June 17, 1947. G. T. BAKER 2,422,285

SELECTOR OPERATING CIRCUIT FOR USE IN AUTOMATIC TELEPHONE SYSTEMS

Filed March 6, 1943 5 Sheets-Sheet 1

Fig. 2.

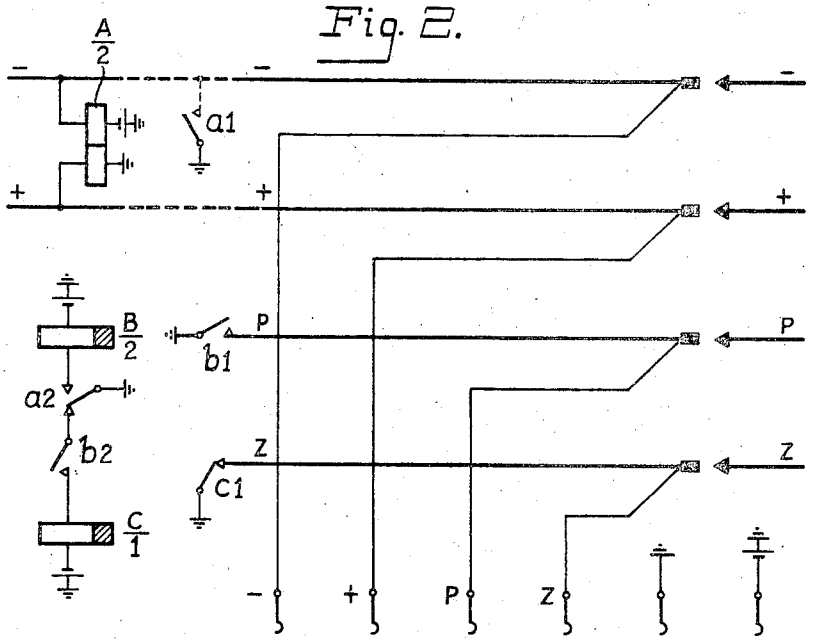
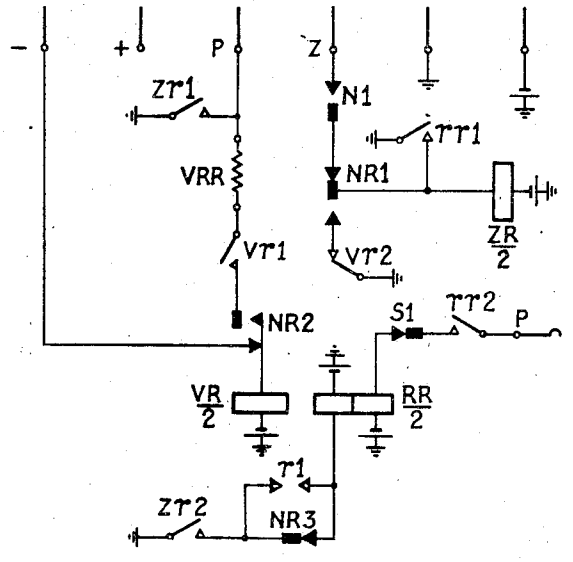


Fig. 1.



INVENTOR
GEORGE THOMAS BAKER
BY Chas. H. Conley.
ATTORNEY

June 17, 1947. G. T. BAKER 2,422,285

SELECTOR OPERATING CIRCUIT FOR USE IN AUTOMATIC TELEPHONE SYSTEMS

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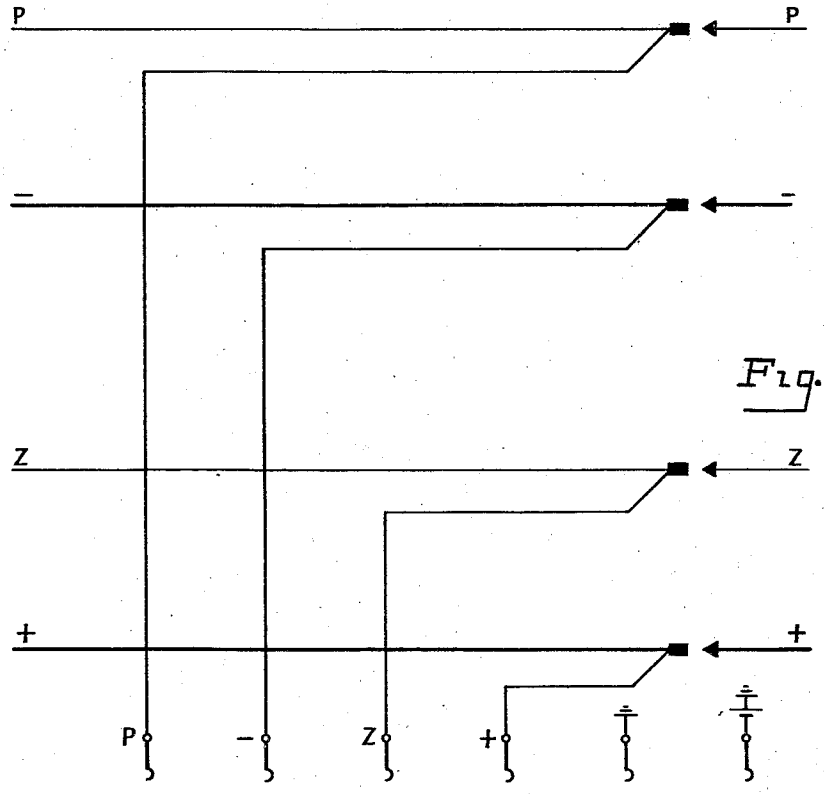

Fig. 3A.

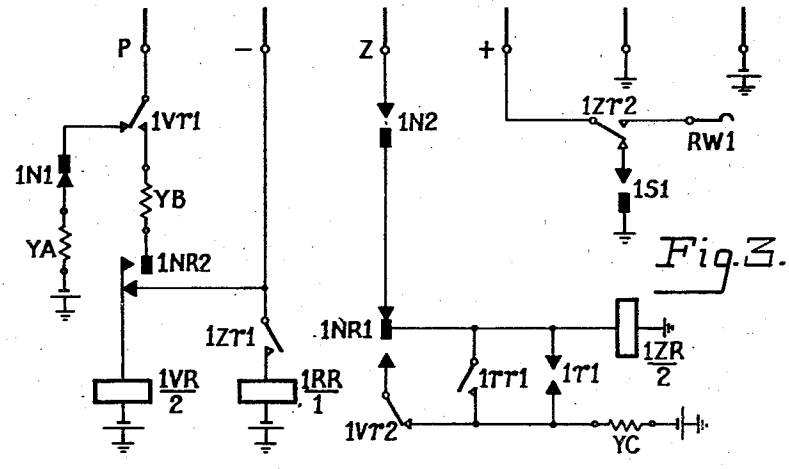

Fig. 3.

INVENTOR
GEORGE THOMAS BAKER
BY Chas. W. Canby
ATTORNEY

June 17, 1947. G. T. BAKER 2,422,285

SELECTOR OPERATING CIRCUIT FOR USE IN AUTOMATIC TELEPHONE SYSTEMS

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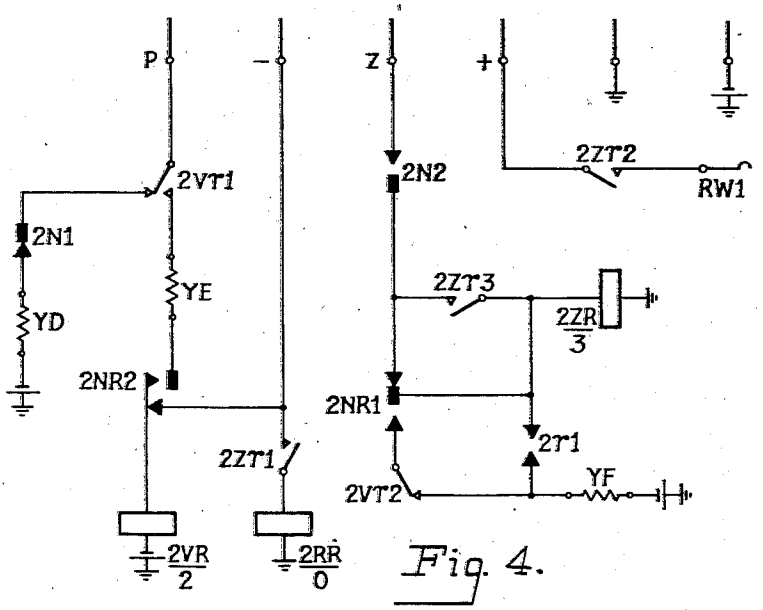

Fig. 4.

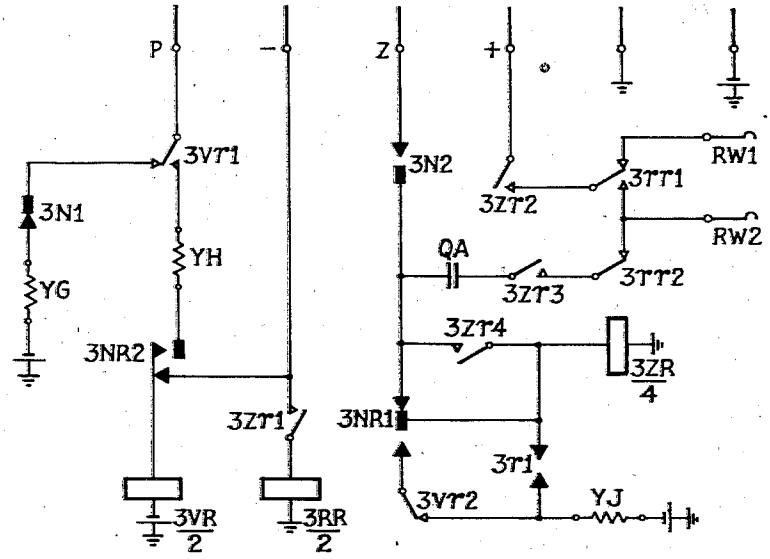

Fig. 5.

INVENTOR
GEORGE THOMAS BAKER
BY Chas. Tu. Candy.
ATTORNEY

June 17, 1947. G. T. BAKER 2,422,285

SELECTOR OPERATING CIRCUIT FOR USE IN AUTOMATIC TELEPHONE SYSTEMS

Filed March 6, 1943 5 Sheets-Sheet 4

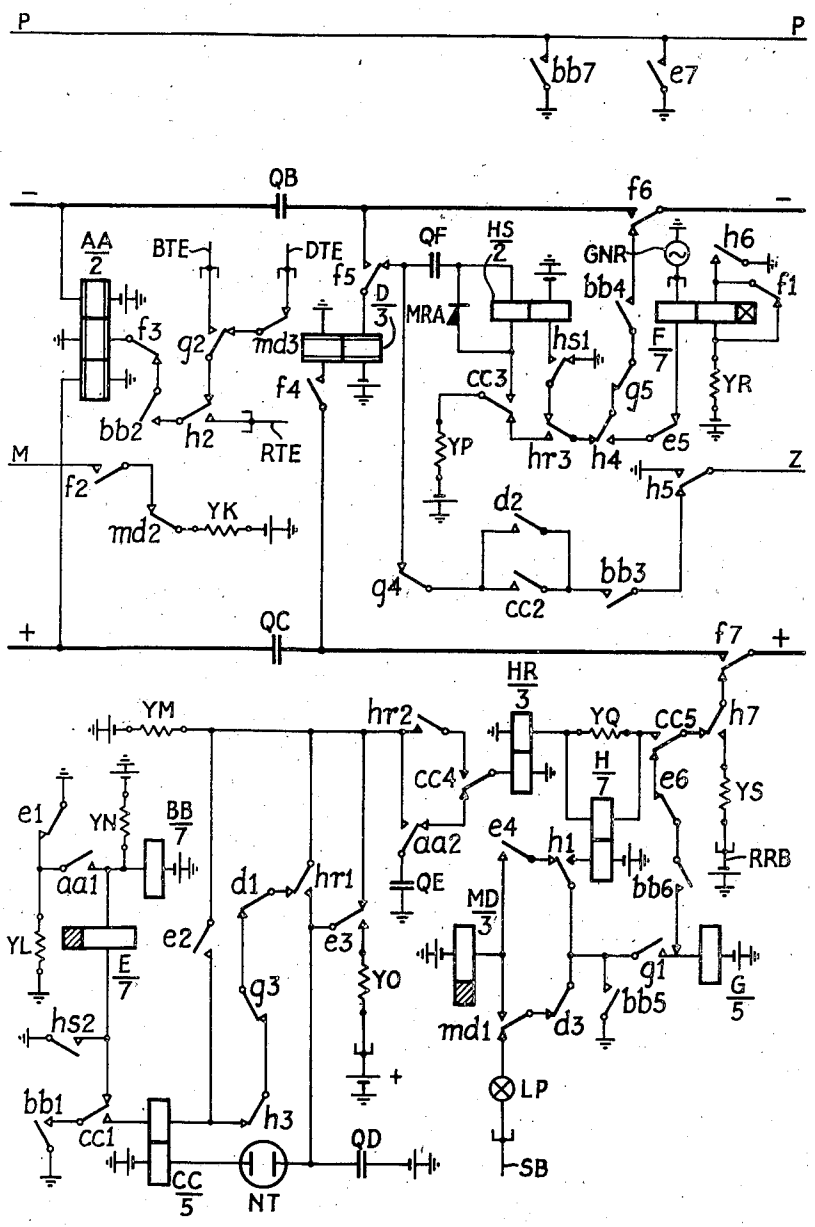

Fig. 6.

INVENTOR
GEORGE THOMAS BAKER

BY Chas. Tu. Candy

ATTORNEY

June 17, 1947. G. T. BAKER 2,422,285

SELECTOR OPERATING CIRCUIT FOR USE IN AUTOMATIC TELEPHONE SYSTEMS

Filed March 6, 1943 5 Sheets-Sheet 5

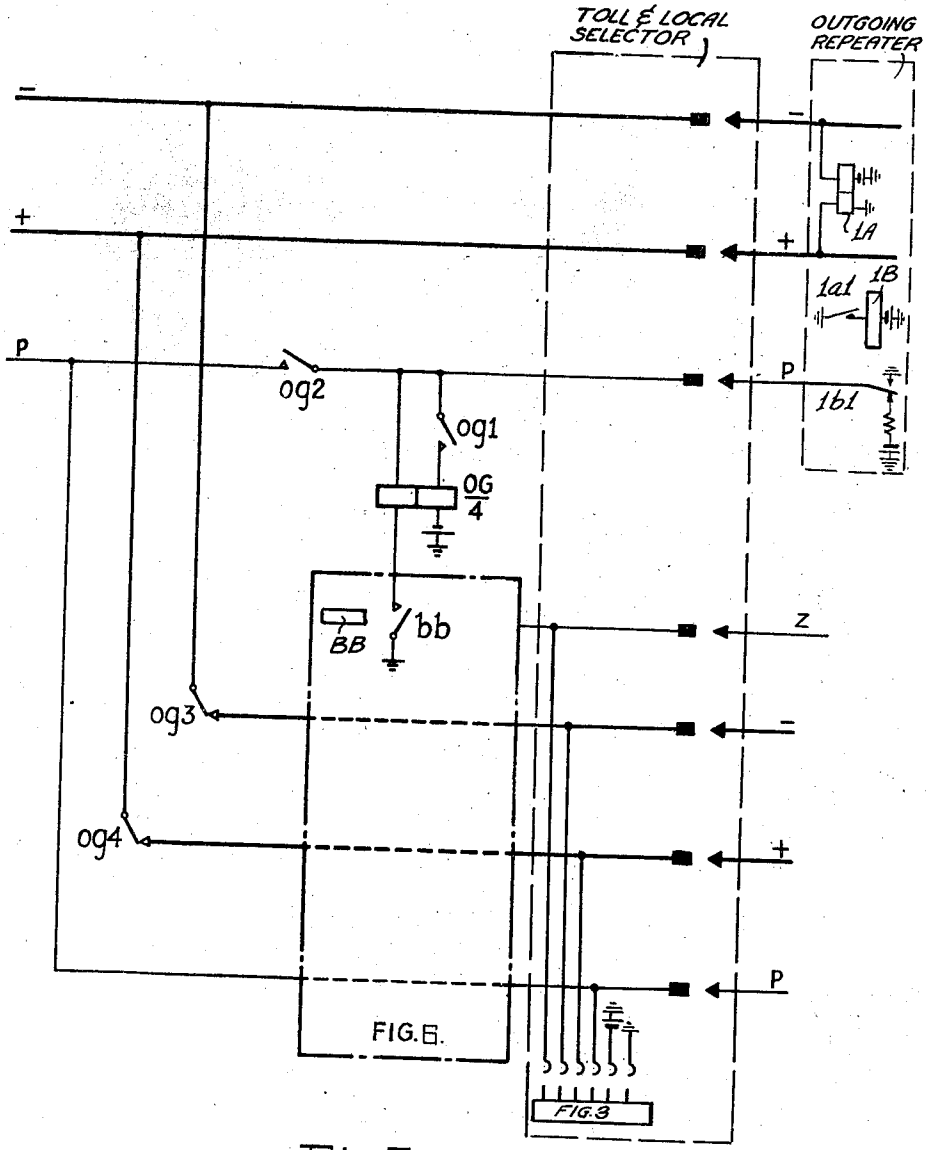

Fig. 7.

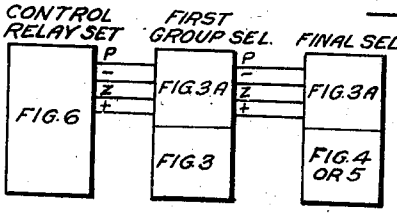

Fig. 8.

INVENTOR
GEORGE THOMAS BAKER
BY Chas. Le Caudy
ATTORNEY.

Patented June 17, 1947

2,422,285

UNITED STATES PATENT OFFICE

2,422,285

SELECTOR OPERATING CIRCUIT FOR USE IN AUTOMATIC TELEPHONE SYSTEMS

George Thomas Baker, Liverpool, England, assignor, by mesne assignments, to Automatic Electric Laboratories, Inc., Chicago, Ill., a corporation of Delaware

Application March 6, 1943, Serial No. 478,243
In Great Britain April 20, 1942

30 Claims. (Cl. 179—18)

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The present invention concerns improvements in or relating to selector circuits for use in automatic telephone or like systems and while the invention is described and has particular application to the selector switch described in my co-pending applications Ser. Nos. 478,242 and 478,245, both filed March 6, 1943, it also has application to other constructions.

The objects of the invention are concerned principally with the simplification of individual switch circuits, the elimination of relays on the individual switches and the rendering of the switch circuits so that they can be adapted for use with different kinds of selectors such as group selectors, final selectors or P. B. X final selectors in a ready manner. To this end the invention is directed to providing a novel exchange layout to permit of switch mechanisms being interchangeable, to a novel control relay set and to novel selector switch circuits. The invention is also directed to the reduction of the number of relay contacts in the switch train. In this specification the expression "control relay set" means a group of relays which precede a train of switches and exert controls over a plurality of circuits to bring about successive operations in the switches taken into use whereby the number of controlling relays individual to the switches may be reduced.

According to one feature of the invention a telephone system includes a control relay set comprising an impulse-responding relay, a hold relay and a changeover relay, each of which exerts a separate forward control, a selector having an individual control circuit such that on co-operation with the forward controls exerted by the control relay set the selector functions as a group selector and a selector having an individual control circuit such that on co-operation with the forward controls exerted by the control relay set the selector functions as a final selector.

According to a further feature of the invention a control relay set is provided for successively bringing about the various steps involved in the operation of a plurality of different kinds of selector switches (group selectors, final selectors, P. B. X final selectors) which is arranged in response to a series of impulses to exert a series of controls over different circuits which are capable of operating a plurality of different kinds of selector which may then be connected up, a specific operation for each kind of selector switch being solely dependent upon the individual circuits of the selector switch which is being operated.

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According to a further feature of the invention a selector switch is employed having pairs of co-operating contacts one of which is made when a line is selected through which a connection is to be extended, the incoming conversational leads being connected directly to corresponding co-operating contacts of each pair while multiple leads extend from said incoming leads to devices by which the operation of the switch is controlled whereby the only contacts in the conversational leads of the switch when a through connection is established consist of the pairs of co-operating contacts which are at that time in engagement.

According to a further feature of the invention the magnets of the switch mechanism of a selector in addition to controlling the mechanical operation of the switch are arranged to effect auxiliary relay operations whereby complete operation of the switch and the disconnection of the magnets from the conversational leads is effected without the employment of any relays or any like independently operated device.

According to a further feature of the invention the magnet of a selector switch which is first operated is maintained operated after responding to the first series of impulses for the first motion of the selector, while a second magnet is subsequently operated to control the second motion of the selector, a third magnet which eventually controls the release of the selector being employed for completing a circuit to the second magnet.

According to a further feature of the invention a selector circuit is provided in which one magnet is normally connected to an incoming lead and subsequently during the operation of a switch and on release other magnets are connected to the same or other incoming leads over which leads the operation of the switch is effected without the intermediary of any relays.

According to a further feature of the invention a telephone installation comprises a control relay set adapted to control the successive operation of switches in a train, switch mechanisms with control circuits of the same standard design, contact banks, cabling interconnecting the relay set and contact bank of a switch of the first stage which is controlled thereby, further cabling interconnecting the contact banks of successive stages and jack-in points adjacent and individual to the contact banks and having discriminating means associated therewith such that when one of said switch mechanisms is jacked into a contact bank of any stage, the

control relay set in conjunction with the standard circuits of the switch mechanism is adapted to cause the switch mechanism to function in the manner determined by the discriminating means whereby the same switch mechanism and its individual circuits may serve for a plurality of different kinds of switches (group selectors, final selectors, P. B. X final selectors).

According to a further feature of the invention a selector switch comprises two readily separable parts, the contact bank and the controlling mechanism, each having circuit wiring to and including contact-making devices and the jack-in arrangement by which the circuit wiring of the two parts is joined when the controlling mechanism is correctly connected up to the contact bank.

According to another feature of the invention a selector circuit for switches having pairs of co-operating contacts in their contact banks is so arranged that corresponding contacts of each pair are multiplied together in separate groups and the other corresponding contacts of each pair are connected to groups of outgoing leads so that all leads of a group are connected to contacts of which the contacts which co-operate therewith are multipled together, characterised in that the selective control of the switch causes the closure of a set of co-operating contacts having connections on the incoming side adapted for use with the particular group of outgoing lines selected. By this means it is possible to arrange a selector circuit which includes a control relay set by which the switch is operated and which includes the control relay set for calls within the exchange but excludes it for calls outside the exchange.

The invention will be better understood from the following description of one method of carrying it into effect, reference being had to the accompanying drawings, of which correspond to similar figures in my co-pending application No. 478,245.

In the drawings, Fig. 1 shows the operative circuits of a 10 level 10 outlet per level (10/10) earth testing group selector, while Fig. 2 shows at the left the basic control circuit therefor and at the right the bank wiring of a group selector.

Fig. 3 shows circuits of a 10/10 battery testing group selector.

Fig. 3-A shows the bank wiring of a group selector.

Fig. 4 shows circuits of a 10/10 regular final selector and Fig. 5 shows circuits of a 2–10 line P. B. X 10/10 final selector.

Fig. 6 shows circuits of the control relay set for a train of group selector and final selector switches.

Fig. 7 shows circuits of the switching arrangements for outgoing selector levels.

Fig. 8 shows a typical switch train embodying the circuits shown in Figs. 3 to 6, inclusive.

In the circuits the number of contact units carried by each relay is shown underneath its designation, as for instance

$$\frac{B}{2}$$

(Fig. 2), and are designated individually in small letters which in this instance will be *b*1 and *b*2. A slow-to-release relay is shown with a hatched portion at one end of the rectangle indicative thereof, while a slow-to-operate relay is shown with a cross at one end, such a relay being in some instances slow-to-release as well as slow-to-operate.

The construction of switch to which the circuits described relate is described in full in my co-pending applications Nos. 478,242 and 478,245. The important features of this construction to bear in mind are that there are no rubbing wipers other than what may be required for testing. The operating magnets simply serve to release power to the switch mechanism through a cam-shaped coupling and may therefore closely resemble telephone type relays. The outgoing leads consist of metal strips forming multiples and arranged in ten groups of four rows each, each row comprising ten outlets and an additional eleventh step position. For each row a comb plate is provided, the individual teeth of which form movable contacts that can be caused to contact with corresponding strips in the row constituting first contacts. Of the four comb plates provided for each set of four rows two correspond to the incoming conversational leads, a third to the incoming private or test lead and the fourth to an auxiliary lead. Usually corresponding comb plates of each group of rows are connected together but this is not essential and in fact advantageous use can be made of isolating one or more sets of comb plates as will be appreciated from the example given in the description of Fig. 7. The wiper or contact-making arms which effect the operation of a selected movable contact are arranged to be first moved across the ends of rows automatically or under impulse control and then to be moved in either automatically or under impulse control or partly impulse-control and partly automatically according to the function of the switch. For testing purposes rubbing wipers are connected to one or more of the wiper arms. The wiper arms after the primary movement, that is across the rows, are lifted in response to the energisation of the release magnet so that there is no contact of the wiper arms with the corresponding comb plates during the "in" movement. When a desired position is reached the release magnet is released, the wiper arms fall and cause the selected teeth of the set of four comb plates to make contact with the corresponding multiple strips. The re-energisation of the release magnet at the end of the call is arranged to result in the release of the switch

One of the major distinctions of this selector switch is that the connecting function is now part of the bank and virtually divorced from the selector. It seems highly desirable to maintain this condition rigidly not only for selector simplification but also for talking efficiency. Hence all switching contacts must be kept out of the through wires which in every selector must look like the right-hand portion of Fig. 2 or like Fig. 3A. It will be understood that the four vertically aligned contacts shown in these figures are bank contacts closed by the associated switch mechanism when same has been stepped to a particular position. In other positions to which the switch may be stepped, other similar sets of bank contacts (not shown) would be closed. Each set of bank contacts when thus closed connects the four incoming conductors shown on the left to a particular set of outgoing conductors like the four shown on the right.

Referring to the bank contacts in Fig. 2, the operating circuits for the switch mechanism which controls these contacts, among others, are shown in Fig. 1. The only controls to reach this switch mechanism come over the four incoming conductors, the operating circuits for the switch being connected to said conductors (and to battery and earth potentials, as well) by means of

a six point jack. It will be seen that the speaking path passes through neither relay contacts nor jack-in plug and socket points.

In designing circuits to meet this condition the following guiding factors were taken into consideration:

1. It is extremely advisable that the holding and battery feeding bridge shall be in the first stage or at least in an early position in the train.

2. The avoidance of line contacts means that selectors provided with two or more sets of wiper arms and banks should not be provided as these need switching relays so that generally there will be only one available outlet per step on any level such as on a 100 outlet (ten levels of ten outlets each) selector and it is proposed to use such a 100 outlet selector in the new system. The new selector drive arrangements may, however, enable a secondary movement search speed to be obtained, which will permit of fifteen or more outlets to be hunted over in a direct line. The use of such selectors also permits four wires to be used and this fourth wire is made use of to simplify subsequent circuit design. It also simplifies the circuit problems which arise when a feeding bridge is employed at any early stage in the switch train.

3. The use of the fourth wire opens up the possibility of avoiding the use of independent relays in the selectors. The primary and secondary magnets may be used as relays, since they can conveniently be of the same general design as the standard British post office type relays.

4. The necessity of eliminating an extra mounting means for relays enables the selector to assume whatever shape is most suitable for its own purpose and it is found that a flat type of construction with a height only of the order of 1½ inches is quite possible.

Every selector normally contains three basic relays usually designated A, B and C. The present circuits are such that these relays need be provided only once per train thus further justifying the use of 100 outlet selectors and effecting material economies in relays.

One of the problems created by employing the battery feeding relays at an early stage in the connection is that of impulsing. In this case the relays usually subject to impulse failure are concentrated in the first stage so no difference is encountered there. The magnets are subject to an initial extra repetition due to this cause, but in any case, this is met by the elimination of a repetition in the selectors themselves where the incoming impulses are delivered direct into the magnets instead of being repeated from an A relay. In addition to this, the magnets are self-correcting and will perform a single operation on one pulse however long or short.

Certain of the principles have been already laid down, and to these another will be added. The group and final selectors are to be kept as simple and standard as possible, and all variations are to be made in the battery feed relay set which is jacked in as a separate unit and serves to control successive switches. Apart from the question of standardisation one of the main advantages of this type of layout is the fact that any new technique can be introduced without affecting the mechanical parts of the exchange. One example of this as is described later is shown in the introduction of the sped timing type of impulsing circuit (United States Patent No. 2,334,591, granted November 16, 1943, to Taylor and Baker) by means of which impulse-responding circuits are

adapted to function independently of the ratio of received impulses, the separate time-measuring functions of the ordinary B and C relays being combined into one timing function which simply measures the overall length of each impulse instead of the length of the separate parts thereof as hitherto. With the normal type of exchange layout it would be necessary to modify every selector in the exchange to introduce this feature. Now it can be incorporated or omitted merely by changing the first relay set. With the increased lengths of connection over which dialling is being effected and the more general use of A. C. methods, this point is very important.

Detailed circuit consideration of Figs. 1 and 2 will now be given and it will be understood that the basic control circuit shown on the left in Fig. 2 is permanently associated with the contact bank of the first group selector shown in Fig. 1; it controls not only this selector, however, but also all switches at subsequent stages in the switch train. Briefly, the combined primary magnet and relay VR (Fig. 1) is impulsed from the control relay set over the negative line, only one step being taken by the switch for each up and down movement of said primary magnet. The Z wire is used for primary/secondary changeover, which is brought about by the combined release magnet and relay ZR. Upon initiation of the secondary movement relay VR is maintained from the private conductor P and serves as a switch holding relay; on its release at the end of the call it reenergizes release magnet ZR to initiate release of the switch. Since the switch is to function as a group selector, i. e. with dialled primary movement and self-driven secondary movement, and is to be controlled from a simple control circuit such as that of Fig. 2, then the primary driving cam will have to be of the two-stage escapement release type while the secondary driving cam will have to be of the single stage simple release type.

When a subscriber calls the control relay set or group of Fig. 2 is associated with the calling line via any suitable apparatus which might conveniently be of the line finder type. Relay A therein operates, followed by relay B, whereupon the selector switch permanently associated with the control relay set is prepared for operation by the extension of earth forward over the negative and P leads. The earth on the negative lead operates the primary control relay VR, corresponding to relay 74 in the aforementioned application Ser. No. 478,242, which at contacts *vr1* prepares a locking circuit for itself on to the private P. The armature extension on relay VR allows the associated driving cam to rotate slightly to the second stop position and when relay A drops at the beginning of the first impulse relay VR releases in turn and frees the driving cam. Under local spring pressure it rotates further and engages with the roller and thereupon completes a revolution independently of the control relay VR as already described. The release of relay A at the beginning of the first impulse also causes contact *a2* to energize relay C. On the next and subsequent impulses of the train the primary carriage is operated in a similar manner to cause it to advance a number of steps corresponding to the digit dialled and it will be noted from Fig. 2 that relays B and C are held operated throughout the train by virtue of their slugs, the B relay guarding the connection and maintaining the P lead earthed while the C relay maintains the Z lead open to prevent the premature operation of the release relay ZR which is connected up to

the Z lead on the first primary step due to the mechanical operation of the switch off normal contacts N1.

At the end of the first impulse train relay C releases after its slow release period and energises relay ZR which lifts the wipers clear of the bank level in question and at contact *zr*2 provides an operating circuit for the secondary control relay RR. This relay in operating locks relay ZR at contacts *rr*1 and also releases the catch on the secondary driving cam which engages with the roller. Thereupon, since in this case the catch arrangement between the extension of the secondary relay armature and the driving cam is not of the escapement type, then until such time as the motion of the cam can be halted by the release of the relay RR and the consequent interposing of the tip of the extension armature into the path of the stop on the driving cam, the cam will continue to be rotated by both the driving roller and also periodically under control of its local drive-engaging spring. This will cause the secondary carriage to advance step-by-step and carry with it the primary carriage; thus the wiper arms secured thereto are caused to enter step-by-step into the selected bank level. On the first secondary step the secondary off-normal contacts NR1 and NR2 are mechanically operated so that the holding circuit of relay VR is transferred to the P lead at contact NR2 and is locked for the remainder of the call via resistance VRR.

At the end of each secondary step the operating circuit of relay RR is broken by the interrupter contacts *r*1, which it will be understood are made during the engagement of the secondary driving pawl with the secondary ratchet, but when this occurs it will be noticed that the second winding of this relay will be connected over a rubbing test wiper P on to the corresponding lead of an outgoing trunk. If such a lead is busy an earth potential will be encountered thereon so that relay RR will remain held and the secondary carriage will step on to the next set of outlets.

When a free set of outlets is encountered the P wiper will not encounter any earth potential and the interrupter contacts *r*1 on opening will cause relay RR rapidly to deenergise and the catch on its armature will thereupon fall into position to halt the secondary movement when the cycle of movement of the cam is completed.

Relay ZR is now released and causes the wiper arms to drop so that the tips thereof will lower into the set of selected bank contacts to press the movable contacts against the fixed contacts in the contact bank and so causing the calling party and the battery feed relay set to be switched through to the succeeding selecting stage, which may be either the final selector stage or another group selector stage. If the latter the relays A, B and C will operate the subsequent group selector in the same manner as previously described. If the former the operation of the battery feed relay set will be as described except that it will function twice while the circuits will be appropriately modified from those shown in Fig. 1. More detailed circuits are described later with reference to Figs. 3 to 6.

If the calling party should now hang up, relays A and B in the control relay set will release and the removal of earth from the P lead will release relay VR, whereupon an operating circuit for relay ZR is re-completed via contacts *vr*2 and NR1. The wipers are again lifted clear of the bank and as previously described, the primary and secondary carriages are now freed to restore

to normal under local spring tension. The mechanically operated springs restore to normal and at contact NR1 relay ZR is released to render the selector ready for further use.

If all outlets on a level should prove to be busy the wipers will advance to the 11th step position in which position the 11th step contacts S1 will be mechanically operated and will open the circuit of relay RR to halt the secondary motion in the same manner as for a free outlet so that the switch will contact the control relay set through to the 11th set of bank contacts. It will be understood that the 11th step positive contact is permanently earthed so that earth will be extended back over the positive lead to the control group which in response thereto will initiate the return of a busy tone to the calling party in a manner discussed in the previously mentioned application. If an overflow for the level is to be provided this could be connected to the 11th step P contacts and the contacts S1 in operating could be in the form of a changeover combination adapted to extend earth forward over the rubbing P wiper to operate the overflow meter in this condition.

Consideration will now be given to the battery testing types of selector switches in which the idle condition is indicated not by the absence of earth but by the presence of negative battery. Such switches normally involve more relays than the earth testing variety, since the fast cut drive relay could not operate quickly enough if it carried the switching load and a relief thereon must therefore be usually provided. In the present instance however, no more relays than usual are required, since the cut drive relay can be located in the control relay set, while the switch banks themselves provide the switching function.

The circuits of a ten level ten outlet per level (10/10) battery testing group selector (Fig. 3), a 10/10 regular final selector (Fig. 4) and of a 10/10 P. B. X final selector (Fig. 5) with P. B. X groups of 2–10 lines will be considered in turn in conjunction with the control relay set circuit of Fig. 6.

A typical switch train including these units in their proper relationship is shown in Fig. 8. It will be observed that the final selector in the switch train may be a standard one employing the circuits shown in Fig. 4 or may be a P. B. X final selector employing the circuits shown in Fig. 5. As a matter of fact, the trunks outgoing from certain levels of the group selector can extend to final selectors of one type while the trunks outgoing from the remaining levels of the group selector can extend to final selectors of the other type. It will be obvious that in large systems the switch train may include, between the first group selector and the final selector, one or more additional group selectors identical to the one shown. On the other hand, in small systems the group selector may be omitted, the trunk outgoing from the control relay set in this case connecting directly to the final selector.

The circuit arrangements of this relay set are such that regardless of whether the secondary movement of a switch is to be under dialled impulse control or to be self-driven in response to an initial stimulus, the secondary cam may be of the simple catch release type. This feature could also be applied to the primary movement were it not for the fact that the primary control relay also serves to hold the switch by being maintained from the P lead after initiation of the

secondary movement, its subsequent restoration bringing about release of the switch.

On examination of the circuits of the battery feeding and control relay group of Fig. 6 it will be noted that the ordinary A. B. C. impulse-responding group employed in the basic control circuit of Fig. 2 is replaced by the speed timing impulse-responding circuit shown and described in the before-mentioned Patent No. 2,334,591, this having been done in order to avoid the use of the normal timed B and C relays and also because it may be said that the present standard impulsing methods have about reached the limit of their usefulness as evidenced by the increasing use which is being made at present of electro-mechanical impulse regenerators in telephone exchange systems. In speed timing arrangements the impulse speed is measured instead of impulse ratio as hitherto, so that line conditions, which have a distorting effect on impulse ratio but not on their speed, are now an almost negligible consideration.

The speed timing circuit comprises a single time measuring circuit including a condenser QD, resistance YO and neon tube NT and is adapted to compare the total length of the make-plus-break period of each impulse of a received train with a predetermined period of the order of 150 milliseconds which is substantially equal to the total length of each impulse at the lowest impulsing speed tolerated in practice.

The circuit is set into operation at the beginning of the first impulse of a train and is restored to normal by each successive impulse of the train until the last pulse is received, after which it functions either to initiate release of the connection or to render the circuit of the switch in question ready for the further function required of it according as to whether the impulse train finished with the impulse accepting relay normal or operated.

When a calling subscriber is connected through to the control group, relay AA operates, and at contacts *aa1* brings up relay BB, while contacts *aa2* rapidly charge up condenser QE to the exchange battery voltage via resistance YM. Relay BB in operating at contacts *bb7* places a guarding and holding earth on the incoming P lead and at contacts *bb4* extends earth potential out over the outgoing (right hand) negative lead to operate the primary relay 1VR in the first group selector associated with the control group, the circuit for which is shown in Fig. 3.

Referring now to Fig. 3 relay 1VR in operating at contact *1vr1* disconnects the idle resistance marking battery comprising the battery connected resistance YA which is normally connected to the P lead to indicate the free condition of the switch to a preceding hunting switch where such a switch is involved. The armature extension of relay 1VR allows the associated driving cam to rotate slightly to the second stop position and the switch is now ready to receive a train of impulses.

Meanwhile relay BB in operating at *bb2* connects up dial tone over common lead DTE to the centre winding of relay AA and the dial tone extends by induction on to the incoming speaking leads and thence to the calling party.

When relay AA releases on the first impulse of a dialled train relay E energises in series with relay BB which is thereby held. Relay E in operating at contact *e4* brings up relay MD which at contacts *md3* disconnects the dial tone circuit and locks via contacts *md1*, *d3* and *bb5* to earth. Contacts *aa2* allow the charged condenser QE to discharge through relay HR which operates, the size of this condenser being so adjusted as to allow contacts *hr3* in the earth circuit to the negative wire to interrupt this circuit for a period long enough to release the selector relay 1VR and so to free the driving cam and cause the selector to proceed to perform one primary step. This rather unusual method of impulse repetition which is more correctly regeneration in another form is primarily adapted to operate in conjunction with the secondary movement simple catch release control so that this movement may be controlled by dialled impulses or may operate independently in a self-driven circuit according to the function required of it. Details of such operations will be given later.

When relay AA re-operates at the end of the first impulse relay BB remains held via relay E in parallel with resistance YL, relay E also remaining operated under this condition and at contacts *aa2* condenser QE is rapidly recharged via resistance YM. The second break impulse of the train therefore re-operates relay HR for a short period in the same manner as for the first, and the second momentary break is made in the earth circuit over the negative lead to the selector relay 1VR, whereupon a second step is delivered to the selector. This happens for each succeeding impulse of the train until at the end of the train relay AA remains operated for the comparatively long interdigital pause period.

During this period the initiation of the selector secondary movement is performed by the impulse speed timing circuit in the following manner. On the first operation of relay E, i. e. at commencement of the first received break impulse, a charging circuit for the speed timing condenser QD is prepared at *e3* via resistance YO to positive battery and when relay HR releases after extending the momentary break impulse to the selector condenser QD starts to charge. The respective values of the resistance and condenser are such that the condenser takes approximately 150 milliseconds to reach a voltage large enough to flash the neon tube NT. More precisely, the charging period is 150 milliseconds less the operated time of relay HR which operates for a given time period at commencement of the break period of each received impulse.

If the second break period is received before the elapse of 150 milliseconds from the commencement of the first break period then relay HR in again operating at contacts *hr1* will rapidly discharge condenser QD via resistance YM and the charging up of this condenser will re-commence on the release of relay HR. The discharging and charging of condenser QD occurs for each received impulse until at the end of the train relay AA remains operated and allows the voltage of condenser QD to reach the flash voltage of neon tube NT 150 milliseconds after the commencement of the last break impulse of the train.

Neon tube NT in flashing brings up relay CC and this relay in operating locks over its upper winding in series with resistance YM and *e2* and at its contacts *cc1* disconnects relay E which commences to release slowly. At contacts *cc2* battery via the winding of relay D is fed out along the Z wire and since the selector primary off-normal contact 1N2 will have closed when the switch stepped off normal in a primary direction this battery potential extends through to the combined release magnet and relay 1ZR. Relays D and 1ZR operate under this condition,

Relay 1ZR in operating lifts the switch wipers clear of the level of contacts into which they are to be inserted and at contacts 1*zr*1 operates the secondary control relay 1RR from the earthed negative lead to initiate the self-driven secondary driving movement of the switch in search of a free outlet to a succeeding switch.

Relay 1RR in operating initiates the secondary drive by freeing the catch on the secondary driving cam and locks relay 1ZR via contacts 1*rr*1 to battery via resistance YC. On the first secondary step the secondary off normal contacts 1NR1 and 1NR2 are operated, the former disconnecting the initial operating circuit of relay 1ZR so that relay D in the control relay set releases without having effected any circuit operation at this stage; at contacts 1NR2 the holding circuit for relay 1VR is transferred to the earthed P lead.

Contacts 1*zr*2 connect the rubbing private test wiper RW1 through over the positive trunk and thence via resting contacts *f*1 and *h*1, operated contacts *cc*5 and resistance YQ to the upper winding of the fast cut-drive relay HR.

When the rubbing wiper RW1 encouters an idle outlet as indicated by an idle resistance marking battery such as that normally connected to the P wire of this switch, relay HR rapidly operates and at contacts *hr*3 disconnects the earth potential being fed out on to the negative lead, whereupon relay 1RR releases to stop the switch motion and at contacts 1*rr*1 de-energises relay 1ZR to drop wipers into action with the banks so as to switch the control relay set through to the succeeding selector stage. The control group relay H has not enough time to operate at this stage, for a reason to be later described.

The secondary drive interrupter contacts 1*r*1 function in the same manner as for the earth testing group selector case previously described.

Returning again to the control relay set it will be noted that when relay CC is operated to initiate the secondary movement it remains locked either until the expiration of the slow release time of relay E when its locking circuit is opened at contacts *e*2 or of the time required to find a free trunk when its locking circuit is opened by contacts *hr*1, whichever is the longer.

When the selector relay 1ZR is disconnected to switch the control relay set through to the succeeding selector stage contacts 1*zr*2 open the outlet testing circuit and so release relay HR in the control relay set, the succeeding selector taken in use being guarded by the extension of earth thereto over the P wire from the control relay set. On release of relay CC the control set will be in readiness for the dialling of the next digit to control the positioning of the succeeding selector now taken into use.

If the subscriber should now hang up relay AA will fall and relay E will operate in series with relay BB which holds. Condenser QE will be discharged through relay HR and a single impulse will therefore be sent out over the negative wire to the succeeding selector. Approximately 150 milliseconds after the release of relay AA the speed timing circuit will come into operation, whereupon relay CC operates and since relay AA is now normal the holding circuit of relays E and BB is disconnected and the former will commence to release slowly due to its slug while the latter will release comparatively slowly due to its non-inductive resistance shunt involving resistor YN. On release of relay BB the locking circuit for relay CC is opened at *bb*1 and on release of relay E the holding earth is removed from the

P lead at *e*1 whereupon relay 1VR which has been previously held is now released and at contacts 1*vr*2 completes a re-operating circuit for relay 1ZR, whereupon release of the group selector is effected in the same manner as for the previously described earth-testing group selector.

As regards the succeeding selector, on seizure its primary control relay will have been operated over the negative lead and on the release of relay AA the momentary break in the earth potential extended on to this lead causes the primary control relay to release to initiate one primary step. 150 milliseconds later relay CC operates, and during the slightly slow to release time of relay BB battery potential via the winding of relay D is fed out over the Z lead to bring up the release relay and the secondary control relay is now operated from the negative lead on to which the earth will have by this time been replaced. The switch now cuts in and proceeds to complete the first secondary step and if relay BB should release during this time then it will be seen that the interrupter contacts equivalent to 1*r*1, which are made during the stepping operation, maintain the release relay independently of the now normal secondary control relay. At the end of the step the interrupter contacts open and release the release relay, whereupon the incoming leads to the selector will be switched through to the set of outlets opposite to which they are positioned, but it will be noticed that since relay BB is normal the seizing negative lead will be disconnected in the control group. On release of relay E the selector primary control relay is released due to removal of the earth from the P lead and the release relay thereupon re-energises and initiates release of the switch.

Returning now to the operation of the group selector of Fig. 3, if all outgoing trunks should prove busy then the secondary movement will continue until the rubbing wiper RW1 reaches the 11th step position, the P contact of which is permanently wired to a resistance battery so that the cut-drive relay HR will operate to release the secondary control relay 1RR and so halt the rotary motion. Relay E will have released by this time and hence relay HR in operating will release relay CC and contacts *hr*1. In the selector relay 1RR in releasing releases relay 1ZR and the 11th step contacts 1S1 thereupon become effective to extend earth back over the positive lead to bring up relay G in the control group. Relay G in operating locks over its contacts *g*1 and at contacts *g*2 connects up a busy tone earth source over common lead BRE to the centre winding of relay AA from whence it is returned to the calling party.

As regards the 11th step P contact the outgoing P contact of which is permanently wired to resistance battery, it will be understood that the incoming P contact of the bank switching pair will have been removed so that when the wiper arm is dropped on the release of relay 1ZR the outgoing contact will not be earthed from the control relay set and further selectors can therefore switch to the same battery. On the release of relay 1ZR the 11th step contacts 1S1 also become effective to extend earth to an overflow meter which will be connected to the 11th step outgoing positive bank contacts.

It should be noted that when controlling a group selector the negative battery encountered by the rubbing wiper RW1 when an idle succeeding switch is encountered is removed some 10 milliseconds after the operation of relay HR, i. e.

when the selector relays 1RR and 1ZR release in turn, and for this reason relay HR is given a locking circuit via contact *cc*4 and *hr*2 to ensure the release of relay CC in case during a secondary hunting movement relay E should not release before relay HR operates in response to the encountering of a free outlet. The switching relay H, a winding of which is in series with the operating winding of relay HR, will be given an operating time longer than this 10 milliseconds period to ensure that it will not operate when the control set is governing the setting of a group selector; under conditions where the control set is governing the setting of a final selector relay H will be given ample time to operate as will be later described.

Assume now that when the group selector has been seized the subscriber hangs up without dialling. In this case an impulse train of a single impulse is simulated but with relay AA remaining normal at the end of the impulse. The release of the selector follows along precisely similar lines to that of the succeeding selector when the calling subscriber hung up after dialling one digit only.

It will now be assumed that the succeeding selector taken into use is a regular final selector, circuits of which are shown in Fig. 4. The bank switching portion associated with the final selector is the same as in Fig. 3A, and the manner in which the two are associated will be clear from Fig. 8.

On seizure the primary relay 2VR is operated and the initial operation of this switch up to the energization of the release relay 2ZR at the end of the first received train of impulses is the same as for the group selector of Fig. 3. Relay 2ZR in operating connects the secondary relay 2RR up to the earthed negative lead, but in this instance since relay 2RR is connected to earth instead of battery it will remain normal due to the shunting action of the earth on the negative lead, which earth also serves to hold the vertical relay 2VR. Hence no automatic secondary movement takes place and the control group relay D remains held in series with relay 2ZR.

When the next train of impulses is received by the control group, then each time relay HR operates for a short period at commencement of the break period of an impulse the earth potential to the negative lead is replaced by a battery potential via resistance YP and the selector secondary relay 2RR for each received impulse, is operated for a length of time governed by the operated time of relay HR.

It will be remembered that the secondary driving cam is of the simple catch release type and hence in order that dialled impulses may be effective thereon it is necessary to ensure that the control relay 2RR after having been operated in response to an impulse shall release in time to put a stop in the path of the secondary cam before this cam has completed the one half revolution necessary to advance the wipers through one step; for this purpose the length of the secondary pulse as governed by relay HR is arranged to be less than the 30 millisecond period required by the cam to complete one half revolution. Each successive pulse is similar to the first and the carriage is thus dialled step by step into the bank.

In the control group at the end of the first impulse train relay CC in operating initiates the slow release of relay E in usual manner, while relay BB remains held. One locking circuit of relay CC is opened by operated contacts *d*1 so that when relay E releases after its slow release period relay CC will immediately restore and the circuit is now in readiness for the next dialled digit.

When relay CC again operates at the end of this next digit the earthed testing relay HR and the switching relay H are connected up in series over the positive wire and thence via contacts 2*zr*2 and the rubbing private testing wiper RW1 to the called subscriber's P conductor.

If the called line is free a resistance battery marking will be encountered on this conductor and relay HR will operate in series therewith; in this case, as distinct from the group selector, since the selector relay 2ZR is locked up to relay D relay HR in operating will be unable to cause the release of relay 2ZR, and accordingly the switching relay H will get time to operate during the slow-to-release time of relay E which will have again commenced to release slowly on the operation of relay CC. On all final selector switches (ordinary and P. B. X) three leads extend to the line circuit of each subscriber concerned, the negative and positive outgoing bank contacts connecting with the corresponding negative and positive leads of the line circuit, while as regards the subscribers' private leads, these connect up with the outgoing Z bank contacts, the outgoing P bank contacts not being wired out. Hence, when relay H operates contacts *h*5 extend earth forward over the Z wire to short circuit and release the final selector relay 2ZR and so effect the switching through of the control set to the called subscribers' line. The earth will also extend forward over the switch banks to the called subscriber's private wire to mark this line as busy and so effect the necessary control in the subscriber's line equipment to receive the incoming call. The connection to the called subscriber's private wire is initially over wiper RW1 and subsequently when 2ZR is released over the main contacts.

Contacts *h*4 and *h*7 respectively, connect up an earthed ringing generator GNR via the winding of relay F on to the negative line and a ringing return battery via lead RRB and resistance YS on to the positive line so as to ring the called party's bell, while contacts *h*2 connect up a ringing tone earth source over lead RTE to the centre winding of relay AA from whence the ringing tone returns to the calling party.

When the called subscriber replies relay F operates and at contacts *f*1 removes the short circuit from its right hand winding over which it locks, while at contacts *f*6 and *f*7 the ringing is tripped and the battery feeding relay D is connected at *f*4 and *f*5 across the outgoing lines and through to the called party. Conversation may now proceed.

It will be remembered that relay MD was operated from relay E when the latter operated in response to the first train of impulses received by the control group and when relay D operates it will be seen that the holding circuit for relay MD is opened at contacts *d*3. On release of relay MD after its slow release period a battery potential via resistance YK is extended backwardly over the metering lead M to register the call against the calling party.

At the end of conversation when the calling party hangs up relay AA releases, whereupon relay E operates in series with relay BB which holds. The speed timing circuit comes into operation and 150 milliseconds after release of relay

AA relay CC comes in and initiates the slow release of relays E and BB. On release of relay BB relays H, F and D are released, while on release of relay E the holding earth is removed from the P lead and the various primary control relays in the selector train which have been held therefrom are released so as to bring up their release relays and so initiate release of their respective switches.

Assuming now that the required line proves to be busy then relay H will fail to operate during the release time of relay E and when relay E releases relay CC will fall and will connect up relay G on to the positive lead. Relay G thereupon operates to the earthed busy subscriber's private encountered by rubbing wiper RW1 and returns busy tone to the calling party at contacts *g*2, while at contacts *g*4 the circuit for extending battery potential via the winding of relay D on to the Z lead is opened and the final selector release relay 2ZR thereupon releases. The final selector wiper arms are thereupon lowered into contact with the bank but it will be appreciated that interference with the busy required subscriber is guarded against by the disconnection in the control group of the negative, positive, and Z wires at contacts *g*5, *g*1 and *g*4 respectively, which wires are, in the case of all final selector switches, respectively connected up at the final selector switch banks to the subscriber's negative, positive and P leads. The P lead from the control group and through the selector train to the final selector remains earthed for the purpose of holding the selector train until the calling party hangs up, and since the P lead does not extend through to the subscriber's line circuit it can do so without intereference to the line of required subscriber.

It will now be assumed that the last two dialled digits are effective on the 2–10 line P. B. X final selector shown in Fig. 5. The primary and secondary setting of this switch is the same as for the regular final selector but in this case, when at the end of the last impulse train the secondary control relay 3RR is released from the control group, relays HR and H are connected in series via the positive trunk, operated contacts 3*zr*2, resting contacts 3*rr*1, the rubbing test wiper RW1 and the contact it is resting on to the private wire of the line circuit in the wanted P. B. X group to which the final selector wipers have been positioned. The contacts engaged by RW1 are connected to the outgoing Z contacts which as in the case of the regular final selector are connected through to the subscriber's private wire. It will be noted in addition that the Z wire is connected through to a corresponding contact on an auxiliary bank via the off normal contacts 3N2, condenser QA, contacts 3*zr*3, contacts 3*rr*2, and the rubbing wiper RW2. The auxiliary bank which is only used for testing purposes may comprise the outgoing P bank contacts which on the final selector are normally unwired while the outgoing Z contacts connect through to the subscribers' privates. On this auxiliary bank it will be understood that the first lines of P. B. X groups are marked by a source of battery with alternating current imposed, on intermediate lines the outgoing P and Z contacts are strapped, while on the last lines a resistance battery is connected.

If the switch wipers are positioned to the first line of a P. B. X group the battery connected alternating current source encountered by wiper RW2 extends back via condenser QA and the Z lead to operate relay HS on its left hand winding in series with resistance YP, this winding of relay HS being arranged in association with condenser QF and rectifier MRA so as to operate satisfactorily on alternating current. Relay HS in operating at contacts *hs*2 maintains a holding circuit for relay E so that relay CC in turn will remain locked after operation from the speed timing circuit, while at contacts *hs*1 it prepares for the extension of battery potential via its other winding on to the negative lead.

If the line is found to be free by test wiper RW1 the free line battery potential will extend back over the positive lead to bring up relay HR. In this case the operation of relay HS will be without effect as the circuit to the negative lead is opened at contact *hr*3. Relay H in operating after the operation of relay HR will, in a manner as already described in connection with the regular final selector, cause the P. B. X final selector to switch through to the first line on the P. B. X group after which ringing is carried out in the manner already described.

If the line is busy however, relay HR will fail to operate and the resistance battery extended on to the negative line via the right hand winding of relay HS will bring up the selector secondary relay 3RR to cause the switch to hunt automatically over the lines in the group.

With relay 3RR operated it will be noted that at contacts 3*rr*1 the positive wire is transferred from the testing wiper RW1 to wiper RW2, but on intermediate lines of a P. B. X group it will be remembered that the associated P and A outgoing bank contacts are strapped so that during movement the control group will still be virtually testing over the subscribers' privates of the group. It will be appreciated that the alternating current circuit over wiper RW2 can operate independently of the D. C. holding circuit for relay 3ZR since it is isolated therefrom at the selector by condenser QA and at the control group by condenser QF. When a free intermediate line in the group is encountered relay HR energises and releases the selector secondary control relay 3RR to stop the movement. Relay H then operates and functions in the manner already described to cause the lines to be switched through.

If the first and intermediate lines of the dialled P. B. X group are engaged the selector on reaching the last line will at its wiper RW2 encounter a resistance battery potential which marks the last line of all P. B. X groups. Accordingly, relay HR will operate over the positive lead and over operated contacts 3*zr*2 and 3*rr*1 whatever the condition of the corresponding line (the relevant outgoing P and Z contacts not of course being strapped on the last line of a P. B. X group). Relay HR in operating at contact *hr*3 opens the locking circuit of relay HS which in releasing at contact *hs*2 opens the holding circuit of relay E which commences slowly to release. The disconnection of the battery via the winding of relay HS to the negative lead (relay CC still being held from relay E) will cause the switch secondary relay 3RR to release so that relays HR and H will be connected up in series over the positive wire to rubbing wiper RW1 and thence to the private of the last subscriber in the group so that if the line is free relay H will operate to effect connection with the called line. If the line is busy relay H will fail to operate but relay HR will remain held over its lower winding to battery via resistance YM. On release of relay E after its slow release period relay CC will fail and will release relay HR, while at contacts *cc*5 relay G will be con-

nected up to the positive lead and will then operate to the busy earth potential encountered by the busy test wiper RW1 with results as already described.

In case a particular line out of a P. B. X group is required, as under night service conditions, then provided that this is not the first line of the group, if the P. B. X selector is positioned accordingly by dialling no P. B. X hunting will take place if it is found to be busy since relay HS will not have been operated to provide the conditions necessary for P. B. X hunting and the operations involved will be as for a regular final selector when an engaged outlet is encountered.

It is to be noted that the circuit of Fig. 5 can be used for a switch to function as well as either a group selector, final selector or P. B. X final selector by simply making appropriate connection to the contacts engaged by the rubbing wipers and in the case of a group selector arranging that the rubbing wipers RW2 engage a normal contact connected to alternating current supplied in series with battery as in the case of the first contact of a group.

Other points and additional features both in regard to the selector switches and the control group will now be discussed.

As previously mentioned the outgoing Z bank contacts in the final selectors connect with the P conductors of the subscribers' line circuits concerned so that when the control group switches through earth will be extended forward over the Z wire from contacts *h*5 to the P conductor of the subscriber in question. The Z wire is carried through between the control group and the final selector without shunt or series resistances, so that various facilities such as toll breakdown which were originally provided from the final selector can now be provided in the control group.

If the circuits of the regular final selector and group selector shown in Figs. 3 and 4 are examined and compared, it will be seen that there is no reason why the final selector circuit should not be employed on the group selector provided that in the control group the Z circuit is opened to release magnet 2ZR by relay HR when it opens the circuit for magnet 2RR on an idle line being found. Certain other modifications will be required in the control group to ensure that relay HR does not open the circuit of 2ZR other than at the end of an impulse series or at the end of hunting. With such circuit modifications the necessity of maintaining the circuit of 2ZR by 2ZR3 is avoided and the circuit of Fig. 4 may be simplified by connecting 2ZR direct to 2N2. It is obvious that it is impracticable to illustrate all the modifications which are possible and it is only proposed to indictate generally the lines on which modifications may be made as a circuit designer skilled in the art can readily make the necessary complementary modifications. For instance when the primary movement has been concluded relay 2ZR will be operated as previously, and the control group will be arranged to extend a resistance battery out over the negative lead to operate relay 2RR via contacts of which the primary relay 2VR will be maintained temporarily until the secondary drive commences and the operation of relay 2RR will cause the secondary drive to take place. When a free line is reached the cut-drive relay HR will operate through the positive lead as before and will thereupon open the negative lead to drop relay 2RR and in this instance the Z wire will be also opened by contacts of relay RR to release relay 2ZR and so effect switching through to the succeeding switch. In the case where the control group will be working into a final selector it will operate almost exactly as shown and described.

In the case described with regard to Fig. 5 it is possible to insert the switch mechanism in any position in an exchange and it will automatically function in the manner required of it, i. e. as group selector, final selector or P. B. X selector. In the case of Fig. 4 it has been explained how this circuit can be adapted to be used either as a group or final selector but in this case a certain amount of discrimination is necessary. This discrimination may take two forms, one involving the modification of the circuit of the control group according to discriminating signals sent back to the control group according to the kind of switch taken into use so that the operation of the control group is adapted in each case to the kind of switch being controlled the other involving a modification of potentials applied to one or more of the magnet relays of the switch when it is plugged into position, for instance relay 1RR is connected in one case to battery potential and 2RR is connected to earth potential if the winding of 1RR or 2RR was connected to a pin of the jack and engaged with a terminal in the contact bank. This terminal could be connected to earth in the case of a final selector and battery in the case of a group selector. Discrimination in the first case may be effected by means such as a resistance inserted at the jack of the group selector and not at the jack of the final selector or vice versa. Proceeding along the lines indicated, one approves of the result that an identical detachable selector circuit is used for both group and final selectors in which case every selector in the exchange could either perform its secondary motion automatically or under the influence of dialled impulses according to the discrimination on the jack.

A group selector could furthermore be adapted to operate in the same manner as a P. B. X final selector, i. e., with an initial dialled secondary movement, and this facility might be used in connection with testing and routining functions and for special trunking arrangements. For instance, the selector can either start to hunt from the first bank contacts or can be dialled to a position on the bank and be caused to hunt on from there.

Another point arises in connection with the selecting switches according to the invention, and that is that they can be rendered self-routining, since each selector can derive from the driving roller the requisite trains of impluses at the rate of ten per second. An unlocking push button at the front of the selector could apply the impulses to the primary control relay in response to which the switch would step in a primary direction to say level 9, where mechanically operated springs would energise the release relay to cause the switch to perform a secondary hunting movement until contact 9 on this level is reached. Further springs would then be operated to halt the switch movement.

It will be noted that no mention has been made of P. B. X groups having more than ten lines. Such large P. B. X groups are the exception rather than the rule. In these cases it is proposed to employ selecting units catering for up to 100 lines and which by virtue of the use of one or more subsidiary relays are capable of performing hunting operations over a level, then of being

released back again to the commencement of the level and stepped up to the next level where they perform another hunting operation, and so on; a method of achieving secondary release without primary release being described previously.

As regards the control group, it will be noticed that the speech transmission condensers are not introduced into the circuit until impulsing has been completed so that the distortion ordinarily produced therefrom, which is especially troublesome when impulsing over long junctions is avoided.

A facility which has not yet been described in connection with the control group is that of switching out the transmission bridge when the call is to be routed over an outgoing junction. This can be done in a simple manner which will involve relay contacts in the through leads but the following method now to be described in connection with Fig. 7 in which relay contacts in the through speaking leads to the outgoing junction repeater relay sets are entirely avoided, is proposed.

Referring to this figure, it will be understood that normally on a selector bank the comb plates relevant to each of the various leads, say, negative, positive and private, are strapped together behind the multiple, but where say levels 1–9 of a first selector are to give access to the local switching train, and where level "0" is to give access to outgoing junctions, the comb plate wiring may be split so that the incoming speaking leads will connect via contacts *og*3 and *og*4 of a relay OG via the control group of Fig. 6 with the comb plates 1–9 and will connect directly with the comb plates of level "0."

If any of the digits 1–9 are dialled, the selector train will be set up in normal manner under control of the control group of Fig. 6 as already described, but if digit "0" is dialled for the purpose of an outgoing junction call, then the directly connected "0" level comb plates will come into operation as follows: When a free outgoing repeater is found, relay OG will be operated from earthed contacts *bb* of the control group relay BB over its left hand low resistance winding to the idle resistance marking battery which will be connected to the incoming P lead at the outgoing repeater, the low resistance winding of relay OG serving as a guarding potential and also to operate relay OG which thereupon at contact *og*3 and *og*4 disconnects the circuit to the control group. During the release of the control group, which will take place at approximately 150 milli-seconds after the opening of the loop thereto, the subscriber's loop will be extended forward to operate the impulse accepting relay 1A and in turn the guard relay 1B in the outgoing relay set and a guarding and holding earth will be extended back to hold relay OG on its other winding, before relay BB in the control group which has previously been holding it, releases. The subscriber will now be directly connected through to the outgoing repeater which will receive the remainder of the trains of impulses to be dialled and which will provide the battery feed to the calling subscriber. The selector will of course remain held over the P lead from earth at the outgoing relay set which will extend via contacts *og*2 and through the control group to the selector primary control relay.

The above arrangement can also apply to the case where the group selector has only one level giving access to the local switches in the exchange and the other levels all have access to outgoing repeaters leading to other exchanges the only difference being that instead of the control relay set leading to the first nine levels it will only be connected to the level leading to local switches while the other levels will be connected direct to the incoming leads. The circuit arrangements of Fig. 7 will equally apply to this arrangement. Similarly it is possible to arrange for more than one level to be used for the local switch train and more than one level to be used for connections to other exchanges again employing the circuit arrangements of Fig. 7.

I claim:

1. In a switching system, an automatic switch having access to a plurality of lines and adapted to take a step by step primary movement followed by a step by step secondary movement in order to select a particular one of said lines; control equipment; an impulsing circuit extending from said control equipment to said switch; a circuit extending from said control equipment to said switch for causing said switch to change over from its primary movement to its secondary movement; and means including said circuits whereby each step of the primary movement of said switch is always directed by said equipment, whereby each step of the secondary movement of said switch at times also is directed by said equipment, and whereby said secondary movement at other times is a hunting movement controlled by said switch.

2. In a switching system, two automatic switches each having access to a plurality of lines and each adapted to move step by step in a primary direction and then step by step in a secondary direction in order to select a particular one of said lines, common control equipment connected to one of said switches at times over a set of conductors outgoing from said equipment and connected to the other one of said switches at other times over the same set of conductors outgoing from said equipment, an impulsing circuit extending over certain of said conductors to the connected switch at each of said times, another circuit extending over certain of said conductors to the connected switch at each of said times for causing the connected switch to change over from its primary movement to its secondary movement, and means including said circuits whereby each step of both said movements of one of said switches is always directed by said equipment, whereby each step of both said movements of the other said switch is sometimes directed by said equipment and whereby one of said movements of said other switch sometimes is a self-controlled hunting movement.

3. In a switching system, a plurality of automatic switches each having access to a plurality of lines and each adapted to move step by step in a primary direction and then step by step in a secondary direction in order to select a particular one of said lines, common control equipment connected to the different ones of said switches at different times over the same set of conductors outgoing from said equipment, an impulsing circuit extending over certain of said conductors to the connected switch at each of said times, another circuit extending over certain of said conductors to the connected switch at each of said times for causing the connected switch to change over from its primary movement to its secondary movement, means including said circuits whereby each step of the primary movement of the connected switch always is directed by said equipment and the secondary movement of the con-

nected switch is a hunting movement controlled by that switch, and a third circuit extending over certain of said conductors at each of said times for testing the lines encountered by said switch during said hunting movement.

4. In a switching system, two automatic switches each having access to a plurality of lines and each adapted to move step by step in a primary direction and then step by step in a secondary direction in order to select a particular one of said lines, common control equipment connected to one of said switches at times over a set of conductors outgoing from said equipment and connected to the other one of said switches at other times over the same set of conductors outgoing from said equipment, an impulsing circuit extending over certain of said conductors to the connected switch at each of said times, another circuit extending over certain of said conductors to the connected switch at each of said times for causing the connected switch to change over from its primary movement to its secondary movement, means including said circuits whereby both said movements of one of said switches are directed by said equipment and whereby one of said movements of the other of said switches is a self-controlled hunting movement, and a third circuit extending over certain of said conductors to the connected switch at each of said times for testing the line selected by the connected switch.

5. In a switching system wherein a connection is extended progressively over a train of two motion selective switches; a control unit for controlling each switch in turn to extend the connection to the next switch in said train; said connection including a first circuit outgoing from said unit over which impulses are transmitted to each switch in turn to move that switch step by step, a second circuit outgoing from said unit for operating each switch in turn to change over from its primary movement to its secondary movement, and a third circuit outgoing from said unit for testing the condition of each switch to which said connection is extended by a preceding switch in said train.

6. In a switching system, automatic switches, control equipment common to said switches, a connection outgoing from said equipment, means in said equipment for operating each of said switches directively in turn over said connection to extend said connection to another one of said switches, whereby said connection is advanced progressively through a plurality of said switches in series, and means in said common control equipment for testing, over said connection, the condition of each switch to which said connection is extended by a preceding switch in said series.

7. In a switching system, a selector switch, a plurality of groups of connector switches accessible to said selector switch, a plurality of groups of lines accessible to each of said connector switches, control equipment, a connection outgoing from said equipment to said selector switch, means in said equipment for operating said selector switch directively over said connection to select a particular group of said connector switches, means for then causing said selector switch to commence hunting for an idle connector switch in the selected group, testing means in said equipment operated over said connection when an idle connector switch is found for causing said selector switch to halt said hunting operation, seize the idle connector switch and extend said connection to the seized connector switch, said first means then effective to operate said connector switch directively first to select a particular group of lines among the groups accessible to that connector switch and then to select a particular line in the selected group, and means in said equipment for testing the selected line over said connection to determine the condition thereof.

8. In a switching system, a selector switch, a plurality of groups of connector switches accessible to said selector switch, a plurality of groups of lines accessible to each of said connector switches, control equipment, two circuits outgoing from said equipment to said selector switch, means in said equipment for transmitting impulses over one of said circuits to said selector switch thereby to operate said selector switch directively to select a particular group of said connector switches, means in said selector switch then controlled by said equipment over the other of said circuits for causing said selector switch to commence hunting for an idle connector switch in the selected group, means operated when an idle connector switch is found for halting said hunting operation, seizing the idle connector switch and causing said selector switch to extend said two circuits to the seized connector switch, said first means then operated to transmit impulses over said one circuit to operate said connector switch directively to select a particular group of lines among the groups accessible to that connector switch, means in said connector switch operated over said other circuit by said control equipment after said group of lines has been selected thereby to prepare a line testing circuit and to condition said connector switch to select a particular line in the selected group, said first means then operated to transmit impulses over said one circuit to operate said connector switch directively to select a particular line in the selected group, and means controlled over said line testing circuit for determining whether the selected line is idle or busy.

9. In a switching system, a selector switch, a plurality of groups of connector switches accessible to said selector switch, a plurality of groups of lines accessible to each of said connector switches, control equipment, three circuits outgoing from said control equipment to said selector switch, means in said equipment for transmitting impulses over the first of said circuits to operate said selector switch directively to select a particular group of connector switches, means in said selector switch then controlled by said equipment over the second of said circuits for causing said selector switch to commence hunting for an idle connector switch in the selected group, means in said equipment operated over the third of said circuits when an idle connector switch is found for causing said selector switch to halt its hunting operation, seize the idle connector switch and extend said three circuits to the seized connector switch, said first means then operated to transmit impulses over said first circuit to operate the seized connector switch directively to select a particular group of lines among the groups accessible to that connector switch, means in said connector switch operated over said second circuit by said equipment after said group of lines has been selected thereby to condition said connector switch to select a particular line in the selected group, said first means then operated to transmit impulses over said first circuit to operate said conditioned connector switch directively to select a particular line in the selected group, and

means in said control equipment controlled over said third circuit for determining whether the selected line is idle or busy.

10. In a switching system wherein a connection is extended progressively through a plurality of switching stages, equipment common to said stages for controlling the extension of said connection, a two motion switch at each stage connected in turn to the same set of control conductors outgoing from said equipment, said set comprising only an impulsing conductor, a guard conductor, a changeover conductor and a test conductor.

11. In a switching system wherein a connection is extended progressively over a train of two motion selective switches, a control unit common to said switches for controlling each switch in turn to extend the connection to the next switch in said train, a stepping magnet in one of said switches controlled by said unit to operate said one switch step by step in one direction, a second magnet controlled by said unit for operating said one switch in another direction, and means for maintaining said stepping magnet energized during the operation of said one switch in said other direction.

12. In a switching system wherein a connection is extended progressively over a train of two motion selective switches, a control unit common to said switches for controlling each switch in turn to extend the connection to the next switch in said train, a stepping magnet in one of said switches controlled by said unit to operate said one switch step by step in one direction, a second magnet, a third magnet controlled by said unit after the operation of said switch in said one direction for connecting said second magnet to said unit, said second magnet then controlled by said unit for operating said one switch in another direction, and means for maintaining said stepping magnet energized during the operation of said one switch in said other direction.

13. In a telephone system wherein a conversational circuit is extended progressively over a train of automatic switches, a primary stepping magnet in each switch connected to said conversational circuit and controlled thereover to operate that switch in one direction, a secondary stepping magnet in each switch connected to said conversational circuit and controlled thereover to operate that switch in a different direction, means effective after each of said magnets has been operated for disconnecting that magnet from said conversational circuit, and a circuit to which one of said magnets of each switch is connected when it is disconnected from said conversational circuit, said one magnet of each switch thereafter operated over said last circuit to initiate the release of its associated switch.

14. In a switching system, a primary switch having access to a plurality of secondary switches, means for transmitting impulses alternating in polarity, impulse receiving means in said primary switch responsive only to the impulses of one polarity for operating said primary switch directively to connect with a particular one of said secondary switches, and impulse receiving means in the seized secondary switch responsive only to the impulses of the other polarity for then operating said seized secondary switch directively.

15. In a switching system, a pair of numerical switches in serial relationship to one another, control equipment common to said switches, means in said equipment for transmitting impulses of one character to operate one of said switches directively and for transmitting impulses of a different character to operate the other of said switches directively.

16. In a switching system, a selector switch, a connector switch, control equipment common to said switches, means in said equipment for transmitting impulses of one character to said selector switch to operate it directively to complete a connection to said connector switch and for then transmitting impulses of a different character over said selector switch and said connection to said connector thereby to operate said connector switch directively.

17. In a switching system, a plurality of switches, control equipment common to said switches, said equipment having outgoing conductors which are connected in an identical way to different ones of said switches at different times, means in said equipment for impressing voltages of two different characters alternately upon one of said conductors, impulse receiving means in a connected one of said switches responsive only to the voltage of one of said characters impressed upon said one conductor for operating that switch directively, changeover means in said connected switch operated over another of said conductors after said directive operation of said switch, means in the connected switch thereupon connected to said one conductor and responsive only to voltage of the other of said characters impressed thereon for controlling a secondary movement of the connected switch.

18. In a switching system, a plurality of switches, control equipment common to said switches, said equipment having outgoing conductors which are connected in an identical way to different ones of said switches at different times, means in said equipment for impressing voltages of two different characters alternately upon one of said conductors, impulse receiving means in each of said switches effective when that switch is connected to said conductors to respond only to the voltage of one of said characters impressed upon said one conductor thereby to impart to that switch a directive primary movement, other means in each of said switches connected to said one conductor after the directive primary movement of that switch, said other means in one of said switches being responsive only to voltage said one character impressed upon said conductor thereby to impart to said one switch a hunting secondary movement, and said other means in another of said switches being responsive only to voltage of the other of said characters thereby to impart to said other switch a directive secondary movement.

19. In a switching system, control apparatus having a plurality of conductors outgoing therefrom, a plurality of switch units each including not more than three electromagnetic devices, means including a jack for detachably connecting each one of said units to said conductors at times, a plurality of lines accessible to the connected switch unit at each of said times, and means in said apparatus operated for controlling the three electromagnetic devices of the connected switch unit to impart to that switch unit a variable primary movement and a variable secondary movement, thereby to select one of the lines accessible to said switch unit.

20. In a switching system, control apparatus having a plurality of conductors outgoing therefrom, a plurality of switch units each including not more than three electromagnetic devices, means including a jack for detachably connect-

ing each one of said units to said conductors at times, a plurality of lines accessible to the connected switch unit at each of said times, and means in said apparatus operated for controlling the three electromagnetic devices of the connected switch unit to impart to that switch unit a variable directive movement followed by a hunting movement, thereby to select one of the lines accessible to said switch unit.

21. In a switching system, a plurality of two motion switches each having electromagnets for exerting mechanical forces upon the switch mechanism to operate same, electrical contacts also operated mechanically by the same electromagnets, circuits individual to each switch controlled by said contacts, and a control unit common to said switches for cooperating with the said electromagnets and contacts of each switch at times to operate that switch in two directions without the aid of any other electromagnetic device individual to said switch.

22. In a switching system, a plurality of switches each having electromagnets for exerting mechanical forces upon the switch mechanism to operate same, electrical contacts also operated mechanically by the same electromagnets, circuits individual to each switch controlled by said contacts, and a control unit common to said switches for cooperating with the said electromagnets and contacts of each switch at times to operate that switch successively in three different directions without the aid of any other electromagnetic device individual to said switch.

23. In a switching system, a plurality of switches each having electromagnets for exerting mechanical forces upon the switch mechanism to operate same, electrical contacts also operated mechanically by the same electromagnets, circuits individual to each switch controlled by said contacts, and a control unit common to said switches for cooperating with the said electromagnets and contacts of each switch at times to operate that switch successively in four different directions without the aid of any other electromagnetic device individual to said switch.

24. In a switching system wherein a line is extended progressively through a plurality of switching stages, said line comprising only four conductors, equipment common to said stages, a switch at each stage connected in turn to said line and controlled thereover by said equipment to operate successively in at least three directions thereby to extend said line to the next switching stage.

25. In a switching system wherein a line is extended progressively through a plurality of switching stages, said line comprising only four conductors, equipment common to said stages, a switch at each stage connected in turn to said line and controlled thereover by said equipment to operate successively in four directions thereby to extend said line to the next switching stage.

26. In an automatic switching system, a plurality of groups of contact sets, each contact set having two parts which normally are not in electrical connection with one another, a plurality of outgoing lines corresponding respectively to the different ones of said contact sets, each line being connected to one part of its corresponding contact set, an incoming line connected in multiple to the other part of every contact set in certain of said groups, another incoming line connected in multiple to the other part of every contact set in other of said groups, contact controlling apparatus, means in said apparatus for receiving different digits at different times and for selecting a contact set in a different one of said groups at each of said times, the group in which a contact set is selected at each of said times depending upon the value of the digit received, and means in said apparatus operated at each of said times after a contact set has been selected for completing an electrical connection between the two said parts of said selected contact set.

27. In an automatic switching system, a switch in one exchange having a plurality of groups of contact sets, each contact set having two parts which normally are not in electrical connection with one another, a plurality of trunk lines outgoing from said one exchange to connect with another exchange, said lines corresponding respectively to the different contact sets in certain of said groups, a plurality of lines local to said one exchange, said last lines corresponding respectively to the different contact sets in other of said groups, each said outgoing line and each said local line being connected to one part of its corresponding contact set, one line incoming to said switch and connected in multiple to the other part of every contact set in said certain groups, another line incoming to said switch and connected in multiple to the other part of every contact in said other groups, contact controlling apparatus, means in said apparatus for receiving different digits at different times and for selecting a contact set in a different one of said groups at each of said times, the group in which a contact set is selected at each of said times depending upon the value of the digit received, and means in said apparatus operated at each of said times after a contact set has been selected for completing an electrical connection between the two said parts of said selected contact set.

28. In an automatic switching system, a plurality of groups of contact sets, each contact set having two parts which normally are not in electrical connection with one another, a plurality of outgoing lines corresponding respectively to the different ones of said contact sets, each line being connected to one part of its corresponding contact set, a repeater, an incoming line connected directly in multiple to the other part of every contact set in certain of said groups and connected via said repeater in multiple to the other part of every contact set in other of said groups, contact controlling apparatus, means in said apparatus for receiving different digits at different times and for selecting a contact set in a different one of said groups at each of said times, the group in which a contact set is selected at each of said times depending upon the value of the digit received, and means in said apparatus operated at each of said times after a contact set has been selected for completing an electrical connection between the two said parts of said selected contact set.

29. In a telephone system, an exchange, a selective switch in said exchange having access to local lines and to outgoing lines, control equipment, a conversational circuit incoming to said control equipment over which impulses indicative of a local line are received at times and over which impulses indicative of an outgoing line are received at other times, said equipment controlled by said impulses to operate said switch to seize a local line at said first times and to seize an outgoing line at said other times, means in said control equipment effective at said first times to extend said incoming conversational circuit through said control equipment and said switch

in series to the seized local line, and means controlled at said other times to disconnect said incoming conversational circuit from said control equipment and connect it through said switch independently of said control equipment to the seized outgoing line.

30. In a switching system, an exchange, a selective switch in said exchange having access to local lines and to outgoing lines, a repeater, a circuit incoming to said repeater over which impulses indicative of a local call are received at times and over which impulses indicative of an outgoing call are received at other times, means in said repeater for repeating part of the received impulses to said switch, whereby said switch is effective to seize a local line at said first times and to seize an outgoing line at other times, said means in said repeater then operated at said first times to repeat the balance of said received impulses over said switch and the seized local line, means controlled at said other times

after said switch has been operated to seize an outgoing line for disconnecting said incoming circuit from said repeater and connecting it through said switch directly to the seized outgoing line, whereby the balance of said received impulses are conducted from said incoming circuit directly over said switch and said outgoing line without repetition.

GEORGE THOMAS BAKER.

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