures *j1* and *j2* a ring-back tone transformer connected to common lead 14 is extended to the

middle winding of relay A whereupon a tone is applied by induction from the middle to the outer windings on the incoming speaking conductors in a balanced circuit so as to inform the calling party that the call is proceeding satisfactorily and that the wanted party is being rung.

When the called subscriber replies relay F operates and at armature *f3* and *f4* disconnects the ringing current and at the same time switches the incoming speaking conductors through, whereupon relay D operates over the called party's loop and contacts *f6* and *f7* in series with the current limiting the resistance BRA. Further at armature *f1* relay F inserts its lower winding in series with the upper winding of relay HA and thus provides a locking circuit for itself while at armature *f8* it disconnects the ringing tone to the calling subscriber. Relay D in operating at armatures *d1* and *d2* provides the usual supervision by reversing the current to the calling side of the circuit while it completes an operating circuit for relay E from earth, armature *b2*, contacts *N4*, winding of relay E, armatures *c4* and *d3*, vertical magnet VM (non-operative in this condition) to battery. Relay E thereupon at armature *e4* locks independently of the armature *d3* and at armature *e6* connects booster battery to the incoming release trunk conductor over armature *j3* to operate the subscriber's meter in the well known manner. At armature *e5* relay J is disconnected and its slow release time determines the duration of application of the booster metering pulse after which earth is reconnected to the release trunk conductor at armature *j3*. Rectifier MRA serves to maintain a guard earth to the P conductor during the transit times of armatures *j3* and *e6*. Clearly if relay D flicks during its operation due to clumsy removal of the receiver by the called party relay E will hold operated due to its slug and there will be no false interruption of the metering pulse.

If the last line only in the group is disengaged when the wipers are advanced to this position the wiper *P21* will encounter no potential since there is no strapping connection between the last line of the group on this bank and terminal B.

Relay PA therefore cannot be operated over its lower winding on release of relay HT hence the latter is not re-operated and thus no further energising circuit for the rotary magnet will be prepared. Relay HS will commence to release and during its release time relay HA will operate over its lower winding over the *P11* wiper to the called party's cut-off relay when the circuit operation will proceed as described previously.

Should all the lines in the group be engaged relay HA will not operate in the last position of the wipers and hence on release of relay HS after its slow release period a self-interrupted driving circuit for the rotary magnet RM is completed as follows: earth, armature *b2*, contacts *N4* and *NR2*, armatures *hs3*, *e5*, *hs6*, *hs8*, *b5* and *ht1*, rotary magnet interrupter contacts *rm*, armatures *pb3*, *pa3*, and *hs4*, vertical magnet interrupter contacts *vm*, armatures *rk7* and *b3*, strapping between terminals K and L, contacts *N3*, armatures *ha7* and *hb7*, rotary magnet RM to battery. Accordingly the switch rotates its wipers to the 11th step position and on reaching this position the wiper *P21* encounters an earth by way of the multiplied 11th step contacts, the cross connections between terminals J and E, armature *ht7* to the earth whereupon relay PA quickly operates over its lower winding and opens the cir-

cuit of the rotary magnet. Relay PA in operating thereupon extends an earth by way of its upper holding winding in series with the lower winding of relay HA on to the *P11* wiper whereupon relay HA operates in series with resistance YC. Relay HA in operating locks up in the normal manner, further disconnects the rotary magnet circuit, short circuits and releases relay PA and operates relay J. Relay F will then be connected up to the negative and positive wipers but since these wipers are standing in the 11th position which is unwired this relay will not be operated. The 11th step cam springs S are also mechanically operated thereby connecting relay A contacts *S1* and *S2* in circuit with the busy flash and tone cam assemblies BF and BT which are connected to common leads *15* and *13* respectively. Busy tone is thereupon returned to the calling party in a balanced circuit, the busy flash arrangement serving in a well known manner to flash the supervisory lamp if the call has been set up by an operator. The arrangements of the windings of relay A are such that this relay is maintained operated under all positions of the busy flash cams.

During the rotation of the switch to the 11th position it will be seen that there is no possibility of switching to a free line in another group on the same level since the resting armature *hs5* prevents earth from being extended to terminal B while the A terminal is disconnected by the operated armature *e5*, so that no circuit can be completed to operate relay PA and thereby cut the magnet drive until the switch reaches the 11th position.

Assuming now that the switch is taken into use over the "even" hundreds set of conductors negative 2, positive 2, and *P2*, the operation will continue in a normal manner until relay E is operated on release of relay C at the end of the first digit when the low resistance left hand winding of relay WS is inserted in the incoming positive line and this relay operates. On the first rotary step made in response to the second digit, the rotary off normal springs *Nr* are operated and at contacts *NR3* short circuit the operating winding of relay WS which, however, remains operated on its right hand winding by way of contacts *NR2* and *N4*, and armature *b2* to earth. Relay WS in operating disconnects the operating earth for the "odd" hundreds test and switching relays PA and HA and transfers it over to the "even" hundreds relays PB and HB which are associated with the test wipers *P22* and *P12* respectively; at the same time at armature *ws4* the normal operating circuit for relay PA is disconnected whilst the upper winding of relay PB is connected up to wiper *P22*. The circuit operation will now proceed in a normal manner except that the testing will be performed over these wipers and when a free outlet is encountered relay HB will be operated to switch the speaking leads through to the negative 2 and positive 2 wipers.

In case the switch is set by the dialled impulses on to an intermediate line of a P. B. X group, on release of relay C there will be no earth extended to operate the test relay PA or PB as the case may be, since terminal A is cross connected only to the first line of a group. Relays HT and HS will not therefore be operated and if the line is free relay HA or HB will operate according to whether relay WS is operated or not, when the operation will proceed in a normal manner. If the line is engaged the switch will not rotate further to test other lines in the group but in this case, on

release of relay E after its slow release period a self-driving circuit will be completed for the rotary magnet as follows: earth, armature *b2*, contacts *N4* and *NR2*, armatures *hs3*, *e5*, *ha6*, *hb6*, *b5* and *ht1*, interrupter contacts *rm*, armatures *pb3*, *pa3* and *hs4*, interrupter contacts *vm*, armatures *rk7* and *b3*, strapping between terminals *K* and *L*, contacts *N3*, armatures *ha1* and *hb1*, magnet *RM* to battery. Accordingly the switch wipers will be advanced to the 11th position where busy tone will be returned in the normal manner.

Should it be desired to extend any P. B. X group advantage may be taken of spare outlets in any of the "odd" or "even" hundreds levels. By the way of example, assume that a P. B. X group which is situated on the first seven outlets of level 3 in the "odd" hundred groups is to be extended to 14 lines. Due to the relative congestion of the switch it will be further assumed that the group of 14 lines must be made from 4 sections situated on various levels as follows:

(a) The first seven "odd" hundreds outlets on level 3.

(b) The last two "even" hundreds outlets on level 3.

(c) The last two "odd" hundreds outlets on level 8.

(d) The last three "even" hundreds outlets on level 8. To enable the switch to perform a hunting operation over this widely scattered group it is necessary to utilise an auxiliary uniselector represented by banks *1d*, *2d*, *3d* and *4d* which serves as a flexible means of marking each of the outlets in the group and the levels on which they are situated. Each group is allocated one or more positions on the banks of the uniselector as will be explained later. In case all outlets in the first section of the group are engaged the uniselector will be caused to rotate to a position marked on the *3d* bank by a cross connection between the last line of the first section on the *P21* or *P22* banks and terminal *Q*. In this position wiper *4d* will mark further outlets in the group on the level dialled (in this case level 3) by means of a cross connection between contacts of the *P21* and *P22* banks corresponding to outlets in subsequent sections of the group on this level and terminal *P*. Terminal *R* is cross connected to the next level of the vertical bank to which the switch must be raised to continue the hunting operation, in this case level 8. On finding all outlets and subsequent sections of the group if any, on level 3 busy the switch will restore to normal and then drive vertically until it reaches level 3 whereupon the uniselector will be stepped to the next position. In this position wiper *2d* will mark the succeeding level to which the switch must be raised while the outlets in the section or sections in the group on level 8 will be marked by wiper *4d* or alternatively if there is no further vertical hunting required there will be no strapping from the contact on which wiper *2d* is now resting whilst the contact on which wiper *3d* is resting will be cross connected to terminal *G* in order to return a busy tone to the calling subscriber in case all outlets in the group are engaged. Terminal *A* will be connected as before to the first outlet and terminal *B* to all other outlets in the first section of the group except the last whilst terminals *K*, *L* and *M* and *E*, *G* and *J* will be connected as shown and not strapped as previously described, it being understood that when the operations previously described require the employment of circuits including the strapping connections other such circuits will be replaced by means involving the use

of appropriate banks and wipers of the uniselector under the conditions to which such circuits relate.

In order to secure access to the first line of the first section of the group the switch will have to be taken into use over the "odd" set of conductors. On dialling digit 3 the switch will be raised vertically to level 3 in the usual manner while on the reception of digit 1 the wipers will be advanced into engagement with the first line of the P. B. X group. At the end of this digit relay *C* releases after a short interval and disconnects relay *E* which remains operated for a further short interval while an earth is extended over terminal *A* and *P21* bank and wiper to operate relay *PA* in the normal manner. Relay *PA* in operating closes a circuit for relay *HT* which in turn operates relay *HS* and disconnects the operating circuit for relay *PA*. Should the line be engaged relay *PA* will release and thereupon the magnet *RM* and relays *PA* and *HT* will interact in the normal manner until the switch reaches an idle line or the last line in this section of the group.

If the last line is also busy, then, since an earth is not encountered by wiper *P21* to operate relay *PA* in this position due to the fact that there is no cross connection between terminal *B* and the last outlet in the first section, relay *HT* is not operated and therefore the rotary magnet is not re-energised. No further operation ensues until relay *HS* releases after having previously been held operated during the rotation due to its slug, when a self-interrupted driving circuit for the magnet *DM* is completed as follows: earth, armature *b2*, contacts *N4* and *NR2*, armatures *hs3* and *e5* (relay *E* having released by this time), armatures *ha6*, *hb6*, *b5* and *ht1*, interrupter contacts *rm*, armatures *pb3*, *pa3* and *hs4*, interrupter contacts *vm*, armatures *rk7* and *b3*, bank *1d*, uniselector magnet interrupter contacts *dm*, magnet *DM* to battery.

Accordingly the *Dm* switch wipers are rotated until wiper *3d* encounters the position which is strapped to the last outlet of the first section. Relay *PA* then operates quickly to earth over wiper *3d* and the cross connections on to the *P21* bank and opens the driving circuit at armature *pa3* and at armature *pa1* re-operates relay *HT*. This relay at armature *ht3* operates relay *RK* which at armature *rk1* locks independently of armature *ht3* and completes an operating circuit for relay *HS* over armatures *rk6* and *ht5* and contacts *N2*. Relay *HT* in operating disconnects the operating circuit of relay *PA* at armature *ht7* and as it has been assumed that the last outlet in the section was engaged and that it is still engaged relay *PA* will release and at armature *pa3* will again prepare an energising circuit for the rotary magnet *RM* and relay *HT* will be released.

On release of relay *HT* at armature *ht1* a self-interrupted driving circuit is completed for the rotary magnet *RM* over earth, armatures *b2*, *f1*, *ha4*, *hb4*, *rk2*, *e5*, *ha6*, *hb6*, *b5*, *ht1* rotary magnet interrupter contacts *rm*, armatures *pb3*, *pa3*, *hs4*, off normal contacts *N3*, armatures *ha1*, *hb1*, winding of rotary magnet to battery and the wipers are thereupon rotated until they reach the 9th position, that is, the first outlet of the second section of the group, when an earth will be extended over operated armatures *rk2* and *hs6*, terminal *D*, wiper and bank *4d*, and cross connection to further outlets of the group on the *P22* bank to operate relay *PB* on its upper winding by way of armature *rk5*.

Relay PB in operating opens the magnet circuit and reoperates relay HT which in turn opens the operating circuit of relay PB which then releases if it is assumed that the even hundreds wiper P_2 is in engagement with a busy outlet. On release of relay PB the rotary magnet is again energised to step the wipers to position 10 and if this second outlet is engaged the magnet will be again energised to step the wipers to the 11th position. Since the wipers are now out of engagement with the group there will be no earth extended over the $3d$ and bank to re-operate relay PB whilst furthermore although the switch is in the 11th position no operating circuit can be completed for either of the switching relays HA or HB since their operating earth is removed at armature $rk4$. Hence the rotary magnet RM will now be operated in a self-interrupted circuit from earth over armatures $b2, f1, ha4, hb4, rk3, e5, ha6, hb6, b5, ht1$, interrupter contacts rm , armatures $pb3, pa3$ and $hs4$, contacts $N3$, armatures $ha1$ and $hb1$, magnet RM to battery, and the wipers are thereupon advanced to the 12th position whereupon they fall and rotate below the banks under spring tension back to their normal position where the off normal contacts $N3$ open and disconnect the driving circuit. Preferably the rotary magnet is mechanically prevented from opening its interrupter contacts during the vertical release movement so that there is no tendency for it to chatter.

It will be noted that armatures $rk3$ and $rk5$ in the operating position provide an alternative circuit to the armatures $ws4$ and $ws3$ respectively of relay WS so that whenever hunting takes place in an overflow group in which case relay RK is always operated the outlet can be over either set of wipers although normally without overflow the outlet is over the set of wipers determined by the incoming leads.

In the normal position the rotary off normal and the off normal springs NR and N are restored to normal and at contacts $N2$ the holding circuit for relay HS is disconnected. This relay thereupon releases after a short interval and completes a self-interrupted driving circuit for the vertical magnet VM as follows: earth, armatures $b2, f1, ha4, hb4, rk3, e5, ha6, hb6, b5$ and $ht1$, contacts rm , armatures $pb3, pa3$ and $hs4$, vertical magnet interrupter contacts vm , armatures $rk7$ and $ht4$, vertical magnet VM to battery, and accordingly the wipers are raised vertically whilst at the same time an energising circuit is completed for the uniselector magnet DM from earth over armatures $rk6, ht5$ and $hs2$. Due however to the reverse drive action of the uniselector switch the wipers are not advanced to the next position until subsequently the magnet DM is de-energised.

On reaching level 2, on which are situated the sections c and d of the group an earth is extended over armatures $rk2$ and $hs6, 2d$ wiper and bank and the cross connection to operate relay PA which thereupon opens the driving circuit and at armature $pa1$ operates relay HT. Relay HT in operating locks up over armatures $ht1$ and $ht2$, at armature $ht7$ opens the operating circuit of relay PA which then releases since its upper winding is in an open circuit, and at armature $ht4$ further opens the driving circuit of the magnet VM. The energising circuit of the magnet DM is opened at armature $ht5$ whereupon the uniselector wipers are stepped to the next position while at armature $ht5$ earth is extended over armature $rk6$ to re-operate relay HS. In

this position the contact on which wiper $2d$ is resting is unwired since it is not desired to mark any further levels to which the switch must be raised to continue hunting while the contact on which wiper $3d$ is resting will be wired to terminal G for a purpose which will be understood later. Relay HS in operating extends earth over armatures $ht2, pb3, pa3$ and $hs4$, contacts $N3$ and armatures $ha1$ and $hb1$ to energise the rotary magnet RM and the wipers are thereupon advanced into engagement with the first outlet on level 3 while relay HT is de-energised by the operated contacts rm . However as the wipers are not set into engagement with an outlet of the group there will be no circuit to operate relay PA and hence on release of relay HT the magnet RM will self-drive until the wipers reach position 3 which is the first line of section d of the group. In this position since an even outlet has been utilised an earth will be encountered over the $4d$ wiper and cross connection to the P_2 bank, thereby operating relay PB. This relay in operating at armature $pb1$ re-operates relay HT which in turn releases relay PB if the outlet is engaged whereupon the switch will be stepped to position 9. Since there are odd and even outlets in the group in this position, on release of relay HT both relays PA and PB will be operated over wiper and bank $4d$ and cross connection to banks P_2 and P_2 respectively and at armatures $pa1$ and $pb1$ relay HT will be re-operated.

If the odd outlet is free relay PA will hold and relay HA will operate to switch connection through in the normal manner, while if the even outlet is free relay PB will hold and relay HB will switch the line through. If both outlets are free both relays PA and PB will hold but relay HA in operating will cut off relay HB at armature $ha3$ thereby giving priority to the odd set of wipers.

If both outlets are engaged relays PA and PB will release and will cause the magnet RM to advance the wipers to position 10 in which are situated the last two outlets in the group. If both the outlets in this position are engaged the wipers will be advanced to the 11th position. In this position a circuit is completed to operate relay PB over a connection made between the contact on which wiper $3d$ is resting and terminal G since this is the last level to be hunted over and at armature $pb3$ the driving circuit is opened while relay HB is operated from earth, armature $pb2$ and the windings of relays PB and HB to battery resistance YC whereupon relay J will be operated in the normal manner to return busy tone to the calling subscriber.

Should the switch be set by the dialled impulses, on any of the lines in the group except the first, the switch will test this line only and will not perform a hunting operation if it is busy. Thus on release of relay C there will be no earth extended to operate relays PA and PB since terminal A is only connected to the first line of the group and therefore relays HT and HS will not be operated to prepare for further rotary hunting. If the desired line is free relay HA or HB will operate according to whether relay WS is operated or not, when the operation will proceed in a normal manner. If, however, the line is engaged, on release of relay E following that of relay C, a self-interrupted driving circuit will be completed for the uniselector magnet DM as follows: earth, armature $b2$, contacts $N4$ and $NR2$, armature $hs8$, armatures $e5, ha6, hb6, b5$ and $ht1$, contacts rm , armatures $pb3, pa3$ and $hs4$, 75

contacts *vm*, armatures *rk1* and *b3*, bank *1d*, unselector interrupter contacts *dm*, magnet DM to battery. This switch thereupon self-drives to the home position 1 where relay PA is operated over wiper and bank *3d* to open the drive circuit and at the same time operates relay HT which in turn operates relay RK. Relay RK operates relay HS while relay HT in operating releases relay PA since there is no holding circuit over its upper winding. On release of relay PA a self-interrupted driving circuit is completed for the rotary magnet RM as follows: earth, armature *b2*, contacts N4 and NR2, armatures *hs8*, *e5*, *ha6*, *hb6*, *b5*, and *ht1*, contacts *rm*, armatures *pb3*, *pa3* and *hs4*, contacts N3, armatures *ha1* and *hb1*, magnet RM to battery. The wipers are thereupon rotated to the 11th position where an earth marking is extended over wiper and bank *4d* to operate relay PB which cuts the drive in a normal manner. Relay HB is then operated in series with resistance YC and in turn operates relay J when busy tone will be returned to the calling subscriber. It should be mentioned that a similar condition is brought about when a call is made to a group comprising a single line, that is to say, on release of relay E a driving circuit will be completed for the unselector magnet DM and the operation proceeds as above described.

On release of the connection at the conclusion of conversation, when the calling party hangs up relay A releases and releases relay B and other relays previously held operated are released in turn. A circuit is then completed from earthed delayed alarm equipment which is connected up over common lead 11 via the resting contacts of all relays and bank and wiper *1d* to home the unselector and when this reaches the home position 1 a circuit is then completed to self-drive the magnet RM which advances the wipers to the 12th position where they are restored to normal in the manner previously described.

A substantially constant initial unguard period which is represented by the release time of relay C is provided on the incoming release trunk conductor to enable the preceding switches to be restored to normal with the minimum of delay. When the switch reaches normal the restoration of the off normal springs removes the guard earth from the incoming P conductor at contacts N1.

A buzzer connected to common lead 17 in conjunction with test jack springs T1 and armature *hb5* enables the set of wipers in use during conversation to be readily determined without removal of the dust cover from the switch.

If the calling party should fail to restore his receiver after the called party has hung up earth will be extended over armatures *d4* and *f2* to light the lamp LP in series with delayed alarm equipment connected to common lead 12.

Referring now to Figs. 3 and 4 these show a circuit diagram of a 200 outlet group selector which is adapted, by the provision of an auxiliary switch of the unselector type to perform repeated hunting operations at predetermined intervals over single lines, adjacent lines forming a single group and lines of a group having a plurality of sections distributed over various levels. After a predetermined number of searches arrangements may be made to stop the hunting and to return busy tone to the calling party. Facilities are also provided whereby any pair of odd and even hundreds outlets in the group except the first may be dialled when busy tone will be returned if they are both found to be engaged, no

hunting taking place, while if they are both idle switching will take place to one or other of them.

The selector, in this example, is of a two-digit type, that is to say, it must be set initially in its two directions of motion by two trains of dialled impulses before hunting can commence. It employs two sets of wipers which have access to so-called odd and even hundreds groups of outlets. The outlets in the various groups may be distributed anywhere over the levels of the switch, the only limitation being that a pair of odd and even outlets on any level must belong to the same group. A maximum of twenty-two outlets on each level is available, due to the inclusion of the 11th step busy contacts which are normally used in such switches for returning busy tone to the calling party and the switch has therefore a maximum capacity of 220 outlets.

For the purpose of description it will be assumed that a particular group comprises thirty outlets, twenty-two of which occupy the whole of level 3 and of the remaining eight, four occupy the first two and four occupy the last two odd and even outlets on level 3. In order that the repeated hunting over this particular group may take place the cross connections shown in the drawings between banks GM2, 3 and 4 and terminals A to E are necessary. Terminal A connects with all contacts on the SW bank which represent the position of the odd and even outlets making up the group, while terminal B connects with a contact on the M bank representing the position of the first pair of outlets in the group and which is therefore in this example connected up to contact 1 in level 3. The connections to the other terminals can be seen from the drawings, whilst the purpose of the cross connections to the GM banks will be appreciated in the ensuing description.

Considering now the circuit operation, on seizure the loop extended over the incoming negative and positive conductors operates relay A which thereupon in turn operates relay B. Relay B in operating at armature *b2* operates relay C on its lower winding and at armature *b3* replaces the idle resistance battery marking potential normally extended on to the incoming P conductor by a guard earth, while at armature *b5* a dial tone transformer is connected up over common lead 11 to the middle winding of relay A to extend dial tone in a balanced circuit to the calling party.

On dialling the first digit 3 relay A responds and impulses the magnet VM and accordingly the switch wipers are raised vertically to level 3. On the first vertical step the off normal springs N are operated and at contacts N2 prepare an operating circuit for relay E, whilst at contacts N3 a circuit is prepared for the rotary magnet RM. Contacts N2 also disconnect the energising circuit of relay C but this relay remains held on its low resistance upper winding due to its slug during the impulse train, while similarly relay B remains held due to the slugging effect produced by the short circuiting of its winding on each release of armature *a1*.

At the end of the train of impulses relay C releases after a short interval and at armature *c1* operates relay E and this relay thereupon locks at armature *e1* independently of the armature *c1*, re-operates relay C on its lower winding at armature *e2* and at armature *e6* prepares the impulsing circuit for the rotary magnet RM. On re-operation of relay C at armature *c3* an ener-

gising circuit is prepared for the uni-selector magnet GMM, at armature c5 relay PA is connected to the vertical bank VB and at armature c1 the impulsing circuit for the magnet RM is further prepared.

On dialling the second digit 1 relay A again responds and impulses the magnet RM which accordingly advances the wipers into engagement with the first odd and even outlets in the group. On the first rotary step the rotary off normal springs NR are mechanically operated and at contacts NR1 disconnect the energising winding of relay C which however in the normal manner remains held due to its slug, while at contacts NR2 an energising circuit is completed for the magnet GMM.

At the end of this digit relay C releases after a short interval and at armature c3 de-energises the magnet GMM while at armature c4 earth is extended to the testing relays HX and HY. On de-energisation of the magnet GMM, since the switch operates on the reverse drive principle, it advances its wipers to position 2 whereupon it operates in a self-interrupted circuit from earthed delayed alarm equipment which is connected to common conductor 10, wiper and bank GM1, magnet interrupter contacts gmm, magnet GMM to battery. On reaching position 11 earth is extended over armature e4, wiper and bank GM3, cross connection to terminal B, M bank and wiper (on first pair of outlets in group) winding of relay PA to battery. Relay PA quickly operates and thereupon at armature pa2 it disconnects the driving circuit and at armature pa1 completes an operating circuit for relay SK. Relay SK in operating at armature sk2 disconnects relay E which commences to release slowly due to its slug, at armature sk6 it further disconnects the GMM magnet driving circuit and prepares a circuit for the rotary magnet RM whilst at armature sk4 a re-energising circuit is prepared for the magnet GMM.

Returning again to the testing relays HX and HY, if the odd outlet is free whilst the even outlet is engaged, relay HX is operated as follows: earth, armatures e1 and c4, rectifier MRC in a conductive direction, low resistance winding of relay HX, P1 wiper and bank to an idle marking battery in the succeeding switch. The low resistance of relay HX provides an immediate guard on the outlet seized in that it is sufficiently low to prevent the HX relay of another group selector switching to the outlet while after operation it will hold operated if another switch should test the outlet. On operation at armature hx1 it completes an operating circuit for relay HA in series with the rotary magnet RM (non-operative in this condition) and the latter in operating at armature ha1 locks independently of armature hx1, at armature ha2 disconnects any subsequent operating circuit for the magnet RM and at armatures ha3 and 4 extends the incoming speaking conductors over the odd set of wipers negative 1 and positive 1 to the succeeding switch. At armature ha5 the incoming P lead is extended through while at the same armature relay HX is short circuited and released by the guard earth extended from armature b3; furthermore at armatures ha3 and ha4 relay A is released and in turn opens the holding circuit of relay B which releases after a short interval. During this time the A and B relays in the succeeding switch will have been operated and will have returned a guard earth over the P1 wiper to maintain relay HA on release of relay B. On release of relay B

relay SK is released and on release of the latter a homing circuit is completed for the magnet GMM at armature sk6. When the GM switch reaches the home position 1 a circuit is prepared over wiper and bank GM1, armature b4 and the SP switch off normal contacts SPN1, for the subsequent operation of the magnet RM on release of the connection at the end of conversation. If, as will be described later, the SP switch has been stepped off-normal thereby indicating that one or more re-searches have been made before finding a free outlet in the group, then on completion of the homing of the GM switch a homing circuit will be completed for the magnet SPM over the off normal contacts SPN1 in the operated position, magnet interrupter contact spm, magnet SPM to battery. When the SP switch reaches the home position the off-normal contacts SPN1 open the homing circuit and prepare the homing circuit for the magnet RM. The above arrangements, whereby the SP and GM switches are restored to their home position at commencement of conversation ensures a more rapid freeing of the selector for further use when the parties subsequently hang up at the end of conversation.

If the even outlet is free and the odd outlet engaged relay HY will be operated and will bring in relay HB to switch the incoming conductors through over the even set of wipers negative 2, positive 2 and P2. If both outlets are disengaged both relays HX and HY will be operated, but on operation of relay HA the operating circuit of relay HB will be disconnected at armature ha2 and thus preference will be always given to the odd outlet of the pair.

The rectifiers MRB and MRC in series with relays HX and HY prevent switching to an engaged outlet whilst metering is taking place thereover, when the normal guard earth on the P conductor is replaced by a booster battery metering potential.

If both the outlets on which the wipers P1 and P2 are standing are already engaged then no further operation ensues until relay E releases after its slow release period when a self-interrupted driving circuit is completed for the rotary magnet RM over a circuit as follows: earthed common lead 10, armatures pa2, rn3, sk6, c2, rotary magnet interrupter contacts rm, armatures e5, hb2, hy1, ha2 and hx1, off normal contacts N3, magnet RM to battery. Relay E also in releasing at armature e1 makes relays HX and HY dependent on the wiper SW for an operating earth and in this case it will be understood that since all outlets on level 3 belong to the group the whole level of SW bank contacts are cross connected to the 11th position on the GM4 bank and the wiper SW will thus encounter an earth in every position during the rotary search. If a disengaged odd or even outlet in the group is encountered relay HX or HY will operate quickly and open the driving circuit at armature hx1 or hy1 when the operation will proceed in the normal manner, but if all the outlets in the group on this level are engaged the switch will rotate to the 12th position when it will restore to normal.

When the switch reaches the normal position the N and NR springs restore and at contacts N2 and NR1 relay C is re-operated over its lower winding. A self-interrupted driving circuit is now completed for the vertical magnet from the earthed lead 10, armatures pa2, rn3, sk6 and c2, vertical magnet interrupter contacts vm, upper low resistance winding of relay C, armature e6,

magnet VM to battery and accordingly the switch wipers are raised vertically while at armature c3 the magnet GMM is again energized and at armature c5 the winding of relay PA is connected to the vertical bank VB in preparation for arresting the vertical motion of the switch at the next level to be hunted over, in this case level 8. On the first vertical step the N springs are again operated and at contacts N2 open the energising circuit of relay C which however remains held during the vertical motion on its upper winding due to its slug.

When the switch reaches level 8 earth is extended over wiper and bank GM2 and cross connection to terminal C, vertical bank VB, wiper VW and armature c5 to battery via the winding of relay PA which accordingly quickly operates and opens the driving circuit. After a further short interval relay C releases and at armature c3 it de-energises the magnet GMM whereupon the GM wipers are advanced to position 12. In this position the outlets in the group on level 8 are marked over wiper GM4 whilst the wiper GM2 marks level 3 so that in this case if all the outlets in the group on level 8 should be found busy the switch on restoring to normal would again step vertically and cut in on the original level dialled whereupon the cycle of operations would recommence. Should the group overflow to a still further level the GM2 wiper in position 12 would mark the next level to which the switch should be raised to continue the search. Relay C in releasing also at armature c5 releases relay PA when a self-interrupted driving circuit is completed for the rotary magnet RM from the earthed lead 10, armatures pa2, rn3, sk5 and c2, interrupter contacts rm, armature e5, hb2, hyl, ha2 and hx1, off normal contact N3, magnet RM to battery. During the rotary hunting operation whilst the switch is passing over contacts of the group an earth feed is supplied to relays HX and HY over the SW wiper and bank so that if a disengaged outlet in the group is encountered one or other of these two relays will be operated to cut the drive.

If all outlets in the group on level 8 are engaged the switch will rotate to the 12th position and will restore to normal. In the normal position relay C is again operated and initiates the vertical hunting. On reaching level 3 relay PA is operated to the marking extended over wiper GM2 in position 12 and arrests the vertical motion and on the subsequent release of relay C a driving circuit is completed for the rotary magnet RM in a normal manner whilst the GMM magnet which has been previously energised during the vertical motion is now released and advances the GM wipers to position 13. In this position wiper GM4 extends an earth marking to terminal B which connects with the first line of the group on the M bank whilst an earth is extended over wiper GM2 and cross connection to terminal E to operate relay RS which locks at armature rs2 and at armature rs4 prepares a circuit to release relay SK. On the first energisation of the magnet RM the wipers are cut in to the position to which they were set by dialled impulses but there is now no operating earth extended to relays HX and HY since there is no strapping connection from contact 13 on the GM bank and terminal A. Earth is however extended over armature sk5, GM4 wiper in position 13, cross connection to terminal B and bank and wiper M to operate relay PA which at armature pa2

opens the RM magnet driving circuit and at armature pa1 completes a circuit from earth over armatures b2, pa1, e3 and rs4 to short circuit and release relay SK. The two-motion switch now remains in this position until a predetermined interval has elapsed when earth is again connected up to relays HX and HY and the rotary magnet driving circuit is re-completed. On release of relay SK relay PA is released at armature sk5 whilst at armature sk2 a circuit is completed to operate relay E over armature c1, contacts N2 and armature b2 to earth whilst at armature sk6 the earth lead 10 is now transferred to wiper and bank GM1 whereupon the GM switch self-drives to the home position 1 where the driving circuit is opened. Earth is now extended over armature e4, wiper GM3 in position 1 and armature rs3 to relay TP which is connected up to common lead 15 extending to time pulse equipment. It will be understood that a pulse of battery potential is applied to this lead at predetermined intervals which might be, for example, of the order of 12 seconds and hence on reception of the next pulse relay TP is operated and at armature tp1 it energises the magnet GMM and at armature tp2 it energises the magnet SPM of a small stepping switch SP whilst at armature tp3 it opens the circuit of relay RS which releases after a short interval. On release of relay TP the magnets SPM and GMM are de-energised whereupon the wipers are advanced to position 2. The GM1 wiper in this position now completes a self-driving circuit for the magnet GMM and the wipers are thereupon rotated until they again reach original position 11 where the earthed wiper GM3 extends a marking to operate relay PA which cuts the drive. At armature pa1 relay SK is now re-operated and this relay at armature sk2 releases relay E, at armature sk5 extends earth to relays HX and HY and at sk6 completes a driving circuit for the magnet RM on release of relay PA by the armature e4. The whole cycle of operations now recommences and is repeated at predetermined intervals until a free outlet in the group is found.

The switch SP is advanced one step before each researching operation and it is arranged that if no free outlet in the group is found after a predetermined number of such operations a circuit is completed from earth, armature sk5, wiper and bank SP1, to battery via relay RN. This relay in operating at armature rn3 opens the earth feed to the driving magnets while at armatures rn1 and rn2 busy tone and flash is connected up over common conductors 12 and 13 respectively to the windings of relay A and thence to the incoming speaking leads to inform the calling subscriber or operator that all outlets in the group are engaged.

If the switch should be set by the dialled impulses on to any line of a group except the first, relay PA will not be connected up to the bank GM3 since the cross connections thereto are only made from first lines of groups. The GM switch will therefore rotate until it reaches the last position when an earth will be extended over armature e4, wiper and bank GM3, and armature rs1 to operate relay PA and cut the drive. Relay PA in operating operates relay SK in the usual manner when an earth will now be extended over armature sk5 and wiper and bank GM4 to operate relay RN which further opens the driving circuit at armature rn3. In the meantime if one or other of the pair of outlets on to which the

wipers are set have been found to be free either relay HX or HY will have been operated and in turn have operated relays HA or HB but if both outlets were found to be busy they will have failed to operate and thus on operation of relay RN busy tone will be returned to the calling party over the resting armatures of relays HB and HA.

When the parties clear at the end of conversation earth is removed from the release trunk conductor thereby releasing either relay HA or HB. A self-interrupted driving circuit is now completed for the rotary magnet RM from the earthed lead 10, armatures *pa2*, *rn3* and *sk5*, wiper GM1 in the home position 1, armature *b4*, SP switch off-normal contacts SPN1, rotary magnet interrupter contacts *rm*, armatures *e5*, *hb2*, *hy1*, *ha2* and *hx1*, contacts N3 and magnet RM to battery, and accordingly the wipers are rotated clear of the banks from where they restore to normal when the off-normal contacts N3 in restoring open the driving circuit. The restoration of the contacts N4 now extends a resistance battery potential over armature *b3* on to the incoming P conductor to render the switch available for further use.

A buzzer connected to common lead 14 in conjunction with test jack springs T1 and armature *hb6*, readily enables the set of wipers in use during conversation to be determined without removal of the cover.

In the arrangement described it has been assumed that a uniselector is provided individual to each switch but the invention also contemplates making the uniselector common to a number of switches, it being borne in mind that the uniselector is only in use for short periods of time.

The invention is not necessarily limited to the employment of a uniselector as a two motion or up and around switch might be used in its place as will be readily understood. A uniselector is usually of small capacity and as the invention in the majority of cases will only require the use of a small capacity switch, it will be seen that the uniselector is generally speaking the more advantageous to use.

We claim:

1. In an automatic switching arrangement, a two-directional hunting switch having a plurality of contacts arranged in levels accessible over two different paths, a plurality of lines accessible to said switch through groups of adjacent contacts of non-adjacent levels, means for setting said switch to one of said groups, means for testing the lines associated therewith, and means effective

when all of a group of adjacent contacts is found busy and when the switch is seized over a certain one of said paths only to cause the switch to be reset to another group of said plurality of lines.

2. In an automatic switching arrangement, a two-directional hunting switch having access to groups of lines divided into non-adjacent sub-groups, means for setting said switch to a certain sub-group of a particular group, means responsive thereto for testing lines of the sub-group and causing the switch to be advanced when a busy line is encountered, and means effective in one instance when the last line of a sub-group is found busy to cause the switch to be reset to another sub-group of said particular group and effective in another instance when the last line of said group is found busy to return a busy signal without resetting the switch.

3. An automatic switching arrangement as claimed in claim 2, wherein the last-named means is effective when the last line of the last sub-group is found busy to cause the switch to be reset to said certain sub-group.

4. In an automatic switching arrangement, a two-directional hunting switch, a group of lines divided into sub-groups accessible to said switch, means for setting the switch to test the lines of a certain one of said sub-groups, an auxiliary switch associated with said hunting switch operated when all the lines of a sub-group are busy to control the resetting of said hunting switch to the next sub-group, said auxiliary switch operated when all lines of said group are busy to control the resetting of said hunting switch to said certain sub-group, means for repeatedly testing said sub-groups, signalling means for indicating that none of the lines of the group are available and means responsive to the testing of said group of lines a plurality of times for rendering said signalling means effective.

5. An automatic switching arrangement as claimed in claim 2, wherein an auxiliary switch is included in said last-named means to mark the position to which said hunting switch is to be reset.

6. An automatic switching arrangement as claimed in claim 4, wherein the encounter of an idle line during any of the testing operations is effective to restore said auxiliary switch and said last-named means to normal.

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