CHAPTER VII

MULTI-EXCHANGE AREAS

Principle of Satellite Working. In the preceding chapter the circuit requirements for the selectors to serve a 4-digit automatic exchange have been described. The first group selectors have access to groups of 1,000 subscribers' lines through each one of 7 levels; the complete 7,000-line exchange may thus be regarded as consisting of seven 1,000-line exchanges which are all provided with trunks outgoing to first selectors, and trunks incoming from first selector levels. Similarly, the second selectors, which give access to a group of 100 lines from each one of their levels, may be regarded as giving access to exchanges having 100 lines; thus the 7,000-line 4-digit system becomes the equivalent of seventy 100-line exchanges all housed in the same building and having complete inter-connecting trunk arrangements.

From the exchange, the external cabling radiates in all directions to the various distribution points in the area served by the exchange, whence the connexion of the subscribers' instruments is made either by overhead or by underground distribution. In a central battery system, the factor limiting the permissible resistance of a subscriber's line is, in general, the amount of current fed over the line from the central battery to the transmitter; the lowest permissible current to provide standard transmission is of the order of 25 milliamps. The permissible loop resistance on a 50-volt system is therefore some 400 ohms; the actual value depends also upon the transmission losses of the transmission bridge used in the main exchange. Because of this limit in the loop resistance, the more distant subscribers' lines necessitate the use of heavier gauge conductors in the underground cables and, in addition, may require heavier gauge conductors in the overhead distribution also. Hence, for the subscribers situated further away from the exchange, a considerable cost in line plant is necessary, for not only are the cable pairs of heavier gauge, but the cables are also of greater length.

There is no reason why the trunks between the ranks of selectors in an automatic exchange should be confined within the limits of a building. By means of a group of relays inserted

at the points of transition from 3-wire control, inside the exchange, to 2-wire control on the junction, outside the exchange, it is possible to detach one or more groups of 100 subscribers' lines and install the equipment required to serve them in a small building centrally situated with regard to a group of the more distant subscribers. By doing this, a considerable saving in the line plant required for distribution from the detached exchange to the subscribers' instruments is effected at the cost of the building, the additional apparatus, and the junctions required between the detached exchange and the main automatic exchange.

In Great Britain the area covered by a unit fee is measured five miles radially from the main exchange. Hence, it is possible to design the whole of such an area—known as a Unit Fee Area—on an automatic basis by the provision of one main exchange and a number of detached exchanges of a size varying according to the telephone density of the area which they serve. The junctions between the main and the detached exchanges will be required for the extension of the outgoing and incoming trunks between the subscribers' line circuits and the selector levels, which are provided by 3-wire trunks in the system described in the preceding chapter. Thus, when a subscriber at a detached exchange removes his receiver from its rest, the uni-selector or line finder in the detached exchange immediately connects the line to a junction which terminates at the main exchange upon a first selector from which dialling tone is extended to the calling subscriber. In other respects the operation follows similar lines to those already discussed, the only additional apparatus being the relay-set inserted between the subscriber's line circuit and the outgoing junction.

It is, of course, possible to use 3-wire junctions instead of 2-wire and so obviate the cost of these relay-sets, but, although this method has been adopted in certain instances in Continental practice, it is not used in this country on account of the additional cost of the junction and the additional fault liability of the circuits between exchanges.

With the adoption of multiple metering, in which calls to the 2d., 3d., and 4d. areas may be completed by automatic switching, the use of detached exchanges in association with the main exchanges becomes possible over a much wider area; such an area, with or without multiple metering facilities, is termed a Multi-Exchange Area. Calls to subscribers outside the area, and consequently requiring more than a 4d. fee, are

obtained through an auto-manual switchboard serving the multi-exchange area. Here, also, are handled the inquiry traffic, incoming junction traffic, trunk traffic, and the various observation facilities which are provided to enable the traffic staff to observe the operation of the automatic switching apparatus from the viewpoint of grade of service.

In the area served by the main exchange and its associated detached exchanges, each subscriber must be able to dial every

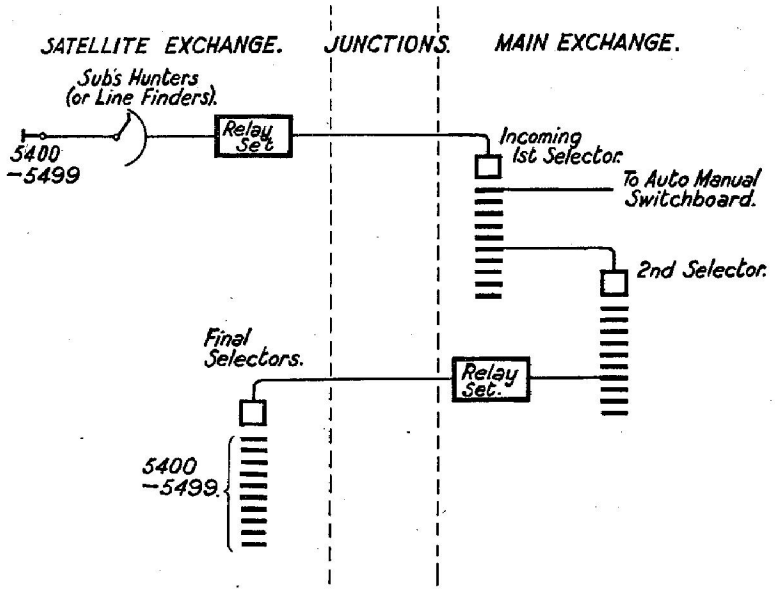


FIG. 189. FULL SATELLITE EXCHANGE

other subscriber in the area; it follows, therefore, that no two subscribers may have the same number.

The Satellite Exchange. The detached portions of the main exchange are known as Satellite Exchanges, since they are dependent upon the main or parent exchange for the completion of all their traffic. A skeleton trunking diagram for a small satellite exchange of the type just described is given in Fig. 189. The exchange is equipped with subscribers' uniselectors and final selectors. The uniselectors are connected through relay-sets to the junctions to the main exchange which there terminate on first selectors, which are known as incoming first selectors in consequence, whence they have access to the

normal trunking network. The final selectors are reached over 2-wire junctions from the levels of second selectors at the main exchange.

At small satellite exchanges it is not economical to provide continuous attendance of engineering staff. The exchanges are left to look after themselves, and any alarm conditions arising are extended over a junction to the main exchange. The ringing generator is not arranged to run continuously, but is operated by a motor start circuit, which is completed whenever the

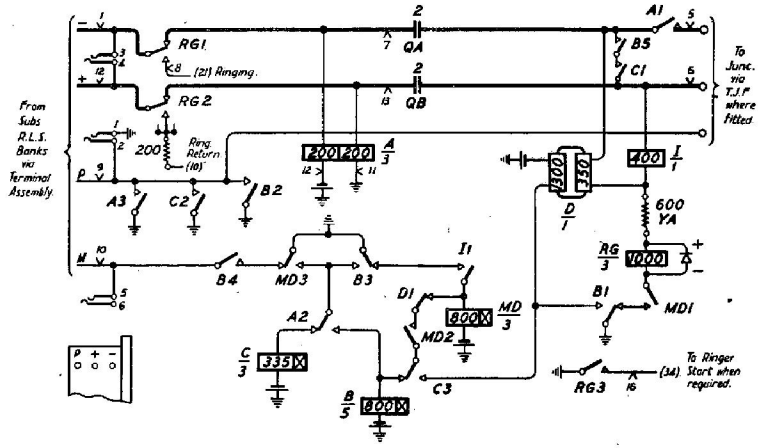


FIG. 190. RELAY-SET, SATELLITE TO MAIN

final selectors in the exchange require the supply of ringing current or tone signals.

Relay-set, Satellite to Main. A diagram of the connexions of the relay-set inserted between a subscriber's line circuit and the 2-wire junction at a satellite exchange is given in Fig. 190. The functions performed by this relay-set are—

(i) To maintain an earth on the *P*-wire in the satellite exchange and so permit the use of 2-wire junctions outside the exchange.

(ii) To provide a transmission feed to the calling subscribers' instrument.

(iii) To transmit impulses to the selectors in the distant exchange.

(iv) To pass back the metering condition.

(v) To provide for operator hold conditions in the event of a call to the auto-manual switchboard.

(vi) To provide for re-ring facilities for trunk demand working.

(vii) To provide ringer start facilities, where required, when facility (vi) is performed.

When the relay-set is seized, relay A operates and **A1** connects relays D and I to the 2-wire junction; **A2** prepares a circuit for relay B; **A3** connects earth to the P-wire to prevent

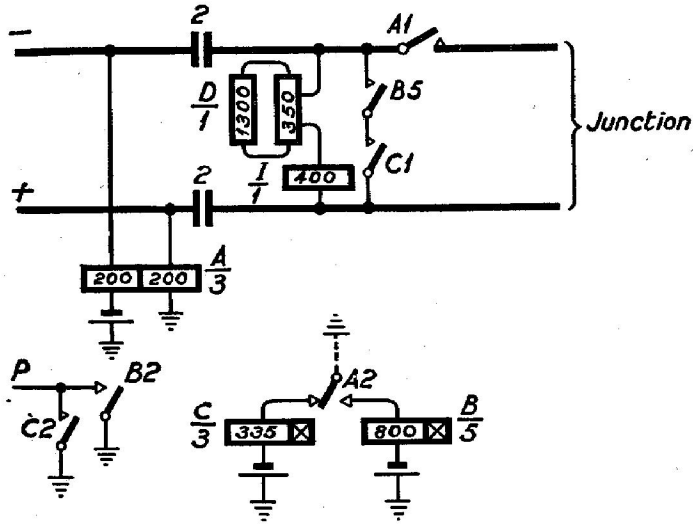


FIG. 191. IMPULSING CONDITIONS

intrusion (i). Relay I operates from the current flowing in the loop from the incoming first selector at the main exchange, and **I1** operates relay MD; **MD1** prepares a circuit for the retention of relay I under manual hold conditions or for the operation of relay RG under re-ring conditions; **MD2** prepares a retaining circuit for relay MD and **MD3** disconnects the earth from $B4$. Relay B operates and **B1** polarizes relay D through the 1,300-ohm coil; **B2** connects a guarding earth to the P-wire (i); **B3** disconnects the original circuit for relay MD and closes an alternative circuit for relay B; **B4** prepares the M-wire for metering later; **B5** prepares the impulsing loop.

Impulsing. When the called subscriber dials, relay A releases at the first break and $A2$ operates relay C; **C1** short-circuits the 350-ohm coil of relay D and the 400-ohm coil of relay I, so providing a zero impulsing loop in the relay-set (Fig. 191); **C2** places a guarding earth to the P-wire; **C3** maintains relay MD from the earth at **B1.** Relay A impulses in response to

the impulse train and contact $A1$ repeats the impulses to the A relay of the incoming first selector at the main exchange (iii).

On the completion of impulsing, the distant final selector returns ringing tone if the called subscriber is being rung or returns busy tone should the subscriber be engaged. The tones are passed over the junction to the calling subscriber at the satellite exchange. Since the satellite exchange serves subscribers only, it is not necessary to provide for passing back the busy flash condition.

Metering. When the called subscriber answers, the reversal on the positive and negative lines at the final selector is extended over the junction to operate relay D; **D1** disconnects relay MD which releases slowly and at $MD3$ connects earth to the M-wire, so operating the calling subscriber's meter (iv). The provision of a meter guard (MD) relay ensures that any momentary operation of relay D due to line or condenser surges shall not affect the subscriber's meter.

Release and Junction Guard. When the calling subscriber replaces the receiver, relay A releases and $A1$ disconnects the junction loop which is holding the incoming first selector and the chain of connexions at the main exchange; $A2$ disconnects relay B, which releases and removes the guarding earth from the P-wire at $B2$; this contact, on releasing, also operates relay C during the release of relay B and **C2** guards the P-wire after $B2$ has released to ensure that the selectors in the main exchange have had ample time for release before the junction is opened for a subsequent call. The relay-set is now normal and the circuit may be seized for another call.

Manual Hold. In the event of a call to the auto-manual switchboard, it is necessary to change the control of the connexion over from the calling subscriber to the operator. This control is effected by relay I, which is operated by the current received from the operator's cord circuit. Relay MD is retained and, should the subscriber replace the receiver in these conditions, relay A releases, disconnecting relay B which connects earth through $B1$ and **MD1** to relay I; $B3$ closes a retaining circuit through **I1** for relay MD; **MD3** closes the circuit of relay C which maintains the guarding earth at **C2** (v), and polarizes relay D at **C3** through **MD2, I1,** and $B3$ to earth. The connexion is therefore held by the operator and the calling subscriber's line is not released

Re-ring. In the trunk demand system, the calling subscriber requests the operator for the required number. The

operator endeavours to connect him immediately, and should she not have succeeded at the end of two minutes, the calling subscriber is requested to replace his receiver. The operator, however, holds the connexion and endeavours to complete the call; this condition persists for a further eight minutes, after which the calling subscriber's line is released. Should the operator, however, complete the call during this eight-minute period, she re-rings the calling subscriber over the original circuit, and it is this facility which is provided by relay *RG*. This relay is shunted by a metal rectifier, which acts as a low resistance shunt across the relay to the normal potential. When, however, the operator re-rings a calling subscriber, a positive battery is connected to the *A*-wire of the junction and flows through relays *I* and *RG* in series to earth at *B*1. The metal rectifier in these conditions offers a high resistance, and relay *RG*, accordingly, operates; **RG1** and **RG2** connect the calling subscriber's line to the ringing and ringing return circuits (vi), whilst **RG3** closes the motor start circuit where this facility is required (vii). Since relay *B* is released in these conditions, *B*5 prevents the operation of relay *D*, which would otherwise be shunted across relay *I*. As relay *I* is non-polarized, it is operated by the positive battery applied for the re-ring condition, and maintains manual hold conditions.

Relay-set Main to Satellite. It will be seen from the trunking diagram in Fig. 189 that a relay-set is inserted between the selectors at the main exchange and the junctions outgoing to the satellite exchanges. Since operators at the auto-manual switchboard have access to these selectors for obtaining subscribers connected to the satellite exchanges, it is necessary to arrange for the relay-set to repeat busy flash conditions, but the re-ring facility is not required. A diagram of the connexions of this relay-set is given in Fig. 192; the circuit performs the following functions—

(i) Maintains an earth on the *P*-wire in the main exchange.

(ii) Provides a transmission feed to the calling subscriber's instrument.

(iii) Transmits impulses over the junction to the satellite exchange.

(iv) Repeats busy flash and returns busy tone to the calling subscriber should the called subscriber be engaged.

(v) Reverses the negative and positive lines for supervisory purposes and applies booster battery metering conditions when the called subscriber answers.

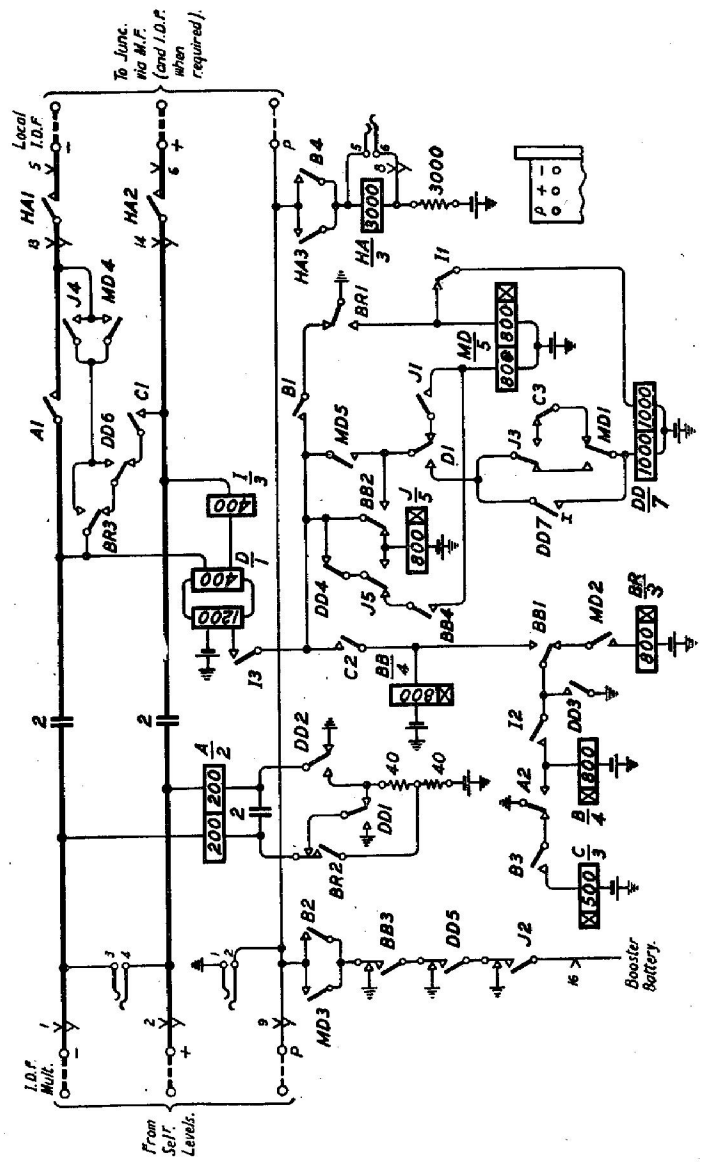


FIG. 192. RELAY-SET, MAIN TO SATELLITE

When the relay-set is seized, relay *A* operates and **A1** connects relays *D* and *I* to contacts *HA*1 and *HA*2; **A2** operates relay *B*; **B1** operates relay *J*; **B2** connects earth to the *P*-wire (i); **B3** prepares a circuit for relay *C*; **B4** closes the circuit of relay *HA*. Relay *HA* operates and extends the loop through relays *D* and *I* to the junction at **HA1** and **HA2,** so seizing the distant selector; **HA3** locks the relay to earth on the *P*-wire. Relay *J* operates to prepare the booster battery at **J2**; **J1** prepares a circuit for relay *MD*; **J3** prepares a circuit for relay *DD*; **J4** prepares for the retention of the holding loop under busy flash conditions; **J5** locks relay *J* through *DD*4. Relay *I* operates from the current flowing in the junction loop from the distant selector; **I1** disconnects one coil of relay *DD*; **I2** prepares a circuit for the retention of relay *B*; **I3** polarizes relay *D*.

Impulsing. When the train of dialled impulses is received, relay *A* impulses; with the first release of this relay, *A*2 closes the circuit of relay *C*; **C1** short-circuits the line coil of relay *D* and relay *I*, so providing a zero impulsing loop in the relay-set; **C2** operates relay *BB*; **C3** disconnects relay *DD*. Relay *BB* operates and **BB1** prepares a locking circuit for the relay through **I2**; **BB2** and **BB4** operate relay *MD*; **BB3** further prepares the booster metering circuit. Relay *MD* operates and **MD1** prepares a circuit for the operation of relay *DD*; **MD2** prepares a circuit for relay *BR*; **MD3** connects an alternative earth to the *P*-wire; **MD4** closes an alternative circuit to that through **J4**; **MD5** prepares a holding circuit for the relay through *D*1 and **J1.** Contact *A*1 impulses and repeats the impulse trains to the selectors in the satellite exchange (iii). On the completion of impulsing, relay *C* releases and *C*1 removes the short-circuit from the line coil of relay *D* and relay *I*.

Metering. When the called subscriber answers, the battery reversal on the negative and positive lines operates relay *D* and **D1** disconnects relay *MD* which releases slowly and guards against possible false metering should relay *D* operate to current surges in the line. On release of *MD*1, relay *DD* operates from earth, *BR*1, **B1, BB2, D1, J3,** *C*3, *MD*1, 1,000 Ω coil to battery, and locks at **DD7** "**x.**" **DD1** and **DD2** reverse the battery and earth supplied through relay *A* to the incoming lines, so giving supervision to a manual cord circuit should the call have been set up by an operator; **DD3** closes a retaining circuit for relay *B*; **DD4** disconnects relay *J*; **DD5** applies

booster battery to the *P*-wire to operate the calling subscriber's meter (v); **DD6** is associated with the busy flash condition. On the release of relay *J*, the booster battery is disconnected from the *P*-wire at *J*2 and the guarding earth restored; the metering pulse is thus applied during the releasing lag of relay *J*.

Busy Condition. If the called subscriber is engaged, busy tone and busy flash are received from the distant final selector;

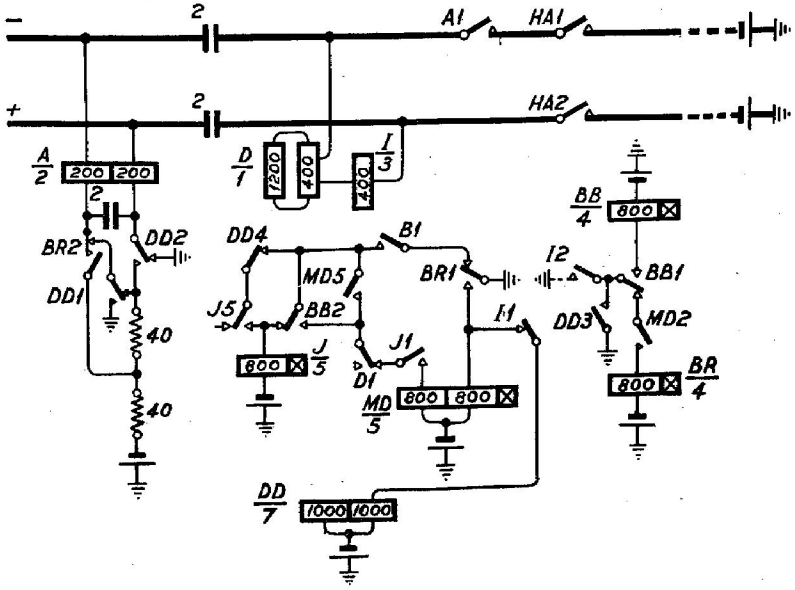


FIG. 193. BUSY FLASH CONDITION

if the call originates from a subscriber, the busy tone is passed through the relay-set transmission bridge. Should the call have originated at the auto-manual switchboard, however, it is necessary to repeat the busy flash condition to provide for the flashing of the supervisory lamp associated with the cord circuit, and Fig. 193 shows the portion of the circuit concerned. Under busy flash conditions, battery is connected to both negative and positive lines for 0·75 second in each 1·5 seconds, with the result that relay *I* releases and re-operates at busy speed. *I*1 prepares a circuit for flashing relay *DD*; *I*2 disconnects relay *BB* to prevent metering; *I*3 disconnects the polarizing coil of relay *D*. *BB*1 prepares the circuit of relay *BR* through **MD2,** and this circuit is closed by **I2** when relay *I* re-operates; **BR2** connects battery through one coil of relay *A* to the

negative wire; **BR1** releases relay J, retains relay MD, and operates relay DD through $I1$, and **DD2** connects battery through the other coil of relay A to the positive wire; **DD3** retains relay BR each time relay I releases; **BR3** retains relays D and I during the release of relay A under busy flash conditions, the normal connexion being broken at $A1$ in these conditions. On the completion of the busy flash cycle, relay I re-operates when normal conditions are connected to the negative and positive wires, and **I2** provides for the retention of relay BR; **I1** disconnects relay DD which removes the battery connected to the positive wire and replaces earth at $DD2$ (iv). In this manner the busy flash cycle is repeated to the cord circuit at the auto-manual switchboard.

Release. When the calling subscriber replaces the receiver, relay A is released and $A1$ disconnects the loop which is holding the selectors in the distant satellite exchange; $A2$ disconnects relay B. During the releasing lag of relay B, however, relay C is operated from $A2$ and **B3**; **C2** operates relay BB through $BR1$ and **B1**. **BB4** operates relay MD through $J5$, $DD4$, **B1**, and $BR1$. **MD3** connects guarding earth to the incoming P-wire. When relay B falls away, all relays are released. It will be seen, however, that the relay-set is held engaged during the sum of the slow-release periods of relays B and MD, during which the selectors at the distant exchange are restoring to normal.

The Discriminating Satellite Exchange. It will be seen from the trunking diagram in Fig. 189 that a call originated by a subscriber connected to the satellite exchange to another subscriber connected to the same exchange requires two junctions and first and second selectors in the main exchange for its completion. Where the amount of local traffic of this type is small, this is not of much consequence, but in larger exchanges, where the community of interest between subscribers connected to the same satellite exchange is likely to be considerably higher, it assumes material proportions and a special type of selector is used, with a view to obtaining local routing of calls between subscribers on the same satellite exchange.

In the design of a multi-exchange area, it may happen that two adjacent satellite exchanges have sufficient traffic between them to warrant the provision of a direct junction cable, so obtaining direct routing instead of routing all calls between these two exchanges through the main exchange. By this means the number of junctions required between the two satellite

exchanges and the main is reduced and there is also a saving in the switching plant necessary in the main exchange.

Subscribers requiring trunk calls are instructed to dial either "0" or "94." Under the trunk demand system, calls are connected immediately and, consequently, the junction originally taken up between the satellite exchange and the main exchange is in use throughout the progress of the trunk call. Where a satellite exchange is situated some distance from the main exchange, it is necessary to provide a junction giving a high grade of transmission in order that the transmission losses permitted on a trunk connexion shall not be exceeded. For local calls, however, junctions providing a considerably lower grade of transmission are suitable; in the satellite exchange

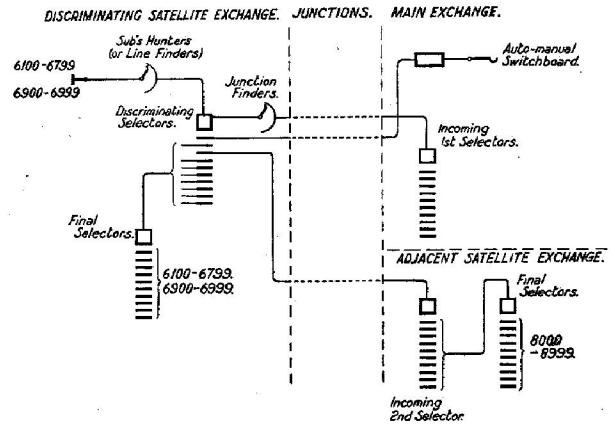


FIG. 194. DISCRIMINATING SATELLITE EXCHANGE

illustrated in Fig. 189, the junctions must be of the requisite standard for trunk transmission, and they may also be used for calls within the multi-exchange area.

The discriminating selector provides the means of segregating the 0 or 94 level traffic and routing it over a separate group of junctions to the auto-manual switchboard. For calls within the multi-exchange area, junctions having a lower grade of transmission are used. The discriminating selector also provides the means of routing a call direct to an adjacent satellite exchange or to the local final selector instead of through the main exchange.

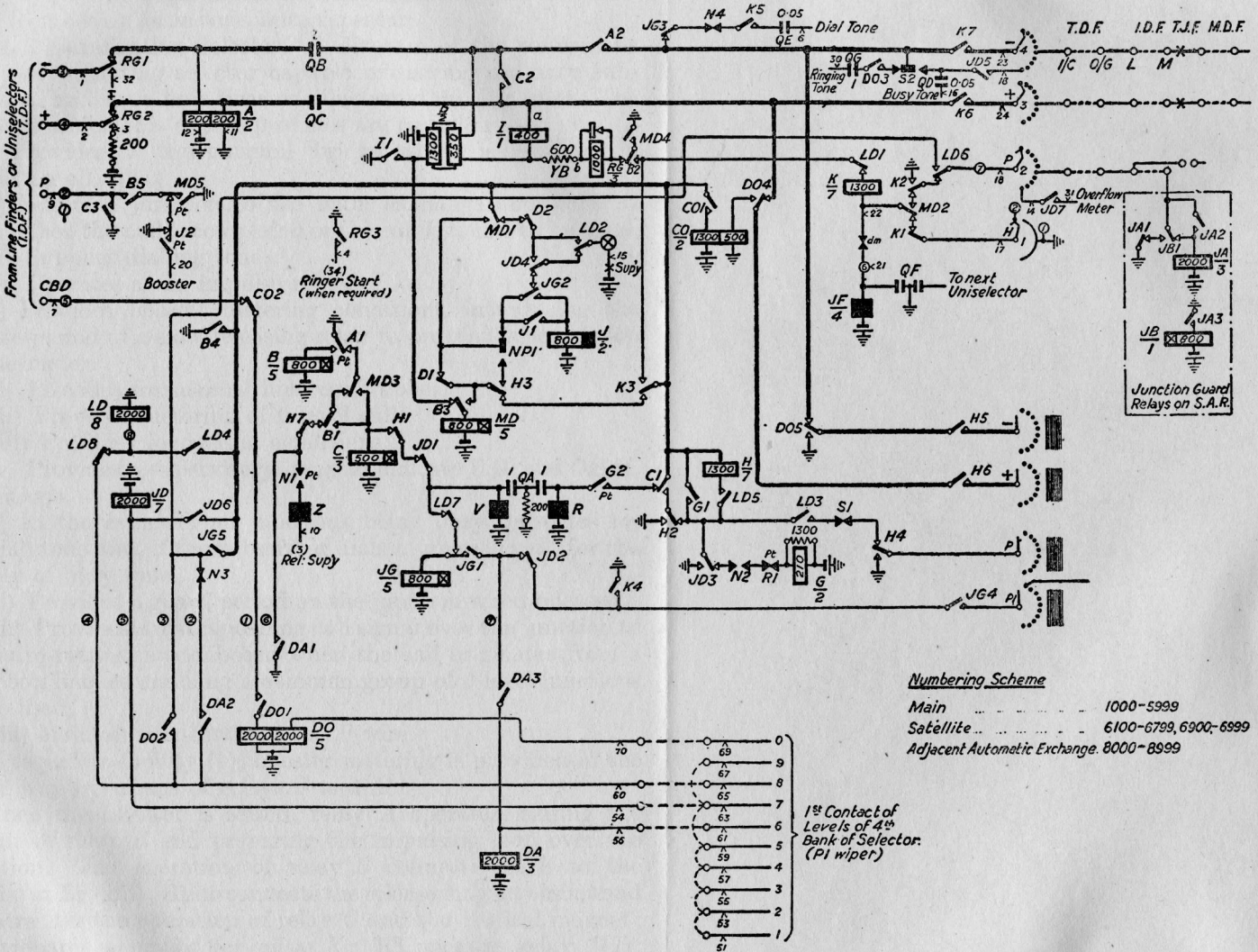
The skeleton trunking diagram given in Fig. 194 illustrates the features of a discriminating satellite exchange which have just been described. When a subscriber originates a call, the hunter

or line finder extends the calling line to a discriminating selector, with which is associated a uniselector, termed a junction finder; the junction finder immediately hunts and seizes the first free junction to the main exchange, where the junction is terminated on an incoming first selector. The discriminating selector is an ordinary two-motion selector mechanism provided with additional relays to enable it to function as an impulse repeater as well as a selector; the junction finder is permanently cabled to it. Thus, the removal of the receiver results in the seizure of a discriminating selector, a junction, and an incoming first selector; dialling tone is supplied to the calling subscriber from the discriminating selector, the reason for this being that in the event of all junctions to the main exchange being engaged, a local call, or a call to the adjacent satellite exchange, shall not be delayed by the absence of dialling tone.

Assuming a call local to the discriminating satellite exchange, the calling subscriber dials 6; the discriminating selector and the incoming first selector step up in unison; when the discriminating selector cuts in on level 6, however, the release magnet is operated and the selector restores, the digit 6 thus being absorbed. The junction finder is restored to normal, the junction and incoming first selector being thereby released. The discriminating selector thereafter functions as a second selector and the call is extended over one of levels 1–7 and 9 to the appropriate final selector in the satellite exchange. The call is thus routed locally and, due to the digit absorbing feature, only two ranks of selectors are required.

For a call to an adjacent satellite exchange, the receipt of the digit 8 by the discriminating selector causes the selector to enter the level and search for the first free junction to the adjacent satellite exchange. The junction finder is released, so releasing the junction to the main exchange and the incoming first selector. Thereafter, the discriminating selector acts as a repeater, and repeats the dialled impulses forward over the junction to step the incoming second selector and the final selector in the adjacent satellite exchange.

For an 0 level call, the receipt of the digit 0 gives rise to similar conditions, except that junctions of a higher grade of transmission are used and the discriminating selector, in its function as a repeater, is required to provide for manual hold and re-ring conditions. For a call to a local subscriber connected to the main exchange, the receipt of digits 1–5 causes both the incoming selector and the discriminating selector to step to the



Numbering Scheme

Main	1000–5999
Satellite	6100–6799, 6900–6999
Adjacent Automatic Exchange	8000–8999

(T.5070) FIG. 195. DISCRIMINATING SELECTOR REPEATER (D.S.R.)

level dialled. The discriminating conditions set up on the vertical marking bank cause the discriminating selector thereafter to function as an auto-auto repeater.

The Discriminating Selector. A diagram of the connexions of a discriminating selector capable of serving ordinary subscribers' and coin box lines is illustrated in Fig. 195. The facilities which this circuit provides are as follow—

(i) Provides a transmission bridge which is retained in circuit on all calls.

(ii) Selects a junction to the main exchange and holds it until either the call is completed or the call is found to be local.

(iii) Supplies dialling tone.

(iv) Operates as an impulse repeater.

(v) Provides booster metering conditions, introducing the release period of a slow-releasing relay to prevent misoperation of the meter.

(vi) Provides for manual hold conditions.

(vii) Prevents metering of 0 level calls.

(viii) Provides for re-ring conditions.

(ix) Provides a supervisory lamp to indicate P.G. and C.S.H. conditions.

(x) In the event of all junctions being busy, provides for dialling tone and, if the subscriber dials a junction call, for the supply of busy tone.

(xi) Provides a guard period on the junction when released.

(xii) Provides a distinguishing call signal over the junction to the auto-manual switchboard when the call originates from a coin box line, so enabling a common group of 0-level junctions to be used.

(xiii) Maintains an earth on the *P*-wire.

In regard to facility (v), booster metering is provided in the usual way by means of relays *J* and *MD*.

When the selector is seized, relay *A* operates, closing the circuit of relay *B* and preparing the impulsing loop over the junction. The operation of relay *B* connects earth to the *P*-wire at **B5** (xiii); **B1** disconnects the release magnet circuit and prepares for the operation of relay *C* and the vertical magnet; **B2** prepares a circuit for relay *K*; **B3** operates relay *MD*; **B4** connects an earth common to various relays and contacts. Relay *MD* operates; **MD1** closes the circuit of the supervisory lamp through *NP*1, *JG*2, *JD*4, and *LD*2; **MD2** extends the *P* wiper of the junction finder to relay *K* and the junction finder driving magnet, so setting up hunting start conditions;

MD3 prepares a circuit for the operation of relay *C* and the vertical magnet; **MD4** prepares a circuit for relay *K*; **MD5** connects earth through **B5** to the *P*-wire of the line finder or subscriber's hunter.

The junction finder now searches in the normal way for the first free junction to the main exchange. When one is found, relay *K* operates to connect dialling tone at **K5** (iii), (x), disconnect the homing circuit at **K1,** busy the *P*-wire of the seized junction at **K2,** lock the *K* relay and disconnect the operating circuit of relay *MD* at **K3,** provide a locking circuit for relay *JG* at **K4,** and switch the positive and negative lines through at **K6** and **K7** (ii). The circuit is now prepared for the reception of dialled impulses which will operate the vertical magnet of the discriminating selector through the impulsing of *A*1, and which will be repeated through the impulsing of *A*2 over the 2-wire junction to the main exchange (iv).

With the first release of relay *A*, relays *C* and *JG* operate. Relay *C* is the usual dialling relay and **C1** prepares for the operation of relay *G*; **C2** short-circuits the line coil of relay *D* and relay *I*, so providing a zero impulsing loop; **C3** connects earth to the incoming *P*-wire to provide an additional guard period in the event of a subscriber replacing his receiver without making a call, a condition usually known as a " clear down." Relay *JG* is the junction guard relay; **JG1** makes the relay dependent upon the release of either relay *K* or relay *JD*; **JG2** disconnects the supervisory lamp and operates relay *J*; **JG3** disconnects dialling tone under " all junctions busy " conditions; **JG4** extends the earth from **K4** to the discriminating wiper and relays; **JG5** extends earth to the *P*-wire of the junction and provides for the guard period in the event of local switching. The operation of relay *J*, the booster metering relay, locks the relay at **J1** through *NP*1 and **MD1,** whilst **J2** prepares for booster metering conditions. Metering is actually effected at a later stage by the operation of relay *D*, which releases relays *MD* and *J*. With the first vertical step, relay *G*, the rotary stepping relay, is operated and **G1** locks the relay to earth at **B4**; **G2** prepares a circuit for the rotary magnet on the release of relay *C* with the completion of the vertical impulse train. This portion of the circuit follows the usual design, relay *G* interacting with the rotary magnet during rotary hunting.

Local Discrimination. The connexion of the discriminating relays in Fig. 195 coincides with the numbering scheme given in the trunking diagram of Fig. 194. In the event of a call local to the satellite exchange, the discriminating selector steps to level 6; the impulses are repeated by contact *A*2 to the incoming first selector at the main exchange, and this selector is also raised to the same level. On the release of relay *C*, however, the rotary magnet circuit is closed and the wipers enter level 6. The earth connected to *P*1 wiper is extended to relay *DA*, which operates and locks through **DA3** and *JD*2 to the earth at **K4**; **DA1** connects earth through **N1** to the release magnet, with the result that the discriminating selector is restored to normal. When the off-normal springs change over, the earth from **B4** is extended through **JG5,** *N*3, **DA2,** *LD*8 to relay *LD*, which operates and locks through **LD4** to earth at **B4**; **LD1** disconnects relay *K*, so releasing the junction and the incoming first selector at the main exchange; **LD2** changes the supervisory lamp circuit from P.G. to C.S.H. conditions (ix); **LD3** and **LD5** prepare for the operation of relay *H*; **LD6** connects **B4** through **JG5** to the *P*-wire of the junction, whilst **LD7** disconnects the original operating circuit of relay *JG*; **LD8** disconnects the original operating circuit of relay *LD*, this contact being arranged to break after *LD*4 has made. Relay *JG* is disconnected at *K*4 and, during its slow-release period, **JG5** maintains a guarding earth on the *P*-wire of the junction.

The discriminating selector now functions as an ordinary second selector with impulse repetition, dialling tone being disconnected at *K*5. The receipt of the second train of impulses steps the wipers to the level dialled, and relay *G*, in conjunction with the rotary magnet, tests for a free outlet. When this is found, relay *H* operates to switch the calling subscriber to the final selector which has been seized. The circuit operations for these conditions follow the usual principles and do not call for special comment.

Direct Routing to Adjacent Automatic Exchange. For a call routed direct to an adjacent automatic exchange, the first digit dialled will be 8. When the selector is stepped to this level, the earth from **K4** is extended through **JG4** and the *P*1 wiper direct to relay *LD*, which operates to convert the circuit to an ordinary first selector with impulse repetition. It is not necessary now to release the selector, since the call is to be routed over the eighth level, and it is for this reason that the figure 8 cannot be used as a second digit in the satellite exchange numbering scheme; the one hundred numbers, 6,800 to 6,899, are therefore lost, due to the provision of the direct routing facility.

0-level Calls. For a call to level 0, the discriminating selector is again brought into use for routing purposes. The selector rises to the tenth level and, on entering this level, the earth on the *P*1 wiper is connected to relay *DO*, which operates. In the event of a call from an ordinary subscriber, **D01** performs no function, since the "coin box discrimination" (C.B.D.) wire is left unconnected; **D02** extends the earth from **B4** through **JG5** to relay *LD*, which operates to set up the necessary switching conditions to enable the discriminating selector to act as a first selector when searching over level 0. When relay *K* releases, the removal of earth at *K*4 releases relay *DO*. The circuit

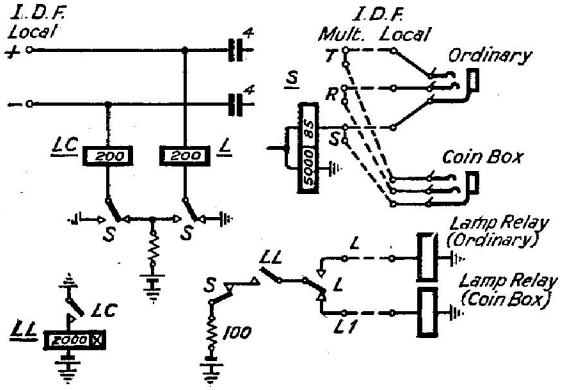


FIG. 196. ELEMENTS OF COIN BOX DISCRIMINATION CALLING CIRCUIT

is now through and ringing tone is provided from the answering equipment at the auto-manual switchboard. The negative and positive wires of the junction are looped through the line coil of relay *D* and relay *I*; this loop causes the calling lamp on the auto-manual switchboard to glow continuously, so indicating to the operator that the call originates from an ordinary subscriber; the portion of the switchboard calling circuit concerned is shown in Fig. 196.

For a call originating from a coin box line, the C.B.D. wire is connected to earth either in the line finder or by being connected to the *P*-wire of the subscriber's hunter. Relay *DO* is therefore locked to this earth through **D01**; **D04** and **D05** disconnect the negative and positive lines from relays *D* and *I*, earthing the negative line and connecting earth through the 500-ohm coil of relay *CO* to the positive line; **D03** returns ringing tone to the calling subscriber, since the junction wires

from the auto-manual switchboard are not now connected to the transmission bridge. This condition on the junction wires causes the coin box calling lamp at the auto-manual switchboard to glow (xii), so indicating to the operator that the call originates from a coin box line. When the operator answers, a battery is connected to the positive line to operate relay *CO*, which locks through **CO1** and disconnects relay *DO* at **CO2.** The release of relay *DO* extends the junction to the transmission bridge and thence to the coin box subscriber's line. (See also page 361.)

Manual hold conditions are provided by relay *I*. Should the calling subscriber replace the receiver after the operator has answered, the release of relays *A* and *B* connects relay *I* to the positive line, and the battery connected to this line operates the relay; **I1** polarizes relay *D* and retains relay *MD* through *B*3; **MD3** closes the circuit of relay *C*, which connects a holding earth to the incoming *P*-wire at **C3** (vi).

Re-ring. The re-ring facility is provided by relay *RG* in the manner already discussed on page 285; the metal rectifier shunting relay *RG* offers very low resistance to a negative battery, whereas it offers extremely high resistance to a positive battery. The application of a positive battery to the positive wire of the junction accordingly operates relay *RG*; **RG1** and **RG2** connect the subscriber's line to the ringing circuit, whilst **RG3** provides for ringer start facilities should these be required (viii).

Routing *via* Main Exchange. In the event of a call *via* the main exchange, the first digit dialled will be within the range 1-5. When the selector enters the corresponding level, the earth on the *P*1 wiper is extended to relay *JD*, which operates and locks through **JD6.** **JD1** disconnects the vertical magnet; **JD2** disconnects relay *JG*; **JD3** disconnects relay *G*; **JD4** changes the supervisory lamp over from P.G. to C.S.H. conditions (ix); **JD5** prepares a circuit for busy tone in the event of all the junctions being engaged; **JD7** prepares a circuit for the overflow meter. The release of relay *JG* is of no material consequence at this stage, its functions being primarily concerned with the provision of a guard period on the junction prior to the release of the junction after local switching. Should all the junctions be engaged, the junction finder steps round to the last contact in the bank; relay *K* operates and **K2** operates the overflow meter through **JD7**; **JD5** extends busy tone to the calling subscriber.

Thereafter, the selector functions as an impulse repeater in a similar manner to the repeater already described on page 294.

Metering is effected by the release of relay J, consequent upon the release of relay MD. Since metering is not required on 0 level calls, the selector is fitted with normal post springs, which are arranged to operate on the tenth level to disconnect relay J; as relay MD is operated in these conditions, the subscriber's meter remains unoperated (vii).

Busy Conditions. Should the discriminating selector encounter busy conditions on any level over which it is hunting, the operation of the cam springs connects busy tone to the calling subscriber's line at **S2**; **S1** disconnects relay H.

Junction Guard Relays. To provide for an effective junction guard period during the release of the junction in any circumstances, relays JA and JB are provided and fitted on the special apparatus rack (S.A.R.). The seizure of a junction operates relay JA, which locks through **JA2**; **JA3** operates relay JB. When the holding earth is removed from the P-wire on the release of relay JG in the discriminating selector, relay JA releases and connects earth through $JA1$ and **JB1** to the P-wire, whilst $JA3$ disconnects relay JB. After the slow-release period of this relay, the holding earth is removed and the junction may be taken for another call. This guarding period is provided to ensure ample time for the release of the connexion set up in the main exchange and prevents the seizure of the junction whilst the incoming first selector is in a partially released state (xi).

Use of Discriminating Selectors. By means of the discriminating selector just described, it is possible to provide for a great variety of numbering schemes incorporating the facilities just discussed. The application to any particular case will naturally depend upon circumstances, and the connexion of the discriminating relays will vary accordingly. It is not possible to treat the various classes of case which might arise, but, whatever they are, the principles just described are employed in meeting them.

The Lettered Dial. In the conversion of a multi-exchange area from manual to automatic switching, one of the major problems is the provision of intercommunication between any one exchange and every other exchange in the area. It has been shown that, in a 5-digit area, the first digit dialled may be regarded as the code digit for the particular 10,000-line exchange required, since the result of dialling the first digit is

to route the calling subscriber to the particular exchange to which the called subscriber is connected. That is, the first selectors in such an area may be legitimately regarded as exchange-choosing selectors. In fact, in one particular case in Great Britain the numbering scheme adopted provides for dialling the name of the exchange as a whole, followed by the four digits of the called subscriber's number. In effect, this is a 5-digit switching system, but the names of the exchanges in the area are engraved on the dial number ring.

The maximum capacity, without having regard to restrictions due to the use of direct routing and other causes, of a 5-digit numbering system is 70,000 lines, but in several multi-exchange areas in this country this number is considerably exceeded, and it is necessary to adopt some other means of numbering to cater for the larger number of lines concerned. A 6-digit numbering scheme could be employed by allotting two code figures to each exchange and providing a 4-digit numbering scheme for each exchange. The limitation in the use of first selector levels restricts this scheme to a maximum of 70 exchanges. Furthermore, in an area of such a telephone density as to call for a scheme of this character, it will not be possible to equip all the automatic exchanges and transfer the whole area *en bloc* to the new system, and for some considerable time the old manual system and the new automatic system must exist side by side. The adoption of a 2-digit code, however, would result in the need for two separate types of telephone directory: one for the use of subscribers connected to a manual exchange and containing exchange names and 4-digit numbers, the other for the use of subscribers connected to an automatic exchange, and containing 2-digit exchange codes and 4-digit numbers. A further difficulty would also arise owing to the fact that the different exchange codes would be difficult to memorize, and the calling party would be required in effect to dial 6-digit numbers. It is with the object of overcoming these difficulties that the lettered dial illustrated in Fig. 27 has been introduced; the figures are enamelled in red and the letters in black. By the introduction of the lettered dial, it is possible to reconcile the exchange names with the two-letter codes allotted to exchanges, with the result that the directory difficulty disappears and calling subscribers have less difficulty in remembering the sequence of letters and figures to be dialled. The use of a two-letter instead of a 2-digit exchange code, however, results in a further restriction in the

total number of exchanges in one area to which the scheme can be applied, owing to the introduction of impossible combinations of letters, e.g. the 2-digit code 66 may be allotted to an exchange, but this code is unlikely to be available when 2-letter codes are introduced, since it is not likely that any exchange name will commence with the letters MM, MN, NM, or NN. The result of these restrictions is such as seriously to reduce the number of exchanges to which the scheme is applicable. Consequently a 3-letter exchange code is used in the large majority of cases, and the calling subscriber dials the first three letters of the exchange name, followed by the four digits of the called subscriber's number. In the Telephone Directory the first three letters of the exchange names are printed in heavy block type, as illustrated in Fig. 197.

Dorlon,Chocolates,259 West End la NW6 **HAM**pstd. 1263
Dorman A. M,Broomleigh Rydens av...Walton-on-T 223
Dorman Arthur G,27 Raymond av E.18. **WAN**stead 2327
Dorman F. J,Fishmonger,73 Brghtn rd.....Redhill. 628
Dorman L. C,Little Elms Fair Oak lane....Oxshott. 66
Dorman L. M,7 Deyncourt gdns.....Upminstr 311
DORMAN LONG & Co. Ltd,
Steel Mfrs, Constructional Engrs,
Terminal ho Grosvenor gardens S.W.1..★SLOane.. 2275
(Plant Depot),Riverside wks SE10..**GRE**enwch 0921
(Constructional Dept),
90 Nine Elms lane S.W.8.....★**MAC**aulay 3274
31 Fenchurch st E.C.3.....**MAN**sn Ho 9423
Dorman & Smith Ltd,Electrcl Engrs,
32 Queen Victoria st E.C.4.....**CITy**.... 4647
Dorman Wallis R,
38 Stoneyfields lane Edgware.....**MIL** Hill 2940
Dorman W. H. S,Nwsagt,
1 Albert rd Belvedere.....Erith... 521
Dorman-Smith Lieut.-Col. E. E,
65 Overstrand mansions S.W.11.....**MAC**aulay 1311
Dormand Francis W,461 Kingston rd.... Ewell... 1918

FIG. 197. TYPICAL DIRECTORY ENTRIES

All subscribers' numbers within the area are converted to four digits, either by the addition of cyphers or by a complete change of number. Cases arise where two manual exchanges may have the same 3-letter code, as Hammersmith and Hampstead; here it is necessary to change the name of one of the exchanges, the name Hammersmith having been changed to Riverside. Other cases arise where the result of dialling the first three letters of either of two different exchange names is the same so far as the automatic equipment is concerned, as, for example, Croydon and Bromley, Victoria and Thames; here, again, a change in one of the exchange names is necessary. One result of this is that the names of telephone exchanges are losing their geographical significance, as instanced by the names of three exchanges in the London area, viz. Gladstone, Byron, and Advance.

Necessity for Translation. If the trunking scheme developed up to this stage be used with 3-letter codes, then every exchange in the area must be able to reach every other exchange in the same area in precisely three switching stages, that is, in the trunking chart shown in Fig. 198, a Byron subscriber requiring another subscriber on the same exchange dials BYR and is routed to a fourth selector in his own exchange; for Bishopsgate he dials BIS, and is routed to a fourth selector over a junction to Bishopsgate exchange, and similarly in the case of

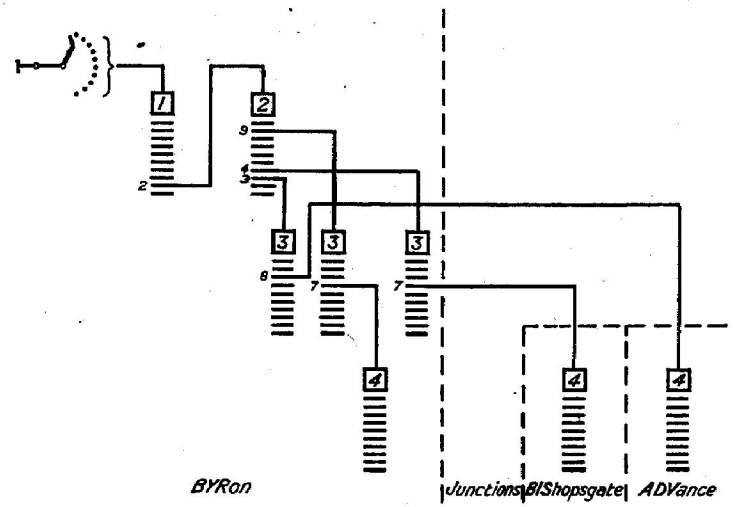


FIG. 198. TRUNKING SCHEME WITHOUT TRANSLATION

Advance. This necessitates a group of junctions outgoing from each exchange to every other exchange in the area, and it is obvious that the cost of the external line plant necessary for such a scheme would be prohibitive, not only by reason of the larger number of small cables, but also because of the fact that a circuit in a small group is by no means so efficient in traffic-carrying capacity as a junction in a larger group. It is therefore necessary to divorce the junction network from the switching scheme in order to provide for the use of junction-lending centres in a similar manner to the method of junction-lending used in manual switching. Such junction-lending or junction-switching exchanges are known as Tandem exchanges, and the elements of Tandem routing are shown in Fig. 2. To render the junction network independent of the numbering

scheme, it is necessary to arrange that the three code letters dialled by a subscriber shall be translated into the necessary sequence of impulse trains required to reach the objective exchange. Where heavy traffic exists between two exchanges, direct routing may be adopted, but where the traffic is light, it may be routed to a Tandem exchange, where, joining similar traffic from other exchanges, it is routed over outgoing junctions to the objective exchange. There are various types of apparatus in use for effecting this translation, but the one adopted by the British Post Office is known as the Director. The circuits used in connexion with the director are dealt with in the succeeding chapter.

Due to the introduction of an exchange code translation scheme, some additional nomenclature is necessary to simplify the identification of the selectors used in a chain of connexions. The three code letters dialled by a calling subscriber are known as the A, B, and C digits respectively, whatever their alphabetical order may be; thus, in the case of Harrow, H is the A digit, A the B digit, and R the C digit. The selectors which respond to the code letters dialled by a calling subscriber are known as the A-digit selector and the BC selector; the latter forms part of the director. The selectors which respond to trains of impulses forming a code as translated by the directors are known as first, second, etc., code selectors. The selectors in the Tandem exchange, which is merely concerned with junction switching and has no subscribers connected to it, are known as first, etc., Tandem selectors. The selectors which respond to the four digits of the called subscriber's number are known as first and second numerical selectors and final selectors. In certain circumstances, third numerical selectors may be used to give access to large P.B.X. groups. The final selectors are similar to those described in Chapter VI, and, with the exception of the A-digit selector, the BC selector in the director, and the first code selector, the rest of the selectors are similar to the group selector already dealt with on page 209.

CHAPTER VIII

THE DIRECTOR SYSTEM

The Principle of the Director System. In a large multi-exchange area in which the director is used, the calling subscriber dials the first three letters of the name of the exchange required, followed by the four numerical digits forming the called subscriber's number. The first portion, consisting of the *A*, *B*, and *C* digits, is known as the code portion, and is translated

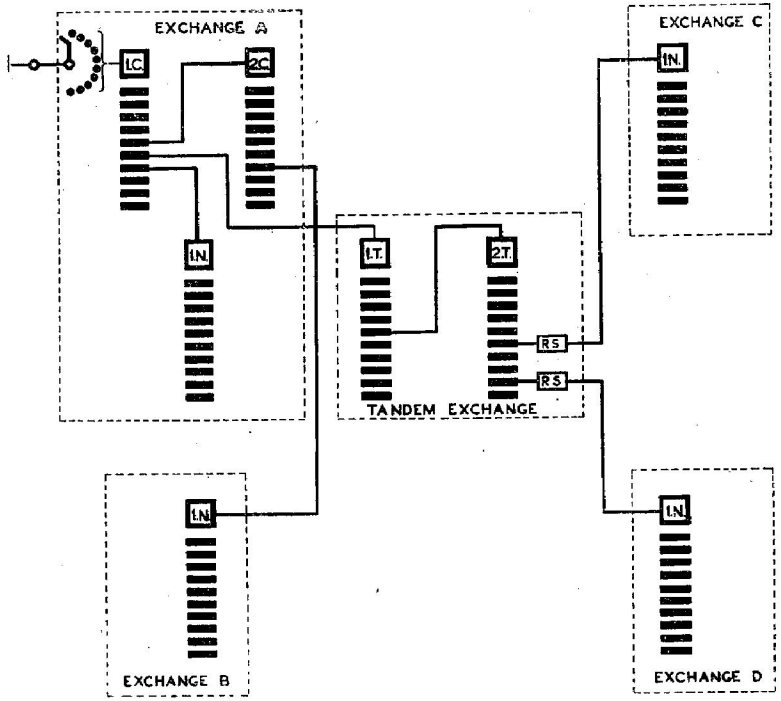


FIG. 199. TRUNKING SCHEME WITH TRANSLATION

by the director into the necessary trains of impulses, as required by the junction network and junction switching scheme to route the call to a first numerical selector in the objective exchange; the second portion, consisting of a 4-digit number, is known as the numerical portion, and this is stored by the