CP 601
PRICE 20c

THE AUSTRALIAN POST OFFICE

COURSE OF TECHNICAL INSTRUCTION

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

INTRODUCTION TO CROSSBAR SWITCHING – PART 2

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1. INTRODUCTION.

1.1 This paper is the second of two papers which describe the basic components and switching principles of L.M. Ericsson's crossbar exchanges. The paper "Introduction to Crossbar Switching - Part 1" should be revised before proceeding with this paper.

1.2 This paper describes some of the facilities offered by crossbar exchanges, other types of relays in use, together with an introduction to crossbar switch multipling and grouping plans. Also contained in the paper is an introduction to the types of circuit drawings encountered and an interpretation of some of the drafting techniques employed in crossbar circuitry.

2. FACILITIES.

2.1 The term "facilities" is rather general in its meaning, but in the sense used here, it denotes those technical functions and possibilities which are inherent in the design of a system and which represent to users the characteristics of its operation.

This section contains some of the facilities applicable to most types of exchanges; facilities which apply to a particular type of exchange are given in other papers as required.

2.2 Classification of Subscribers' Lines. One of the major features of a crossbar exchange is the classification of subscribers' lines, or as it is often termed, "class of service". The usage of this term requires explanation so that it will not be confused with other similar terms in current use.

Subscribers' services are "classified" in many ways - there are "business" and "residence" services; "exclusive", "duplex", "P.B.X.", "public telephone", etc., and in some quarters the class of service might be known as "handset", "leased coin - attachment", "extension telephone", "Telex subscriber", and so on. Many of these interpretations are applicable in crossbar working, but it is important to note the particular significance of the term when used to denote a crossbar facility.

Arrangements are made in the circuitry of the marker equipment and associated relay sets so that each subscriber's line is permanently "marked" according to its particular classification, and upon connection to a register, the particular "class marking" is conveyed to the register where it is recognised and further access permitted or denied accordingly. The important point is the word "access", and it will be seen that "class-of-service" can be interpreted to mean not only the type of sub-station equipment, but also the degree of access available from or to a particular service.

The subscriber classifications can be subdivided into:-

- Originating classifications. Those which in some way modify or restrict a subscriber's capacity to originate a call.

- Terminating classifications. Those which pass back special information to the calling end when a subscriber is to receive a call.

2.3 P.B.X. Group. We saw in the paper "Introduction to Crossbar Switching - Part 1" that on all calls incoming to the subscriber's line stage, a test is made at the P.B.X. equipment to ascertain if the called number is a P.B.X. service. If the number is a P.B.X. service, the P.B.X. equipment selects a free line associated with the particular P.B.X. group and the connection is established to the selected line. The term "auxiliary line" is used to denote a line in a P.B.X. group other than the principal line, which is the one listed in the directory. Since the P.B.X. equipment selects a free auxiliary line as a first choice, the directory number is chosen only when all auxiliary lines are busy, and is the last choice in the group.

No P.B.X. equipment is provided in a telegraph ARM or a telephone ARM exchange.

2.4 Time Supervision. Since the operation of a crossbar exchange is dependent upon the use of common control equipment, it is necessary to ensure that such equipment is not held out of service by mal-operation or fault conditions in the system. To achieve this, a system of time supervision (or time-release) is employed, whereby if a given condition is encountered for a predetermined period, the equipment is released and the calling line placed on "line lock-out". Since the exchange equipment is caused to release by the time supervision feature, similar protection is given against unnecessary holding time on junction and trunk lines.

Time Supervision in Markers. When on any one connecting operation, a marker is unable to find a free outlet within a second or so, the marker is released and the "busy" condition indicated to the caller. If a call occurs when the markers are busy, the call waits until a marker becomes idle; the delay being a fraction of a second and difficult for a subscriber to detect.

Time Supervision in Registers. The holding time of a register is limited to 45 seconds in an ARF exchange from the time of seizure. During this period, all routing information must be received and subsequent equipment switching operations completed, otherwise the line lock-out condition is applied. It is also necessary for the register to be informed of the number of digits in the called number, and where the number length cannot be determined by analysis of the first three or four digits, provision is made for an inter-digital time-out period of four seconds on subsequent digits.

Time Supervision in SR Relay Sets. A time supervision period of 90 seconds is provided in each SR relay set. The timing commences from the instant the connection is established between the two parties, and is disconnected when an "answer" line signal is received.

If an answer signal is not received within 90 seconds, the connection is broken down, and the calling party placed on line lock-out. The time supervision circuit is also put into operation when a "clear back" signal is received but no "clear forward" is received (called party clears, calling party holds).

On calls to step-by-step equipment or manual exchanges, the answer signal is a reversal of line potentials on effective calls to metering services, and since it is not practicable to discriminate between working services and intercepted or other non-metering lines at these exchanges, the time supervision period provided before answer is cancelled. Time supervision is still provided following receipt of a clear back signal when no clear forward signal is received.

2.5 Line Lock-out. When a connection cannot be established due to congestion or "called subscriber busy" conditions, or when time supervision has expired, the line relay of the calling party is forcibly released, the caller connected to busy tone, and the exchange switching equipment released. This is called "line lock-out" and prevents the unnecessary occupation of circuits and switching stages on calls to busy routes or subscribers' lines.

A further feature of the line lock-out facility is in the event of a cable failure causing short circuiting of subscribers' lines (PGs). The connecting equipment in the exchange cannot be blocked out since such circuits, by virtue of the time supervision circuits in the register, are automatically placed on line lock-out.

Normally, a connection is broken down immediately the caller clears, and should the called party continue to hold on after the calling party clears, the line is immediately connected to line lock-out.

2.6 Interception. The interception facility is mainly used to enable incoming calls to certain subscribers to be filtered by an operator and "switched through" or re-directed.

In ARF exchanges, on every incoming call, the subscriber stage marker (SLM) makes a test via a special circuit to a central interception point to check if the called subscriber is "on interception".

If so, the call is automatically re-routed to the interception centre. Subscribers lines connected to the interception facility are divided into categories such as:-

- filtered by operator,
- changed number, and
- vacant lines in fully equipped portions of the exchange.

The interception centre, which can serve a complete closed numbering area, is equipped with a special jackfield in addition to manual and recorded answering facilities. The jackfield contains one jack for each subscriber in the area served, and by inserting a special plug in a jack, the particular line is marked for interception.

2.7 Public Telephones (and Leased Coin Attachments). Existing types of public telephones and leased coin attachments operate satisfactorily with crossbar exchanges.

Multi-coin instruments connected to ARF exchanges can be marked with a classification which causes calls to 011 and 015 to be specially identified to operators, either as a special calling lamp signal or by diversion to a special answering point. Alternatively, tone can be inserted at the trunk exchange and calls combined with the normal queue.

Local call public telephones are grouped with lines classified "local calls only".

Provision is also made for S.T.D. coin telephones, including leased services, to be marked with a distinctive classification, which, while permitting access to the trunk dialling network, causes calls to the standard trunk service codes to be specially identified by operators.

2.8 Nuisance Calls. The main difficulty with the nuisance call is the tracing of its origin. With step-by-step exchanges, this can only be done whilst the connection is held intact from the calling telephone, which usually means maintaining conversation with the offending party.

This method is unsatisfactory, since it is quite often unsuccessful because of the time taken to effect the tracing of a call which may have originated anywhere within a network. The length of time involved is such that an annoying call will probably be terminated long before it is possible to identify its source.

With ARF crossbar exchanges, it is possible to arrange a special connection in the marker equipment of the complaining party so that the clearing of a connection is controlled by the called subscriber. The called subscriber, by leaving the handset off the rest, can then hold any connection back to the originating exchange SL stage equipment, permitting the calling line to be identified. Even though this connection is held, the caller is not prevented from making or receiving further calls and would be unaware that the call could be traced.

When the caller replaces the handset, the clear forward signal starts time supervision in the SR, and when the time supervision period expires, an exchange alarm is given. The Technician can take over the holding of the connection and trace the call.

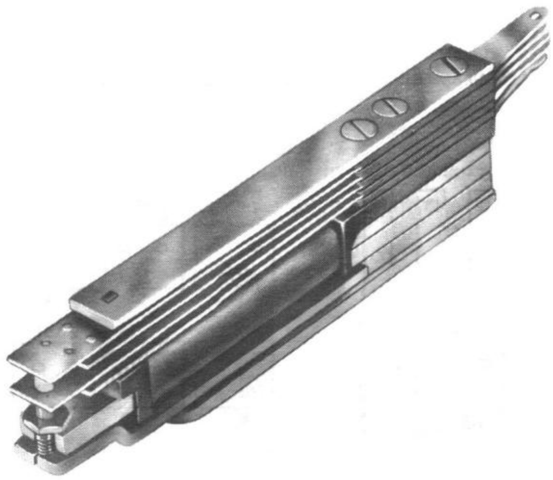
This facility is fully effective only in a wholly crossbar area. Where other types of automatic exchange are involved, it is only practicable to hold the connection as far as the step-by-step junction incoming to the crossbar network.

At ARK exchanges, tracing facilities are not provided, but connection to interception is sufficient to meet requirements in areas served by ARK equipment.

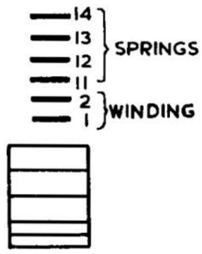
3. RELAYS.

3.1 Miniature Relay. Miniature relays are used in crossbar circuitry where only one springset pile is required. The relay is of such a size that six units can be mounted in the same space as a general purpose relay. A miniature relay can also be mounted on the yoke of a general purpose relay in the place of one springset pile.

A photo of a miniature relay is shown in Fig. 1a and the contact spring and coil tag numbering is shown in Fig. 1b. The circuit symbol is the same as that used for a general purpose relay.



(a) Photo.



(b) Spring and Coil Tag Numbering.
(rear view)

FIG. 1. MINIATURE RELAY.

3.2 Thermal Relay. A thermal relay is used to provide the long supervisory times which are beyond the capacity of slugs on general purpose relays. This relay unit, which consists of a coil wound on a bimetal strip, is the size of a springset and is designed to be mounted in the space normally occupied by the right hand springset of a general purpose relay in a similar manner to that used when mounting a miniature relay.

A thermal relay is usually designated by "T", followed by the designation of the relay on which it is mounted. For example, TK6 is a thermal relay mounted on relay K6.

When current passes through the coil the bimetal strip is heated, causing the two metals to expand at different rates. This bows the bimetal strip and operates the contact unit.

Fig. 2 shows the contact and coil tag numbering of a thermal relay.

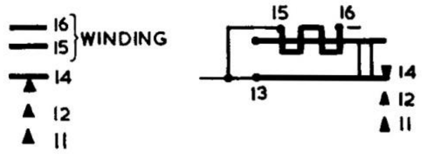


FIG. 2. SPRING AND COIL TAG NUMBERING OF A THERMAL RELAY.

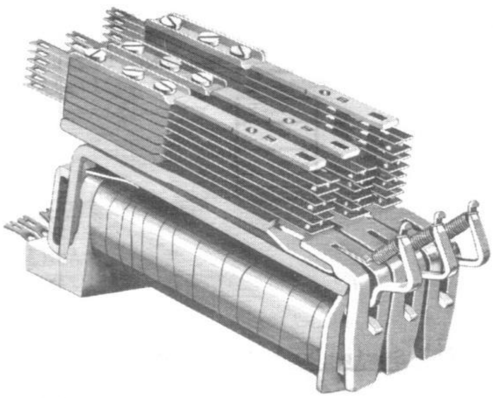
3.3 RAH Relay. A special relay, type RAH, has been developed to obtain a space saving relay where only simple relay functions are required. This relay has three separate coils each with its own springset and armature, the whole being mounted on a common yoke.

The springsets used are the same type as those used on relay type RAF, and the complete RAH relay with its three coils occupies the same space as the RAF relay.

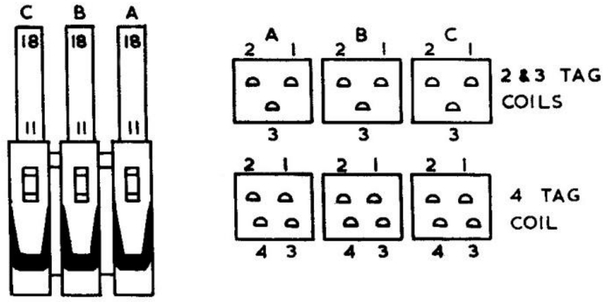
Generally it can be said that relay RAH is used when up to 8 contact springs are sufficient, and when the requirements are simple.

The main use of relay RAH is in the line circuits in ARB and ARK systems. However, RAH relays are also used in relay sets of other systems.

Fig. 3a shows a photo of an RAH type relay and Fig. 3b shows the contact spring and coil tag numbering.



(a) Photo.



(Front View) (Rear View)

(b) Contact spring and coil tag numbering.

FIG. 3. RAH TYPE RELAY.

3.4 Reed Relay. Fig. 4 shows the basic construction and magnetic circuit of a reed relay. The relay consists of two "reeds" of magnetic material, (these form the contact springs), enclosed in a gas filled glass tube around which is wound the relay coil. The ends of the "reeds" are plated with the contact material. When the relay is energised, the magnetic field produced causes attraction of the reeds and the making of the contact.

One or more reed relays are enclosed in a magnetic shield and mounted on a component board employing the printed circuit technique. The component board plugs into a special jack in a relay set.

Typical uses of the reed relay are as a dial pulse receiving relay, and as a signal receive relay in code receiving equipment.

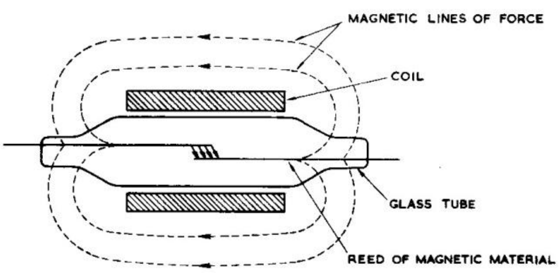


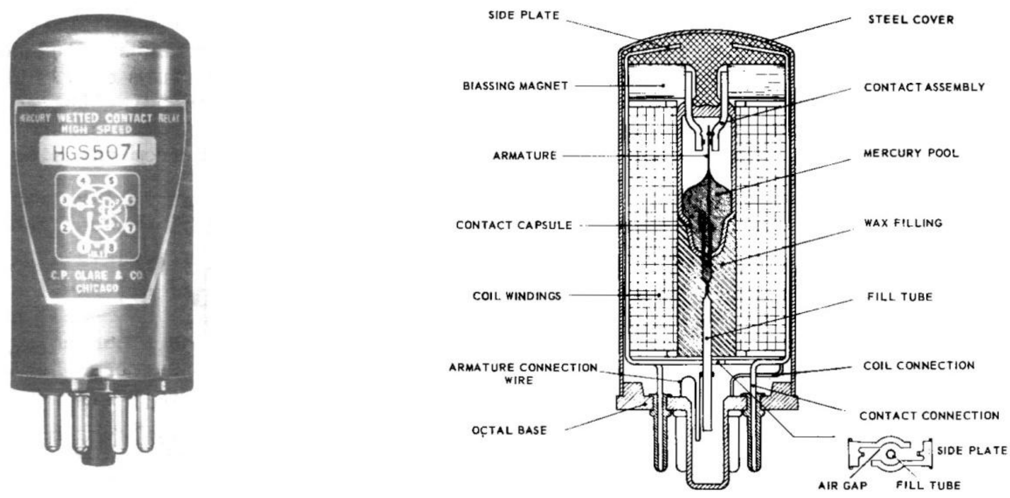
FIG. 4. REED RELAY.

3.5 Clare Relay. The Clare relay is a polarised relay with mercury-wetted contacts, and is used where fast switching and high sensitivity are required. Several types of Clare relays are available with different coil windings and contact arrangements; the type described in this paragraph is type HGS5071, which is an each-side-stable polarised relay used for telegraph signalling. Other types of Clare relays are similar to type HGS5071 in construction and operation.

Compared with other types of relays, the Clare relay has the following features:-

- Mercury-wetted contacts. A major source of trouble in conventional relays is arcing (bridging), with subsequent wearing of contacts and the necessity to clean and re-adjust. The Clare relay features mercury-wetted contacts which are non-bridging and free from contact bounce.
- No maintenance is required. The design does not permit contact adjustment, and correction of circuit failure due to a faulty relay can be made only by replacement. The apparent disadvantage of this is cancelled by the reliability of the relay.

Fig. 5 shows a general purpose, each-side-stable type HGS5071 Clare relay.



(a) (b)

FIG. 5. CLARE RELAY.

Construction. Fig. 5 shows the construction details.

- Armature. The armature is looped into and soldered to the Fill Tube (Fig. 5b), which is connected to a pin of the octal socket with a connecting wire soldered to the tube. The armature reed is positioned in the narrow gap between the two fixed contacts, with its lower end immersed in a mercury pool. A film of mercury is carried up the reed by capillary action to the contact area to form the armature contacting surface, no contacts being attached to the armature itself. The armature reed is made of magnetic material.
- Contact Assembly. The contact assembly consists of the contact mounting pieces (pole-pieces), which extend outside the capsule, and the contacts. Three contacts are mounted horizontally across each pole-piece. Contacts are platinum, 0.012" diameter, spherical shape, slightly flattened, and welded to the pole pieces.
- Glass Capsule. The glass capsule has the required amount of mercury inserted and is filled with hydrogen via the Fill Tube, which is then crimped and sealed with solder. The hydrogen removes oxide films from the parts so that they readily "wet" with mercury. Because it is a good conductor of heat, the hydrogen gas also cools the contact region.

- Bias Magnets. The polarising magnets are soldered to the pole-piece extensions outside the capsule, and connection is made to the pins of the octal socket by means of the side plates (Fig. 5b), the upper sections of which also form part of the permanent magnetic circuit.
- Coils. The relay has two coils, each of 135 ohm resistance, 0.15H inductance, 3,400 turns, and a sensitivity of 22 ampere turns. A minimum energisation 60 ampere turns is recommended in circuit application.
- The relay capsule is enclosed by the coil, and coil and contact connections are brought out to a standard octal type base. The entire relay is enclosed in a metal container potted with wax. No external arrangements are provided for relay bias elimination.
- Mechanical Features. Physical dimensions are:-

  Diameter 1.2 inches.

  Height (Overall) 3.3 inches.

  Height (above socket) 2.64 inches.

  Because of the mercury pool in the contact capsule, Clare relays must be mounted base down within 30 degrees of vertical.

Operation. The contact assembly, bias magnets and upper portions only of the side plates, form the permanent magnet circuit. The electromagnet flux does not traverse the permanent magnet flux circuit, and affects the armature only. The coil flux responds to changes of polarity of the input signal, changing the polarity of magnetisation of the armature. The armature is moved from a contact by magnetic repulsion. The air gap insulates the armature circuit from the side plate connections to the contacts.

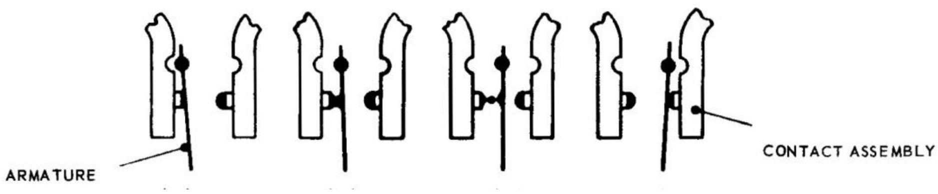


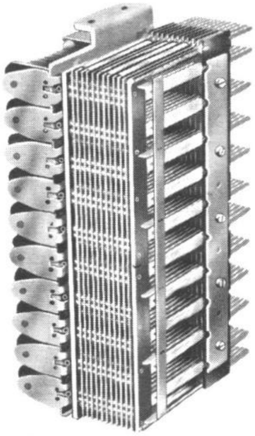
FIG. 6. MERCURY-WETTED CONTACT ACTION.

The mercury-wetted contact action is shown in Fig. 6. With the armature reed resting against one of the side contacts, a small pool of mercury is formed around the fixed contact and the section of the armature resting against it (Fig. 6a). When the armature is driven away from the contact, the mercury pool becomes elongated (Fig. 6b) and finally ruptures, breaking the circuit very quickly and preventing the formation of arcs. The mercury does not break in the middle, but at two points so that a globule of mercury is isolated (Fig. 6c). This globule is not lost, but is attracted either to the armature or to one side contact. More mercury is fed up the armature by capillary action to replenish the mercury pool on the depleted contact.

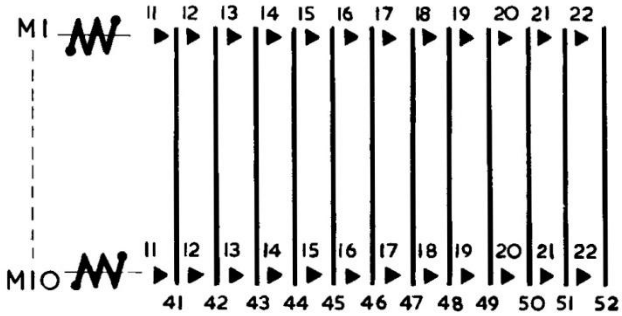
Contact bounce may occur due to mechanical shock, but because of the ability of the mercury to bridge the two mating surfaces during the bounce period, there is no break in the output circuit. Fig. 7 shows the contact, winding, and socket connections of a typical Clare relay.

FIG. 7. WINDING AND SOCKET CONNECTIONS.

3.6 Multicoil Relay (RAM). This relay (Fig. 8) is used to save space and simplify wiring when the multipling of contacts over many relays is required, as in the provision of bypath circuits.



(a) Photo



(b) Spring and Contact Strip numbering.

Fig. 8. MULTICOIL RELAY.

The multicoil relay consists of a contact field of ten springsets under the control of ten armatures and relay coils, all mounted on a common yoke.

The contact field consists of a number of twin contacts of the make type. The fixed contacts are made in the form of thin silver contact strips mounted on strips of insulation, each contact strip being common to all sections of the relay. The contact strips are numbered 41 to 52 from the armature end. The movable springs are individual and under the control of the associated armature. Each springset consists of a maximum of twelve contact units, and number from 11 to 22 from the armature end.

The common contact strips are provided with soldering tags at both ends, so that when necessary the strips can be divided into two completely separate units each with five springsets. To facilitate the division, a small gap is left in the centre of the insulation strip on which the contact strip is mounted. When a multicoil relay is divided into two sections, the contact strips of one section are numbered 41-52 and the other section 61-72. The combination of common contact strips and individually operated units is shown in Fig. 9. The springs associated with the second armature are shown operated.

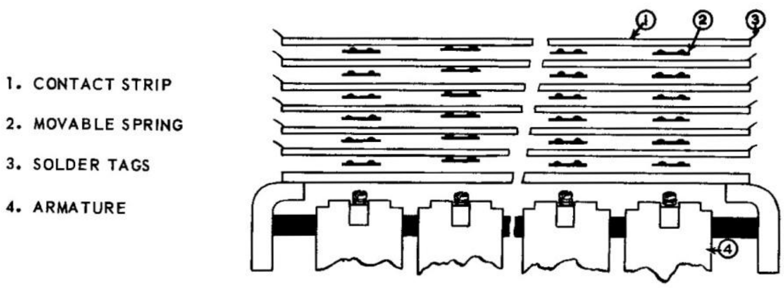


FIG. 9. CONTACT ARRANGMENT - MULTICOIL RELAY.

4. CROSSBAR SWITCH MULTIPLING.

4.1 Multipling of Outlets. We saw in the paper "Introduction to Crossbar Switching - Part 1" that by providing additional horizontal springsets (HA and HB) and an associated selecting bar, the outlet capacity of a vertical unit can be increased from 10 to 20 outlets.

One crossbar switch consisting of ten 20-outlet vertical units has an outlet capacity of 200 outlets. When other switches are required to have access to the same 200 outlets, each vertical unit is multipled as shown in Fig. 10.

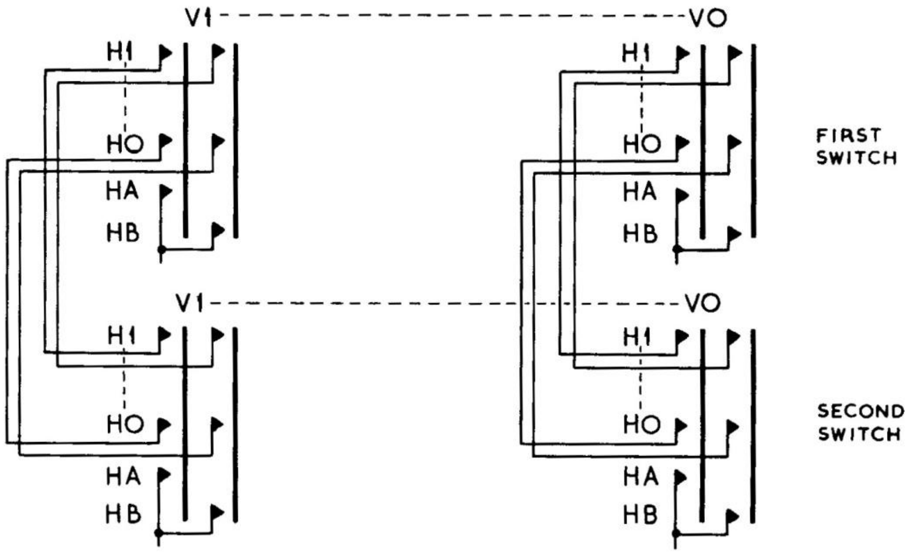


FIG. 10. MULTIPLING BETWEEN 200-OUTLET SWITCHES.

When only 20 outlets are required from a switch, the horizontal springsets of the first vertical unit are multipled to the corresponding horizontal springsets of the second vertical unit (Fig. 11), and extended to the same horizontal springsets of other vertical units. In this way, the 10 inlets of the switch have access to the same 20 outlets. The multipling can be continued over all of the verticals of another switch thus providing 20 inlets with access to any one of the 20 outlets.

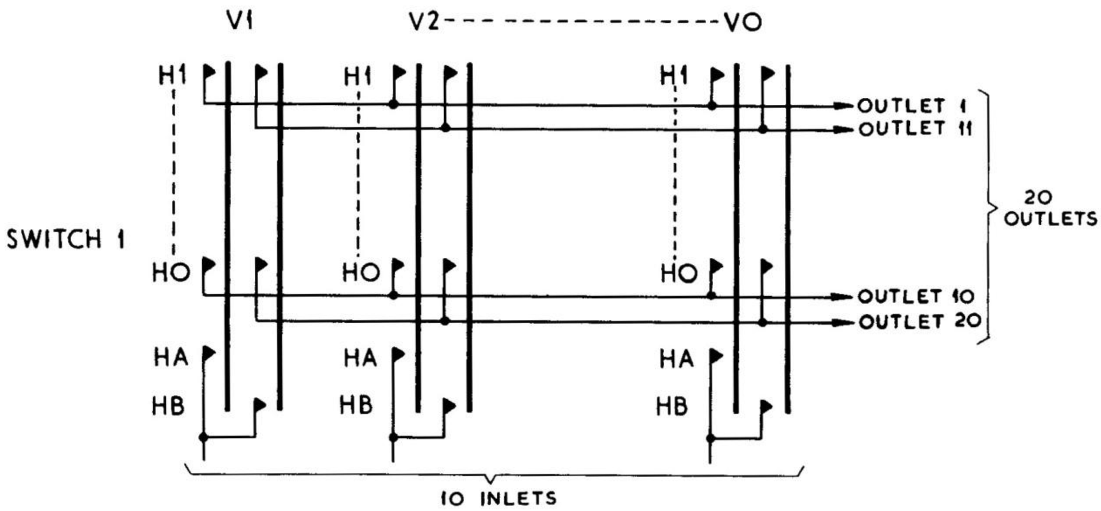


FIG. 11. MULTIPLING WITHIN A SWITCH.

4.2 Multipling of Inlets. In some instances of internal trunking, the inlets to vertical units are multipied.

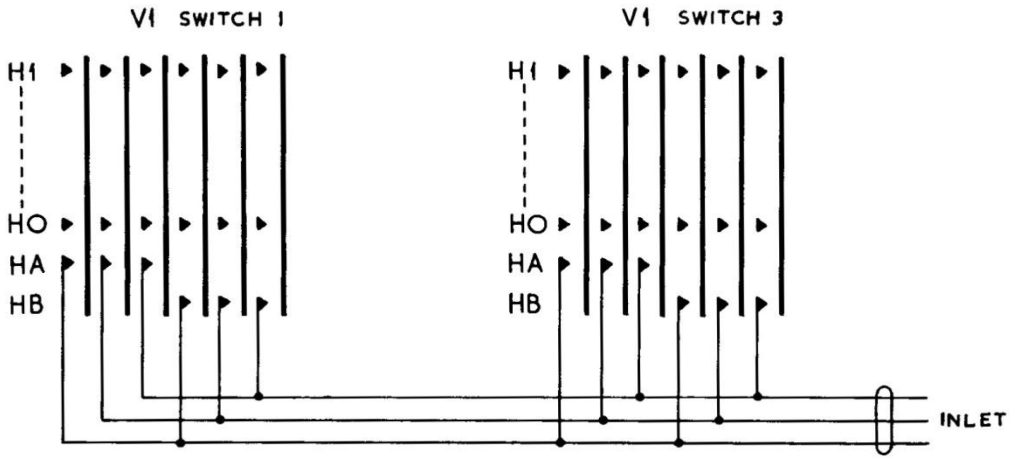


FIG. 12. MULTIPLING OF INLETS - ONE INLET~ 40 OUTLETS.

In the example shown in Fig. 12, one inlet is multipled to vertical 1 on two different switches, so that the inlet has access to 40 outlets (20 outlets from each vertical). This type of multipling is used in some switches in ARB exchanges.

Another example of multipling of inlets is shown in Fig. 13.

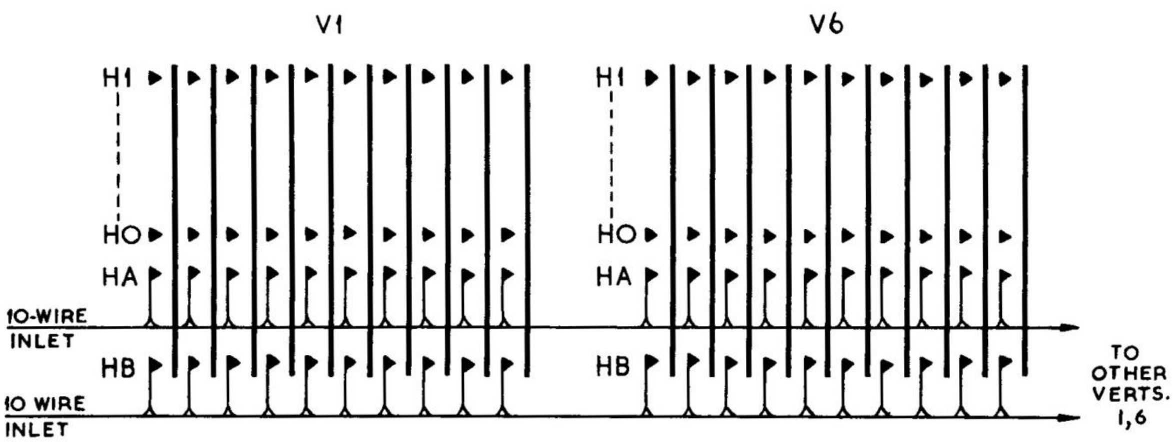


FIG. 13. MULTIPLING OF INLETS - TWO INLETS, 20 OUTLETS.

The 10-wire inlet terminating on the HA springset of vertical 1 is multipled to the HA springset of vertical 6 and extended to verticals 1 and 6 of another crossbar switch. The HB springsets are multipled in the same manner.

With the verticals multipled in this manner, any one of the two inlets, which are multipled over four verticals, can be connected to any one of 20 outlets. This type of multipling is used in the register finder stage in ARF exchanges.

5. GROUPING PLANS - MULTIPLING.

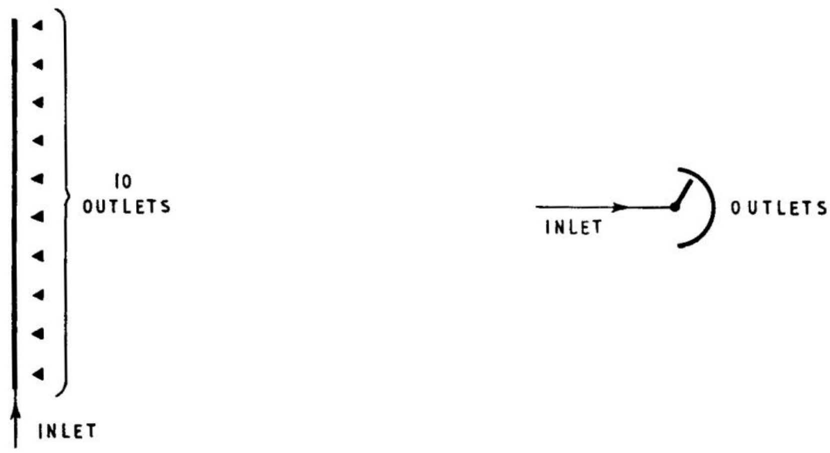
5.1 In crossbar grouping plans, which are a special type of trunking diagram designed to show the connections between partial switching stages, special grouping plan symbols are used. Fig. 14a represents a crossbar vertical, with the number of the vertical shown inside the circle and the line connected to the circle pointing to the available outlets. These are often represented by a circle, with the number of the outlet shown beside the symbol (Fig. 14b). As the vertical symbol resembles a chicken's head it is often referred to as a "chicken" symbol, while the grouping plans containing these symbols are referred to as "chicken" diagrams.

(a) (b)

FIG. 14. VERTICAL AND OUTLET SYMBOL.

5.2 In grouping plans, chicken symbols are arranged in varying group combinations according to the type of exchange and the switching stage concerned. Therefore, in the maintenance of crossbar exchanges, it is essential to understand the meaning of these symbols in the grouping plans.

5.3 Figs. 15a and 15b show common methods of representing a crossbar vertical having 10 outlets. Fig. 15a is the mechanical symbol of the vertical, and Fig. 15b is the standard trunking symbol.



(a) (b)

FIG. 15. SYMBOLS OF A 20-OUTLET CROSSBAR VERTICAL.

5.4 In Fig. 16a the same vertical is represented using the chicken symbol, showing that vertical 1 has access to 10 outlets. Fig. 16b shows a method of simplifying the drawing. Where a number of outlets are available from the same vertical, only the first and last outlets need to be drawn, the intermediate ones being shown by a broken line.

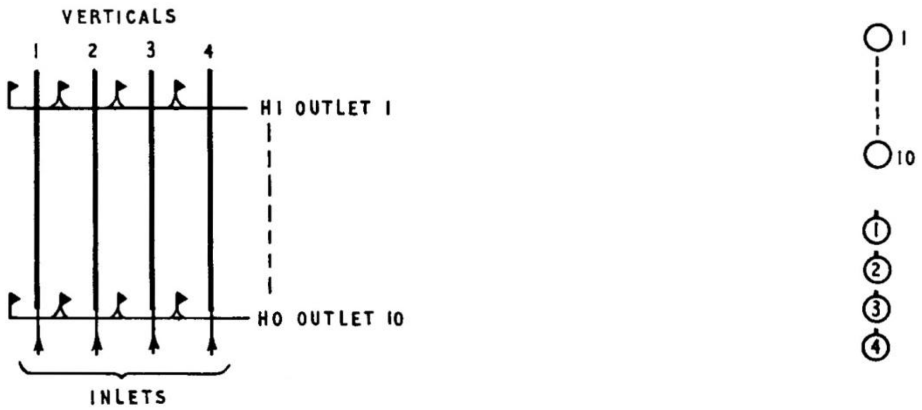
(a) (b)

FIG. 16. CHICKEN SYMBOL OF 10 OUTLET VERTICAL.

5.5 In many of the practical applications of the grouping plan, two or more verticals have access to the same group of outlets. To illustrate this condition using chicken symbols, the symbols representing the verticals are placed so that their "beaks" point in a line towards the group of common outlets. Fig. 17 shows a condition in which either of two verticals may be switched to any of ten outlets.

FIG. 17. TWO VERTICALS WITH ACCESS TO THE SAME 10 OUTLETS.

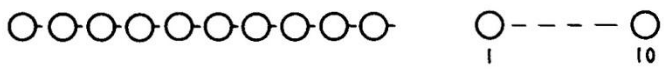
5.6 To give a number of verticals access to the same group of outlets, the outlets are commoned together with a multiple wiring form. For example, when four verticals are to be given access to the same outlets, the outlets are commoned together as shown in Fig. 18a. The 1st horizontal springset on the 1st vertical is connected to the 1st horizontal springset on each of the other verticals. The other horizontal springsets are multipled in a similar manner. Fig. 18b shows the equivalent chicken diagram.



(a) (b)

FIG. 18. VERTICALS WITH ACCESS TO COMMON OUTLETS.

5.7 In Fig. 19a, ten verticals all have access to the same ten outlets. This diagram is simplified in Fig. 19b by showing the first and last verticals and connecting them with a broken line.



(a)

(b)

FIG. 19. TEN VERTICALS WITH COMMON OUTLETS.

5.8 When all the verticals shown are part of the same crossbar switch, the chicken symbols are enclosed in a rectangle (Fig. 20). As before, the number enclosed within the symbol indicates the number of the vertical on the switch.

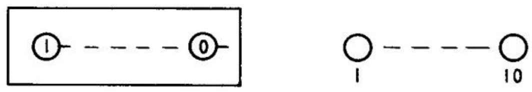
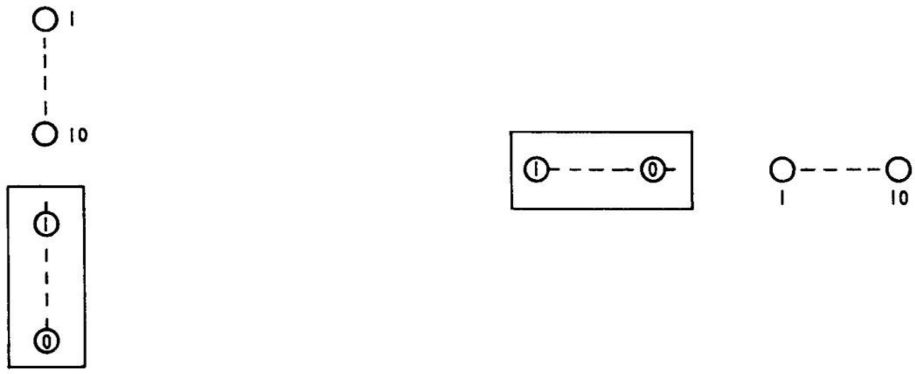


FIG. 20. VERTICALS IN THE SAME SWITCH WITH ACCESS TO THE SAME 10 OUTLETS.

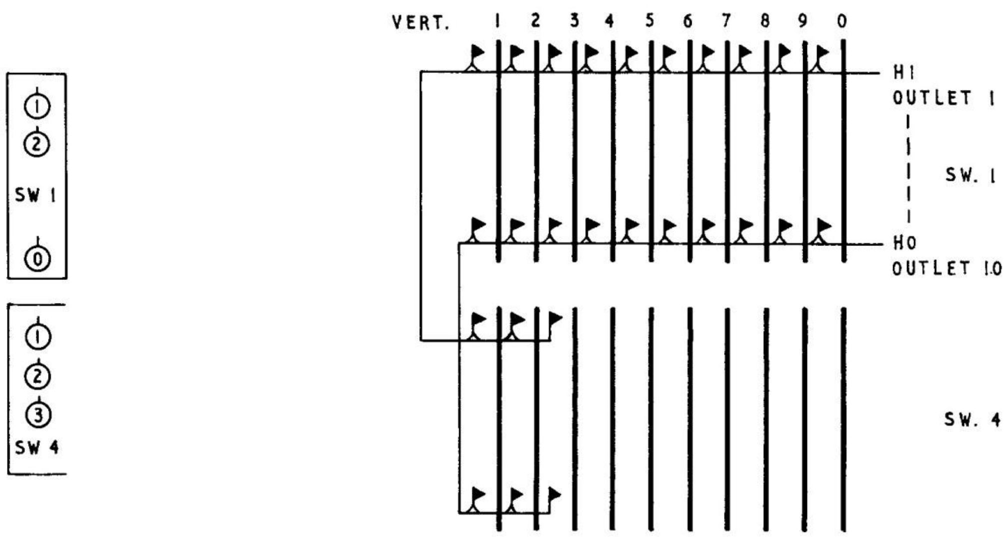
5.9 It is important to understand that the symbols can be shown either vertically or horizontally and still have the same meaning. For example Figs. 21a and 21b both indicate that the ten verticals of one crossbar switch all have access to the outlets shown.



(a) (b)

FIG. 21. ALTERNATIVE METHODS OF USE OF SYMBOLS.

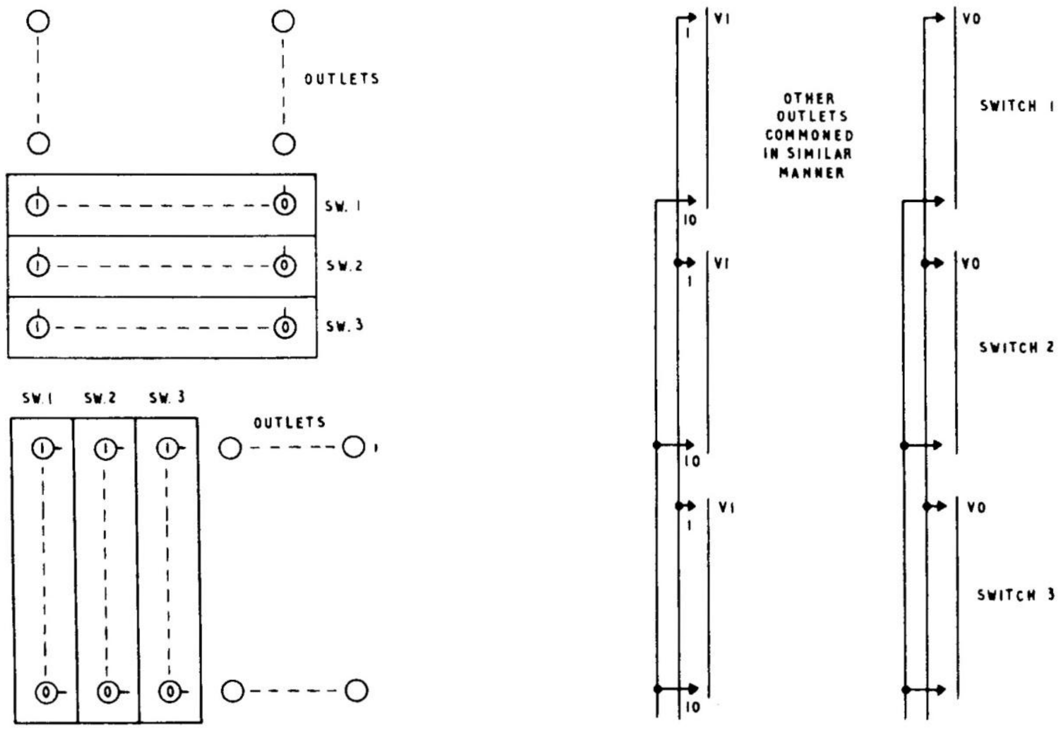
5.10 Fig. 22a indicates that ten verticals on one switch and three verticals on another switch all have access to the same outlets. Fig. 22b shows the commoning on the verticals.



(a) (b)

FIG. 22. MULTIPLE BETWEEN SWITCHES.

5.11 Fig. 23a shows another alternative arrangement of chicken symbols. Each rectangle indicates that the verticals enclosed within that rectangle all belong to the same switch. The direction of the "beaks" indicates that vertical 1 in switch 1 has access to the same outlets as vertical 1 in switches 2 and 3. The outlets from other verticals would be multipled in the same manner (Fig. 23b).



(a) Symbols indicating multiplying between switches.

(b) Method of commoning.

FIG. 23. MULTIPLING BETWEEN SWITCHES.

As in Fig. 21, the switch vertical symbols can be shown either vertically or horizontally so that both illustrations in Fig. 23a have the same meaning.

5.12 It is possible to summarise these examples under two rules:-

(i) When the vertical symbols are all enclosed in a rectangle and the beaks point in the same line, all the verticals in that switch have access to the same outlets. The horizontal springsets on vertical 1 are multipled to the same numbered springsets on each of the other verticals.

(ii) When vertical 1 in one rectangle points in the same line as vertical 1 in other rectangles, these verticals have access to the same outlets. The horizontal springsets on vertical 1 in switch 1 are multipled to the same numbered horizontal springs on vertical 1 in each of the switches.

Other springsets on each vertical are multipled in a similar manner.

6. LINK TRUNKING.

6.1 The term "trunking" is used to describe the interconnecting arrangements between various switching stages within an exchange or between exchanges. The interconnecting circuits (trunks) can be arranged in a variety of ways, but two basic methods are generally adopted:-

- Direct trunking, in which the outlets from one switching stage connect direct to the inlets of the following stages; for example the outlets from the GV stage are trunked direct to the inlets of the SL stage.

- Link trunking, in which the connection between the inlets and outlets of a particular switching stage is via an intermediate switching device. The switching stage is divided into two or more partial stages connected in tandem, the connections between the partial stages are known as "links" or "link connections".

6.2 By connecting switches in tandem, the number of outlets available to a particular inlet is considerably increased. For example, Fig. 24 shows that when the 20 outlets of the vertical unit of the A partial stage are connected to 20 inlets of the B partial stage, and each vertical unit in the B partial stage has 20 outlets, the capacity of the switching stage is such that the one inlet to the switching stage has access to any one of 400 outlets, twenty times the capacity compared with one vertical unit for a switching stage.

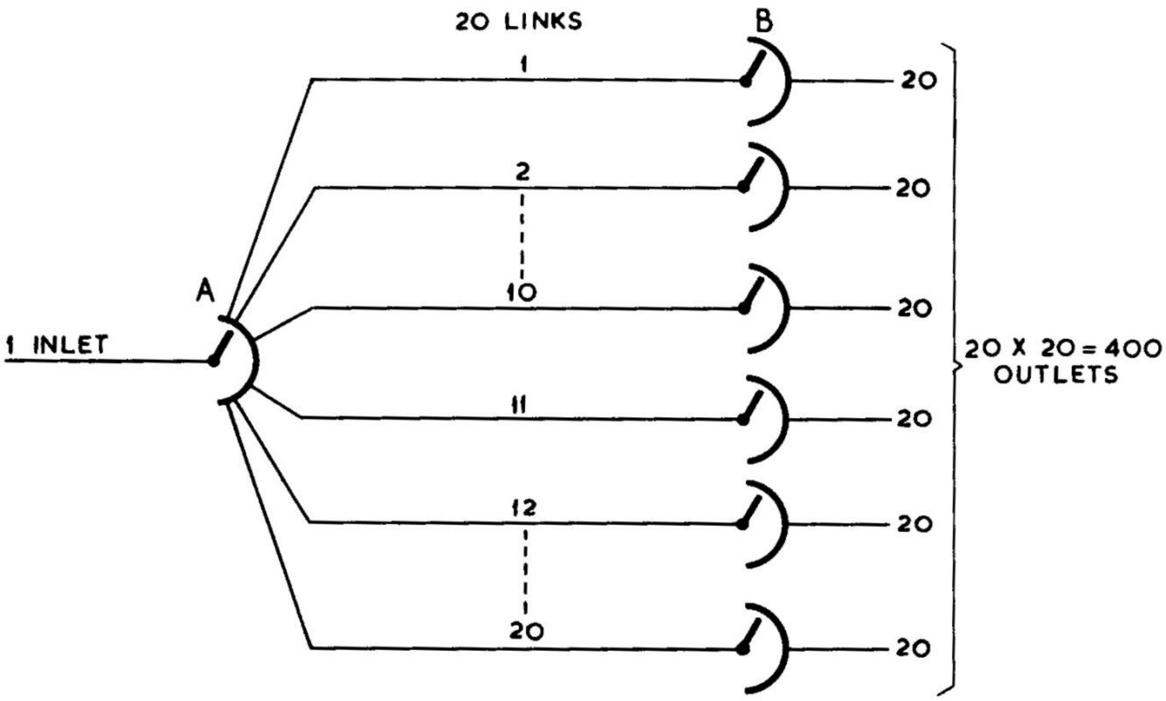


FIG. 24. TWO PARTIAL STAGES - ONE INLET, 400 OUTLETS.

Fig. 24 also shows that for a connection through the switching stage, only one of the associated B stage verticals is occupied, the other nineteen are idle and cannot be used.

6.3 By providing more inlets, and allowing these inlets access to the same B stage verticals, the number of idle B verticals is reduced. Fig. 25 shows 10 A stage verticals having access to 20 B stage verticals via 20 links, and that any one inlet has access to any one of the 400 outlets.

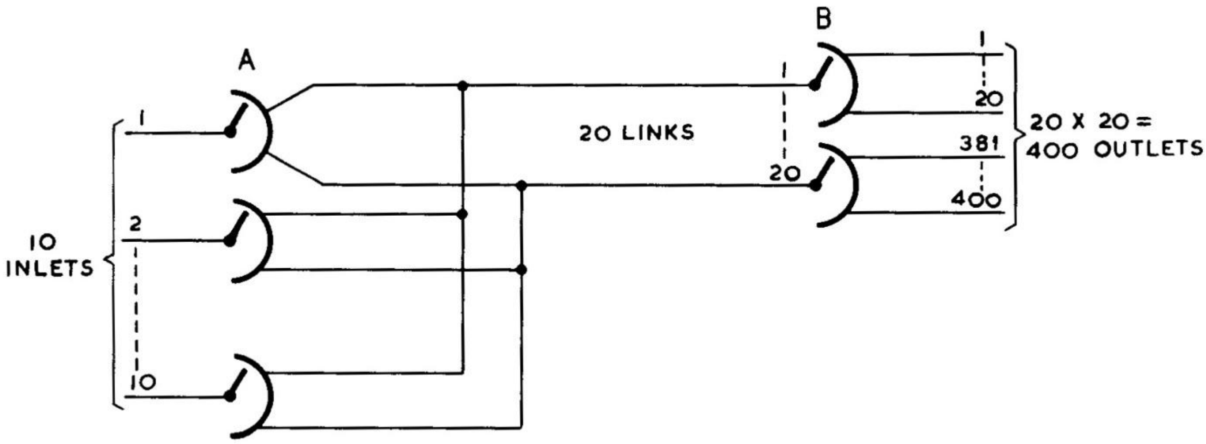


FIG. 25. TWO PARTIAL STAGES - 10 INLETS, 400 OUTLETS.

The example of link trunking shown in Fig. 25 is used frequently in the various switching stages, where the 20 outlets (links) from one or more A stage switches are connected to 20 verticals (two switches) of the B partial stage; HA switches to links 1-10, and HB switches to links 11-20.

6.4 With this arrangement of link trunking, it is not possible in all cases to reach all outlets. For example, when vertical 1 in the A partial stage (Fig. 25) is connected to outlet 1, the path must be via vertical 1 of the B partial stage, as this vertical provides the only connection to outlets 1-20. A connection to any one of the idle outlets 2-20 from any one of the inlets 2-10 is not possible, as vertical 1 in the B partial stage is occupied on a call to outlet 1. This condition is known as "internal congestion". In link trunked systems the number of verticals in the various stages is so balanced to keep the congestion within specified limits.

6.5 With partial stage arrangements, internal congestion is kept to a low value by various methods. One method adopted is known as conditional selection, that is, if a connection is required with a particular route, there must be a free line in the route. There must also be free links with access to the free lines in the route and these links must be accessible from the inlet. This conditional selection is controlled by the common equipment (marker) which also controls the switches of the switching stage. This equipment first marks all free paths between the calling line and free outlets, chooses one of them and sets the switches to this path.

6.6 The foregoing is a simplification of a complex subject, but suffices to indicate the principles involved. To summarise, link trunking can be defined as a split or partial stage arrangement between inlets and outlets, the switches being grouped into at least two partial stages.

7. GROUPING PLANS – TWO PARTIAL STAGES.

7.1 When two partial stages are combined, the outlets from one partial stage are connected to the inlets of the next partial stage (Fig. 26).

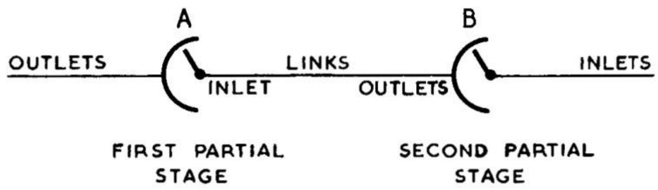


FIG. 26. TRUNKING DIAGRAM TWO PARTIAL STAGES.

7.2 When representing two such partial stages on a grouping plan, the circle symbol indicating the outlets is not used. Instead, the verticals of one partial stage now point towards the verticals of the other partial stage (Fig. 27).

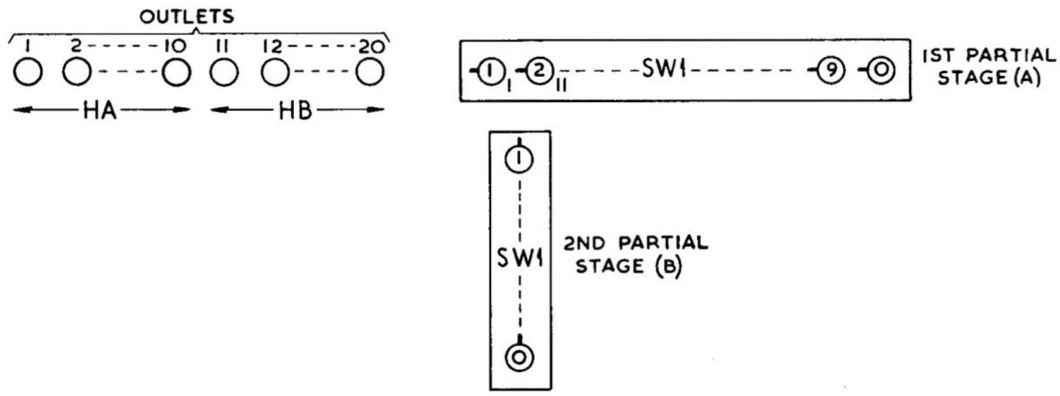


FIG. 27. SECTION OF GROUPING PLAN TWO PARTIAL STAGES.

The number of the vertical is included in the usual manner inside the symbol, while the figure placed adjacent to it represents the number of the link from the previous partial stage which is connected to that vertical.

For example, link number 1 from any one of the verticals 1-0 of the switch in the B partial stage is terminated on vertical 1 of the switch in the A partial stage, and link 11 terminates on vertical 2. The remaining links (2, 12, 3, 13, ... 10, 20) terminate on verticals 1 and 2 of other A partial stage switches as shown in Fig. 28, which is a section of the grouping plan for an ARM20 exchange.

To switch to an outlet via the two partial stages, it is necessary to operate two horizontals in each switch. Assume for example that it is required to switch vertical 1 of B stage switch 1, to outlet 1 via link 1. To connect to outlet 1 from the A stage switch, HA and H1 would operate, and in the B stage switch, HA and H1 operate to select link 1 between the two partial stages. The operation of vertical 1 in both switches connects the outlet through both partial stages.

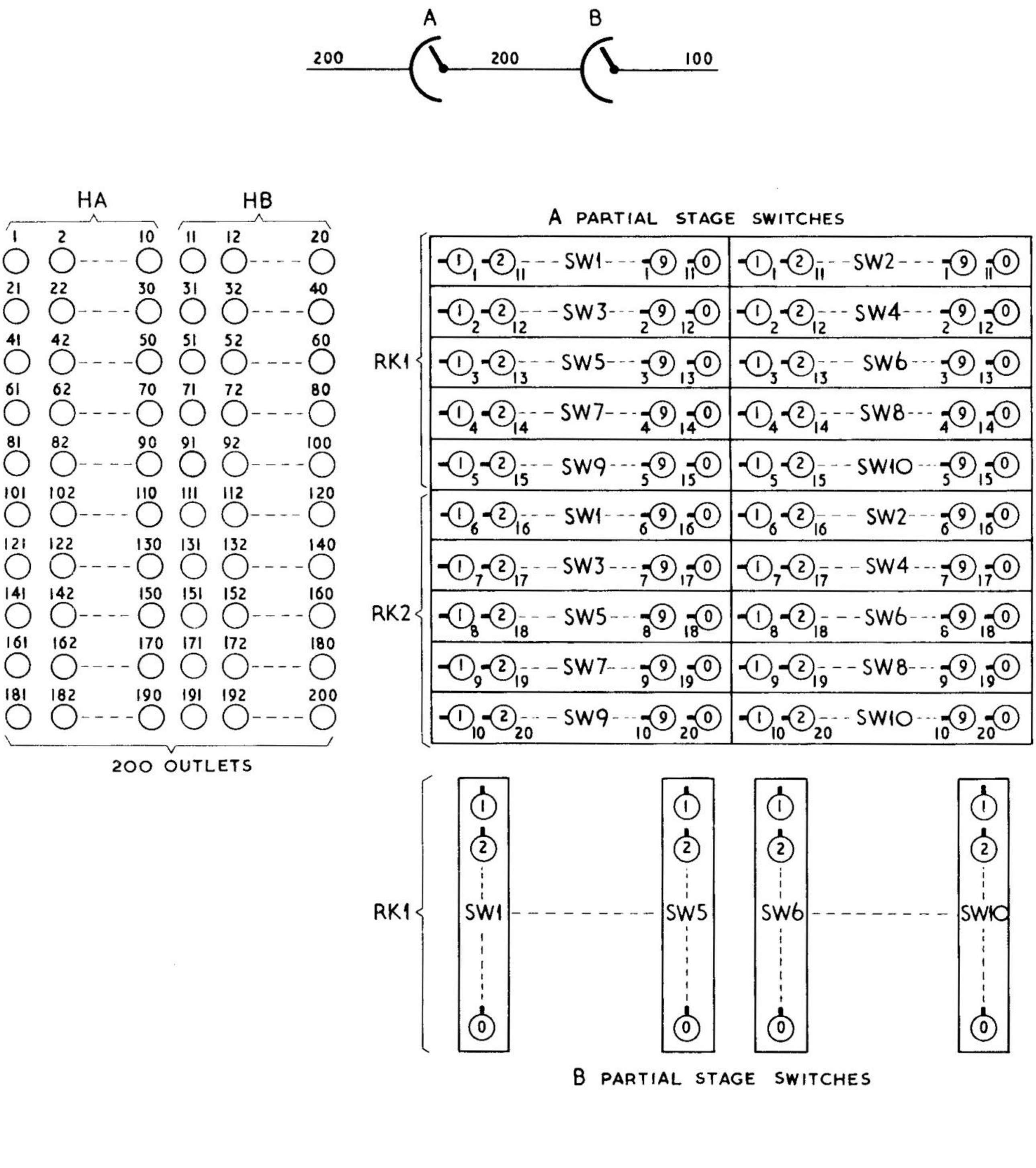


FIG. 28. SECTION OF ARM20 GROUPING PLAN - TWO PARTIAL STAGES.

8. TYPES OF CIRCUIT DRAWING.

8.1 The types of L.M.E. circuit diagrams continually encountered on exchange installation and maintenance are:-

(i) Block diagrams.
(ii) Trunking diagrams.
(iii) Circuit diagrams.
(iv) Survey diagrams.

8.2 Block Diagrams. This type of diagram is used to indicate the relationship between groups of apparatus. Each group usually represents apparatus concerned with a particular function and is shown by a rectangular block. The connections between blocks of equipment are shown by single lines which are sometimes marked with arrows to indicate the direction in which the operation is proceeding. Fig. 29 shows a diagram representing functional groups of equipment forming a GV marker.

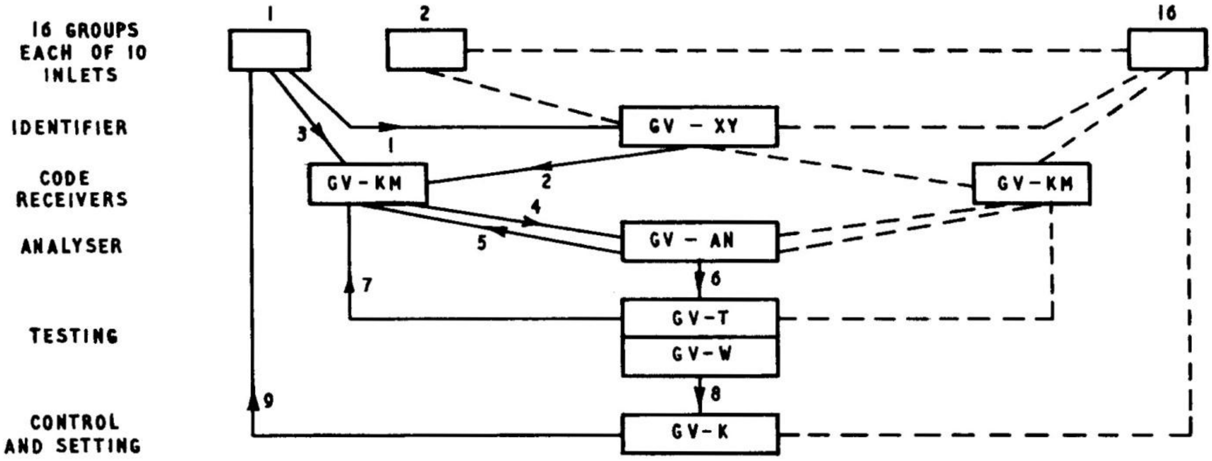


FIG. 29. BLOCK DIAGRAM OF A GV STAGE.

Although there are 16 groups of inlets, only the first two groups and the last group are shown. A dotted line extending from group 2 to group 16 means that there are other similar groups connected in the same way. However, the other dotted lines in the block diagram have a different meaning. Where one group of common equipment (GV-XY in Fig. 29) has access to a number of other groups, a full line is drawn showing one connection, and dotted lines are used to indicate the other possible connections.

In Fig. 29, each block represents a relay set designed to perform a particular function. It should be noted, however, that in many block diagrams, particularly those of the SL marker, the functional group of relays shown in one block may in actual practice be divided over several relay sets.

Fig. 30 shows section of a block diagram in which relay and switch symbols have been inserted. In the case of the relay coil and contact symbols, they represent a number of relays performing a particular function, and have been included to distinguish between the operating and switching paths. These types of diagrams are generally referred to as functional block diagrams.

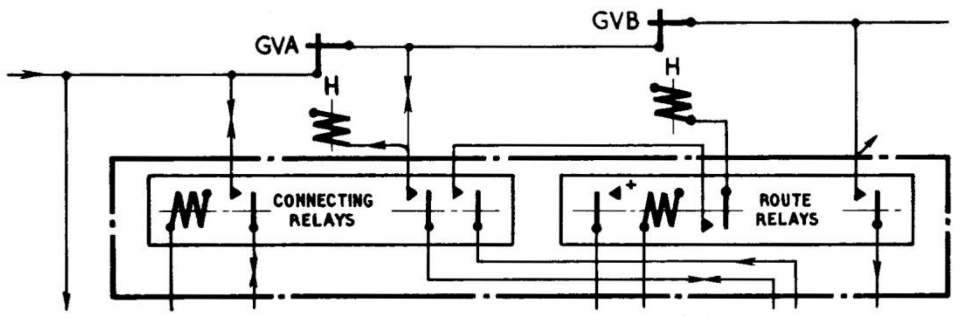


FIG. 30. USE OF SYMBOLS IN A BLOCK DIAGRAM.

8.3 Trunking Diagrams. This type of diagram is used to indicate the relationship between switching stages or partial switching stages in an automatic crossbar exchange. Each stage or partial stage is represented by a switch symbol, and the connection between succeeding stages is shown by a single line, except where one partial stage is connected to several different types of equipment. Fig. 31 shows a typical trunking diagram of a crossbar exchange. Intermediate frames and marker control sets are not usually shown in this type of diagram, but may be included where it is desired to illustrate some particular point. Each relay set in the switching path is represented by a rectangle enclosing the relevant designation.

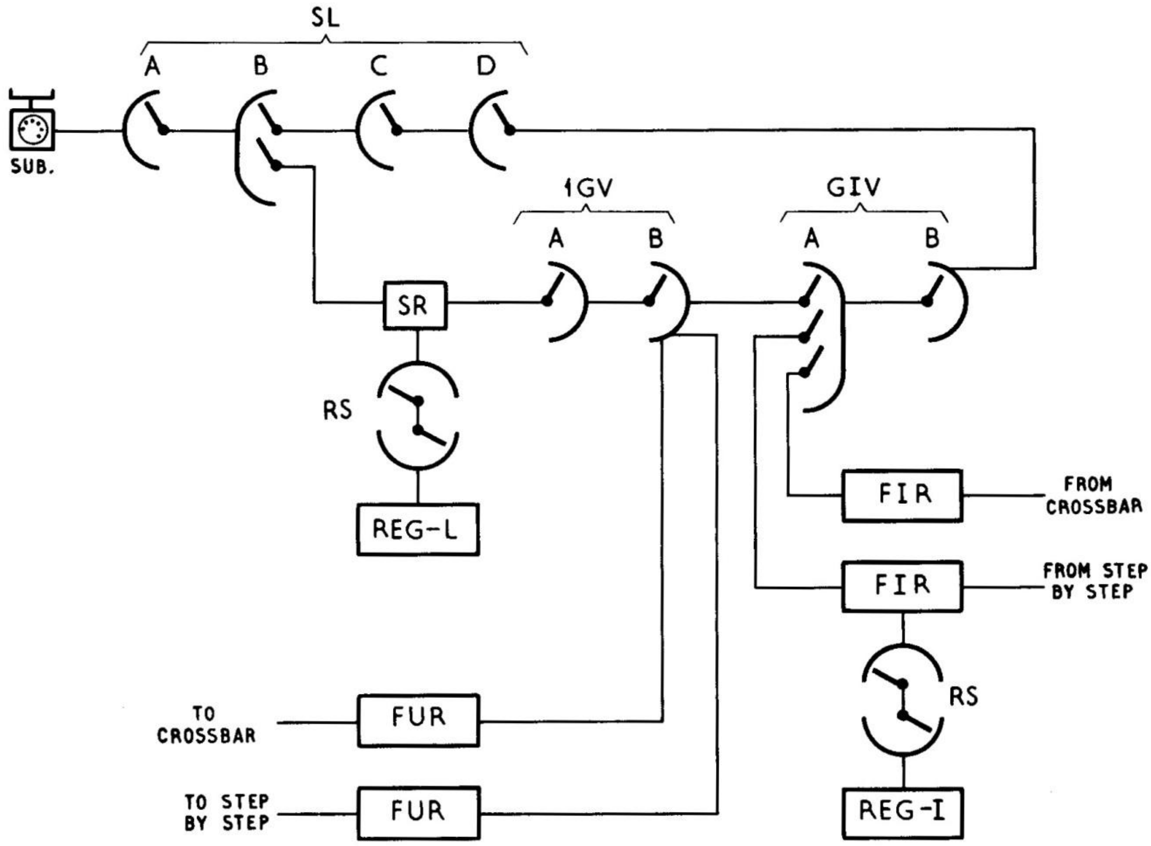


FIG. 31. TYPICAL TRUNKING DIAGRAM.

The three types of symbols used in Fig. 32 are used throughout crossbar trunking diagrams and must be understood. Where several verticals from one partial stage are connected to different types of apparatus, the usual switch or partial stage symbol (Fig. 32a) is varied to show additional verticals (Fig. 32b). The two arcs of the register finder symbol (Fig. 32c) represent the normal horizontal springsets connected to SR or FIR relay sets and the HA and HB springsets which are wired to registers.

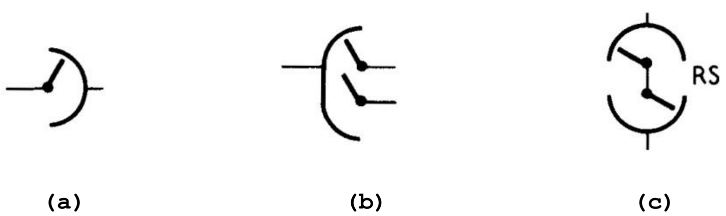


FIG. 32. TRUNKING SYMBOLS.

8.4 Circuit Diagram. These diagrams are divided into two groups:-

(i) A circuit diagram referring to one unit group of equipment such as a relay set or rack. On such a diagram, the boundary line indicating the limits of the separate unit consists of alternate heavy dashes and dots. Within the boundary line, full information is provided regarding the connections between circuit elements assembled on that particular relay set or rack, but only a limited amount of information is provided relating to other interconnected groups of equipment.

(ii) A special circuit diagram designed to give more detailed information concerning only the connections between circuit elements in a particular circuit function.

Fig. 33 shows how the area beyond the boundary in a circuit diagram of type (i) is divided into sections. The designation shown in each section is the designation given to one of the special "functional" circuit diagrams which gives further information relating to the connections between the relay set and other associated elements.

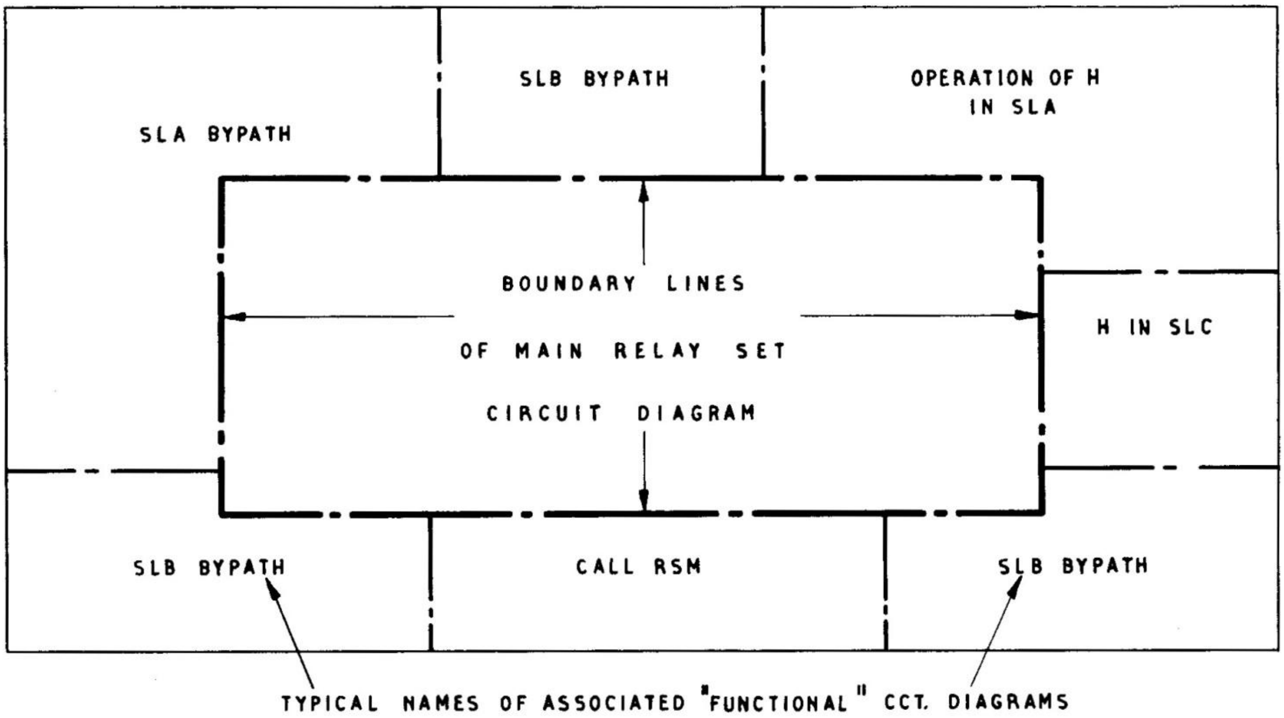


FIG. 33. RELATIONSHIP BETWEEN TYPES OF CIRCUIT DIAGRAM.

8.5 Survey Diagrams. The normal crossbar circuit usually refers to a specific item of equipment such as a relay set, register, or a rack.

A special "survey" diagram has been evolved to allow an overall appreciation of a complete stage or phase. These circuits do not supply interconnection details between relay sets, nor do they contain the complete circuit detail, but consist of various circuits combined, simplified and abbreviated to supply just sufficient information to understand the fundamental operation of that stage or phase.

Further information regarding circuit diagrams and survey diagrams, together with examples of circuit techniques, is given in the next section.

9. CIRCUIT TECHNIQUES.

9.1 Some of the techniques used in crossbar circuitry differ in technical and non-technical aspects from those used in A.P.O. standard drafting procedure. The more important technical differences are:-

- The use of a semi-attached method of relay and contact representation;
- the representation of a number of wires by a single line and numbers placed beside each branching point;
- the procedure of showing wires connected to each end of moving spring symbols;
- the method of showing plug and jack or terminal block tag numbers where wires enter or leave relay sets;
- the use of + and - symbols to indicate positive and negative battery connections;
- the method of indicating parallel connections to other identical circuits;
- the procedure of showing only the first two and the last relay where a number of relays are connected to identical circuits.

9.2 On circuit diagrams, the relays and their associated contacts are shown semi-attached; relay contacts are shown linked by a divided centre line to their controlling relay windings, but the contacts are not arranged on the circuit in the same order that they appear on the relay. Where possible, relays and their associated contacts are arranged vertically, but restriction of space and a desire to group together certain relays can result in some relays and contacts being arranged horizontally as shown in Fig. 34. It is understood that each moving spring moves toward the coil symbol when the relay operates.

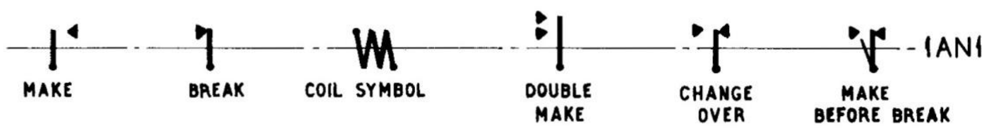


FIG. 34. RELAY AND CONTACTS ARRANGED HORIZONTALLY.

9.3 Relay Designations. The designation of each relay is placed at the end of the centre line linking the winding and contacts (Fig. 34). Many relays in crossbar circuits have designations containing both letters and figures. Where a designation includes a figure before the letter, for example 1AN1, it usually means that there are other relays 2AN1, 3AN1 and so on, which assist the first relay to perform a particular function. The figure placed after the letter indicates that there are similar relays performing the same function for other sections of the circuit.

Many crossbar circuits contain examples of a miniature relay mounted on a general purpose relay. Such relays are identified on a circuit by a designation ending in X, Y or Z. The first section of the designation indicates where the relay is mounted. For example, MA1X represents a miniature relay mounted in place of the right hand springset on the MA1 relay. A designation ending in Y means that the miniature relay is mounted in place of the centre springset, while one ending in Z means that the miniature relay is mounted in place of the left hand springset.

9.4 Miniature relays can also be attached directly to the mounting base of the relay set. When mounted in this way, 6 miniature relays occupy the same space as one general purpose relay. To identify directly mounted miniature relays, the designation often consists of a combination of figures and letters which give the position occupied by the relay in the relay set. For example, a designation 30Z1 means that the miniature relay is mounted in position 30, which is the space occupied by a general purpose relay. As six miniature relays can be fitted in the same space, the rest of the designation is necessary to locate the relay in one of the six positions. Fig. 35 shows the principle of this method of designation.

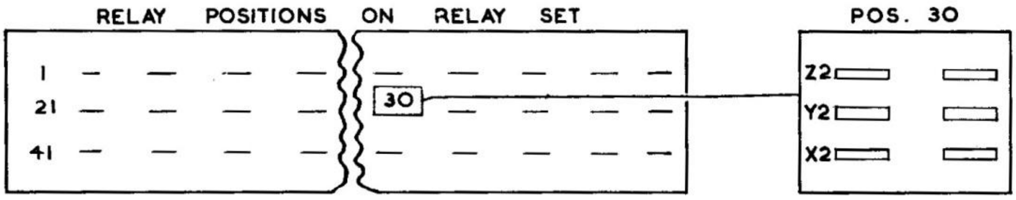


FIG. 35. DESIGNATION AND LOCATION OF MINIATURE RELAYS.

9.5 The use of a semi-attached method of relay and contact representation has the tendency to create a large number of parallel lines on the circuit drawing. A technique frequently used to reduce the number of lines on the drawing is shown in Fig. 36.

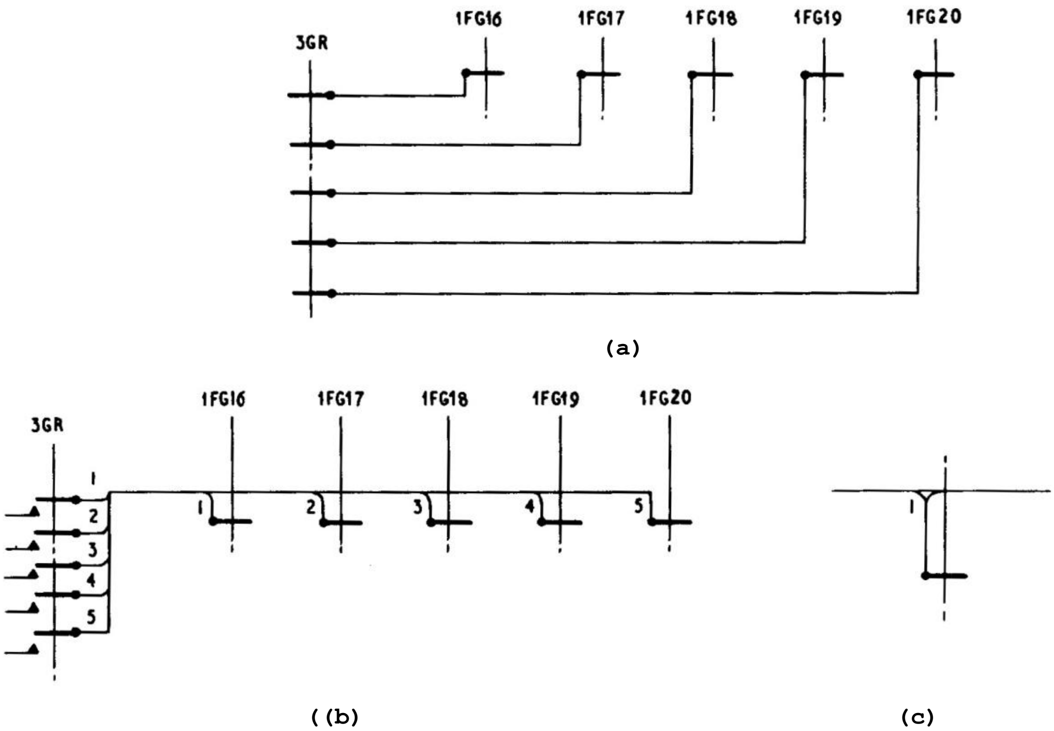


FIG. 36. REPRESENTING A NUMBER OF WIRES BY A SINGLE LINE.

Fig. 36a shows five wires from 3GR contacts connected to contacts on five other relays. In Fig. 36b, the five individual lines have been replaced by one single line. A number is placed beside each wire where it enters the common form, and the same number is again placed beside that wire where it leaves the form at the distant end.

Fig. 36c shows a wire "looped in" to a relay contact and then wired on to some further point. In this case, the designating figure '1' appears in three places - at the starting point, at the "loop in" point, and at the final termination.

9.6 Each crossbar circuit usually refers to one unit group of equipment such as a relay set or a rack. The boundary line around each separate unit consists of alternate heavy dashes and dots. Many wires pass in and out of each relay set, and the plug and jack number of the connection is shown at the point where the conductor line crosses the boundary line. Use of the boundary line and jack numbering is shown in Fig. 37.

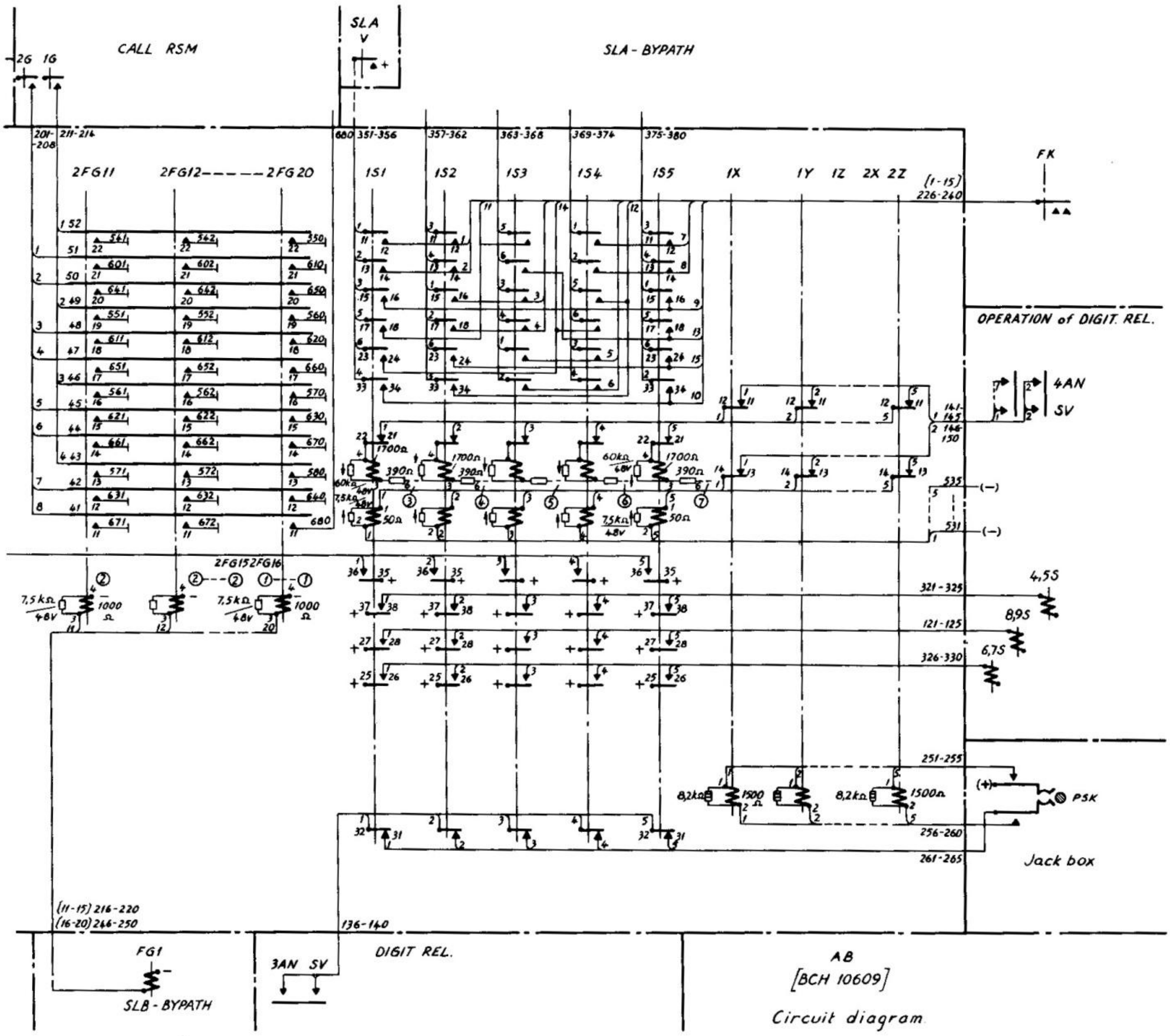


FIG. 37. SECTION OF TYPICAL RELAY SET CIRCUIT.

Fig. 37 also shows an example of a complete multicoil relay (2FG11-2FG20). The multiple strips of such a relay number from 41 to 52. These strips can be divided, resulting in two separate groups of five relays. In the first group of five, the multiple strips number from 41 to 52 and in the second group they number from 61 to 72. In each case, the numbering starts at the strip nearest the armatures.

All contacts of the relays 2FG11-20 are connected via plug and jack connections to equipment in other units. As it would require 120 lines to show these connections, each contact is shown terminating on a short boundary line drawn close to the contact.

The same group of relays also illustrates another common practice in crossbar circuits. Where there are a number of identical relays in one group and all are connected to similar circuits, it is a standard practice to show only the first two and the last relays, a dotted line from the second relay to the last indicating that there are other relays, connected in a similar manner. The same procedure also applies to the contacts of a group of relays. Where the contacts of a group of relays are connected in a selection chain, the contacts of the first two relays and the last relay are shown. A dotted connection between contacts of the second relay and those of the last relay, indicates that the selection chain is wired through identical contacts of the other relays in the same way.

9.7 Special functional diagrams have been evolved to show the operation of each main step in the marker operation. Each of these drawings combines part of the information from various circuits into one drawing, to show the principle of operation of one particular step in the complete operation.

The names shown around the outside of the boundary line in Fig. 37 are the names given to some of these functional diagrams. When a wire is shown passing from a relay set on one rack to a circuit on another rack, the information showing the connections at each point is obtained from the functional circuit indicated outside the boundary of the relay set circuit. Fig. 38 shows section of a functional circuit in which wires pass from a relay set on an SL marker rack to other relays mounted on an SLA/B switch rack.

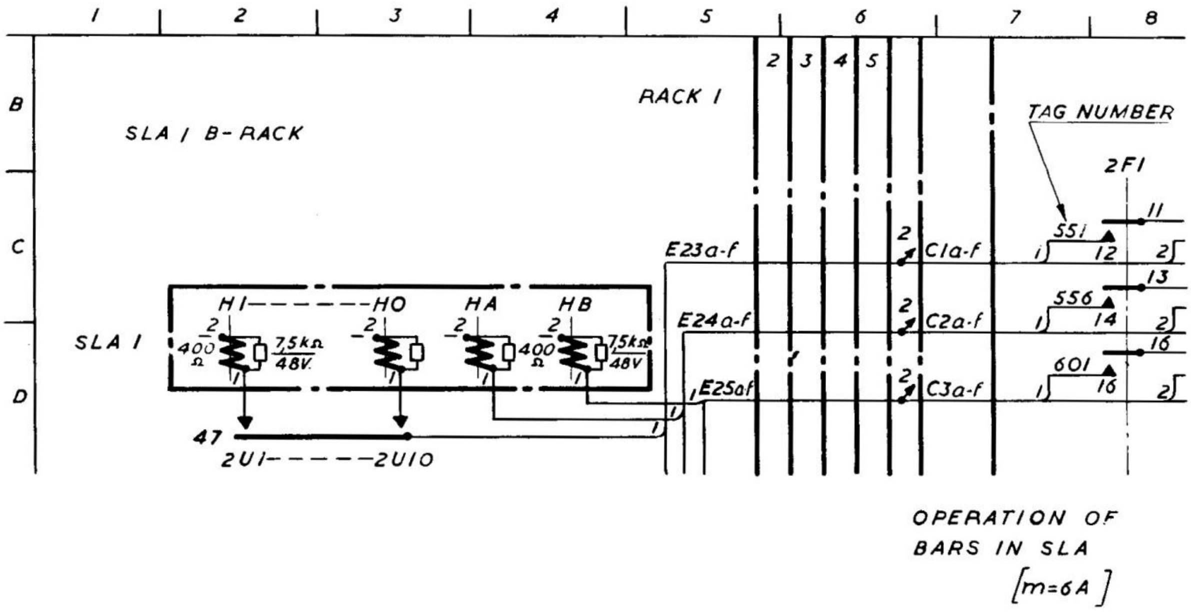


FIG. 38. SECTION OF A TYPICAL FUNCTIONAL CIRCUIT.

The wire from spring 12 of the 2F1 relay is marked 551, indicating that this wire leaves the relay set via plug and jack connection 551 (tag 51 on the 5th plug of that relay set). Tracing the same wire to the left, the designation C1a indicates the tag (1a) and terminal block (C) to which the wire is connected at the top of the marker rack. At rack 1, the wire is connected via the Jack field at the top of the rack, and the designation E23a indicates the position in the jack field. From that point, the wire is included in the rack cabling and is finally connected to a contact strip on a multicoil relay.

Functional circuits generally use a cross reference grid system with figures along the top and bottom of the drawing, and letters arranged vertically at each side. This enables any relay, contact or component mentioned in descriptive text, to be readily located on the drawing.

9.8 Circuit Tracing. Some equipment is divided into two or more relay set parts, and a circuit diagram, appropriately titled, is supplied for each relay set part. To assist in the tracing of a circuit path between the relay set parts, each diagram is given a designation, for example a letter. When a letter is used, the designation is placed adjacent to the circuit title and at the margin of the circuit (Fig. 39).

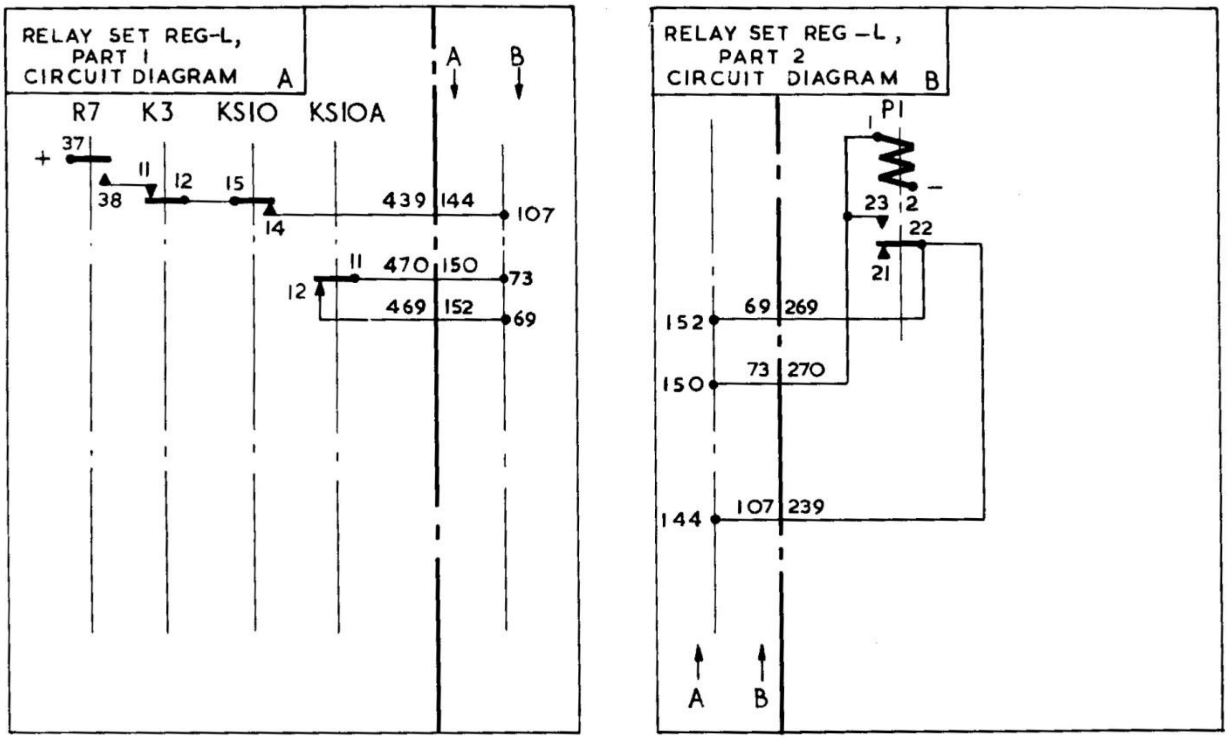


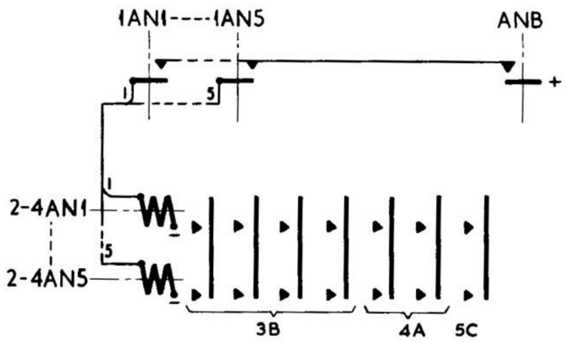
FIG. 39. TRACING CIRCUIT PATHS BETWEEN CIRCUIT DIAGRAMS.

Fig. 39 shows that relay. set part 1 of Reg-L is designated with the letter 'A', and relay set part 2 is designated 'B'. Circuits of relay set part 1 which are wired to relay set part 2 are extended beyond the margin of the circuit to a vertical reference line designated 'B', and given a number. Referring to circuit diagram 'B', these same numbers are also located outside the margin of circuit diagram 'B', and arranged in odd numerical sequence from the top of the margin. A similar scheme is used for circuit paths between relay set part 2 and relay set part 1, with the exception that even numbers are used.

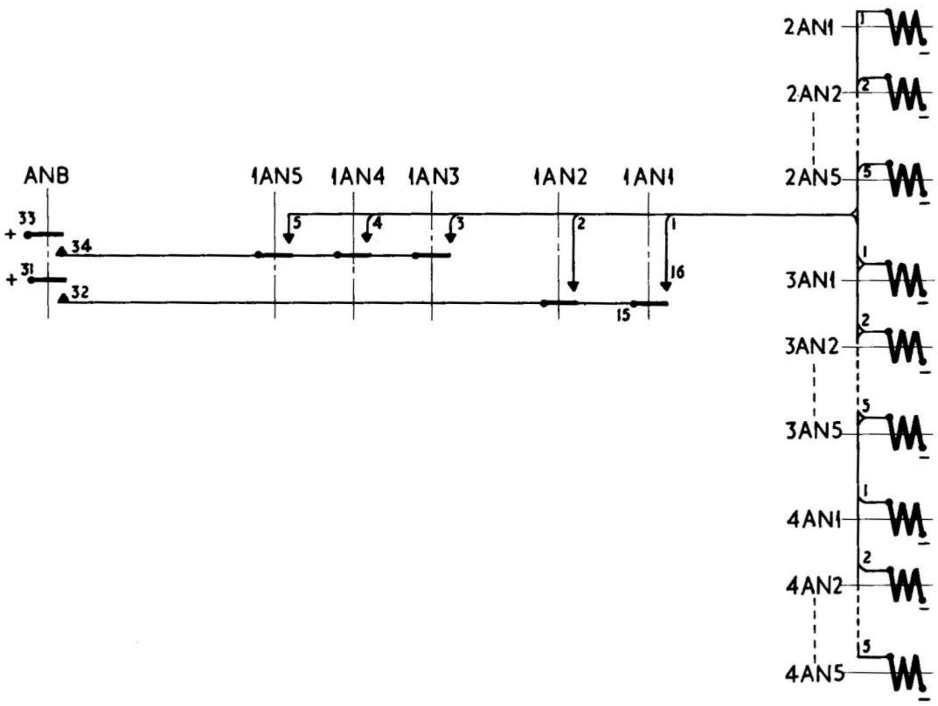
For example, assume that it is required to trace a circuit path for the operation of relay P1 when relay R7 operates. When contacts of R7 operate (circuit diagram 'A'), the positive potential is applied via contacts of K3, KS10, plug and jack connection 439, to reference number 107 of circuit diagram 'B'. Referring to circuit diagram 'B' and locating reference number 107 adjacent to the margin, the positive potential is extended via plug and jack connection 239, spring 22 of relay P1, plug and jack connection 269, to reference number 152 on circuit diagram A. Locating reference number 152 on circuit diagram 'A', the circuit path is extended via plug and jack connection 469, KS10A 12/11, plug and jack connection 470, to reference number 73 on circuit diagram 'B', which is wired to the winding of P1 relay in relay set part 2 (circuit diagram 'B') via plug and jack connection 270.

There are several variations of the method described for the tracing of circuit paths between circuit diagrams, but all use reference lines for circuit paths which extend into other relay set parts.

9.9 Survey diagrams are used to give an overall appreciation of the operation of a complete switching stage. Circuits from all of the marker relay sets, switch racks, etc., are combined into one simplified diagram. Full information is not given in these circuits as they are only intended to convey the principle of operation. Any further information required can be obtained from rack circuits, relay set circuits or functional diagrams. In the survey diagrams, boundary lines are not usually shown between relay sets, but they are used to separate groups of equipment such as markers, racks, etc.. Fig. 40a shows information extracted from a survey diagram, and Fig. 40b shows the same information extracted from a circuit diagram.



(a)



(b)

FIG. 40. COMPARISON BETWEEN SURVEY AND CIRCUIT DIAGRAM DETAILS.

In Fig. 40a, only one operating ANB contact unit is shown, although in the relay set two units are used. The designation 2-4AN1 beside one relay symbol means, in this case, that there are three separate relay coils operated in parallel. The references 3B, 4A and 5C placed beside certain springsets are an indication that those springsets are used in the circuit at the reference points indicated. Survey diagrams use a location reference system identical to that described for functional diagrams (para. 9.7).

10. SEQUENCE DIAGRAMS.

10.1 Because of the number of relay operations in many crossbar circuits, there is a difficulty in remembering the sequence of operations and the individual relays operated at any one instant. Various types of sequence charts can be developed to minimise this difficulty, and such charts, once the fundamental principles are understood, can assist considerably in fault finding and general understanding of the circuit.

10.2 When studying crossbar circuitry, a chart can be constructed for a complete circuit or for a small section of a circuit. When constructing a chart, the operated time of a relay is represented by a horizontal line commencing at the left hand and finishing at the right. Place the corresponding relay designation a little to the left of the horizontal line (Fig. 41).

FIG. 41.

Place a dot (•) between the designation and the commencement of the line to indicate the instant that the relay circuit is completed. The gap between the dot and the line represents the operate lag of the relay (Fig. 42a).

Increase the gap to indicate a slow operating relay (Fig. 42b), and reduce the gap to indicate a fast acting relay (Fig. 42c). As a guide to the circuit operation, a vertical line connected to the dot of the first relay is usually designated to indicate the cause of the first relay operation in the sequence.

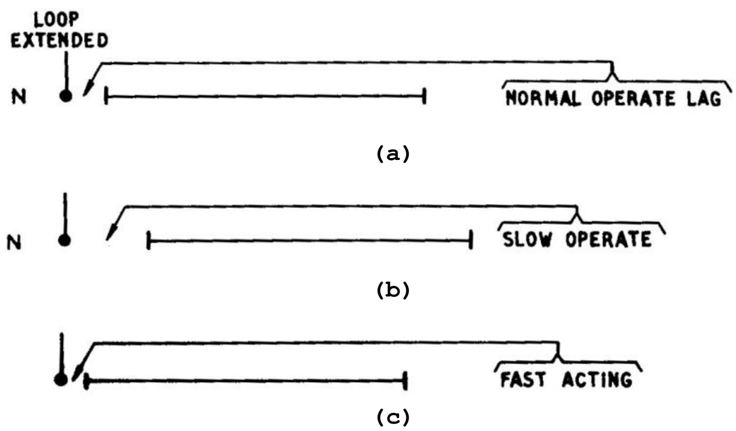


FIG. 42.

To indicate which relays are operated by N relay contacts, drop a vertical line from the start of the N relay line. The example shown in Fig. 43 indicates that when the N relay operates, it completes the circuit for NS1 relay at the instant indicated by the dot. Once again, the gap between the dot and the start of the NS1 line represents the operate lag of the NS1 relay.

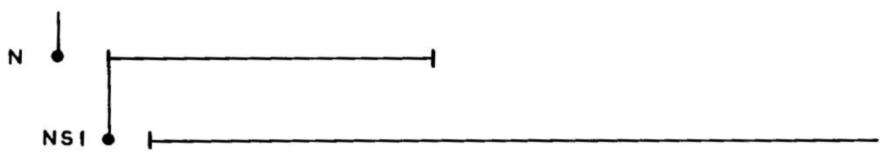


FIG. 43.

10.3 To indicate the instant that a circuit is opened, place a circle (o) near the end of the line representing that relay. The distance between the circle and the end of the line indicates the release lag of the relay. In the example shown in Fig. 44, the same circuit operation causes the release of two relays, NS2 and N1. This is represented by using one vertical line connecting the two circles, one near the end of the NS2 line and the other near the end of the N1 line. As the distance between the circle and the end of the NS2 line is much greater than that on the N1 line, it indicates that NS2 is a slow releasing relay.

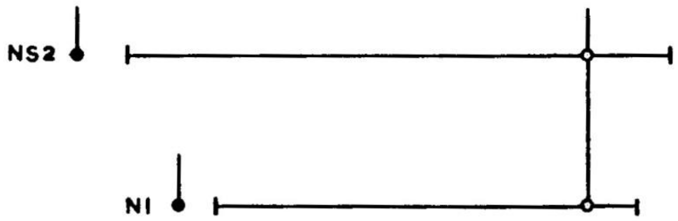


FIG. 44. INDICATING RELEASE OF RELAYS.

When any line (NS1 in Fig. 45) extends to the extreme right of the chart, it indicates that the corresponding relay remains operated for the period of circuit operation covered by the sequence chart.

10.4 Other constructional points can be seen by an examination of Fig. 45, which shows a sequence chart constructed to indicate the operations that take place during the counting and storing of the first digit received in a local register.

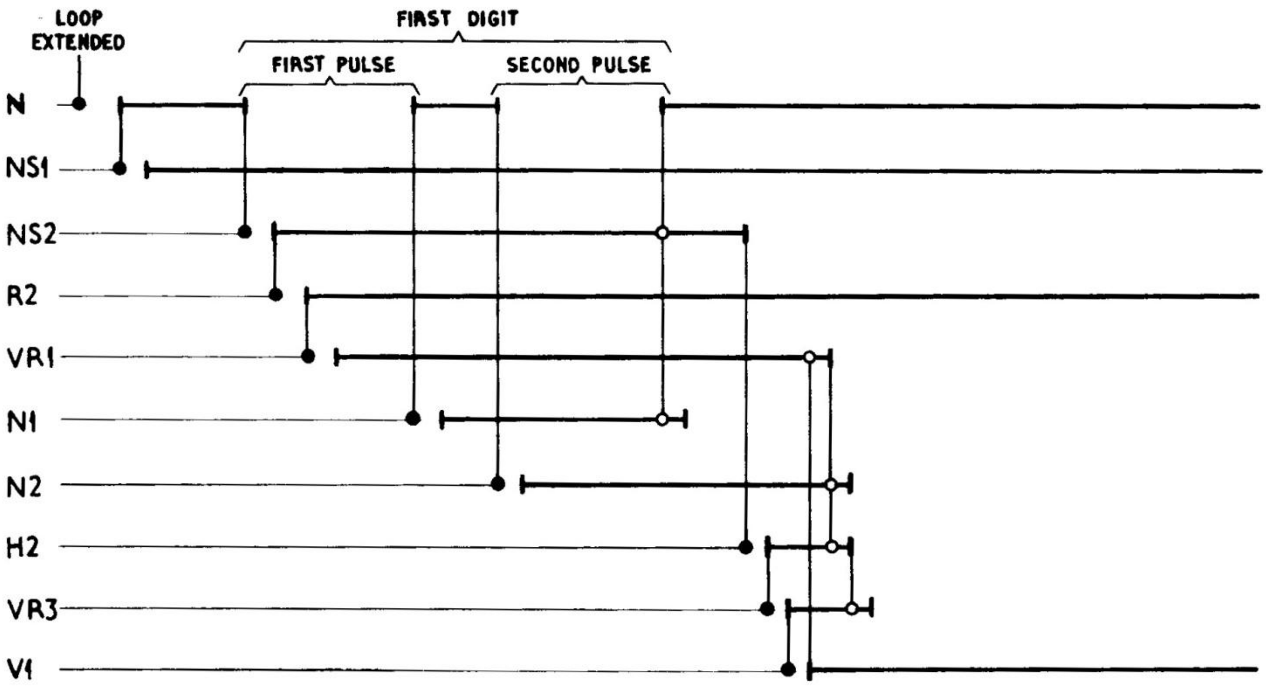


FIG. 45. TYPICAL SEQUENCE CHART.

10.5 The circuit operation represented by Fig. 45 starts when the subscriber's loop is extended to the register and operates relay N. The line dropped vertically from the start of the N relay line means that immediately the N relay operates, it completes a circuit to NS1. The NS1 line is extended to the extreme right of the chart and indicates that the NS1 relay remains operated for the period covered by this section of the circuit operation.

The first pulse received from the dial causes N to release, completing the circuit of relay NS2. When NS2 operates, it completes the circuit for relay R2 which in turn completes the circuit for VR1. When N relay re-operates, it completes the circuit for N1. When the second pulse is received, N releases again and operates N2. The re-operation of N opens the circuit for NS2 and N1. The chart shows N1 releases normally but NS2 is a slow release relay.

When NS2 releases at the end of the pulsing, it operates H2, a horizontal magnet of the crossbar switch in the register. Contacts of H2 operate VR3 relay, which operates the vertical magnet V1. Operation of V1 causes the release of relay VR1, which then releases relay N2 and the horizontal magnet H2. The release of the horizontal magnet releases relay VR3.

It must be realised that a sequence diagram of this type can only show a typical circuit operation. For example, the diagram in Fig. 45 shows the relay operations when the first digit is "2". If the first digit was "3", then N1, N2 and N3 would have been operated, and at a later stage H3 would have been operated instead of H2. Also, if the digit received was the second digit, then the vertical magnet operated would have been V2 instead of V1. Where there are similar conditions and alternative circuit operations are possible, it is necessary to assume one typical set of conditions and construct the sequence chart on that basis.

10.6 Although sequence diagrams for other circuits may contain more operations, the principle involved is the same, provided each step is taken in strict chronological order (represented on the diagram by working from left to right). Provided the diagram has been constructed accurately, and with due regard to operate and release lags, a line drawn vertically at any point of the diagram will indicate by the horizontal lines crossed, the relays operated at that instant.

Sequence diagrams can also be related to block diagrams, each line representing a functional block.

Fig. 46 shows a sequence diagram constructed to indicate the operation of the functional groups in Fig. 29. Operate lags are not shown, as each group represents number of relays.

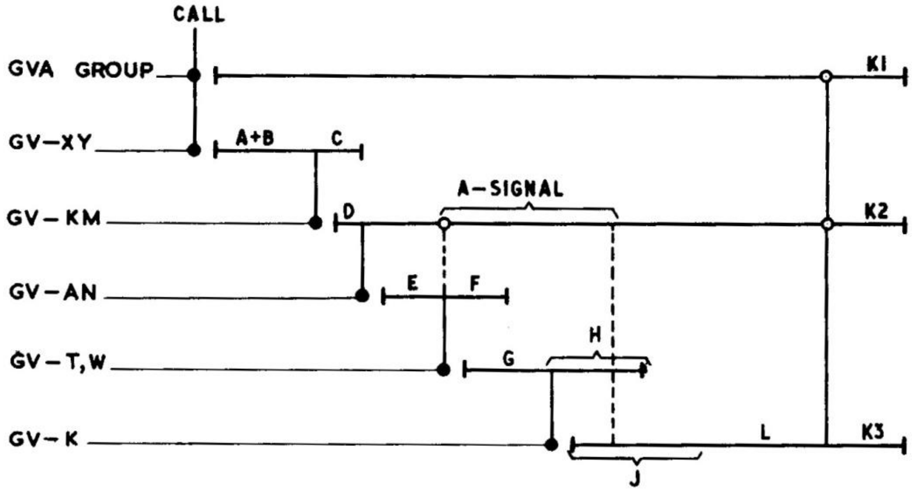


FIG. 46. SEQUENCE CHART APPLIED TO FUNCTIONAL GROUPS.

10.7 An example of a more complex sequence diagram is shown in Fig. 47, which represents the sequence of relay operations and release of an SL marker in an ARF exchange for an outgoing call.

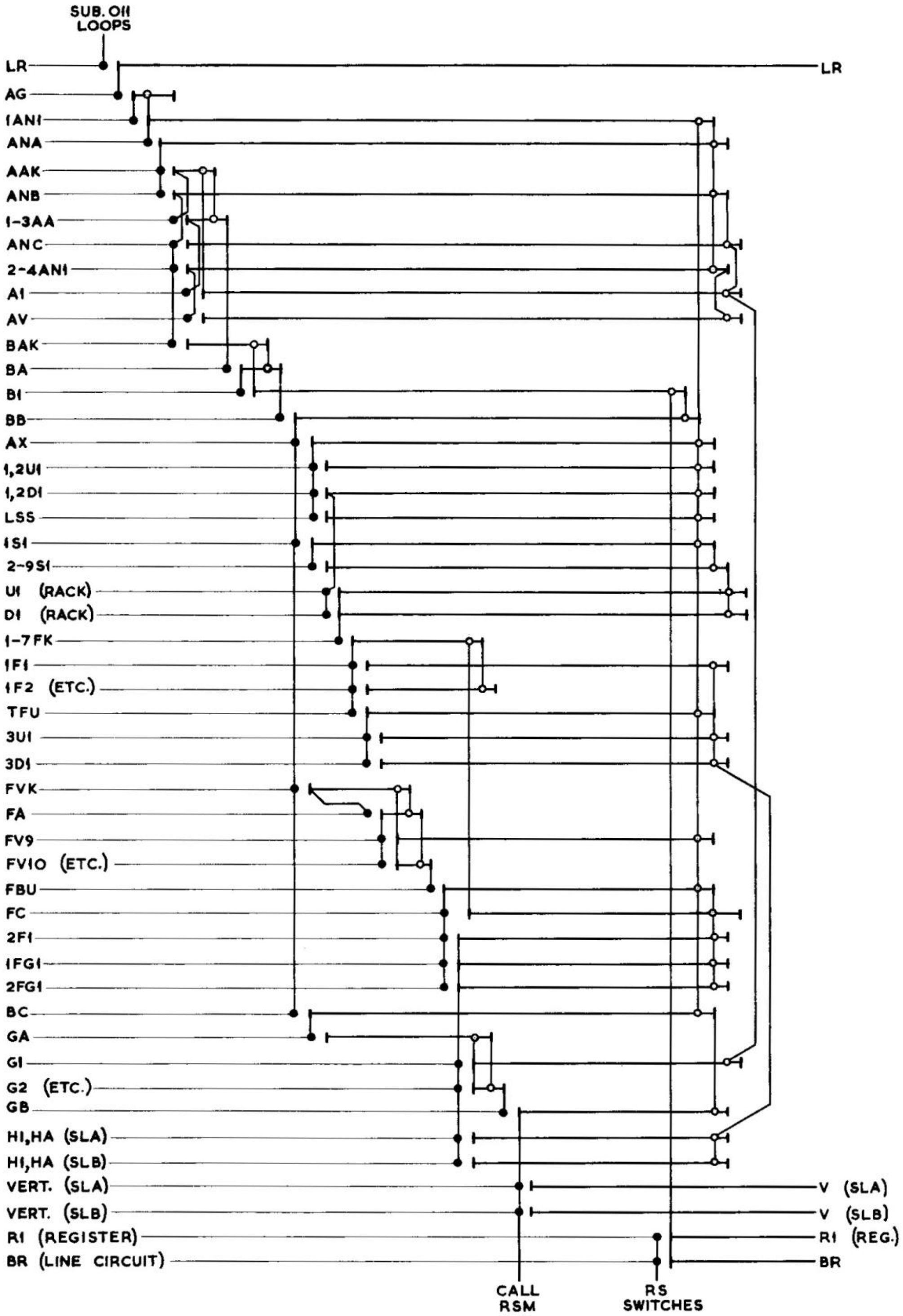


FIG. 47. SEQUENCE DIAGRAM - OUTGOING CALL SL STAGE.

11. SYMBOLS.

11.1 Fig. 48 shows some of the symbols frequently used in crossbar circuits.

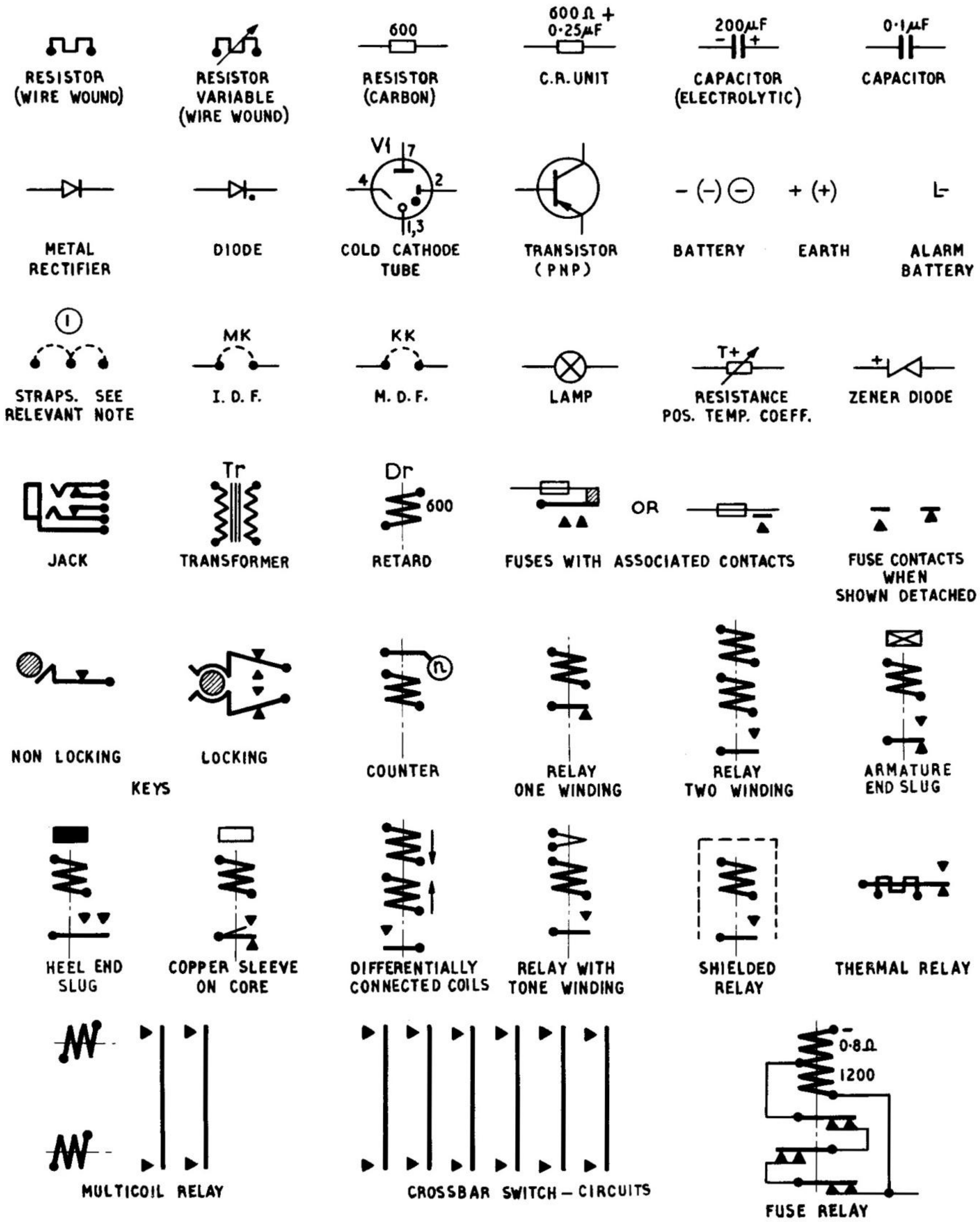


FIG. 48. CROSSBAR CIRCUIT SYMBOLS.

NOTES

NOTES

12. *TEST QUESTIONS.*

1. Explain briefly what is meant by the facility "Classification of Subscribers Lines".

2. Why is the time supervision facility provided in crossbar exchanges?

3. Give two conditions that can cause the operation of the time supervision facility in an SR relay set.

4. What is the main purpose of the interception facility?

5. Explain briefly the principle of operation of a thermal relay.

6. Show by means of a suitable diagram the spring and coil tag numbering of:-

(i) A thermal relay. *(ii) An RAH type relay.*

7. (i) State two features of Clare relays.

(ii) Draw a diagram showing the contact, winding, and socket connections of a typical Clare relay.

8. Draw a diagram showing the spring and contact strip numbering of a multicoil relay.

9. Show by means of a simple wiring diagram how the horizontal springsets of a 20-outlet crossbar switch are multipled so that each of the 10 inlets to the switch has access to the same 20 outlets.

10. A crossbar switch vertical is wired to provide two 10-wire inlets with access to ten 10-wire outlets. Show, by means of a simple wiring diagram, how the horizontal springsets associated with the insets are wired.

11. Answer Question 3 using grouping plan symbols.

12. What is the difference between "direct trunking" and "link trunking"?

13. Explain, with the aid of a suitable diagram, how internal congestion can occur in two partial stages.

14. Explain briefly what is meant by the term "conditional selection".

15. Examine Fig. 28.

(i) What is the significance of the numbers shown adjacent to the vertical units of the A partial stage switches?

(ii) Indicate on Fig. 28 the outlet used when horizontals H6 and HB are operated in vertical 2 of switch 1 in the B partial stage, and horizontals H2 and HB are operated in vertical .2 of switch 1 on rack 2 of the A partial stage.

16. Name four types of L.M. Ericsson circuit drawings.

17. Explain briefly the difference between a circuit diagram and a survey diagram.

18. A relay is designated 1AN1. Explain the significance of the numbers before and after the letters "AN".

19. A relay is designated 28Z2. What information can be obtained from this designation?

20. Examine Fig. 37. What is the significance of the numbers shown adjacent to the boundary lines of the circuit?

END OF PAPER.