CP 602
PRICE 15c

THE AUSTRALIAN POST OFFICE

COURSE OF TECHNICAL INSTRUCTION

Engineering Training Section, Headquarters, Postmaster-General's Department, Melbourne C.2.

CROSSBAR CIRCUIT PRINCIPLES

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1. INTRODUCTION.

1.1 Many crossbar circuits, particularly those associated with marker control sets, appear complicated because of the large number of relays involved. Closer examination usually reveals a number of circuit "elements" which appear in several stages of the marker operation, and a recognition and understanding of these elements will assist in the understanding of the complete circuit.

1.2 This paper contains a description of the circuit principles of the various circuit elements which occur regularly in markers and associated equipment.

2. RELAY SELECTION CHAINS.

2.1 We saw in the paper "Introduction to Crossbar Switching - Part 1" that a relay selection chain is used where it is necessary to select one relay from a number of operated testing relays. The function of the relay chain is to provide a holding circuit when any one relay operates, but when more than one operates, to select a holding circuit for only one of the operated relays.

The types of relay chains generally encountered in crossbar circuits are:-

- Fixed forward priority.
- Fixed reverse priority.
- Variable priority.
- Partial or group priority.

2.2 Fixed Forward Priority. A testing relay is provided for each circuit or line to be tested and contacts of these relays are arranged as a continuous chain as shown in Fig. 1.

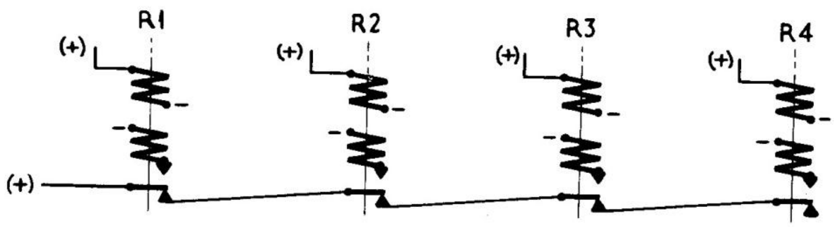


FIG. 1. BASIC CIRCUIT OF A RELAY CHAIN WITH FIXED FORWARD PRIORITY.

The operation of the chain is as follows:-

- The upper winding of each relay is momentarily connected to the devices which are to be tested.
- If only one relay operates, the contacts of that relay complete a holding circuit via the lower winding.
- When more than one relay operates, only the left hand operated relay receives a holding path.

2.3 Fixed Reverse Priority. When the chain is arranged in the opposite formation as shown in Fig. 2, the right hand operated relay receives holding priority.

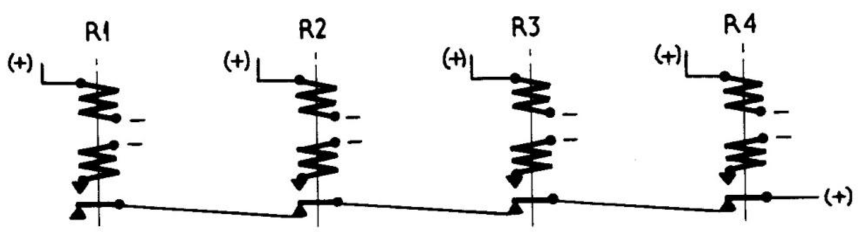


FIG. 2. RELAY CHAIN WITH FIXED REVERSE PRIORITY.

The relay chains shown in Figs. 1 and 2 have fixed call distribution. The positive potential in the holding circuit is connected via a controlling relay which finally releases the circuit.

2.4 Variable Priority. Paras. 2.2 and 2.3 show that when a relay selection chain is arranged for fixed call distribution, the first relay in the chain always receives priority of holding over all others. In Fig. 1, relay R1 is always given priority over relays R2, R3 and R4, and in Fig. 2, relay R4 receives priority over R3, R2 and R1.

In many crossbar circuits, the priority of holding of a relay in a selection chain is changed at each call. Fig. 3 shows a relay chain arranged to give priority of holding to a different relay at each call. Leads from the holding circuit are wired to a call distributor, which places a holding potential on a different lead for each connection. A description of call distributors is given in Section 3.

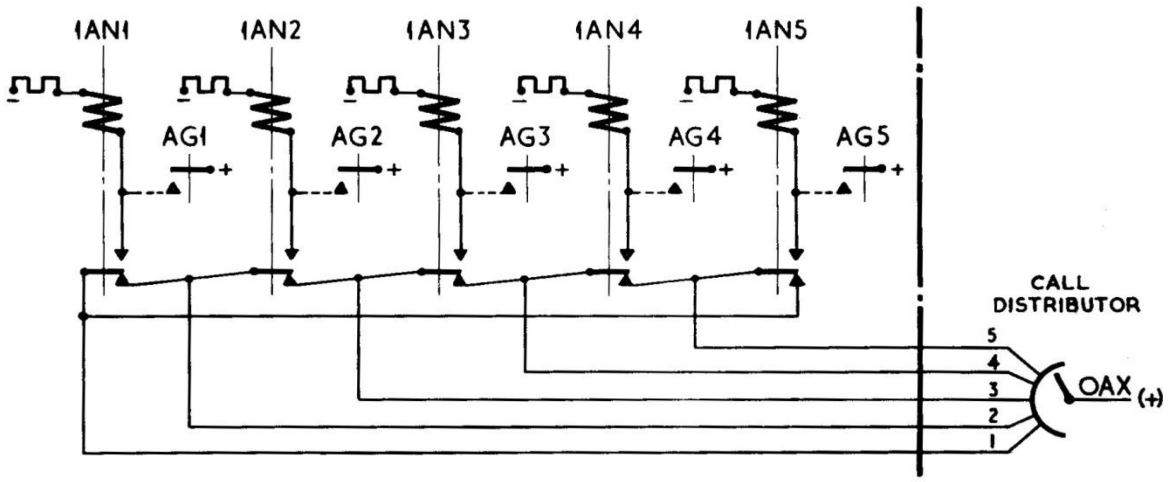


FIG. 3. RELAY SELECTION CHAIN WITH VARIABLE PRIORITY.

The five relays shown represent five testing relays which are connected to five testing leads (shown by the dotted connections). A relay operates for each completed test lead. The original testing circuit is then disconnected and one of the operated relays must hold to a potential supplied at the call distributor.

The contacts of these relays are again arranged in such a manner that if any one relay operates, its contacts complete a holding circuit via one of the leads to the call distributor.

When more than one relay operates simultaneously, the relay to receive priority is decided by the position of the holding potential on the leads from the call distributor. Assuming that the holding potential for this call is on lead 1, then the order of priority is 1AN1, 1AN2, 1AN3, 1AN4, 1AN5.

When the holding potential is on lead 3, the order of priority is 1AN3, 1AN4, 1AN5, 1AN1, 1AN2, and if relays 1AN1 and 1AN5 operate, 1AN5 receives priority over 1AN1. Other combinations of relays and holding leads can be traced in a similar manner. In every case, the chain is arranged so that only one relay receives a holding circuit.

Trace out the following conditions and determine the relay which remains operated:-

(i) + on lead 2 with 1AN1 and 1AN4 simultaneously operated.

(ii) + on lead 4 with 1AN2 and 1AN6 simultaneously operated.

(iii) + on lead 3 with 1AN1, 1AN4, and 1AN5 simultaneously operated.

2.5 Partial or Group Priority. We saw in para. 2.4 that each relay in a relay selection chain can be given first priority of holding by providing one lead from the call distributor for every relay in the chain. It is not always necessary for the number of leads from a call distributor to equal the number of relays in a chain. In one example of crossbar circuitry, the identification of a calling subscriber's line, twenty relays are included in one selection chain, but only four leads are provided from the call distributor as shown in Fig. 4. The four leads give priority to a group of relays.

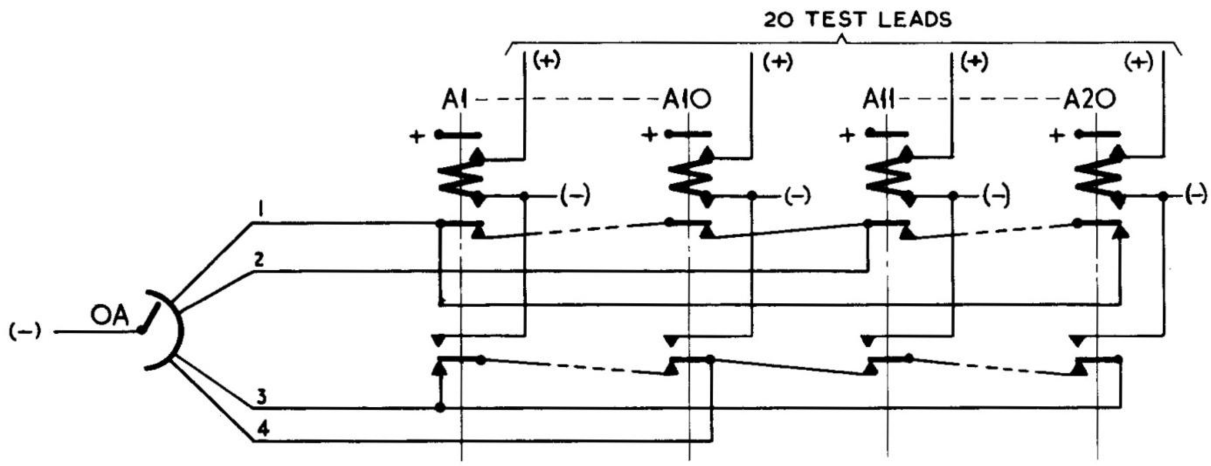


FIG. 4. RELAY SELECTION CHAIN WITH PARTIAL OR GROUP PRIORITY.

The twenty relays are arranged in two groups of ten (A1-10 and A11-20). When the holding potential from the call distributor is placed on lead 1, a forward priority is given, with relays AI-10 receiving priority over relays A11-20. Within the A1-10 group, A1 relay receives priority over relays A2-10, and within the A11-20 group, relay A11 has priority over relays A12-20.

When the holding potential is applied to lead 2, a forward priority is maintained but the group priority is changed. Relays A11-20 receive priority over relays A10-1.

When the holding potential is applied to lead 3, a reverse priority is applied via the lower set of chain contacts. Relays A20-11 receive priority over relays A10-1.

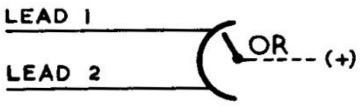
With the holding potential on lead 4, the group priority changes, with relays A10-1 receiving priority over relays A20-11. With this type of circuit, it is not possible to provide each relay with an absolute priority over all others.

When only one relay operates, it receives a holding circuit irrespective of the position of the call distributor. When two or more relays operate simultaneously, the position of the call distributor determines which relay receives priority of holding.

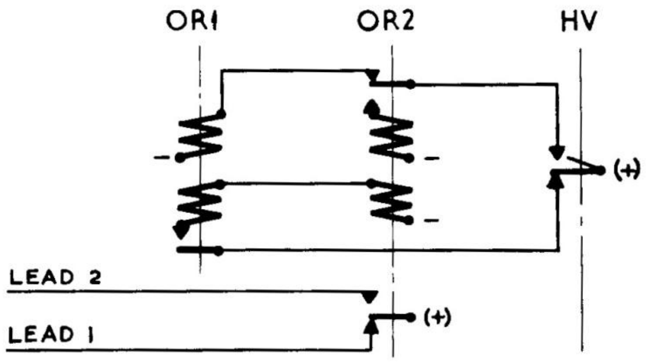
3. CALL DISTRIBUTORS.

3.1 The purpose of a call distributor (or allotter) is to distribute the occupation evenly over devices selected by the selection chains. This is achieved by allotting a varying priority to the relays in the associated selection chains. The circuit can be arranged to place a holding potential on the leads to the selection chains in either a strict cyclic order or a purely random manner.

Fig. 5b shows a simple call distributor circuit arranged to operate in cyclic order, and Fig. 5a shows the symbol for the call distributor.



(a)



(b

FIG. 5. CYCLIC CALL DISTRIBUTOR.

The call distributor consists of two parts:-

(i) The relay section which "steps" for each call via contacts of a controlling relay HV.

(ii) The associated relay contacts which place the holding potential on either lead 1 or lead 2.

The controlling relay operates and releases once during the progress of each call. This gives a pulse to the call distributor, causing it to "step" and vary the position of the holding potential in readiness for the next call.

The circuit shown in Fig. 5 operates as follows:-

1st Call. Positive potential on lead 1.

During the first call, the controlling relay HV operates.

HV relay contacts operate relay 0R1 on its upper winding.

At the end of the first call the controlling relay HV releases. Relay 0R1 holds and relay 0R2 operates via the operated 0R1 contact.

The holding potential is now changed to lead 2.

2nd Call. Positive potential on lead 2.

During the second call, the controlling relay HV again operates.

Relay OR1 releases and relay 0R2 holds on its upper winding.

At the end of the second call the controlling relay HV releases, opening the circuit to 0R2 relay.

0R2 relay releases, and its contacts change the holding potential to lead 1.

This cycle is then repeated.

3.2 Fig. 6 shows the circuit of a four relay cyclic call distributor, and Fig. 7 shows how contacts of this distributor place a potential on leads to associated relay chains. The number of relays used in the distributor determine the number of leads to each associated relay chain.

All cyclic call distributors, irrespective of the number of relays, are wired in a similar manner to that shown in Figs. 6 and 7.

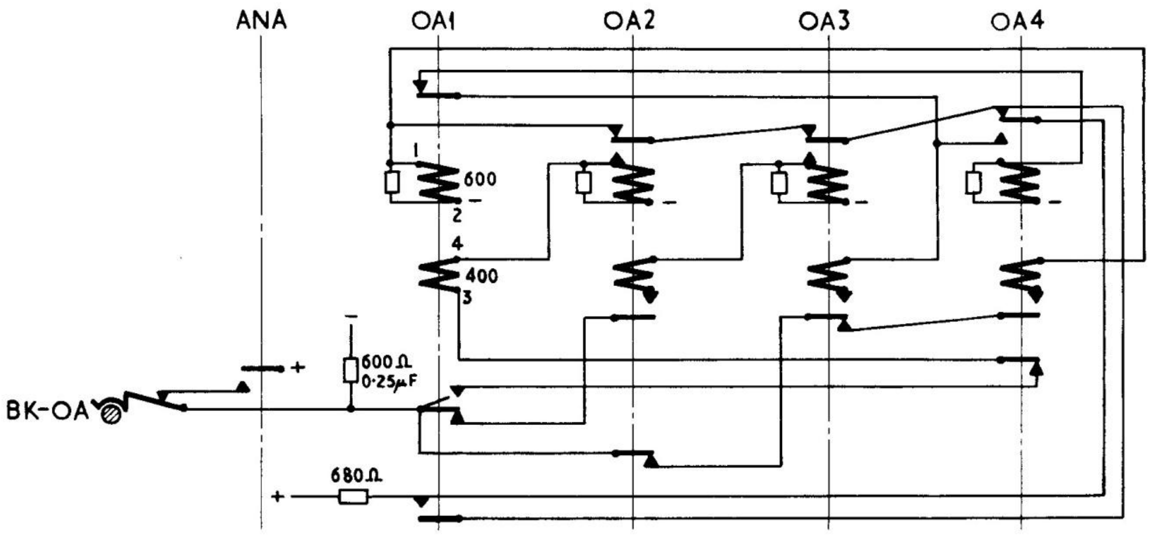


FIG. 6. FOUR RELAY CYCLIC CALL DISTRIBUTOR.

The call distributor shown in Fig. 6 is known as the "OA" call distributor and is associated with a number of relay chains in an SL marker. Each associated relay chain is connected via four leads to a separate set of contacts in the call distributor (Fig. 7).

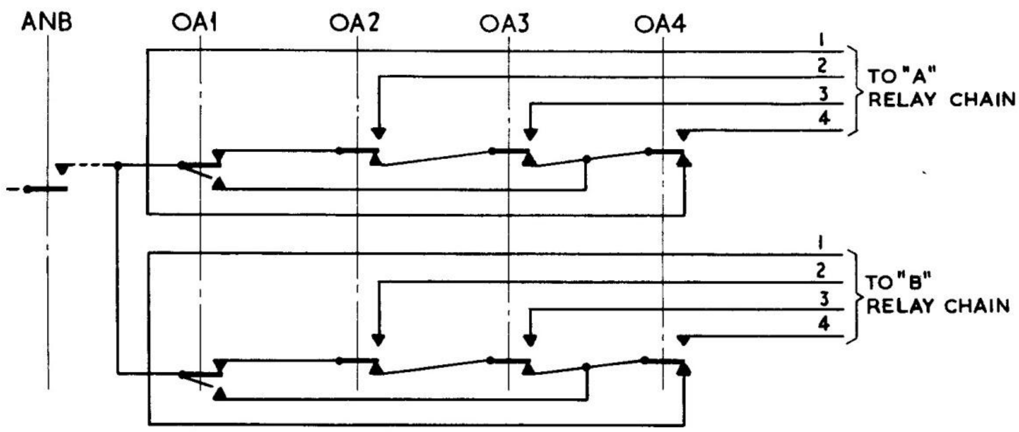


FIG. 7. "OA" CALL DISTRIBUTOR LEADS.

The control relays ANA and ANB operate at an early stage in the SLM operation and release at the completion of SLM switching.

3.3 Circuit Operation of OA Call Distributor. At all times one of the distributor relays is operated. When power is first connected to the relay set, the chain operation commences with the operation of OA1 relay from negative potential, upper winding of 0A1, contacts of OA2, OA3, 0A4,680Ω resistor, to positive.

When relay ANA operates at the start of a call, positive potential is extended via 0A1 and 0A4 contacts, to hold the 0A1 relay on its lower winding, and operate OA2 relay on its upper winding. Relay 0A2 completes a holding path for its upper winding, and opens the original operating path for relay 0A1.

The holding potential for this call is supplied via operated ANB and OA1 contacts to lead 1 of each associated relay chain (Fig. 7).

After the SLM switching for this call is completed, control relays ANA and ANB release. The holding circuit for 0A1 is opened and this relay releases. Relay 0A2 remains operated on its upper winding.

When the next call is originated, relays ANA and ANB are again operated. Positive potential is extended via 0A1 and OA2 contacts to hold OA2 relay operated on its lower winding and operate 0A3 on its upper winding.

The holding potential for this call is connected to the associated relay chains via contacts of 0A1 normal, 0A2 operated, to lead 2 in each chain.

After the SLM has completed its functions for the second call, ANA and ANB release. Relay OA2 releases and OA3 holds on its upper winding.

At the start of the third call, relay ANA connects positive to the lower coil of 0A3 in series with the upper coil of OA4. The holding potential is applied to lead 3 of each associated circuit. When the ANA contacts restore, relay 0A3 releases and OA4 holds on its upper winding.

The fourth call causes positive to be connected via the lower winding of 0A4 and the upper winding of OA1. The holding potential for the associated relay chains is connected to each lead 4.

Further calls cause this cycle to be repeated.

When key BK-0A is operated, the call distributor is prevented from stepping each time the SL marker is used. This facility is provided to lock the distributor in one position for fault tracing purposes.

3.4 Call Distributors with Random Priority. Fig. 8a shows another example of a call distributor circuit, together with an associated relay selection chain (Fig. 8b). It is used to allot priorities to the five 200-line units forming a 1,000 line group in an ARF exchange.

This call distributor differs from the previous example, as the relays are not operated in strict rotation. The relay to be operated is determined by the chain relay used for the previous call.

The dotted paths shown associated with the relay chain are temporary circuits used originally to operate the relays.

Assuming that relay 1AN1 is used for a call, then contacts of 2AN1 (a switching relay under the control of 1AN1 prepare an operate path of relay OAX1 (Fig. 8a).

When relay OAX1 operates at a later stage of the call, it extends the holding potential on lead 2, giving relay 1AN2 priority for the next call (Fig. 8b).

Relay OAX1 provides a self-holding path and disconnects the holding circuit for the OAX relay operated on the previous call.

When the next call is originated, the number of the rack on which the call originates determines which identifying relay operates. If only one call is made at that instant, the identifying relay obtains a holding circuit, irrespective of the priority allotted by the call distributor.

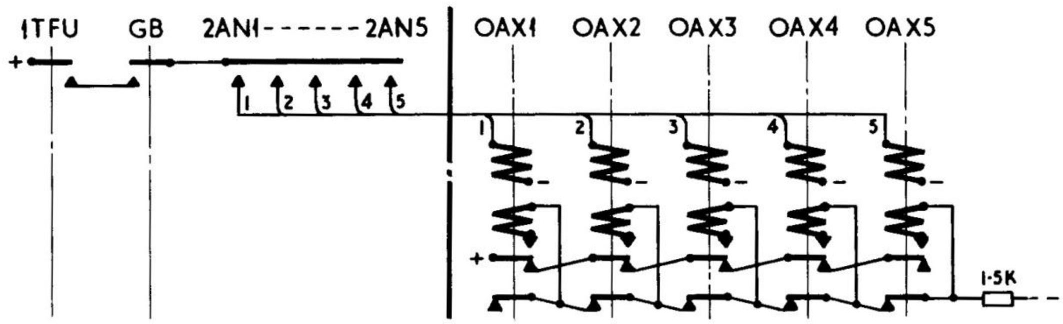
When two subscribers on different racks in the same 1,000 group originate simultaneous calls, two different identifying relays can operate in the same marker. The priority determined by the previous call then decides which relay receives a holding circuit. (Although two calls can originate simultaneously, it is not certain that two identifying relays operate in the same marker. As two markers can be provided for each 1,000 group in the SL stage, it is possible for one call to be connected to each marker).

Assuming that identifying relays 1AN3 and 1AN5 operate simultaneously, with the holding potential on the lead 2 (0AX1 operated), then priority is given to relay 1AN3.

As relay 1AN5 has no holding circuit, it releases after the original operating circuit is disconnected.

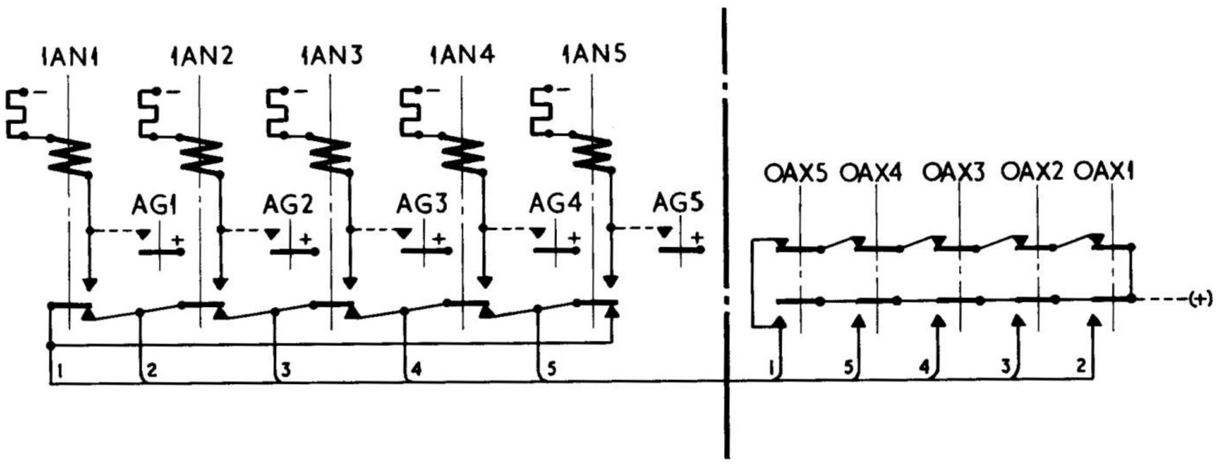
At a later stage of the call, relay 2AN3 (a switching relay controlled by 1AN3) causes the operation of 0AX3 in the call distributor circuit. This relay completes a self-holding circuit, and its contacts extend the holding potential to lead 4, giving priority for the next call to relay 1AN4.

This method of providing priority is arranged to prevent a busy group of subscribers excluding other calling groups from the available devices.



Part of Marker Circuit. Call Distributor.

(a)



Identification Relay Chain. Call Distributor Contacts.

(b)

FIG. 8. CALL DISTRIBUTOR AND ASSOCIATED RELAY CHAIN.

3.5 In some cases, the contacts of one call distributor are arranged to step a second call distributor. Fig. 9 shows that contacts of the OR call distributor control the stepping of a five-relay cyclic call distributor "TO".

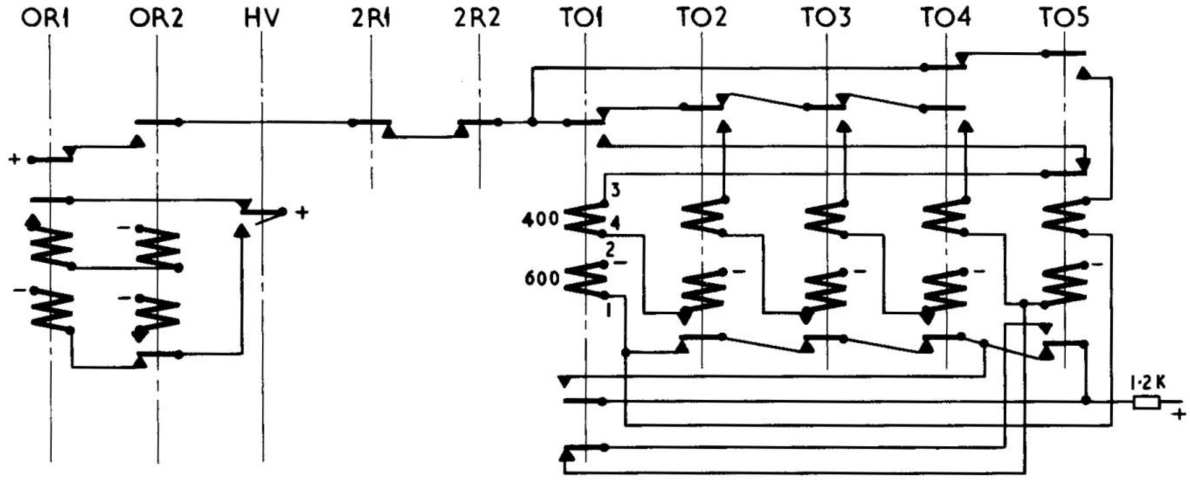


FIG. 9. COMBINED CALL DISTRIBUTORS.

We saw in para. 3.1 that relays OR1 and OR2 form a two-relay cyclic call distributor operating under the control of HV contacts. At every second call, OR2 is operated and OR1 is released.

By providing additional contacts on relays OR1 and OR2, and arranging them as shown in Fig. 9, positive potential is applied to the TO call distributor every second call via contacts of 2R1 and 2R2. This positive potential causes the TO call distributor to step in the same manner as the OA call distributor (paras. 3.2 and 3.3).

Contacts associated with the TO call distributor (not shown in Fig. 9) are arranged to provide a rotating priority of holding to 5 test relays for selection of a register.

Table 1 shows the call distributor relays operated at the start of each call, and the register which receives priority of selection.

CALL No.	1	2	3	4	5	6	7	8	9	10
CALL DISTRIBUTOR RELAYS OPERATED	TO1	TO1 OR2	TO2	TO2 OR2	TO3	TO3 OR2	TO4	TO4 OR2	TO5	TO5 OR2
REGISTER No.	1	2	3	4	5	6	7	8	9	10

TABLE 1.

4. IDENTIFIERS.

4.1 When a call arrives at a switching stage, the marker for that stage must connect itself to the calling inlet. Before this is possible, the marker must identify the calling inlet from all other circuits having access to the same common equipment.

The two types of identifiers used extensively in crossbar switching are "one-wire identifiers" and "two wire identifiers".

The one-wire type of identifying circuit is used at almost every stage of crossbar switching to identify a calling inlet.

4.2 One-Wire Identifiers. In its simplest form, a relay is provided in the identifier for each calling circuit. When a call is made, a potential applied to a wire of the calling circuit causes the operation of the corresponding relay in the identifier.

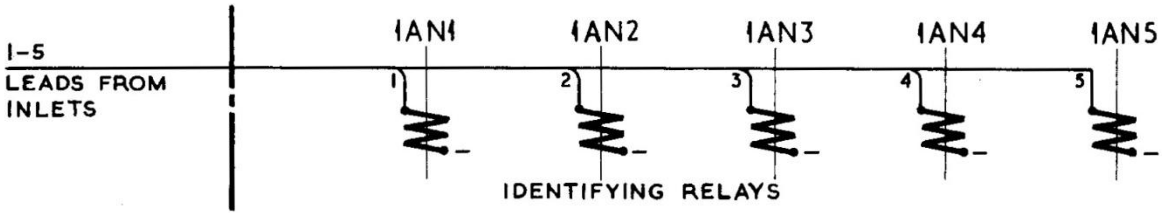


FIG. 10. SINGLE STAGE ONE-WIRE IDENTIFIER.

When it is possible for calls to originate on two circuits simultaneously, the relays must be connected to a relay selection chain, where one of the relays receives a holding circuit via a call distributor.

One example of this type of circuit is in the 200-group identifier of an SL marker (Fig. 11). The operation of this circuit is explained in para. 2.4.

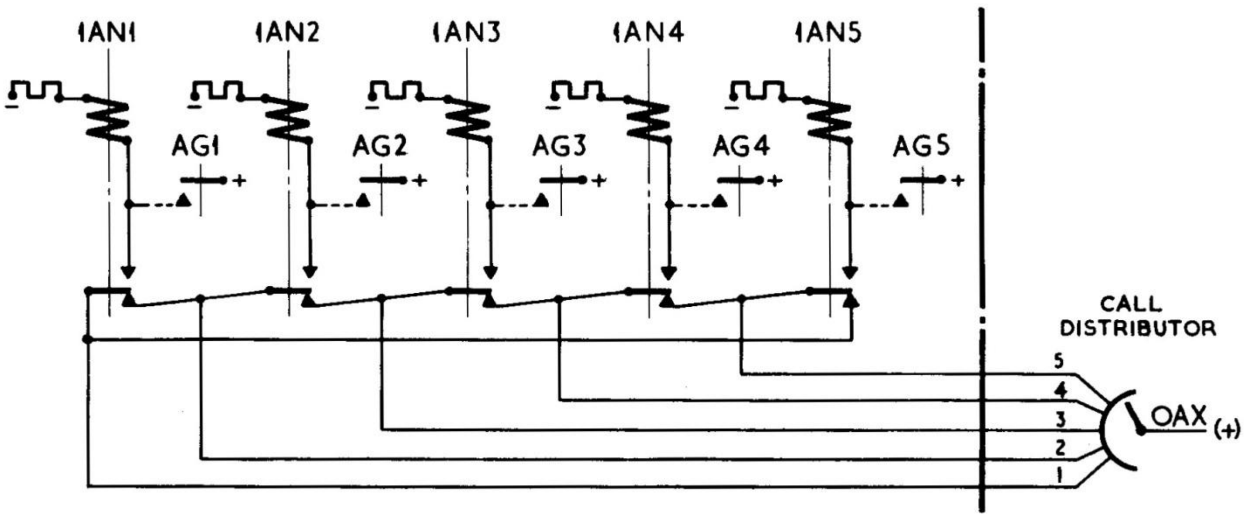


FIG. 11. GROUP IDENTIFIER.

4.3 A control relay is usually associated with this type of identification chain; this ensures that identification is complete before allowing the circuit operation to proceed.

An example of this is shown in Fig. 12 in which a control relay ANB is associated with the group identification.

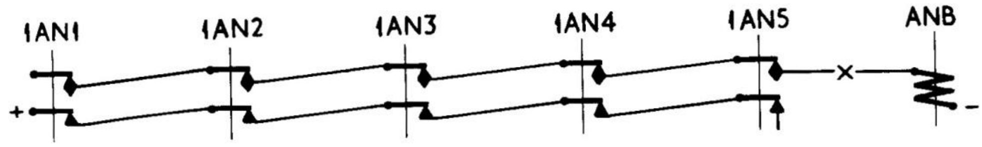


FIG. 12. CONTROL RELAY CIRCUIT.

When more than one identifying relay operates, the circuit to the control relay ANB is open. After the identification is complete and only one identifying relay remains operated, a circuit is completed to operate relay ANB, which then extends the circuit operation to the next stage.

4.4 Single Wire Two-Stage Identifier. When a large number of calling circuits have access to a common control, more than one stage of identification is often used. The number of stages used is governed, in the main, by:-

- The time required for identification.
- The division of relays over relay sets.
- The number of interconnecting wires.
- The number of springs required for each relay.
- The number of soldered joints.
- The total power consumption.

Fundamentally, a two-stage identifier divides the calling devices into two groups. The first stage selects the group containing the calling circuit; this group of lines is then switched to the second stage, which selects the individual circuit from the group.

One advantage of this method of identification is to considerably reduce the number of identifying relays. Fig. 13 shows a block diagram of a single wire two-stage identifier consisting of 14 relays which ~re used to identify any one of 40 SR relay sets.

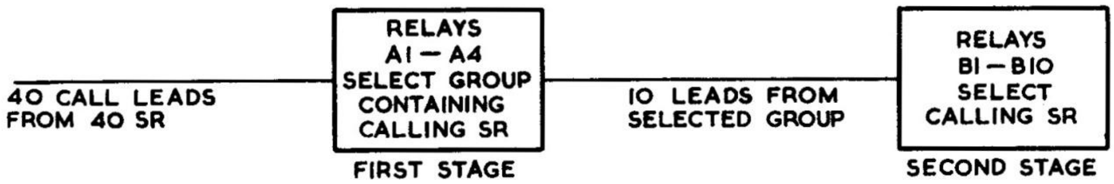


FIG. 13. PRINCIPLE OF SINGLE WIRE TWO-STAGE IDENTIFIER.

4.5 Fig. 14 shows a simplified circuit of a single wire two-stage identifier as used in the RSM in an ARF exchange.

When the call is from a circuit in the group SR1-10, a negative potential placed on the call lead from that SR causes the operation of relay A1.

Contacts of relay A1 then connect the ten call leads of that group to the second identifying stage. In this stage, a separate B relay is provided for each extended call lead, and assuming that the calling circuit is SR5, the operation of relay B5 indicates the calling circuit in that Group.

The operated A relay indicates the calling group.

The operated B relay indicates the calling circuit within the group.

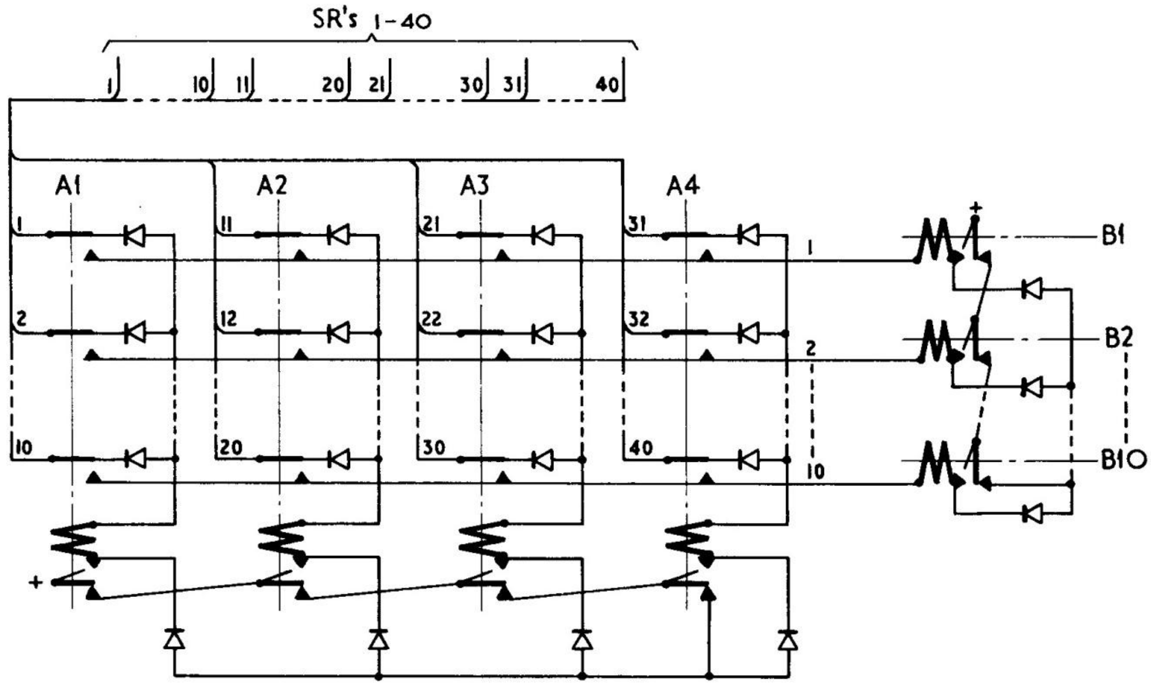


FIG. 14. TYPICAL SINGLE WIRE TWO-STAGE IDENTIFIER.

When it is possible for simultaneous signals to be applied to two or more call leads the holding paths for the identifying relays are via a series chain which ensures that only one relay in each stage receives a holding circuit.

Although the number and designation of identifying relays will vary, a similar type of identifying circuit is used in most crossbar switching stages.

The dotted line between the coils of relays B2 and B10 indicates that there are other relays (B3 to B9) connected in a similar manner to those shown. Similarly, the dotted line between the B2 and B10 contacts indicates that contacts of B3-9 are connected in series with those shown.

4.6 Two Wire Identifiers. A two wire identification system is used to identify a calling subscriber within a 200-line group. When the 200-line group has been identified (para. 3.2), multicoil connecting relays extend 30 identifying leads from the SL marker to an identifying grid of LR contacts on the calling rack.

If Fig. 15, which shows a two-wire line identification circuit, a grid has been drawn showing LR contacts connected across the intersection of each vertical line (representing the subscriber's "tens" figure) and each horizontal line (representing the subscriber's "units" figure). LR contacts are multiplied to form a similar grid on each SLA rack.

When the group identifying relay operates, it causes the operation of ANA relay. Contacts of ANA relay operate relay AAK, which prepares the circuit for relays 1-3AA. For simplicity, relays 1-3AA are shown as a single relay, although three relays operate in parallel to provide sufficient contact units.

4.7 Unit Identification. When the group identification is complete, control relay ANB operates and completes the circuit for relays 1-3AA and BAK. Contacts of these relays connect a positive potential to each vertical line of the grid and a negative potential via an identifying 'A' relay to each horizontal line. A circuit bridging between a vertical and horizontal grid is completed by an operated LR contact in the calling subscriber's line circuit. An identifying 'A' relay operates for each horizontal grid bridged to a vertical in this manner, the number of the 'A' relay corresponding to the "units" figure of the calling subscriber's number.

For example, when a subscriber whose number ends in 011 originates a call, the A1 identifying relay operates.

The operation of any 'A' relay causes the release of relay AAK, which in turn releases relays 1-3AA. The operated 'A' relay holds via a relay chain and the OA call distributor.

When more than one 'A' relay operates (due to simultaneous calls), the relay to remain operated is decided by the priority allotted by the OA call distributor. The operated 'A' relay places a positive potential on one horizontal of the grid.

4.8 Tens Identification. The release of 1-3AA causes the operation of relay BA, and contacts of this 'relay place a negative potential via an identifying 'B' relay, to each vertical line of the grid.

Any calling subscriber with a "umit" figure the same as the operated 'A' relay now operates a 'B' relay, the number of the 'B' relay corresponding to the "tens" figure of the subscriber's number.

When more than one 'B' relay operates, the holding relay is again decided by a relay chain and the OA call distributor. As there are only four positions on the OA call distributor, it is not possible to allot an individual priority to each relay, a group priority being provided in the manner described in para. 2.5.

The final operation of one 'A' relay and one 'B' relay identifies the calling subscriber's line. An indication that identification is completed is given by 'B' relay contacts operating the control relay BB, which then allows the marker operation to proceed to the next step.

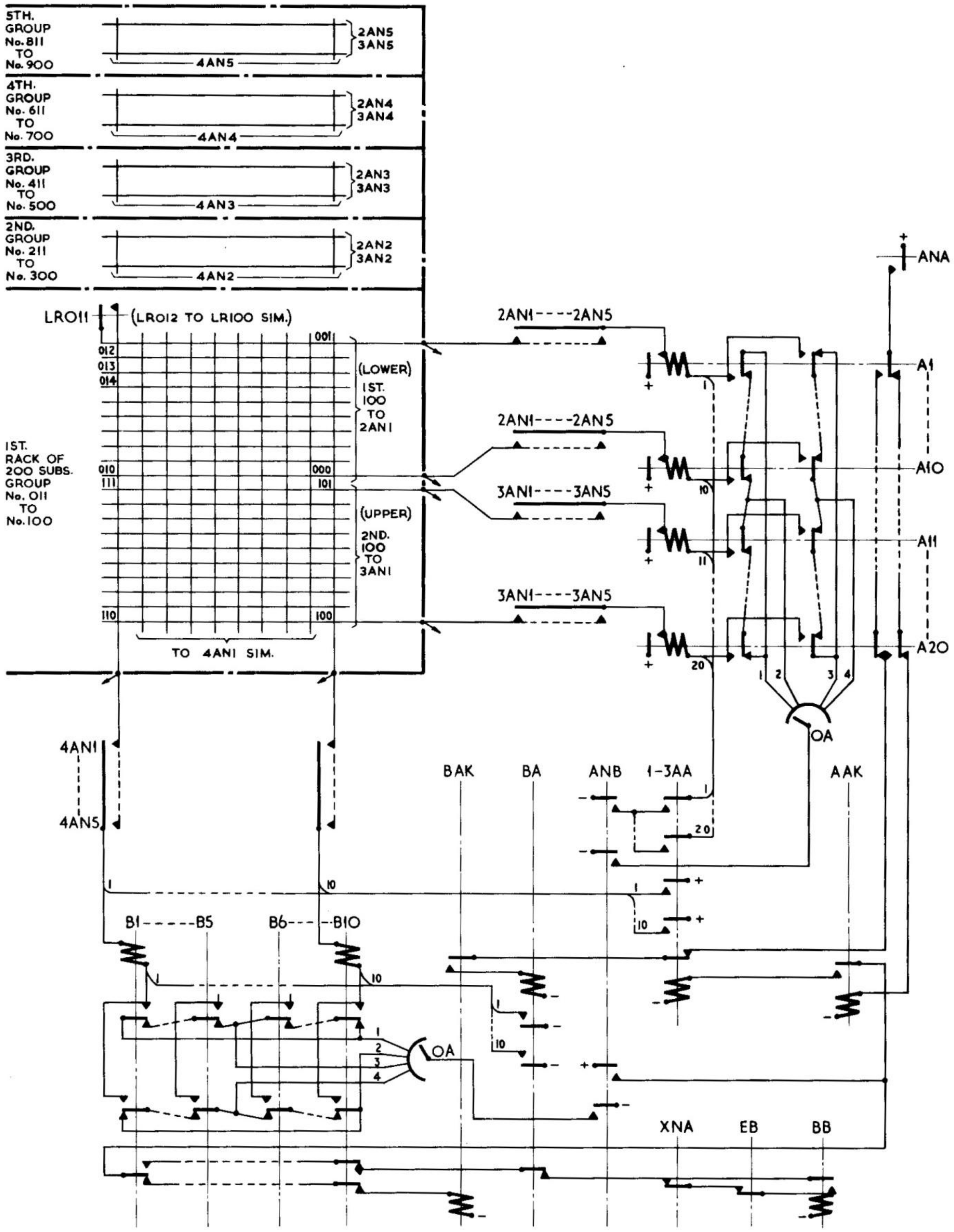


FIG. 15. TWO WIRE IDENTIFIER.

5. CODE SENDING.

5.1 We saw in the paper "Introduction to Crossbar Switching - Part 1" that information signalling between registers and markers is effected by means of a compelled sequence multi-frequency code (M.F.C.).

Since the normal speaking path is used for the transmission of the various signals, the frequencies must lie within the limits of the normal speaking or voice frequency range. The range of 540-1980Hz is fixed to avoid interference with international line signalling systems which employ frequencies between 2,000 and 3,000Hz. To enable simultaneous signalling in both directions, different frequencies are used in the forward and in the backward directions. A maximum of six frequencies are provided for forward signals and another six are available for the backward signals. Each signal is composed of two frequencies out of the six, and in this way, 15 frequency combinations can be obtained.

The frequencies in each of the backward and forward series are given a code number ranging from '0' for the first frequency to '11' for the last frequency.

The 15 signal combinations are allotted a numerical value 1-15, and with three exceptions, the addition of the code numbers is equivalent to the numerical value of the signal. This feature provides a ready means of checking the composition of each signal.

SIGNALS		FREQUENCIES (Hz)						
Numerical Value	Code No. Composition	Denomination	F0	F1	F2	F3	F4	F5
		Forward	1380	1500	1620	1740	1860	1980
		Backward	1140	1020	900	780	660	(540)
		Code No.	0	1	2	4	7	11
1	0 + 1		X	X				
2	0 + 2		X		X			
3	1 + 2			X	X			
4	0 + 4		X			X		
5	1 + 4			X		X		
6	2 + 4				X	X		
7	0 + 7		X				X	
8	1 + 7			X			X	
9	2 + 7				X		X	
10	4 + 7					X	X	
11	0 + 11		X					X
12	1 + 11			X				X
13	2 + 11				X			X
14	4 + 11					X		X
15	7 + 11						X	X

TABLE 2.

5.2 Equipment for sending and receiving M.F.C. signals is associated with registers and code receivers. Since each signal consists of two frequencies, the system is self checking, in that the absence of one of the elements, or the presence of a third, indicates malfunction.

Fig. 16 shows the circuit principles involved in the transmission of an M.F.C. digit signal from the code sending relay set associated with a register.

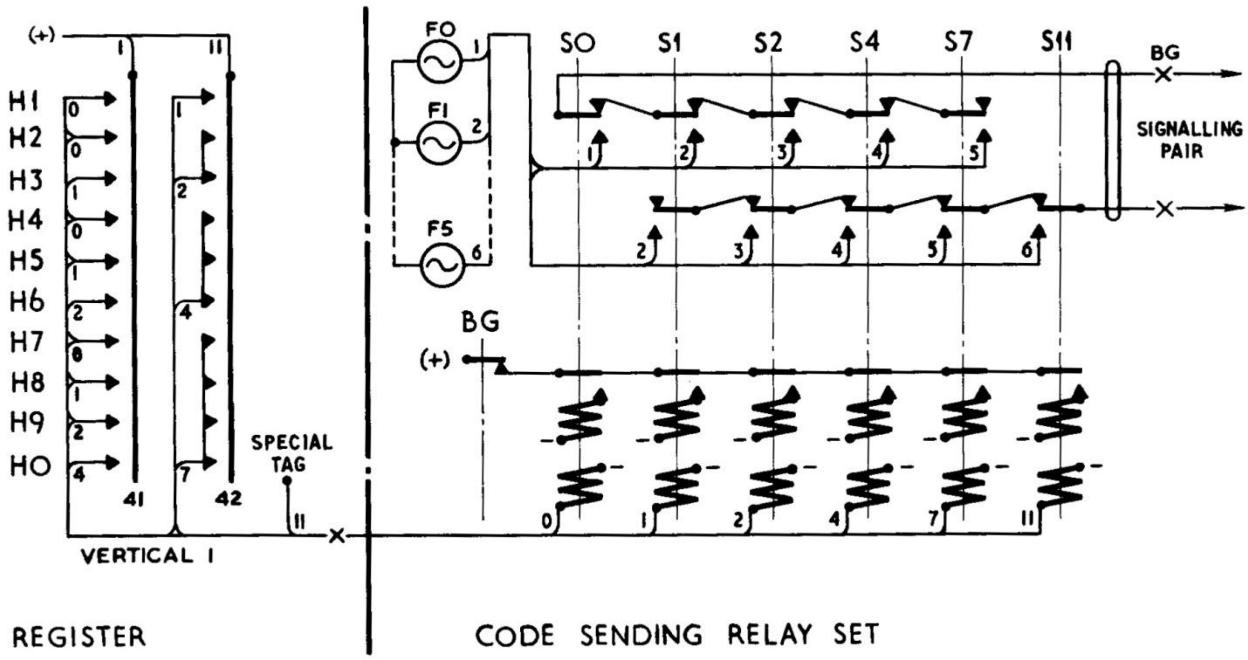


FIG. 16. PRINCIPLE OF TRANSMISSION OF M.F.C. DIGIT SIGNALS.

When the register is ready to start digit transmission, a code sending relay set is connected, and positive potential is placed on wires 1 and 11, which are connected respectively to contact strips 41 and 42 of vertical 1. The horizontal springsets of the vertical are code wired, so that a positive potential is placed on 2 out of 6 wires when any one of the ten horizontal springsets is operated. For example, when digit 1 is stored on the vertical, the positive potential on the contact strips is applied to wires 1 and 0, and when digit 0 is stored, positive is applied to wires 4 and 7.

According to the digit signal to be transmitted, two of the six S relays operate from the positive potentials extended via vertical 1. The two S relays lock on their second windings, and the register prepares for transmission of the second digit by transferring the positive potentials from vertical 1 to vertical 2.

Contacts of the two operated S relays connect the correct two tone generators for the digit to the signalling wires. Transmission of the digit signal is maintained until acknowledged by a backward (control) signal, which causes the operation of BG contacts. Contacts of BG release the two S relays and disconnect the two tone generators. The register is then prepared to transfer the second digit to the code sending relay set, which transmits the digit in M.F.C.

With the exception of the first digit, digits cannot be transmitted until a control signal is received. The digits are transmitted one at a time, commencing with the first digit, the second digit and so on, until the register store is emptied.

6. CODE RECEIVING.

6.1 Para. 5.2 shows that an M.F.C. digit signal consists of two frequencies applied to the line simultaneously by a code sending relay set associated with a register.

The signal is applied to the line via a high pass filter (Fig. 17).

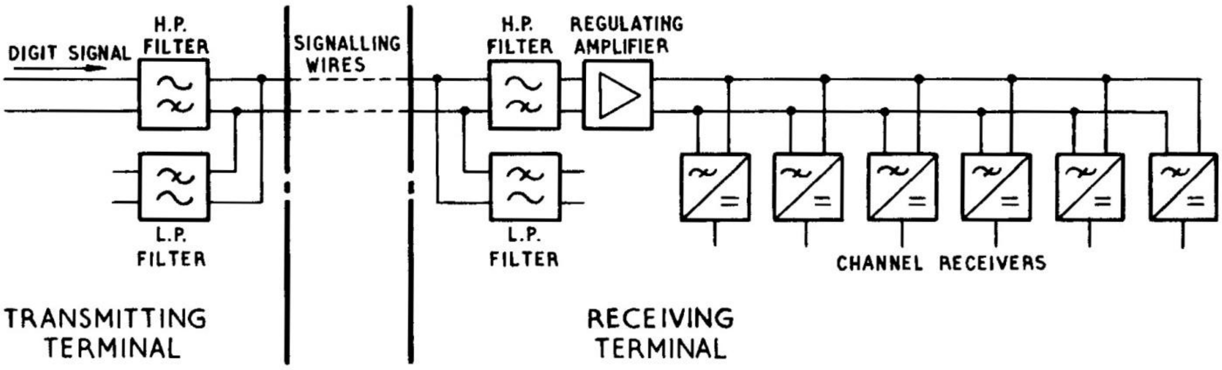


FIG. 17. SIGNALLING EQUIPMENT.

At the receiving terminal, the digit signal is applied via another high pass filter to a regulating amplifier, which adjusts the level of incoming code signal. The output from the regulating amplifier is then applied simultaneously to six channel receivers.

Each channel receiver contains a filter which is tuned to accept one of the six frequencies allocated for digit signals. The accepted frequency is then amplified and rectified.

In the two channel receivers responding to the digit signal, a reed relay operates and applies positive potential to the receive relays in the code receiver relay set (Fig. 18).

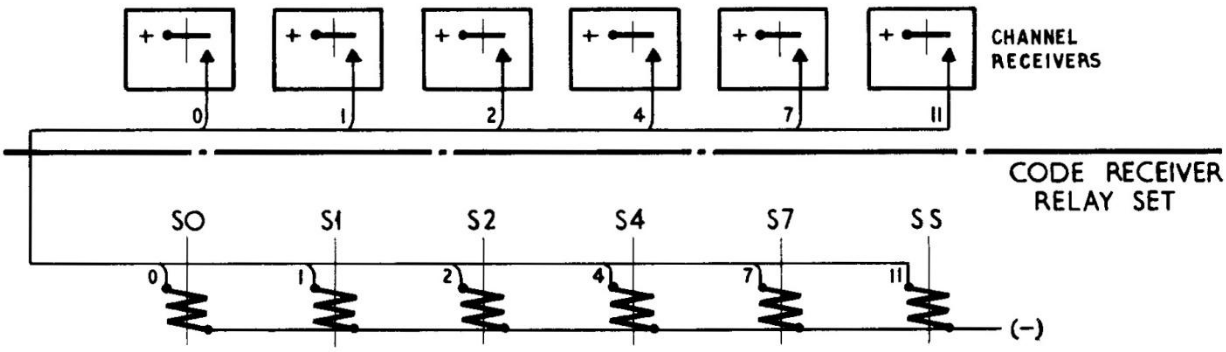


FIG. 18. RECEIVING'THE DIGIT SIGNAL IN THE CODE RECEIVER RELAY SET.

Two S relays operate according to the digit signal received. For example, when the code for digit 1 is received, the first two channel receivers accept the code, and the respective reed relays operate and apply positive potential to wires 0 and 1. Relays S0 and S1 operate and hold to the positive potential in the respective channel receivers.

6.2 Storing the Received Digit. When two S relays operate for the received digit, the digit is stored by operating two of the digit store relays 1SO-1SS via a contact combination of the SO-SS relays (Fig. 19).

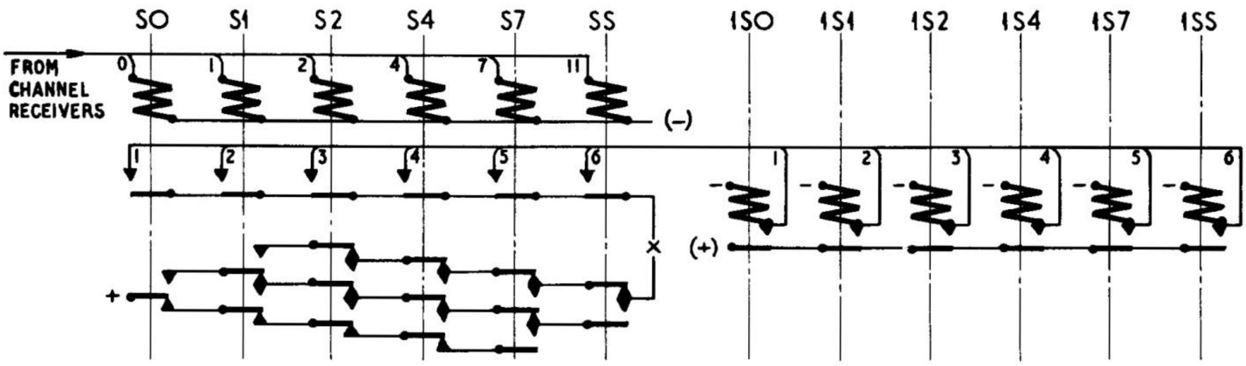


FIG. 19. STORING THE RECEIVED DIGIT.

Contacts of the SO-SS relays are arranged so that a circuit is only completed to the digit store relays 1SO-1SS when two of the SO-SS relays operate. When one, or more than two S relays operate, the received digit cannot be stored.

Table 3 lists the relays operated for receiving and storing any one of the digits 1-0.

DIGIT	RECEIVE RELAYS OPERATED	DIGIT STORE RELAYS OPERATED
1	SO + S1	1SO + 1S1
2	SO + S2	1SO + 1S2
3	S1 + S2	1S1 + !s2
4	SO + S4	1SO + 1S4
5	S1 + S4	1S1 + 1S4
6	S2 + S4	1S2 + 1S4
7	SO + S7	1SO + 1S7
8	S1 + S7	1S1 + 1S7
9	S2 + S7	1S2 + 1S7
0	S4 + S7	1S4 + 1S7

TABLE 3.

The receive relays are released when a control signal is received in the code sending relay set associated with the register. The code sending relay set acknowledges the control signal by disconnecting the digit signal, which causes the reed relays in the channel receivers to release, followed by the receive relays. The digit store relays remain operated.

Subsequent digit signals are received in the same manner as the first digit, and are stored on other groups of digit store relays (2S relays for the second digit, 3S for the third digit, and so on).

7. DIGIT ANALYSIS.

7.1 When digital information is transmitted between two points, for example from a subscriber to a register or from a register to marker equipment, it is stored in the receiving equipment and analysed to determine one or more of the following:-

- The subscriber's class of service.
- Whether a call is allowed to proceed or is to be redirected.
- When digit transmission is to commence.
- The charging rate for the call (trunk exchanges).
- Whether the received information is sufficient to select the required route.
- If alternative routes exist.
- The number length and type of terminating exchange.
- The type of signalling required to complete the setting up of a call.
- In the case of P.B.X. equipment, whether the received digits are that of a directory number belonging to a P.B.X. group.

7.2 The analysing function is performed by relays which are caused to operate via one or more predetermined strappings between contacts of the digit storing device (verticals of a crossbar switch or groups of relays).

Fig. 20 shows typical strappings between the verticals of a crossbar switch and associated tags, to enable a register in an ARF exchange to analyse whether the digits being stored are those of the local exchange prefix (7-digit number, prefix 560).

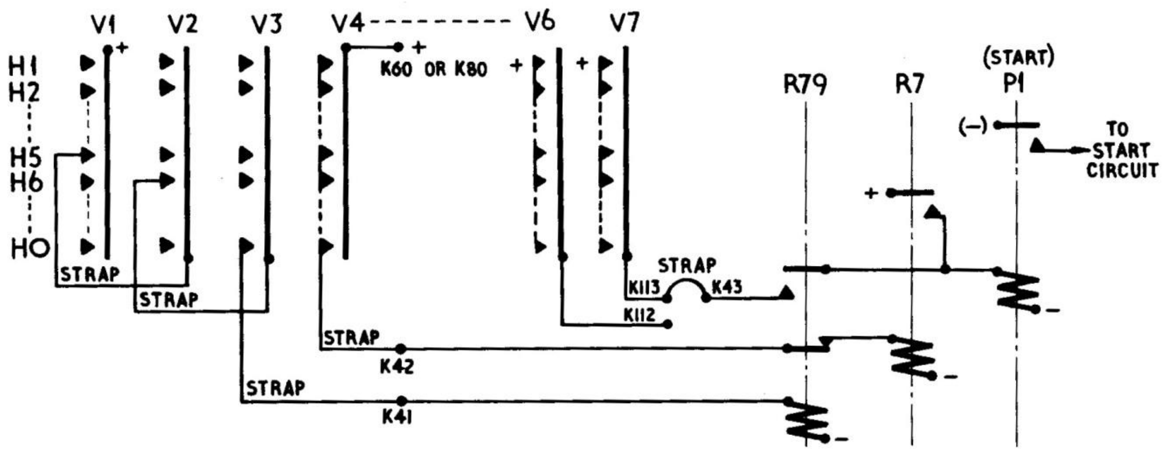


FIG. 20. DIGIT ANALYSIS IN A REGISTER.

The strappings shown on each vertical are made on separate springsets and contact strips, and are made on all registers in exchange 560. The tags designated "K" are part of a tag block, and the relays R79 and R7 perform the analysing function of discriminating between a local call and a junction call.

When the local prefix (560) is stored, positive potential from the contact strip in vertical 1 is applied via the operated horizontal contacts and strappings in verticals 1, 2 and 3, to tag K41. R79 operates and its contacts open circuit R7 to prevent the start relay (P1) operating when the fourth digit is stored. When the last (seventh) digit is stored, P1 operates to prepare digit transmission.

On calls to other exchanges, R7 operates when the fourth digit is stored. Contacts of R7 operate the start relay P1 to prepare for digit transmission.

7.3 Fig. 21 shows the principle of analysing routing information in a GV marker, following the storage of one and two digits.

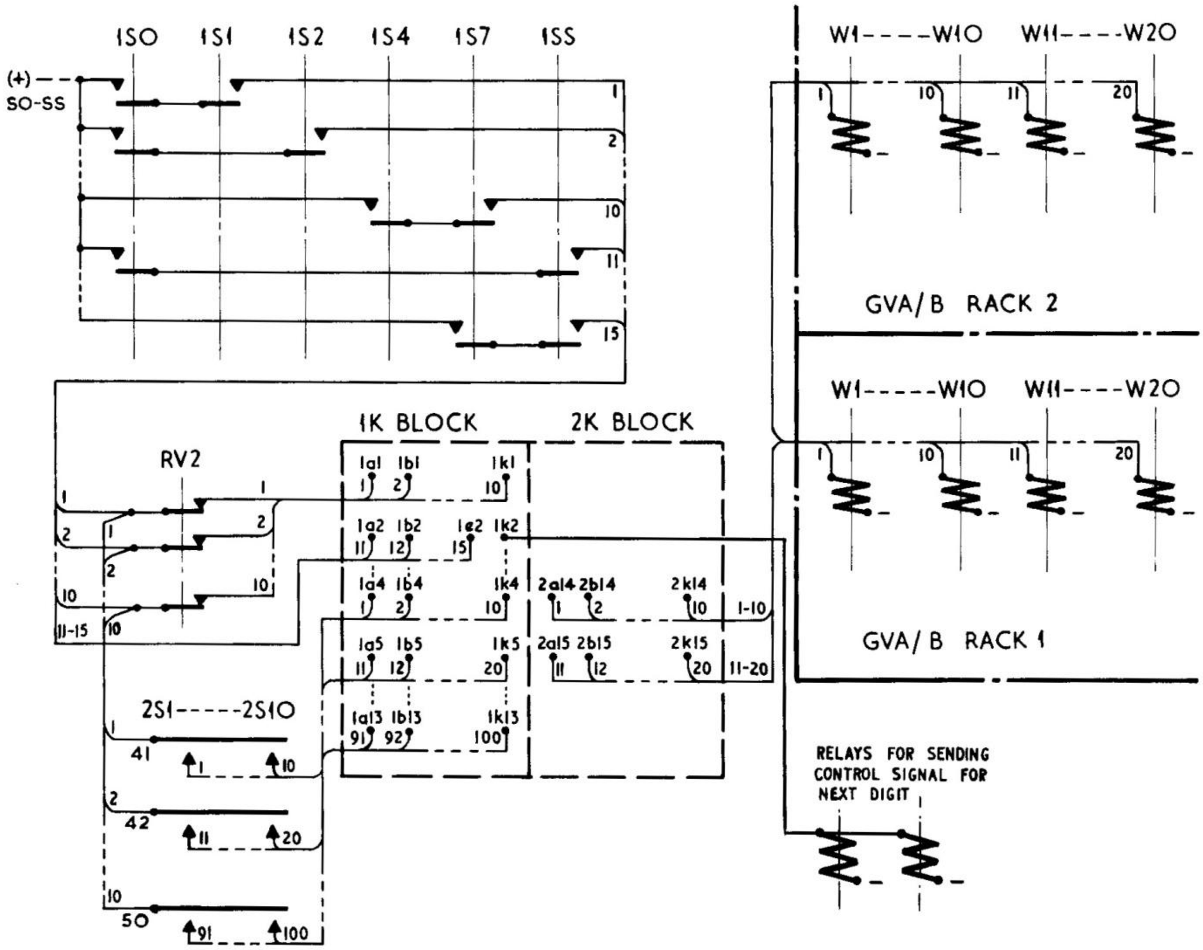


FIG. 21. ANALYSIS OF ROUTING INFORMATION IN A GV MARKER.

When the first digit is received, two of the 1S0-1S7 relays operate to store the digit. Positive potential is applied via operated contacts of the digit store, to one of 10 tags (1a1-1k1) on the terminal block 1K. For example, if the stored digit is "2", positive potential is applied via contacts of 1S0 and 1S2, to tag 1b1. If this digit is sufficient information for determination of a route, a strapping would exist between tag 1b1 on the 1K block, to one of the 20 tags (2a14-2k15) on the 2K block. The positive potential from the first digit store contacts operates a W relay on each of the GVA/GVB racks, to connect the lines of the route for test.

When two digits are required to determine a route (assume "01"), a strapping is made from tag 1k1 to 1k2, and from tag 1a13 to one of the tags 2a14-2k15. The positive potential from the first digit store contacts is applied via the strapping 1k1-1k2 and causes a control signal (next digit) to be transmitted to the code sending relay set associated with the register. Relay RV2 operates and disconnects the positive potential from tag 1k1.

When the second digit (1) is received, it is stored by the operation of relay 2S1. Positive potential from the first digit store is applied via wire t0, contact strip 50 and operated contacts of 2S1, wire 91, tag 1a13 strapped to one of the tags 2a14-2k15, to operate the route relays associated with the routing code "01".

8. TEST AND SELECTION OF OUTLETS.

8.1 We saw in the paper "Introduction to Crossbar Switching - Part 1", that the common control equipment associated with a switching stage operates on the bypath principle and performs the following functions:-

- Identification of the calling line.
- Determination of a route through the switching stage.
- Test and selection of an outlet on the desired route.
- Switching the calling line to the selected outlet.

8.2 The test and selection of an outlet can be performed by one of the following methods:-

- Relays, in the form of a relay selection chain.
- Cold cathode tubes, in association with a relay selection chain.
- Transistors, in association with a call distributor.

The method used depends on the type of marker equipment.

8.3 Fig. 22 shows the principle of outlet test and selection using relays, in an ARM20 exchange.

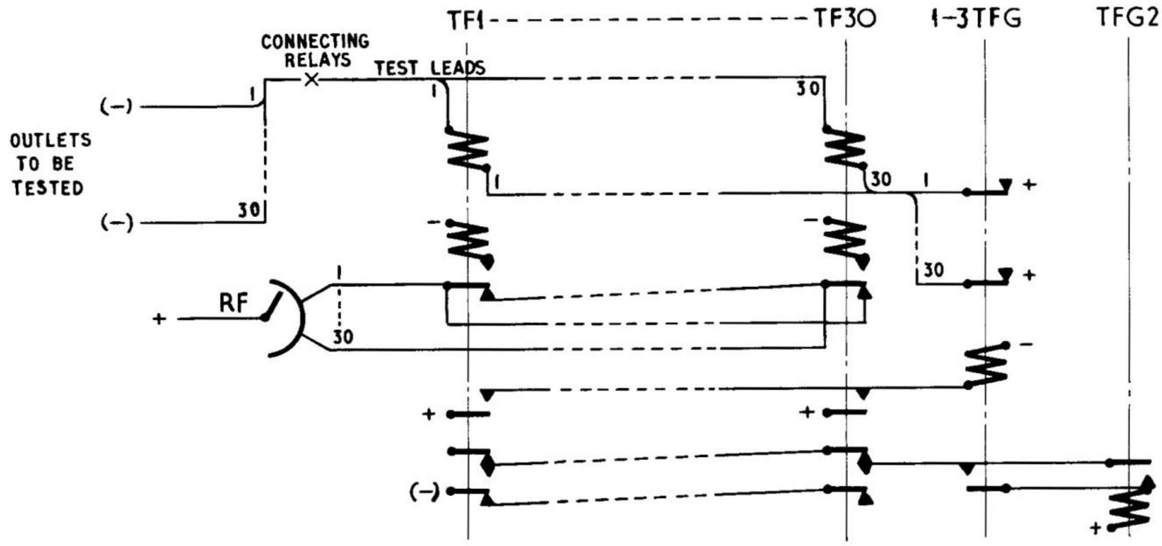


FIG. 22. TEST AND SELECTION OF OUTLETS USING RELAYS.

When the marker equipment operates the connecting relays, the outlets to be tested are connected to the testing relays TF1-30. A free outlet is indicated by the presence of negative potential on the test leads, and one or more TF relays operate to positive potential at 1-3TFG contacts.

Contacts of the operated TF relay(s) operate relays 1-3TFG, which disconnect the positive potential from the operate windings of the TF1-30 relays. One of the TF1-30 relays receives a holding circuit on the hold winding via the RF call distributor.

When only one TF relay is holding, relay TFG2 operates via the lower chain contacts, to indicate the completion of outlet selection.

8.4 In some types of common control equipment, the test and selection of an outlet is performed electronically by means of cold cathode tubes. Fig. 23 shows a simplified diagram of a typical test and selection circuit in a GV marker, which uses gas filled cold cathode tubes.

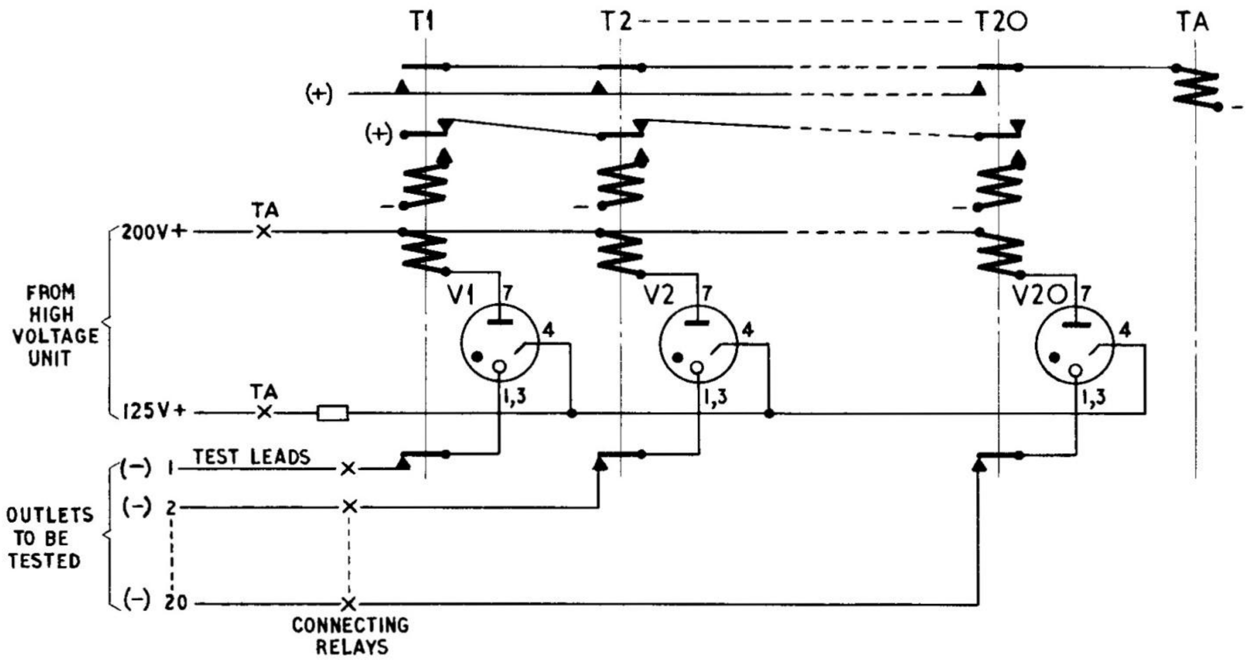


FIG. 23. TEST AND SELECTION OF OUTLETS USING COLD CATHODE TUBES.

Each test circuit consists of a cold cathode tube connected in series with a winding of a test relay. When the marker equipment is ready to test the outlets associated with a route, the outlets are connected to the test circuits, and a high voltage supply is connected to the anodes (pins 7 and 4) of the cold cathode tubes.

A free outlet is indicated by the presence of negative potential on the test leads, and the difference in potential across pins 1, 3 and 4, causes a tube to ignite across this gap and immediately over the main gap (pins 1, 3 and 7). The resultant current causes a test relay to operate and lock.

When more than one tube conducts and operates more than one test relay, the T1-20 relay selection chain ensures that only one relay holds. Priority of holding is given to the lowest numbered relay to operate. TA relay operates when any T relay operates, indicating that an outlet is selected. Contacts of TA disconnect the voltage supply to the cold cathode tubes.

Ignition delay characteristics of the tubes are such that a different tube ignites for each test, giving random selection of outlets. Because of this design feature, a call distributor is not associated with the T relay selection chain.

8.5 Another type of common control equipment uses transistors for the testing of outlets, and an associated call distributor for the selection of an outlet. Fig. 24 shows a simplified circuit of one of the testing circuits used in one type of GV marker.

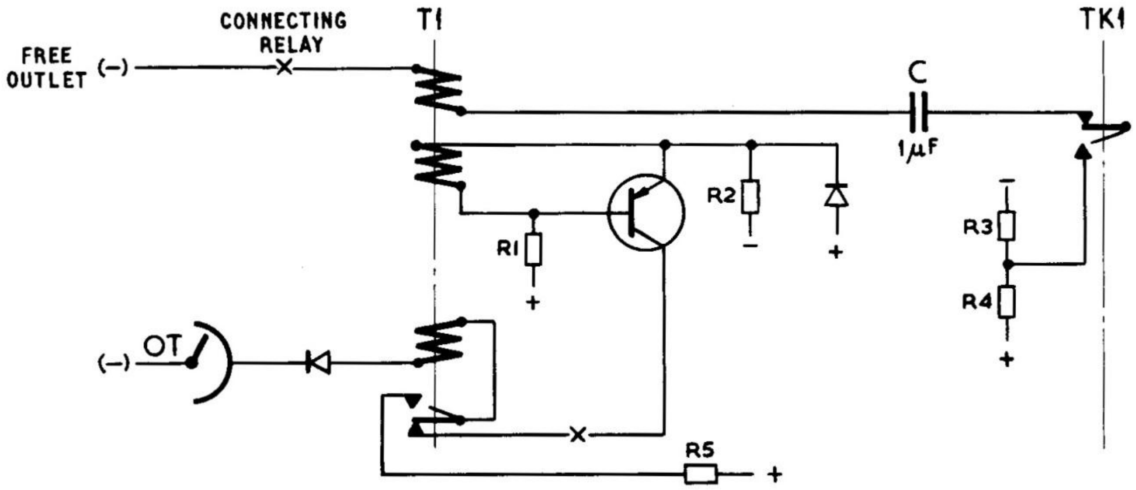


FIG. 24. TEST AND SELECTION OF AN OUTLET USING A TRANSISTOR.

When the marker equipment is ready to start testing, connecting relays operate and connect the outlet to be tested, to the upper winding of T1 relay. At the same time, the collector of the transistor is connected to the lower winding of T1 relay to negative potential via the OT call distributor.

At this instant, the transistor is biased so that there is no collector current. The path over which the base-emitter bias is obtained includes resistor R1, the centre winding of T1, and resistor R2.

The test is started when the marker control equipment causes relay TK1 to operate. When TK1 contacts bunch, the 1μF capacitor charges in series with the upper winding of T1. The changing current through this winding causes a voltage to be induced across the centre winding in opposition to the normal bias. When the bias voltage is exceeded, the resultant base current causes collector current through the lower winding in such a direction as to cause a further increase in base current, with a consequent increase in collector current.

This reaction continues until the transistor starts to "saturate". Towards saturation, the change in collector current decreases, the induced e.m.f. decreases across the centre winding, the base current decreases, and collector current decreases. This "reverse" reaction continues until the normal bias voltage causes base current and collector current to cease.

During the period of maximum collector current, the T relay operates on its lower winding and locks to positive potential at resistor R5.

When a number of T relays operate to free outlets, the 'OT' call distributor selects one of the free outlets by providing a holding circuit for only one 'T' relay.

9. TIME SUPERVISION.

9.1 We saw in the paper "Introduction to Crossbar Switching - Part 1" that when a marker cannot find a free outlet or when link congestion occurs, the marker is disconnected. The disconnection of the marker is started by an inbuilt supervisory unit which usually consists of a normally operated relay.

Fig. 25 shows a typical supervisory circuit associated with a marker. The complete marker operation consists of three stages, beginning with AA then followed by RV1 and WK3.

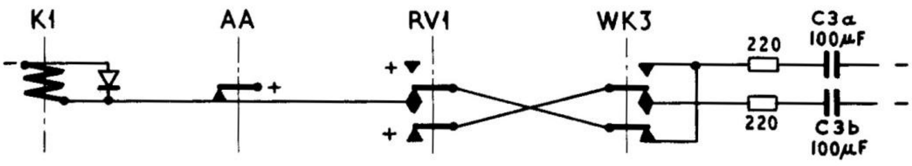


FIG. 25. TYPICAL TIME SUPERVISION CIRCUIT IN A MARKER.

When the marker is not in use, relay K1 is normally operated and the capacitors C3a and C3b are charged.

After the marker is seized, AA operates and disconnects the holding positive to K1 relay, which is slow to release due to capacitor C3a discharging through the winding. This slow release period of K1 is used as a supervisory time, during which the marker must complete the first stage of operation. Under normal conditions, the operation is completed well within the supervisory time.

The second stage of marker operation is provided with a similar supervisory time when RV1 operates. Contacts of RV1 connect the charged capacitor C3b across K1 and recharge C3a.

The final stage of marker operation is also provided with the same supervisory time when WK3 operates. Contacts of WK3 reconnect the recharged capacitor C3a across K1.

If K1 releases at any stage of the marker operation, contacts of K1 are arranged to given an alarm and the marker equipment is disconnected.

9.2 When longer supervisory times are required, for example in a register and SR, use is made of the combined operate and release times of a thermal relay. Fig. 26 shows a typical time supervision circuit using a thermal relay.

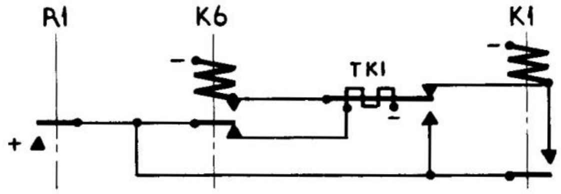


FIG. 26. TYPICAL TIME SUPERVISION CIRCUIT USING A THERMAL RELAY.

The timing circuit starts when relay R1 operates and completes a circuit to the winding of TK1 (a thermal relay mounted on K1 relay). After a delay period, the contacts of TK1 operate and complete a circuit to K6, which locks. Contacts of K6 disconnect the winding of TK1. When TK1 has cooled sufficiently, its contacts restore to normal and operate K1 via contacts of K6. Contacts of K1 are arranged to give an alarm and disconnect the relay set in which the time supervision circuit is located. Supervisory times of 30-90 seconds can be achieved with this type of circuit.

9.3 In ARM exchanges, time supervision for the various relay sets is achieved by means of pulses, separated by predetermined time intervals.

NOTES

NOTES

10. *TEST QUESTIONS.*

1. What is the main function of a relay selection chain?

2. List four types of relay selection chains.

3. Examine Fig. 2. List the priority of operation of the 1AN relays when 1AN3 and 1AN4 operate simultaneously and the potential via the call distributor is on lead 5.

4. What would be the effect on the operation of the circuit (Fig. 3) if the wiping between the lever spring off 1AN1 and the break spring off 1AN5 was open circuit?

5. What is the main function off a call distributor?

6. What is meant by the term "cyclic call distributor"?

7. Examine Fig. 5. Construct a sequence diagram to show the operation of the circuit for two successive calls.

8. Show by means of a simple block diagram the principle of a single wire two-stage identifier.

9. Examine Fig. 14. Name the relays held operated to identify a call from:-

(i) SR2. (ii) SR15. (iii) SR24. (iv) SR27

10. What would the effect on the operation of the circuit (Fig. 14) if a rectifier associated with the A1 contacts was short circuited?

11. Examine Fig. 15.

(i) Name the identifying relays held operated to identify a call from subscriber 101.

(ii) What is the main function of relay BB?

12. Draw a labelled block diagram show the signalling equipment used for the reception of M.F.C. information signals.

13. Explain briefly the meaning of the term "compelled sequence" signalling.

14. One of the functions of a code receiver is to ensure that if an incorrect combination of frequencies is received, the digit store relays are not operated. How is this achieved?

15. Why is analysis of received digits performed in a register?

16. Referring to Fig. 21, list the strappings that would be made on the K blocks to operate relays W4 for the two-digit code "04".

17. Examine Fig. 22.

(i) Give three functions of relays 1-3TFG.

(ii) What is the main function of relay TFG2?

END OF PAPER.