COURSE OF TECHNICAL INSTRUCTION BOOK

TELEPHONY IV.

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TELEPHONY IV.

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COMMONWEALTH OF AUSTRALIA.

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1. INTRODUCTION.

1.1 The Strowger two-motion selector, described in Telephony III, was the standard for fully 30 years. This basic fact of practically fixed design over so long a period definitely demonstrates the fundamental simplicity and universality of the two-motion selector, and the soundness of its design and construction.

1.2 The economic depression of the 1930's resulted in demands for a more economical switch, particularly as regards first cost and the saving of floor space in exchange buildings. After a period of fully six years spent in its development, the type [illegible] selector was introduced by the Automatic Telephone and Electric Co. Ltd., Liverpool, and was adopted as a standard two-motion selector by the British Post Office. Known as the B.P.O. 2000 type selector, it is now the Australian Post Office standard and has been used in most new exchanges installed since 1938.

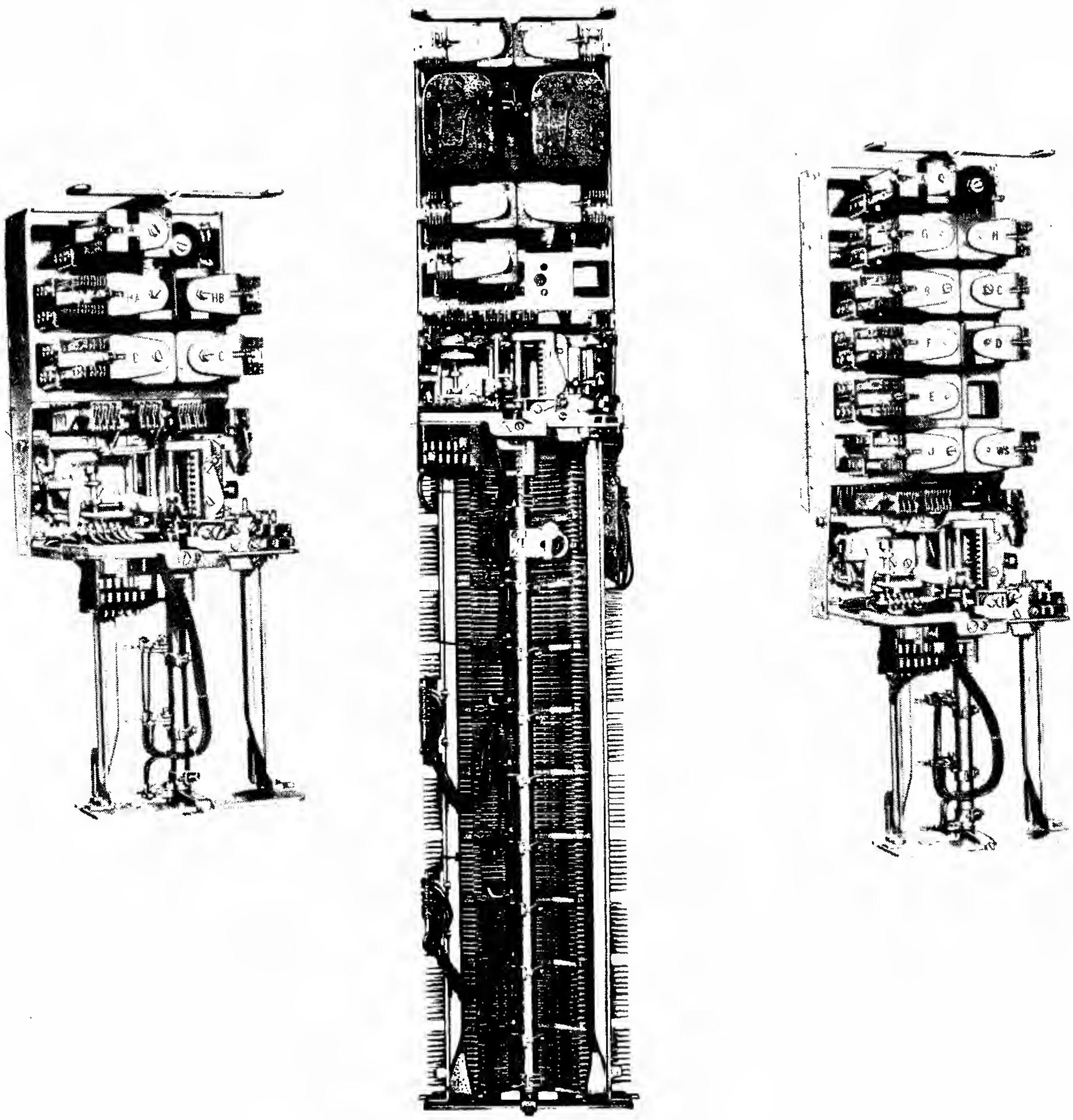


FIG. 1. 2000 TYPE SELECTORS.

The main objects aimed at in developing the 2000 type selector were the attainment of substantial improvements, as compared with the pre-2000 type switch, as follows -

(i) Reduction in over-all dimensions.

(ii) Improvement in operating characteristics.

(iii) Simplification and greater permanence of adjustments, and ease in replacement and maintenance operations.

(iv) Greater flexibility of application.

(v) General economy.

Some special features of 2000 type switches are -

(i) The release action is normally a continuation of the rotary movement in a left to right direction off the level and then vertically downwards and back (right to left) to the normal position under spring control. Thus, a separate release magnet is not used.

(ii) Vertical and rotary magnets are single coil magnets with cast iron cores, pole pieces and coil cheeks.

(iii) A brass tube called the wiper carriage, provided with an upper and lower bearing, moves on a fixed shaft. In pre-2000 type switches the length of shaft below the lower bearing allowed whip of the shaft and did not give the required protection against bending, so that the length was limited to that required for three banks. The fixed shaft on 2000 type bimotional switches, however, allows the bank capacity and the number of wipers to be greatly increased.

(iv) The wipers are fastened to the wiper carriage which moves up and down and rotates on a fixed shaft. The carriage is connected to the shaft by a helical spring.

(v) Special vertical and rotary magnet interrupter springs, called the "toggle" springs, are used. The springs are adjusted to break at the end of the operating stroke of the magnet armature and do not remake until the extreme end of the return stroke. This provides a "self-interrupted drive" which does not need an interacting relay.

These features, together with many others, such as ease of adjustments, twin contacts, easily replaceable wipers, etc., have been incorporated into the new switch. The complete mechanism is smaller and lighter than its predecessors. Some 2000 type switches are shown in Fig. 1. The centre picture shows, as a matter of interest, such a switch with 10 contact banks and a vertical marking bank.

/Fig. 2.

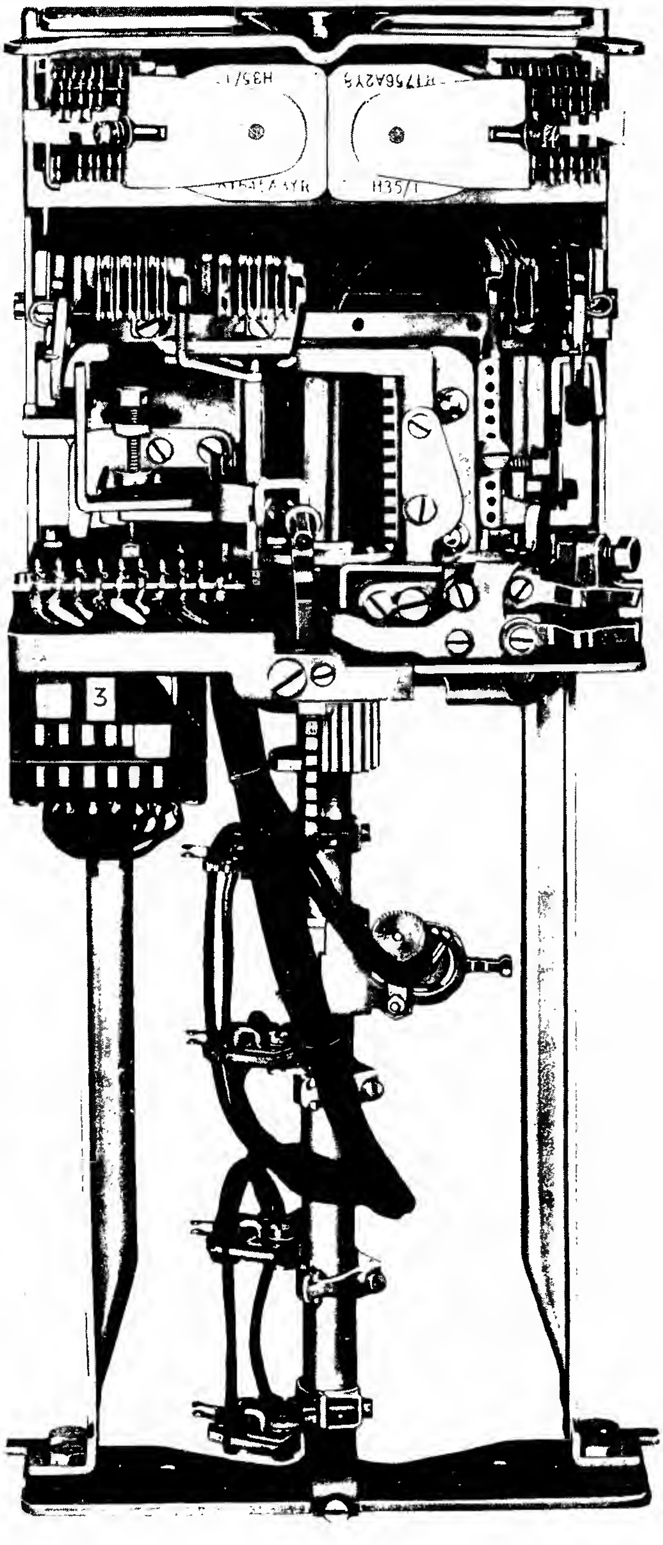


FIG. 2. TYPICAL 2000 TYPE TWO-MOTION SELECTOR.

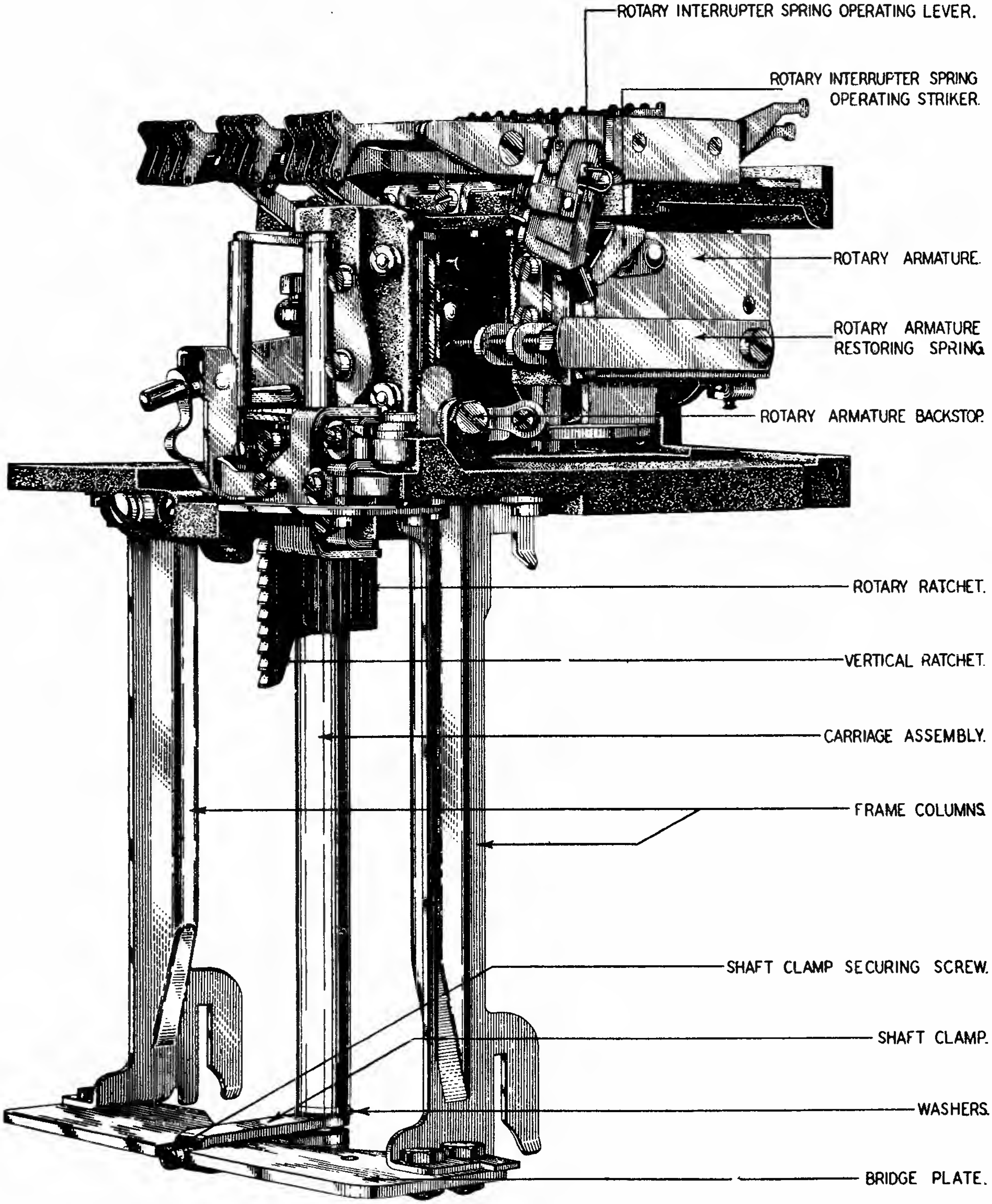


FIG. 3. DETAILS OF THE 2000 TYPE MECHANISM.

2. DETAILS OF THE 2000 TYPE MECHANISM.

2.1 The general form of the switch mechanism is shown in Figs. 1, 2, 3 and 5. Fig. 2 shows the mounting of the two 3000 type relays on the switch base and wipers on the carriage. If additional relays are required, the mounting plate extends upward to the extent necessary for the relays, as in Fig. 1. The frame of the switch is a die casting in I formation of a 90% aluminium alloy, which weighs about 10 oz. The cast iron frame of the pre-2000 type selector weighed approximately 2 lb.

2.2 The principles of the vertical and rotary action will be described from Fig. 4, which is a detached schematic view of the wiper carriage, pawls and detents. The conically cut teeth for vertical stepping in the pre-2000 type switch give place to the vertical ratchet of hardened steel, which is in alignment with the vertical pawl only when the wiper carriage is in the normal position. The rotary pawl and detent do not come into alignment with the rotary teeth until the carriage has made one vertical step.

2.3 Vertical Action. When the vertical magnet is operated and released one or more times, the carriage is stepped to the corresponding level. The upper end of the helical restoring spring is attached to the top of the wiper carriage and the lower end to the shaft and, thus, during vertical stepping the helical restoring spring is extended. As the rotary pawl and detent must come into alignment with the rotary teeth at the first vertical step, adjustable stops (not shown in Fig. 4) are provided to hold both in the correct positions.

2.4 Rotary Action. When the rotary magnet is operated to rotate the carriage assembly and wipers, the vertical ratchet, being fixed to the carriage, moves out of engagement with the vertical pawl and detent. It is necessary, therefore, to prevent the carriage from falling. This is effected by entering the rotary disc into a notch in the comb plate. When the desired rotary position is reached, the carriage stops. During the forward rotary motion, the helical restoring spring is wound up.

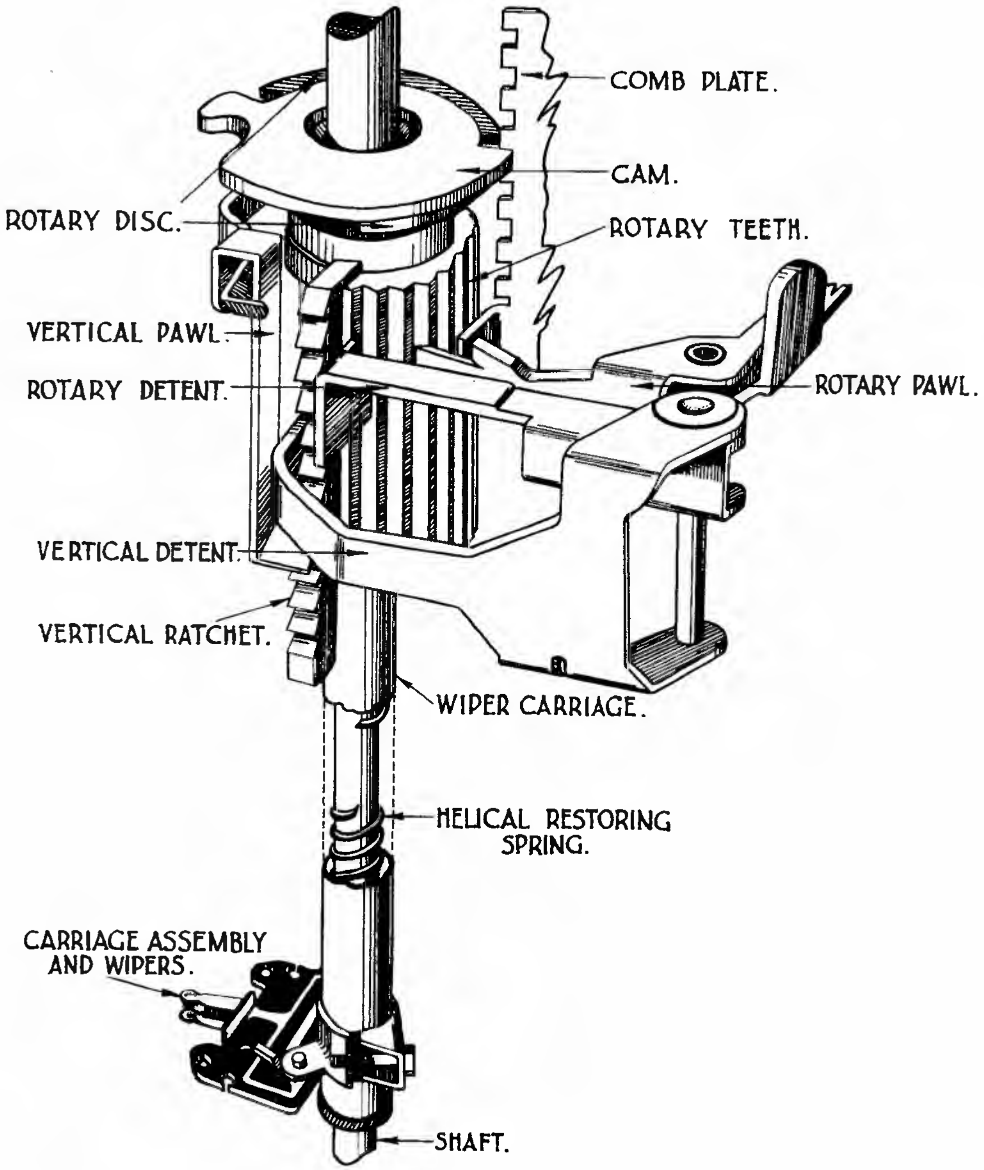
2.5 Rotary Release. On release, the carriage is stepped forward by the rotary magnet to the 12th rotary step. In this position, a notch (L) in the rotary disc comes into line with the comb plate and the disc and wiper carriage are then free to fall under the tension of the spring until arrested by the special bottom tooth, called the extended lug, on the comb plate. While the carriage is falling, the rotary detent slides along the 12th rotary tooth until the carriage reaches the normal level.

2.6 When the carriage reaches the normal level, the rotary restoring effort of the helical spring is free to act and the wiper carriage rotates back to the normal position. The contact springs are not under tension during the falling and reverse rotation period and, consequently, retarding forces are not applied to the wiper carriage during release. A lightly tensioned restoring spring therefore suffices. This statement is qualified in respect to the off-normal springs, which impose a load on the wiper carriage at the very end of its releasing movement. This applies a braking action at the moment the carriage movement is arrested, thereby relieving the stop that determines the normal carriage position from undue shock.

2.7 The rotary detent is provided with a projection which prevents rebound and serves as a latch to hold the wiper carriage in its normal rotary position. The wiper carriage must otherwise make one vertical step before it can rotate.

Fig. 6 shows schematically the various motions involved in positioning and releasing the selector when 03 is dialled.

/Fig. 4.



2000 TYPE SELECTOR.
DIAGRAM OF VERTICAL AND ROTARY MECHANISMS.

FIG. 4.

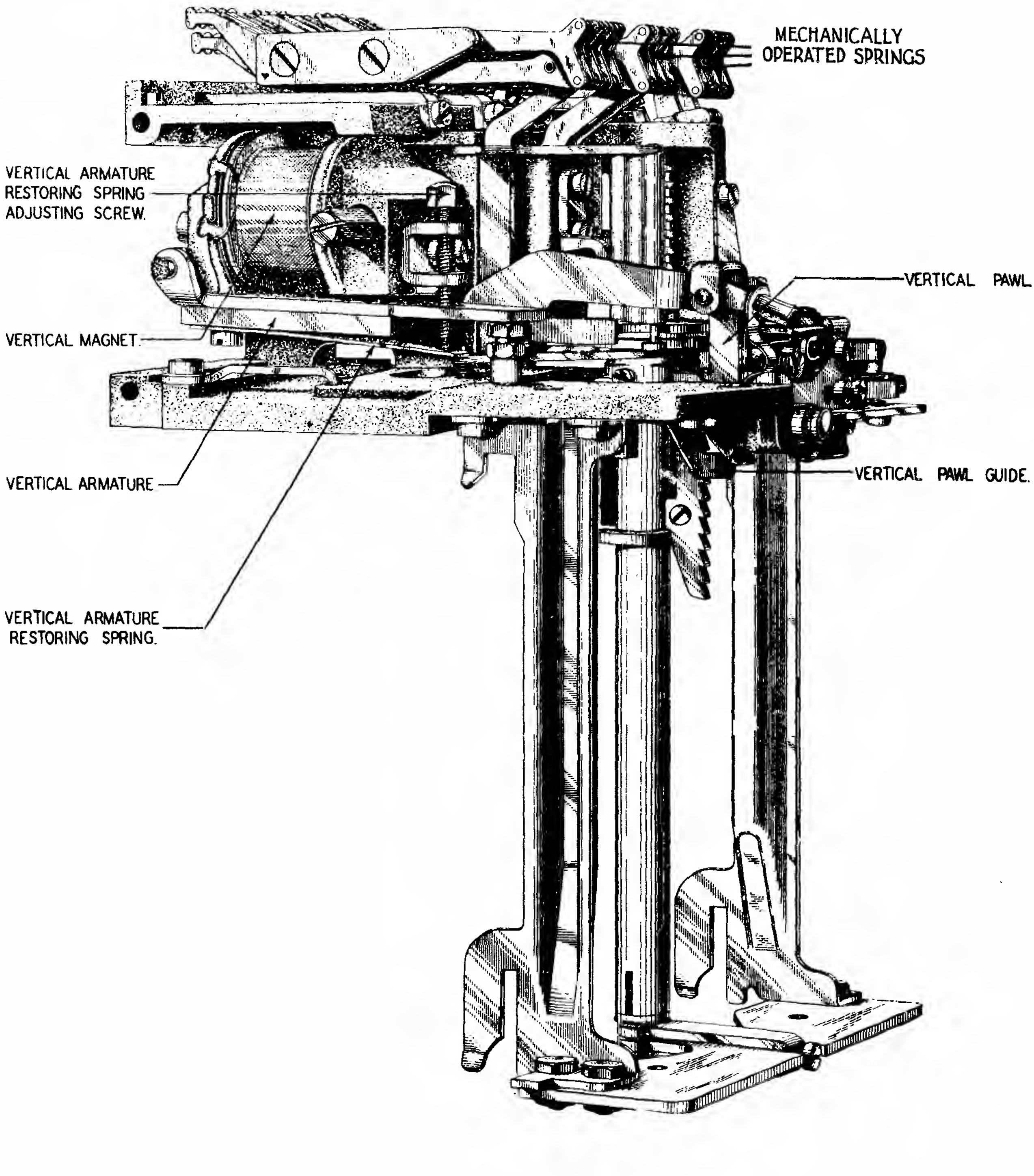
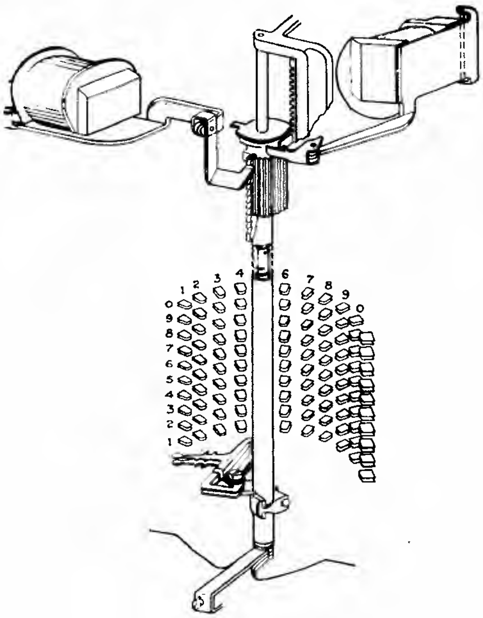
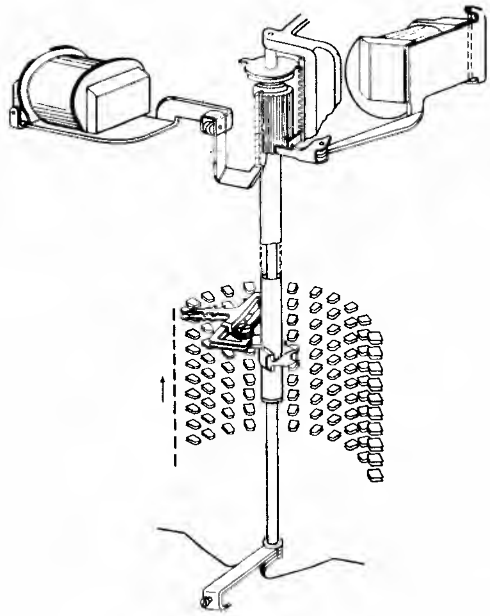


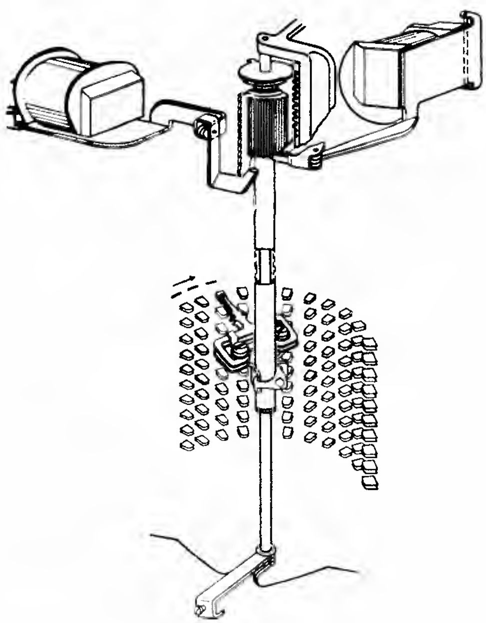
FIG. 5. DETAILS OF THE 2000 TYPE MECHANISM.



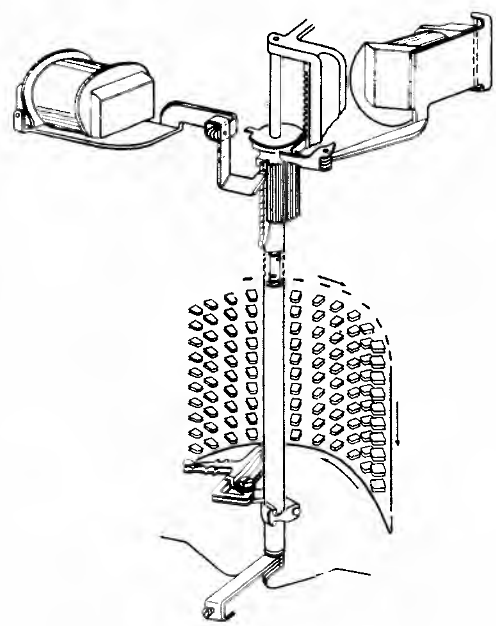
Wiper carriage in normal position.



Wipers stepped to 10th level.



Wipers stepped to 3rd contacts on 10th level.



Release action.

FIG. 6. VERTICAL, ROTARY AND RELEASE ACTIONS OF 2000 TYPE SELECTOR.

2.8 Special Release Actions. It will be realised from the foregoing description that a separate release magnet is not used and that only vertical and rotary magnets are fitted. In addition, however, to the normal forward, downward and backward release action described, the release action may be accomplished in various other ways. These special release conditions will not be described here as they are not used to any extent in Australia.

2.9 The magnets, which are identical for both vertical and rotary functions, consist of a single casting of iron, the pole piece also serving as coil cheeks. Cast iron, on account of its relatively high specific resistance, is particularly suitable for this type of magnet, since eddy current losses, caused by the rapidly changing magnetic flux which occurs when the switch is hunting, are reduced to a minimum. The one-piece construction of the magnets tends to make them self-protecting, that is, they are not damaged if left energised for long periods. This is largely due to the solid construction of the magnet and its large area of contact with the selector frame. The flow of heat is thus facilitated and limits the maximum temperature rise of the windings. The assembly of the Vertical and Rotary magnets, with armature fitted, is shown in Fig. 7.

2.10 The coils are wound to a resistance of 50 ohms. Originally they were wound with 900 turns of 37 gauge enamelled wire, but, since 1938, more powerful magnets wound with 1,300 turns of 35 gauge wire have been fitted to switches.

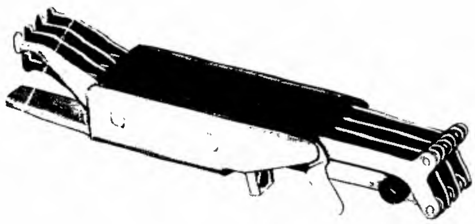
2.11 The vertical and rotary magnet armatures are generally similar and comprise a plate of annealed Swedish iron riveted to an unannealed bracket of steel having high mechanical strength. The bracket provides the lugs for the armature and pawl bearings; the latter are of phosphor bronze tube about 1/8th inch diameter and 1½ inches in length. This bearing pin is held in place on the frame by a plate over the centre part, and the lugs on the armature bracket work on the ends of the tube, which is split to provide for lubrication from a wick running down the inside of the bearing tube for its full length. The bearing tube enters a hole in the frame and thus locates the position of the magnet and armature.

The design of the ratchet teeth and pawls is such that any tendency towards a "pawl throw-out" effect during the release stroke of the armature is entirely eliminated. This is accomplished by ensuring that forces due to inertia tend to hold the pawls in engagement with the ratchet teeth.

FIG. 7. 2000 TYPE MAGNET ASSEMBLIES.

3. MECHANICALLY OPERATED SPRINGS.

3.1 Various mechanically operated contact springs are assembled in a row on the top plate of the selector frame, as shown in Figs. 3 and 5. To facilitate and simplify the wiring operation, the tags of the springs project through the mounting plate rearwards into the same space as the relay tags. Except in the case of interrupter springs, which are of special design, the springs are fitted with twin contacts and assembled in compact sets on a mounting bracket. Fig. 8 shows a typical spring set.



MECHANICALLY OPERATED SPRING SET.

FIG. 8.

Each spring set is located in position by the end of the bracket passing into a slot at the back of the selector frame and is secured by a single screw at the front. The twin contacts are on wide centres giving maximum visibility, and the design of the springs is such that contact bounce is eliminated. In Fig. 5, three groups of springs are marked mechanically operated springs. Reading from left to right these are -

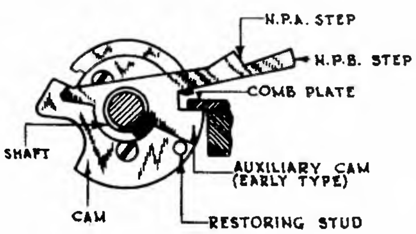
(i) Rotary off-normal springs,
(ii) Vertical off-normal springs, and
(iii) 11th step springs.

3.2 The mechanically operated springs which may be fitted to the switch are -

Vertical off-normal springs	... Maximum of 9 springs.
Rotary off-normal springs	... Maximum of 8 springs.
11th rotary-step springs	... Maximum of 9 springs.
Vertical interrupter springs	... Maximum of 3 springs.
Rotary interrupter springs	... Maximum of 3 springs.
Level springs, single set	... Maximum of 6 springs.
Level springs, two independent sets ...	... Maximum of 3 springs each.

It is possible, in certain cases where some combinations are not required, to increase the number of springs in the next set. For instance, if rotary off-normal springs are not fitted, the off-normal spring set can be extended up to fourteen springs.

3.3 Operation of Mechanical Spring Set. The general arrangement of the springs and operating levers can be traced in Figs. 2, 3 and 5 with the help of the following description applying to Figs. 9-13, which give details of the spring operating elements.



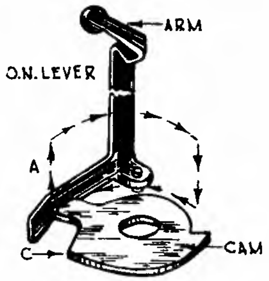
CAMS FOR OPERATING MECHANICAL SPRINGS.

FIG. 9.

The cam and auxiliary cam (which is only fitted when required) on the wiper carriage, shown in Fig. 9, operate all the mechanically operated springs other than the interrupters which are, of course, controlled directly by the magnet armatures. Reference to Fig. 4 will indicate how the cam is attached to the wiper carriage. The operating cycles of the spring sets are as follow.

/3.4

3.4 Vertical Off-Normal Springs. These operate at the first vertical step from the normal position, and reset during the final rotary return movement to the normal position. The springs are operated by a trip action, resetting being effected by the rotary momentum of the wiper carriage. The off-normal springs will not operate unless the wiper carriage is lifted at least 90% of the first step. This is necessary to ensure that a clipped first pulse will not cause the automatic rotary release action to come into effect unless the wipers are aligned to cut into the bank and the rotary disc is in alignment with a slot in the comb.

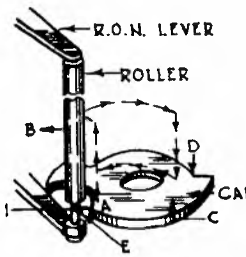


OPERATING THE VERTICAL OFF-NORMAL SPRINGS.

FIG. 10.

At the first vertical step, when the cam, which is attached to the top of the wiper carriage as shown in Fig. 4, moves upwards in the direction of the arrow A (shown in Fig. 10), the off-normal lever trips inwards below it in the direction of arrow C, due to the pressure of the contact springs applied to the arm at the top of the lever. The off-normal spring-set is thus operated. During the vertical, rotary and release actions of a switch, the cam traces the path shown and resets the off-normal lever in the reverse direction to arrow C during the final portion of its return movement on the normal level.

3.5 Rotary Off-Normal Springs. These springs operate at the first rotary step on all levels and release at the 12th rotary step. The wiper carriage must first make at least one vertical step before the rotary off-normal springs can operate.



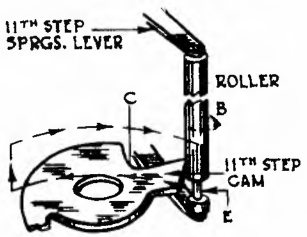
OPERATING THE ROTARY OFF-NORMAL SPRINGS.

FIG. 11.

The first vertical step of the wiper carriage brings the periphery (A) of the cam in line with the full diameter of the roller on the rotary off-normal (R.O.N.) lever (see Fig. 11). On the first rotary step, the cam, which is attached to the top of the wiper carriage, causes the roller to ride along the inclined cam face I on to the periphery of the cam at A and moves the R.O.N. lever in the direction of the arrow B to operate the rotary off-normal spring.

At the 12th rotary step, during the release action of the switch, the roller drops into the recess D, releasing the rotary off-normal springs, and the cam then falls clear of the roller. During the reverse motion to the normal position, the cam face C clears the roller at the portion of reduced diameter (E) at the bottom, so that the springs remain unoperated.

3.6 11th Step Springs. These operate, as shown in Fig. 12, at the 11th rotary step on all levels except the normal level, and release at the 12th rotary step. At the 11th rotary step on any but the normal level, the 11th step cam engages the roller and moves it as indicated by arrow B to operate the 11th step springs. At the 12th rotary step, the roller falls into recess C and the springs release. The wiper carriage to which the cam is attached falls and rotates back to normal, and the cam clears the roller at the portion of reduced diameter E at the bottom.



OPERATING THE 11TH STEP SPRINGS.

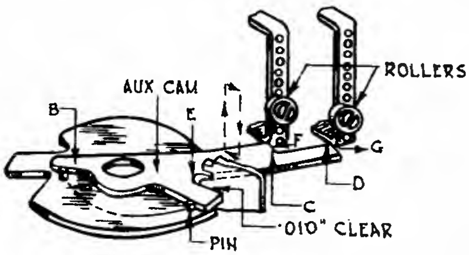
FIG. 12.

3.7 Level Springs. These are two independent assemblies which can each carry a maximum of three springs. If only one assembly is required, this can carry a maximum of six springs, in which case the right-hand assembly is omitted. These springs operate on any chosen level, as determined by fixing a small roller in any one of ten

/positions

positions. A roller fitted in position is shown on the right of the comb plate in Fig. 2. The springs remain operated while the selector is rotating to the 11th step, but release at the 12th step. The two sets can operate on the same or adjacent levels, if necessary, and, by the substitution of cam plates for rollers, the springs can be held operated for a number of successive levels or be made to operate and release and re-operate in any desired order.

The auxiliary cam shown in Fig. 13 (for purposes of simplicity an early type auxiliary cam is shown) rises and falls with the wiper carriage, but it is only permitted to rotate through an angle of about 5°, this limitation being imposed by the comb engaging in the slot. In the normal rotary position of the cam, the pin holds the auxiliary cam so that the near side of the slot (E) and the comb are almost in contact.



OPERATING THE LEVEL SPRINGS.

FIG. 13.

As the cam and auxiliary cam rise, the projecting tongues, C and D, engage with the rollers and move the level spring levers in the directions shown by arrows, F and G, to operate the springs. Whilst the selector is rotating, the pressure of the level springs holds the rollers against the auxiliary cam and prevents it being carried round in a rotary direction by the frictional drag of the cam. At the 12th rotary step, however, the pin engages with the tongue at B on the auxiliary cam and rotates it until the rollers trip over the rear edges of the tongue C and D. The levers and springs then restore. The auxiliary cam then falls with the cam without re-operating the level springs. When the cam rotates to normal on the normal level, the pin resets the auxiliary cam so that it will engage with the rollers at the next operation of the selector.

3.8 Interrupter Springs. Fig. 14 shows the interrupter spring-set designed to give a higher degree of reliability of self-interrupted drive than that previously attained by relay drive.

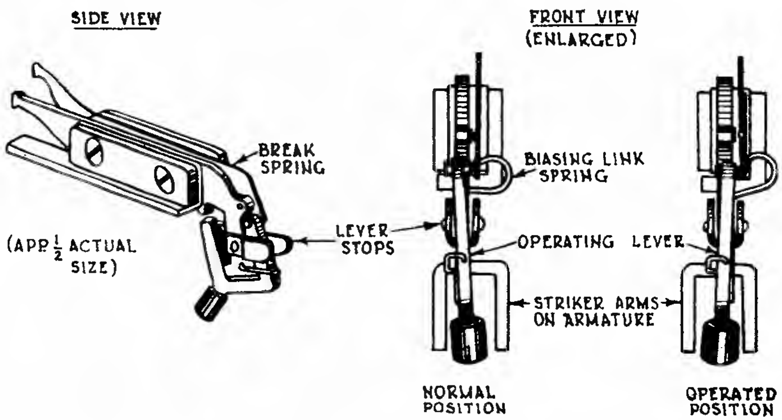
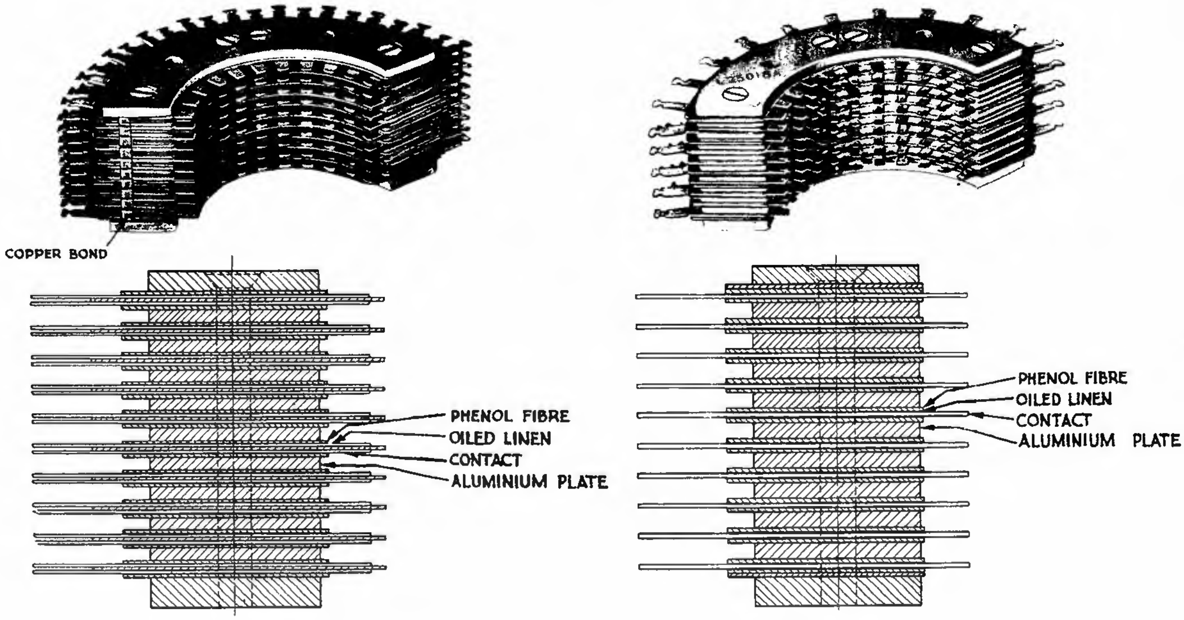


FIG. 14. INTERRUPTER SPRINGS.

The spring-set functions as follows: There are two striking arms on the armature. Towards the end of the operating stroke, one arm engages the operating lever and carries it over so that the contact spring is lifted off the fixed contact. The lever is held in this position by the biasing link spring. The contacts being now broken, the armature returns. Towards the end of the return stroke, the second striker arm engages the opposite side of the lever and carries it over again to its original position, allowing the contact spring to fall on the fixed contact. The lever is held in this position again by the biasing spring at the other extreme of its travel. The contacts now being re-made, the armature moves forward again and the process is repeated until the series of operations is stopped. The action described ensures positive operating and release strokes of the armature when the springs are used to interrupt the magnet circuit by direct action.

4. CONTACT BANKS AND WIPERS.

4.1 Two types of contact bank are available, namely, the 220 point line or twin contact private bank and the 110 point single contact private bank. The respective assemblies are shown in Fig. 15.



(a) 220 Point. (b) 110 Point.

FIG. 15. CONTACT BANKS.

Note that there are 11 contacts per level. The eleventh contact is usually required for traffic metering or routining purposes. While the insulation mainly consists of phenol fibre plates, the contacts actually lie on tacky oiled linen which retains them in position. Aluminium plates act as screens against electrostatic induction between adjacent levels. On line banks, the aluminium plates are electrically bonded by means of a thin copper ribbon which is inserted into notches in the plates during the assembly operation.

4.2 Mounting the Contact Banks. Fig. 16 shows how the contact banks are rigidly secured to specially shaped cradles by means of two long bolts and nuts. The switches are seated in these cradles, being located by tongues engaging at the top and bottom of the banks. This enables the switches to be conveniently withdrawn and replaced, as shown in Fig. 17, no screws or nuts having to be removed.

The cradles are mounted on rubber and secured to the shelf by one screw. This rubber mounting is to prevent the transmission of vibration from a switch, in the course of impulsing or driving, to adjacent selectors whose wipers may be standing on bank contacts and carrying a conversation. Such vibration can cause undesirable noises during conversation, owing to small movements of the wipers on bank contacts.

4.3 Wiring of Contact Banks. Although not strictly part of the switch, the method of wiring and terminating the bank multiple is of special interest and is shown in the lower part of Fig. 16, which will be recognised as the rear view of the upper part of Fig. 16. This shows a panel of banks which is complete with its terminal assembly. Adjacent panels are connected together by tie cables wired to the tags shown. In Fig. 16, the wiring from the switch jacks for the switch on the extreme right can also be seen.

/Fig. 16.

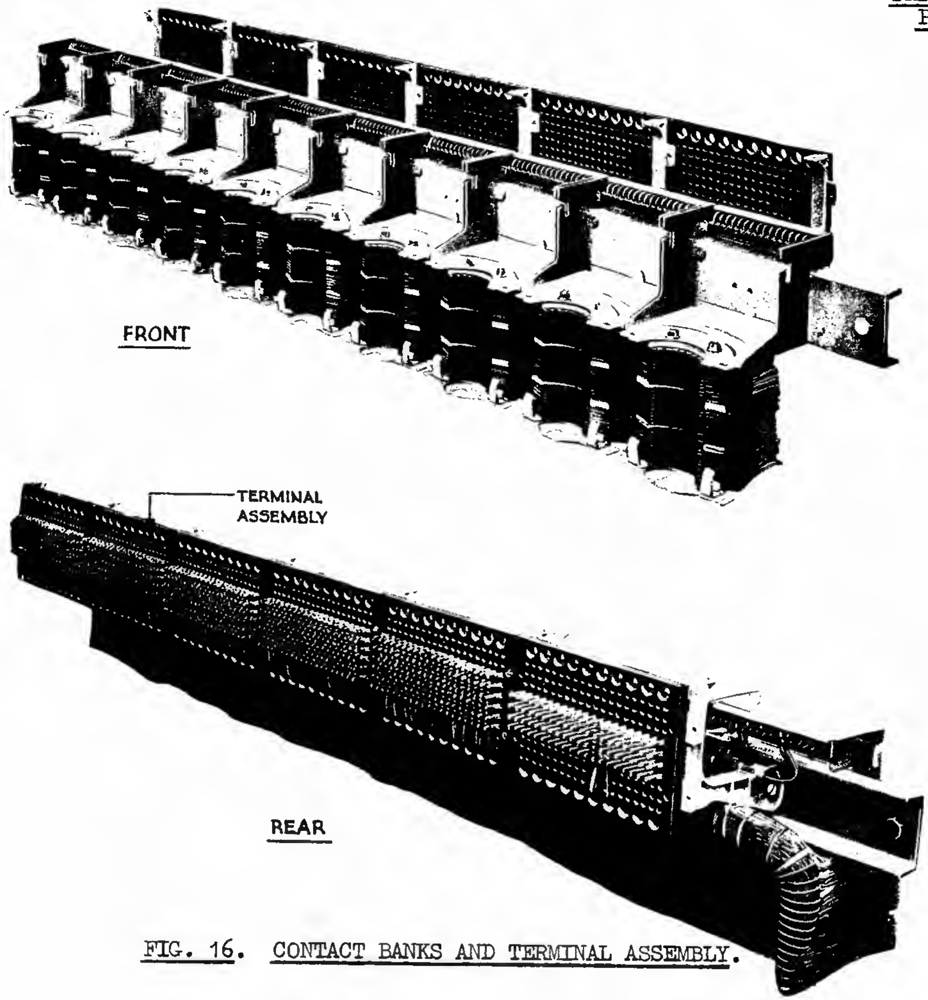


FIG. 16. CONTACT BANKS AND TERMINAL ASSEMBLY.

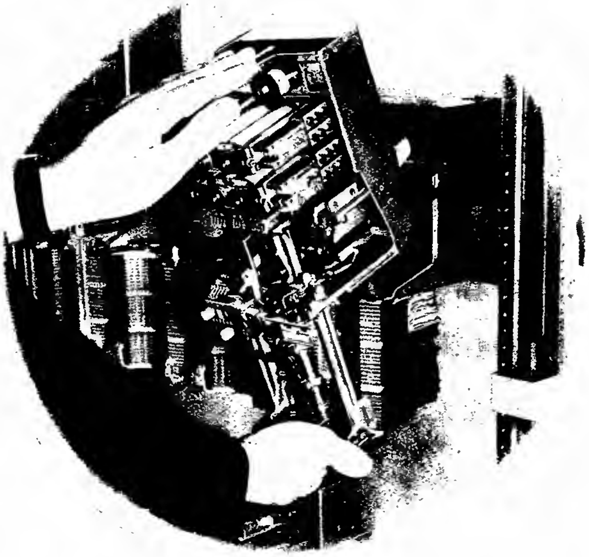
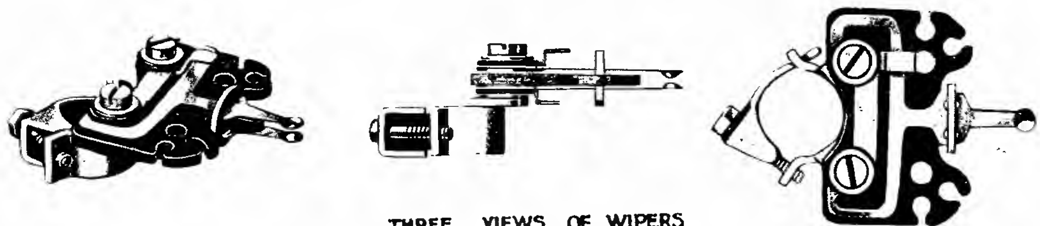


FIG. 17. REMOVING A SWITCH FROM A BANK.

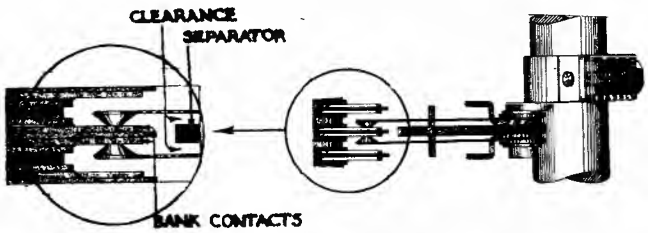
4.4 Wipers. The special type of wipers used with these switches is shown in Fig. 18. The wiper springs are held together by a fibre collar located in notches a short distance back from the tips. The springs are bent outwards from the roots so that the tips are about 3/8 inch apart before this collar is put into position. The portion of the wiper spring behind the collar is long and flexible. Between the wipers, and extending through the collar to within a short distance of the tip, is a rigid plate of insulating material.

The complete adjustment required by the wiper is that the springs must be about 0.010 inch clear of the insulator and the tips from 0.012 to 0.020 inch apart.

One result achieved by this form of construction is that the pressure exerted by the springs, when they engage a bank contact, is dependent on the shape of the springs and on the amount of opening, so that accurate pressure is obtained by adjusting the tip gap only. The fibre collar anchors the two springs together so that they float up and down as a pair and equalise the pressure on upper and lower tips.



THREE VIEWS OF WIPERS



WIPER ON BANK CONTACT

FIG. 18. 2000 TYPE WIPERS.

The shape of the wiper spring provides such a degree of vertical flexibility behind the collar that there is practically no variation of contact pressure with wide inaccuracy in the vertical adjustment of the wiper tips opposite the bank levels.

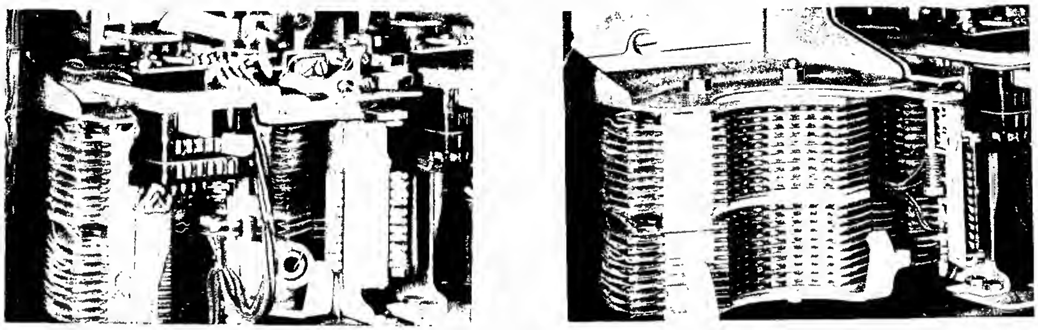
The damping of the springs at a point along their length by the collar is designed to eliminate wiper bounce.

The rigid central insulator, which the springs nearly touch, is intended to prevent the tips vibrating during the vertical stepping of the selector and thus avoid the necessity of any pause period before rotary "cut-in." Immediately cut-in occurs, the springs widen out well away from this insulator and are thus free from any restraining influence. This allows some tolerance in cut-in alignment.

The tips are a truncated cone in shape. The greatest diameter of the tip is less than the space between bank contacts, so that, even if it should wear badly, the wiper is non-bridging. Wipers can be removed from a switch and replaced without disturbing the other wipers.

/4.5

4.5 Vertical Bank and Wiper. In some types of switches a vertical bank and wiper assembly is required. There are three alternative methods of mounting the vertical bank, the usual one being shown in Fig. 19.



(a) "Working" Position.

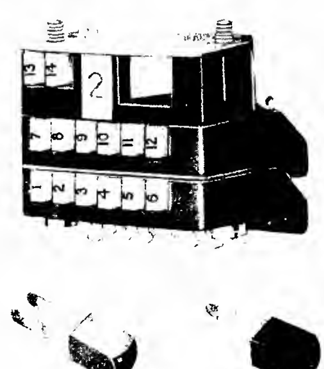
(b) "Disengaged" Position.

FIG. 19. VERTICAL BANK AND WIPER.

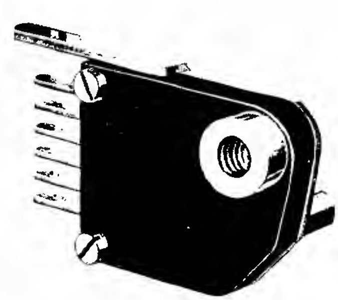
An arm extending forward from the cradle carries a small bracket free to pivot on a vertical axis. The vertical bank is secured to this bracket in front of the selector frame extension. The action of removing the selector from the shelf engages the frame extension with this bracket, which is caused to swing forward and to the right, thus automatically disengaging the bank from the wipers. The bracket is held in the "working" and "disengaged" positions by a spring plunger.

The vertical wipers are fixed to a simple bracket which is free to rotate on the wiper carriage tube but which rises vertically with it. The vertical wipers thus rise and fall with the wiper carriage but remain stationary when the latter rotates.

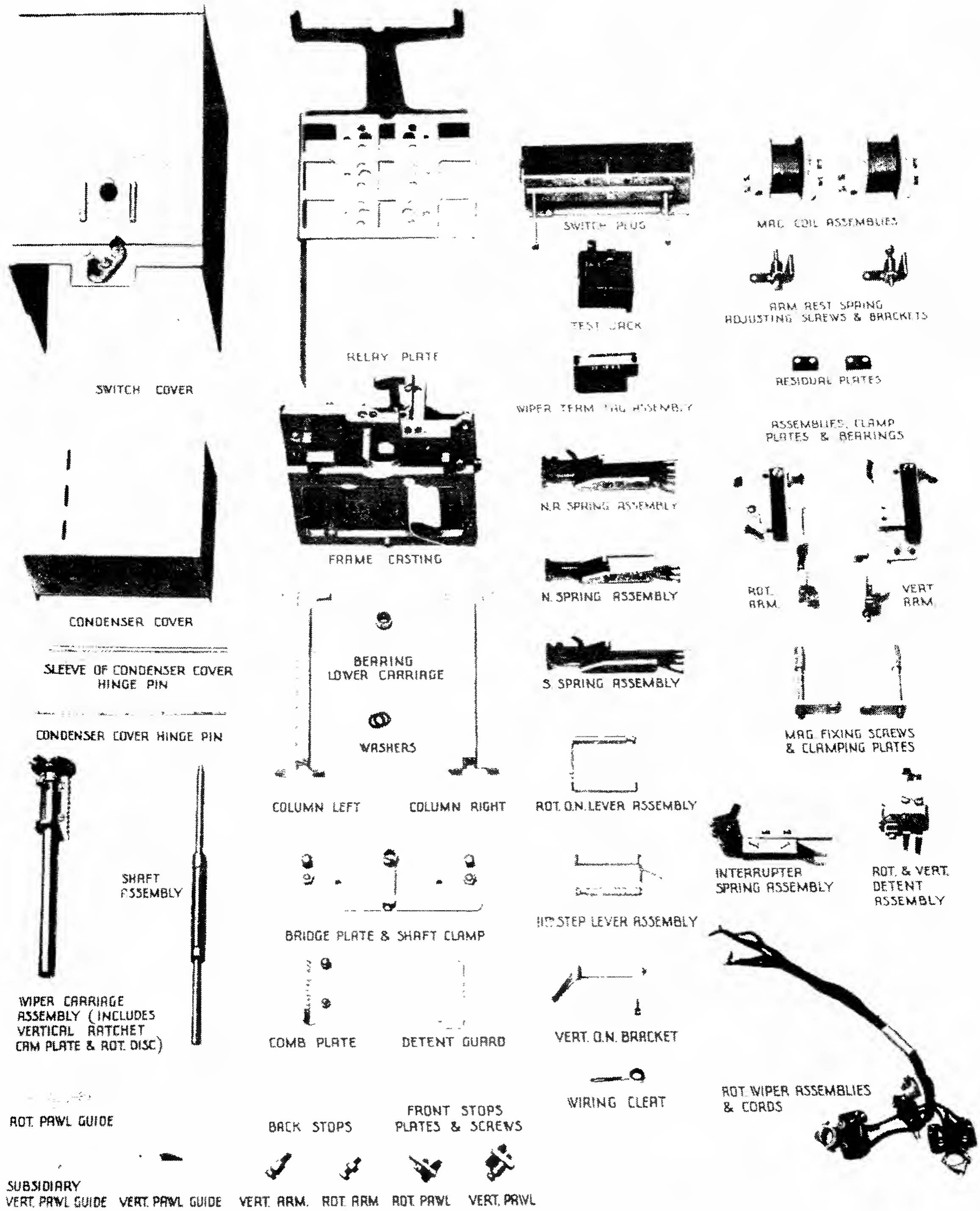
4.6 Test Jack and Lamp Jack. These items, together with the test "U" links, are shown in Fig. 20. The test jack consists of slotted rectangular blocks of moulded bakelite, built up in multiples of six test points. The lamp jack is a similar moulding, containing also a label holder and two test points. The complete assembly is secured by two screws below the left-hand corner of the frame. The test "U" links, available in two colours, provide convenient means for various testing purposes, including "busying," opening the release magnet circuit, etc. A test plug (Fig. 21) is available with either six or twelve contacts.



TEST JACK AND LAMP JACK.
FIG. 20.



TEST PLUG.
FIG. 21.



PARTS OF 2000 TYPE SELECTOR

5. MOUNTING ARRANGEMENTS.

5.1 Type 2000 selectors are arranged for mounting on single-sided racks, the shelves of which have capacity for 10 selectors. The shelf itself consists simply of a suitable channel iron on to which the cradles for mounting the individual selectors are cushioned with rubber and secured by a single screw.

The contact banks are rigidly fixed to the cradles, and the multiple wiring does not project beyond the rear of the apparatus. In cases where the number of relays per switch exceeds 16, an auxiliary shelf is employed to provide a second supporting point (see Fig. 22). This method of mounting enables the switches to be easily removed and replaced since it involves only lifting them from, or placing them in, position. Relay groups, without switch mechanisms, are mounted in a similar manner, the cradles for these, however, being different from those used for selectors.

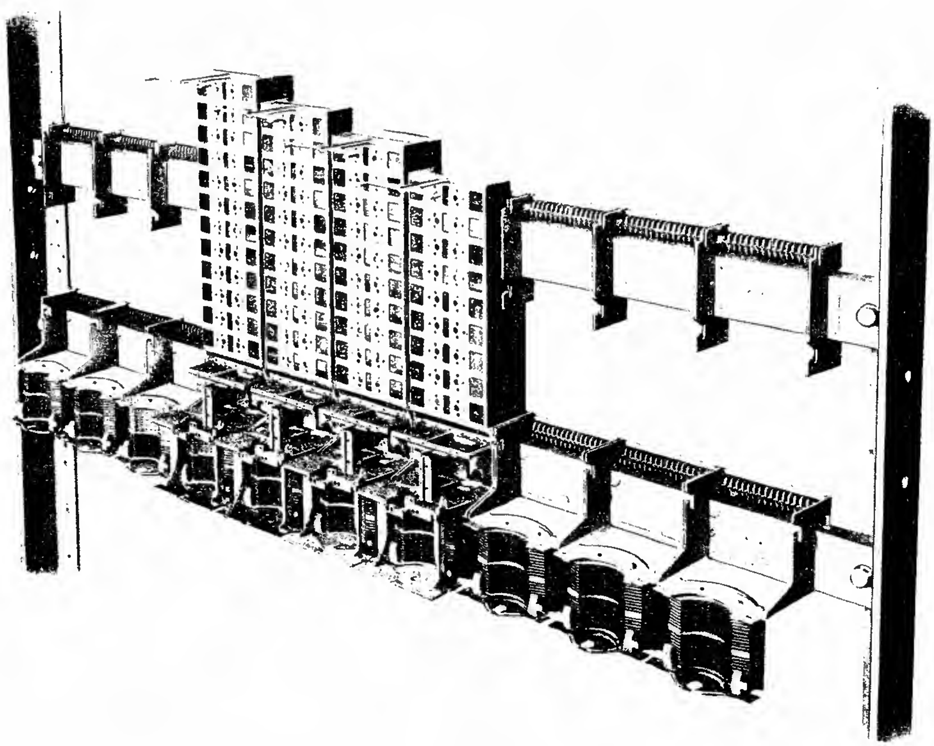


FIG. 22. MOUNTING OF 2000 TYPE SELECTORS.

5.2 The permanent wiring and cabling are accommodated at the rear of the shelves, being supported on brackets which also serve as jumper rings. The brackets also support the moulded bakelite single-sided connection strips which terminate the circuits in a manner suitable for grading or cross-connecting, as required.

5.3 The mounting racks are available in three standard heights, namely, 8 ft. 6½ in., 10 ft. 6 in., 11 ft. 9½ in., thus providing for exchange buildings of various ceiling heights and eliminating wastage of space. The 10 ft. 6 in. racks are most commonly used in our installations. More details of the mounting arrangements are given in Paper No. 6.

6. MODIFICATIONS TO 2000 TYPE SELECTORS.

6.1 2000 type equipment is now in extensive use, both in Australia and overseas. From time to time, experience has shown that modifications could be introduced to improve manufacturing techniques or performance in service. Various changes have therefore been made, the more recent developments being listed hereunder.

6.2 Anti-Bounce Plate. A die cast plate has been fitted to the underside of the bridge plate to act as a counterweight against carriage bounce. This occurs when the carriage restores vertically to its normal position, and may cause the wipers to catch on the bank contacts and also cause damage to the hub assembly. When the carriage assembly restores from, say, level 0, the impact on the bottom clamp may be sufficient to cause the shaft to move in its top seating.

6.3 Rotary Off-Normal Spring-Set Operating Lever. Trouble has been experienced on the existing rollers due to excessive wear on the roller bearings and breakages of rollers at the point of reduced section. Later switches are supplied with a fixed operating plate and operating lever in the form of a single steel pressing.

6.4 Wipers. The wiper assembly bracket has been redesigned to prevent distortion of the wiper carriage with excessive pressure. The bracket is now reversible, and the fixing screw threads into a "log" nut instead of directly into the rear of the bracket.

The shape of the wiper tips has been modified to reduce wear and to prevent catching between the banks on cutting-in. Further investigations are in progress, tending towards the replacement of the collar type wiper assembly with a completely new design.

6.5 Rotary Detent. The upper projection is case hardened and manufactured from thicker material in order to reduce wear and improve latching.

6.6 Hub and Rotary Disc Assembly. The shaft hub, rotary disc and cam plate are now made in a complete unit, and the rotary disc is offset to improve latching.

6.7 Vertical Magnet Fixing Screw. It has been found that the vertical magnet loses part of its magnetic flux due to the existing mild steel fixing screw and its proximity to the switch cover. This is now replaced by a non-magnetic fixing screw.

6.8 Mechanically Operated Spring-Sets. These have been replaced with 600 type relay spring-set assemblies and buffer blocks. This will facilitate adjustments, as standard relay adjustments may be used.

6.9 Interrupter Assemblies. These have been redesigned with the object of improving the reliability and ease of adjustment of the unit. The new assembly is shown in Fig. 23, and a view of the 2000 type selector, with the modifications designated, is shown in Fig. 24.

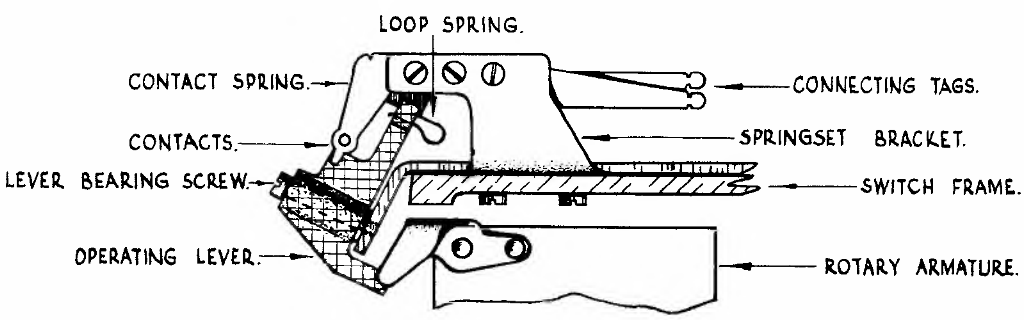


FIG. 23. NEW TYPE ROTARY INTERRUPTER ASSEMBLY.

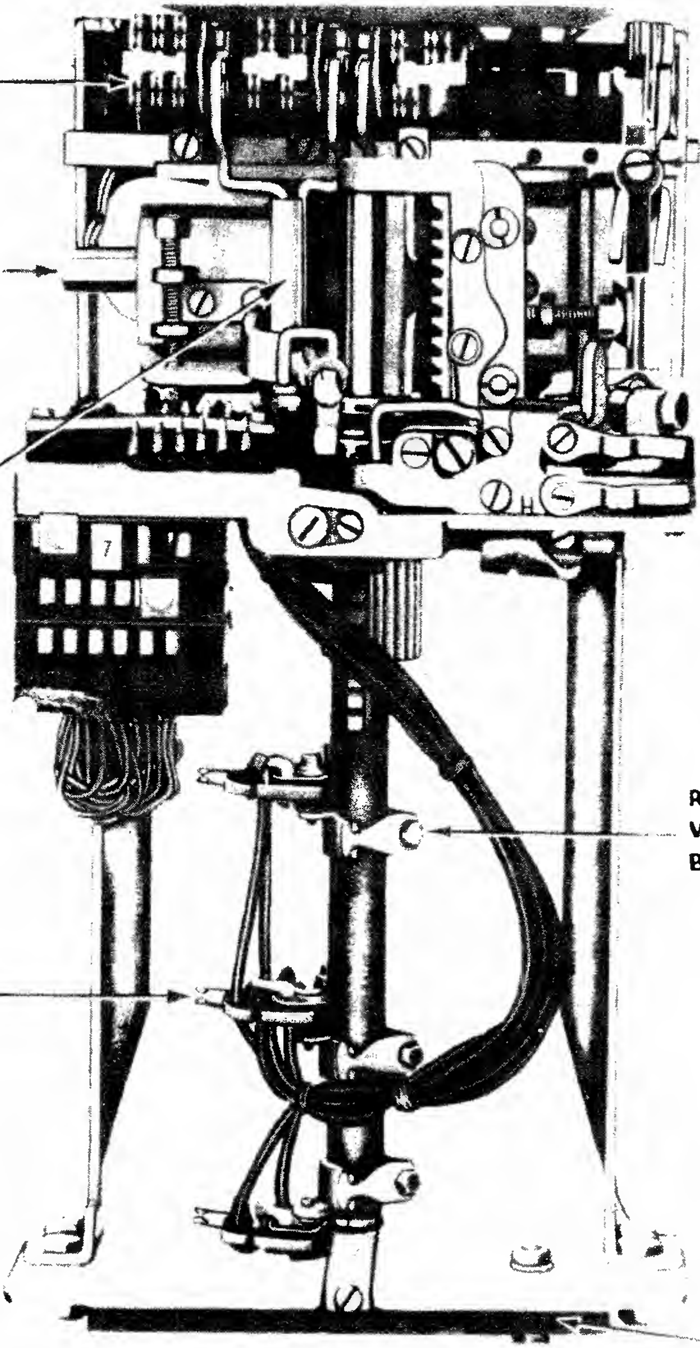
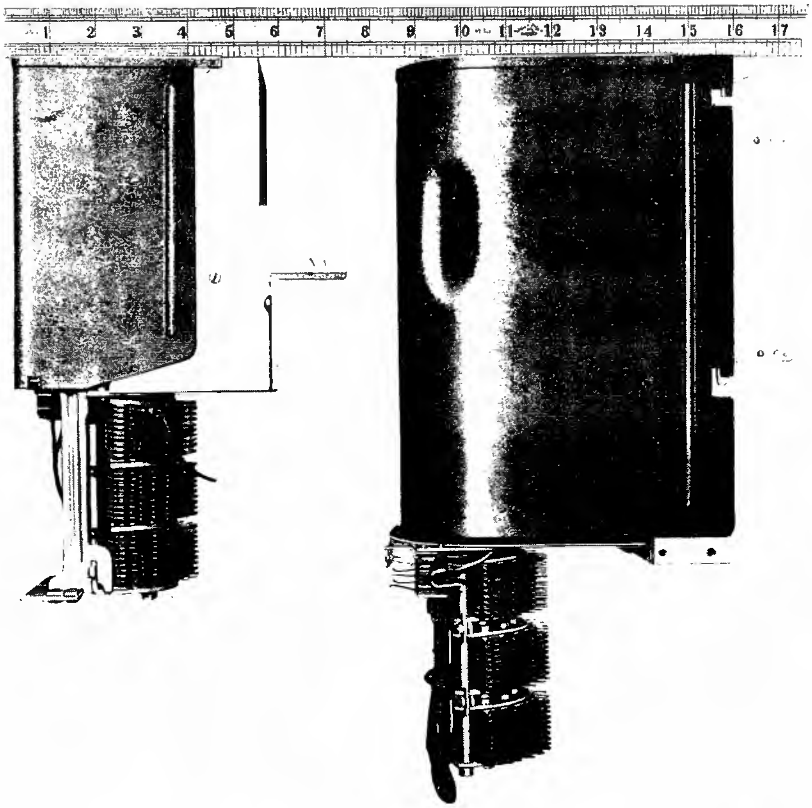


FIG. 24. MODIFIED 2000 TYPE SELECTOR.

7. COMPARISON OF 2000 TYPE AND PRE-2000 TYPE SELECTORS.

7.1 The 2000 type selector saves approximately 40% in the cubic contents of self-contained selectors and effects a saving of 25% in weight per selector. For comparison, it is shown with its pre-2000 type equivalent in Fig. 25. Other points of comparison are noted below.



COMPARATIVE SIZES OF 2000 AND PRE-2000 TYPE SELECTORS.

FIG. 25.

7.2 Shaft. In pre-2000 type selectors the shaft is movable and the lower end carrying the wipers is unsupported. This enables the shaft to become accidentally bent and, owing to whip in the shaft, limits the number of banks that can be fitted to this type of switch to three.

A fixed shaft is provided on 2000 type selectors, and the wipers are attached to a cylindrical carriage which slides on the shaft. Thus, whip in the shaft is eliminated and up to 10 banks may be fitted.

7.3 Magnets. Pre-2000 type selectors use double coil vertical and rotary magnets and a single coil release magnet. If energised for excessive periods, these coils will heat unduly and may cause a fire.

The vertical and rotary magnets of 2000 type selectors are of single-coil construction and are more powerful than those of the earlier switch. This is necessary on account of the large number of wipers that can be carried, and gives an improvement in impulsing performance to this switch. The magnets are self-protecting.

/7.4

7.4 Release. In the 2000 type selector the "forward" release principle is used, and no separate release magnet is necessary. Compared with the "backward" release of the earlier switch, this has the advantage of more uniform wear on the bank contacts, but the time taken for the release action is longer. Approximate releasing times are -

	Pre-2000	2000
Maximum release time	150 mS (up 10, in 10)	350 mS (up 10, in 1)
Minimum release time	50 mS (up 1, in 1)	100 mS (up 1, in 10)
Average release time	100 mS	250 mS

In cases where a specially rapid release action is required, such as in a digit absorbing selector or D.S.R. where one or more digits must be absorbed during the dial inter-digital pause, special arrangements must be made when using 2000 type selectors which are unnecessary with the pre-2000 type switch.

7.5 Hunting Speed. Owing to the nature of the interrupter spring assembly, pre-2000 type selectors require an interacting relay for hunting and reach a speed of approximately 33 steps per second.

Due to improved design of magnets and interrupter springs and the lightness of the moving parts, the 2000 type selector may hunt at a speed of 50 steps per second, both vertically and rotarily. The interacting relay is not necessary.

7.6 Mechanically Operated Spring-Sets. These are standardised in a fixed number of types, and are installed in their entirety without the possibility of falling apart. In pre-2000 type switches, this falling apart often entails considerable work in aligning and adjusting the spring-sets.

7.7 Adjustments. One of the features of the 2000 type mechanism is the simplified means of adjustments provided and the fact that almost every adjustment can be made from the front of the selector whilst it is in position on the shelf. All the adjustments are simple, and a comprehensive set of tools has been developed to enable them to be effected in the minimum of time with maximum accuracy.

Wherever possible, lock nuts are eliminated on adjustable screws, since lock nuts have the disadvantage that they tend to disturb the adjustments when being tightened. The friction screws used facilitate adjustments and ensure that they remain perfectly constant in service.

To remove a pre-2000 type selector from the shelf, it is necessary to remove the bank rod nuts and ease the switch off the bank. The bank is unsupported until the switch is replaced, and it is necessary to readjust the wipers to the bank.

A 2000 type switch can be removed or replaced in the shelf simply by lifting it out or in as required. Readjustment of the wipers is unnecessary, and the bank is supported by the switch cradle. Rubber insulation between the cradle and the shelf overcomes vibration and microphonic noise.

8. TEST QUESTIONS.

1. Describe and sketch the mounting of the shaft and carriage assembly in the 2000 type switch mechanism, and discuss the advantages of the fixed shaft.

2. Explain the mechanical action of the rotary interrupter spring contacts.

3. On a 2000 type two-motion selector, explain how the wiper carriage assembly is supported during rotary motion.

4. On the same type of switch explain why the vertical detent is adjusted to ride on the left-hand side of the vertical ratchet during vertical stepping.

5. What is meant by the term "self-protecting" as applied to electromagnets associated with two-motion selectors?

6. What are the adjustments required by the wipers on a 2000 type selector, and how do these adjustments guarantee adequate contact pressure between wiper and bank contacts?

7. List the essential differences between the pre-2000 and 2000 type two-motion selectors, in regard to the mechanism only.

9. REFERENCES.

Telecommunication Journal of Australia. Volume 1, No. 4 "The B.P.O. Type 2000 Line-Finder System" by W. A. Phillips.

Strowger Engineering Bulletin No. 400. "The 32A Selector."

Telephone Engineering Instructions. Exchanges Automatic AD 4221 - "Adjustment of Bimotional Switches - Type 2000."

END OF PAPER.

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Melbourne, C.2.

COURSE OF TECHNICAL INSTRUCTION.

2000 TYPE CIRCUITS.

CONTENTS.

1. INTRODUCTION.

2. FEATURES OF 2000 TYPE CIRCUITS.

3. GROUP SELECTORS, 200 OUTLET.

4. ORDINARY FINAL SELECTOR, 200 LINE.

5. 2-10 P.B.X. FINAL SELECTOR, 200 LINE.

6. LARGE GROUP P.B.X. FINAL SELECTOR, 100 LINE.

7. TEST QUESTIONS.

8. REFERENCES.

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1. INTRODUCTION.

1.1 The circuits of 2000 type selectors differ in many respects from those previously described in this Course. These changes are partly due to the abolition of the release magnet and introduction of the "forward" release principle. Also, due to its greatly increased bank capacity, the 2000 type selector is much more flexible in its application, and, as a result, the capacity of a 2000 type selector is generally larger than its pre-2000 type counterpart.

The introduction of the new switch has presented an opportunity to improve on certain of the circuit elements as listed below -

(i) Improved impulsing circuit.

(ii) Balanced transmission of tones.

(iii) Improved hunting circuit, using self-interrupted drive of high speed.

(iv) Minimum unguarded period on switching through.

(v) Effective reguard during release action.

(vi) Avoidance of "x" or "y" contacts.

(vii) Avoidance of marginal adjustments.

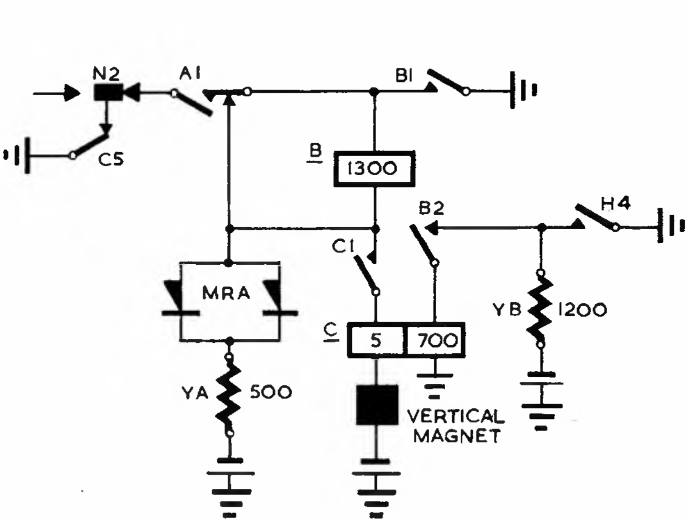
These features are outlined on the following pages preparatory to a detailed examination of the complete circuits.

2. FEATURES OF 2000 TYPE CIRCUITS.

2.1 Impulsing Circuit. Fig. 1 shows the vertical stepping circuit of a typical 2000 type selector.

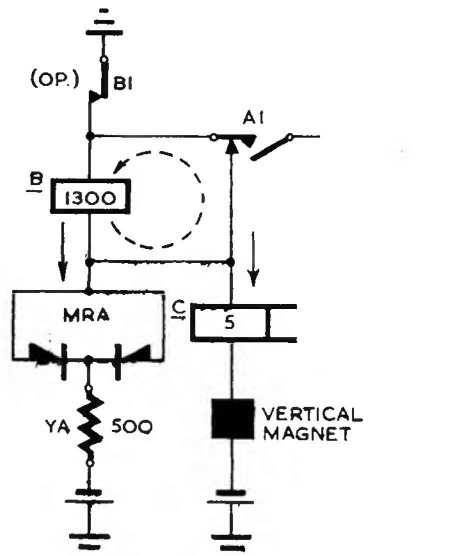
When the selector is seized, relay A operates to the calling loop and A1 operates relay B from earth via C5 and N2 to battery via rectifier MRA and 500 ohm resistance YA. B1 supplies an earth to hold relay B when C5 subsequently opens and B2 operates relay C on its 700 ohm winding to battery via 1200 ohm YB.

The preoperation of relay C in this manner allows this relay to carry a much heavier spring load than the earlier type. C1 closes the circuit of the vertical magnet preparatory to impulsing. A false impulse, due to "bunching" of the contacts of relay A during its operation, is not possible with this circuit arrangement.



IMPULSING CIRCUIT.

FIG. 1.



SIMPLIFIED IMPULSING CIRCUIT.

FIG. 2.

The rectifier is included in the operating circuit of relay B to prevent this circuit from affecting the release time of the selector magnets. The impulsing circuit is shown in simplified form in Fig. 2. It will be seen that, when C1 closes, the vertical magnet is shunted by resistance YA and rectifier MRA. Without the rectifier, the resistance of YA alone would not be sufficient to prevent the inductive discharge from increasing the release lag of the magnet armature to such an extent that the impulsing characteristics of the selector are seriously affected. Note that the circuit via the winding of relay B also provides a path for the inductive discharge of the magnet. The impedance of this path, however, is sufficiently high to prevent any appreciable current flow, and the effect on impulsing is negligible.

When the caller operates the dial, relay A releases with each impulse and A1 short-circuits the winding of relay B, allowing sufficient current to flow for the full operation of the vertical magnet. Relay B is not fitted with a copper slug, but holds during impulsing because of the inductive current circulating in its short-circuited winding, shown by the dotted arrow in Fig. 2. The full arrows indicate the paths for the operating currents of relay B and the vertical magnet.

The wiper carriage is raised a number of steps according to the digit dialled and, on the first step, the off-normal (N) springs operate. This causes the operation of relay H (not shown in Fig. 1) and H4 connects a short-circuiting earth to relay C, making that relay slow to release. Relay C holds during dialling because of the pulses through its 5 ohm winding, and releases slowly after the last impulse in the train.

/ The

The use of short-circuited windings in lieu of copper slugs on relays B and C has the following advantages -

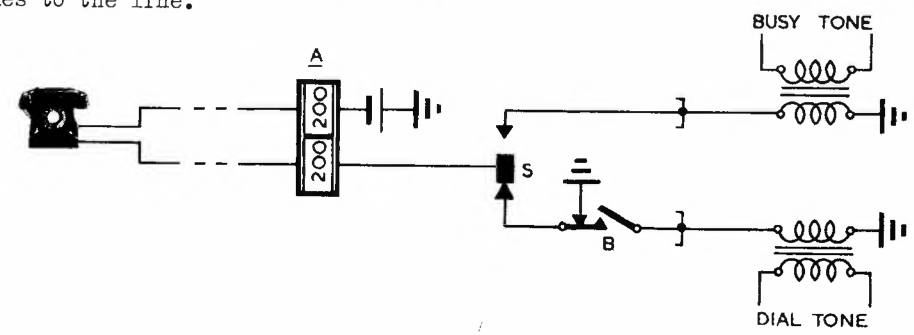
(i) The relays operate faster due to the absence of a slug.

(ii) As a greater space is available for the windings, it is possible to provide a greater number of contact springs, or to use higher contact pressures.

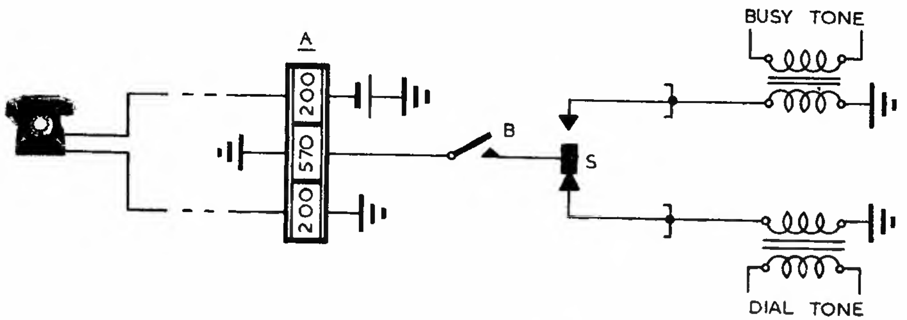
(iii) A greater slugging effect is obtained as, in the case of relay B, the whole of the winding space is used for this purpose.

Due to these improvements and to the more efficient mechanism, the impulsing limits of the 2000 type selector are considerably wider than its predecessor. For example, the 2000 type selector will function satisfactorily with an impulse ratio of up to 90 per cent. break.

2.2 Balanced Transmission of Tones. Fig. 3 shows the earlier and new methods of applying tones to the line.



PRE-2000 TYPE



2000 TYPE

METHODS OF APPLYING TONES.

FIG. 3.

The pre-2000 arrangement connects the tones to one wire of the line through a winding of the battery feed relay. The high impedance of this relay adversely affects the transmission of the tones and, as the circuit is not balanced, a certain amount of interference results.

In 2000 type circuits, the tones are connected to a third winding of the battery feed relay. This "tone" winding thus functions as the primary winding of a transformer, inducing the tone voltages equally into the two line windings. The new method has the advantage of giving less distortion of the tones, and also reduces mutual interference between lines, since the series impedances to earth of both line wires are balanced.

2.3 Hunting Circuit. In pre-2000 type circuits, the hunting drive is obtained by interaction between a relay and the rotary magnet. This gives a slower hunting speed than that obtained with a self-interrupted drive circuit as used, for example, for uniselectors. It should be noted that the heavy restoring spring tension of a uniselector causes its armature to restore, despite the fact that the magnetic flux begins to rise at an early stage of the release action.

Because of the special design of its interrupter contacts, a self-interrupted drive circuit can be arranged on 2000 type selectors. The interrupter springs are actuated by a "toggle" action, causing the contacts to open when the armature nears the end of its operating stroke, and the contacts do not remake until the armature has almost completed its release stroke. However, it is not possible to arrange a self-interrupted drive circuit for a two-motion selector via the P wiper and bank as in a uniselector, because the two-motion selector is a forward drive switch and an erratic motion would result. Also, as two-motion selector wipers are non-bridging, sparking would occur, causing rapid destruction of wipers and bank contacts.

The essential feature of earth-testing circuits is that busy contacts are connected to earth potential and free contacts are marked by absence of earth. It is possible, therefore, to stop the hunting drive by arranging that a testing relay (a contact of which completes the rotary magnet circuit) shall remain operated while the P wiper is passing over earthed contacts and shall release and cut the drive circuit immediately a free outlet is reached. This principle of disconnecting a local self-drive circuit by means of a testing relay is known as the "cut-drive" principle. In such a circuit the speed of drive is independent of the testing circuit and, with the 2000 type selector, hunting speeds of over 40 steps per second are obtained. It will be appreciated that the testing relay must release very quickly to cut the drive circuit before the interrupter contacts remake to step the wipers on to the next contact.

Fig. 4 shows the elements of the cut-drive earth-testing circuit. During the first vertical step, the testing relay H is operated on its 500 ohm winding via B5 and N1 to earth at C3, and holds via the interrupter contacts R1 to earth at H4. On the release of relay C at the end of the impulse train, a self-drive circuit for the rotary magnet is completed via C3, N1 and R1 to earth at H4. Relay H remains operated while the wipers are passing over busy contacts, being held as follows -

(i) On its 500 ohm winding via B5, R1 and H4 while the wipers are being stepped from contact to contact.

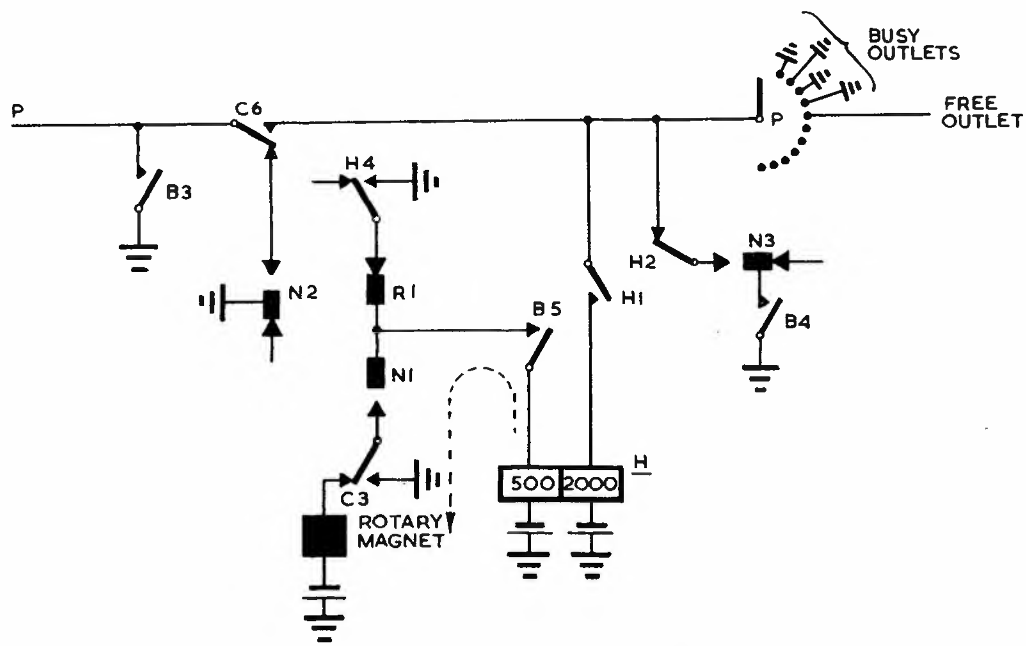
(ii) On its 2000 ohm winding via H1 to the earth encountered by the P wiper on busy contacts.

When a free outlet is reached, absence of earth on the private bank contact allows relay H to release when the interrupter contacts open. H4 cuts the self-drive circuit of the rotary magnet to prevent further stepping, and relay C (not shown in Fig. 4) is reoperated. The operation of relay C switches the negative, positive and private wires to the seized outlet, and relay H reoperates via B5 and N1 to earth at C3. When relay B releases after its slow release period, relay H holds on its 2000 ohm winding via H1 to the earth returned over the P wire from the seized outlet.

/ 2.4

2.4 Minimum Unguarded Period on Switching Through. In pre-2000 type circuits, the seized outlet is not guarded until the switching relay operates, and, as this relay has an operate lag of approximately 15 milliseconds, the circuit may be seized by another searching selector during this time. This unguarded period is reduced to between two and three milliseconds in the 2000 type circuit, thus reducing the possibility of double connections.

Immediately the P wiper is stepped to a free contact, not only is the 2000 ohm winding of relay H opened but its 500 ohm winding receives an inductive kick from the rotary magnet as shown by the dotted arrow in Fig. 4. Relay H is thus caused to release very rapidly, and the seized outlet is immediately guarded by earth via H2, N3 and B4. Subsequently, relays C and H reoperate and the guarding earth is applied at B3.



CUT-DRIVE EARTH-TESTING CIRCUIT.

FIG. 4.

2.5 Effective Re-guard during Release Action. 2000 type selectors are guarded during the release period as follows. When earth is removed from the P wire, relay H releases, followed by the release of relay C. After the combined release lags of these relays (approximately 20 milliseconds), the P wire is again earthed via N2 and C6 to guard the switch. N2 also opens the operating circuit of relay B (see Fig. 1) so that, even if the switch is seized during this brief unguarded period, the release of the switch is unaffected.

2.6 Avoidance of "x" or "y" Contacts. Relays employing "x" or "y" contacts are more difficult to adjust than relays without special sequence of operation. For this reason, 2000 type circuits are designed, wherever possible, to eliminate the necessity for such contacts.

2.7 Avoidance of Marginal Adjustments. For the same reason, all marginal adjustments have been eliminated from the new circuits, giving a higher operating efficiency in service. The maintenance of the relays of 2000 type switches, therefore, should prove to be more simple than the earlier type.

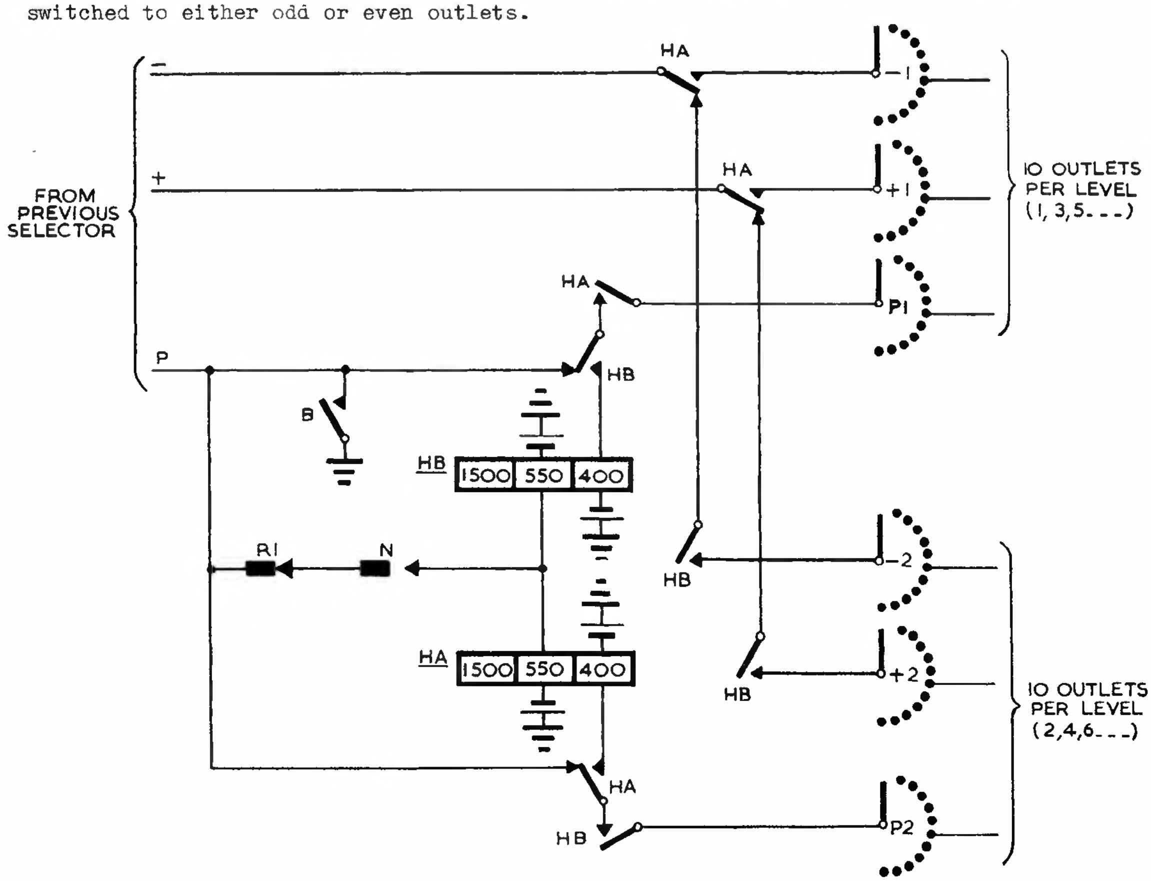
/ 3.

3. GROUP SELECTORS, 200 OUTLET.

3.1 Group selectors previously described in this Course are of the 100 outlet type, that is, having ten outlets on each of their ten levels. The number of levels is limited because of the decimal dialling system used, but it is often desirable to increase the number of outlets on a level. As an example, take a level which has ten outlets arranged as a full availability group. From traffic capacity tables, assuming a standard grade of service (one lost call in 500), it is seen that the ten outlets can carry a traffic load of 3.43 T.U., that is, an average of 0.343 T.U. per outlet. Under the same conditions, however, a level having 20 outlets can carry 10.07 T.U., that is, an average of 0.503 T.U. per outlet. Thus, increasing the availability of the selector increases the traffic capacity of the outlets and the use of 200 outlet group selectors results in an average saving of approximately 20 per cent. in the number of switches required in the next rank.

In the 200 outlet group selector, normal banks having ten levels each with ten outlets are used, but the banks are duplicated and the circuit is so arranged that two outlets are tested simultaneously at each rotary step. The switch is fitted with a 600-point bank, made up of three 200-point units. The bottom unit takes the negative and positive line wires of the odd-numbered outlets of each level, the centre unit takes the line wires of the even outlets while the upper unit takes the 200 private wires. At each rotary step, therefore, a test is made of an odd outlet (in the lower bank) and an even outlet (upper bank), so that in ten steps the 20 outlets are tested.

The wiper switching arrangement of a 200 outlet group selector is shown in Fig. 5. Two switching relays (HA and HB) are necessary to allow the calling line to be switched to either odd or even outlets.



WIPER SWITCHING CIRCUIT OF 200 OUTLET SELECTOR.

FIG. 5.

It may be seen from Fig. 5 that the calling line is connected to an odd outlet when relay HA switches or to an even outlet if relay HB switches. Briefly, the operation is as follows -

Relays HA and HB are operated on their 500 ohm windings when the wiper carriage is stepped off-normal but, during rotary stepping, this circuit is opened at R1 each time the rotary magnet operates. If the outlets on which the wipers rest are busy, these relays hold on their 400 ohm windings to earth on the P2 and P1 wipers, respectively, and the wipers are stepped to test the next outlet. If the odd-numbered outlet is found to be free, relay HB releases, allowing relay C (not shown in Fig. 5) to reoperate, and relay HA is held on its 1500 ohm winding. If the even outlet is free, relay HA releases and relay HB holds on its 1500 ohm winding, switching the call to the even outlet.

Gradings are designed on the principle that the outlets are always seized in consecutive order and, to meet this requirement, the circuit is so arranged that when the wipers reach a rotary step where both odd and even numbered outlets are free, the odd outlet is seized.

Although the use of 200 outlet group selectors increases the traffic capacity of the outlets, this does not necessarily mean that they are more economical than 100 outlet selectors. The savings in selectors or junctions to which the outlets give access must be weighed against the increased cost of the 200 outlet switches because of their larger size. Where the traffic is light the 100 outlet selector is more economical, but, in the majority of cases, particularly where the outlets are connected to expensive external junctions, the balance is in favour of the 200 outlet switch. It is, however, desirable to standardise one type of group selector for all purposes, and it has been decided that 200 outlet group selectors will be provided for all 2,000 type exchanges in the Commonwealth.

3.2 The functions of the 200 outlet group selector are -

(i) When seized, returns an earth on the P wire to hold and guard the connection.

(ii) Gives dial tone to the caller when used as a first selector.

(iii) Steps vertically under the control of impulses received.

(iv) Cuts-in on the level reached and, if the first outlets are busy, hunts for and seizes the first free outlet in the level.

(v) Provides facilities for testing two outlets at each rotary step.

(vi) Switches the calling line through to the seized outlet.

(vii) Clears the line of all apparatus bridges.

(viii) Retains the earth on the P wire for a sufficient time for it to be returned from the seized circuit.

(ix) Should all outlets in the level be busy, the switch steps to the 11th contacts, operates the overflow meter and transmits busy tone to the calling subscriber.

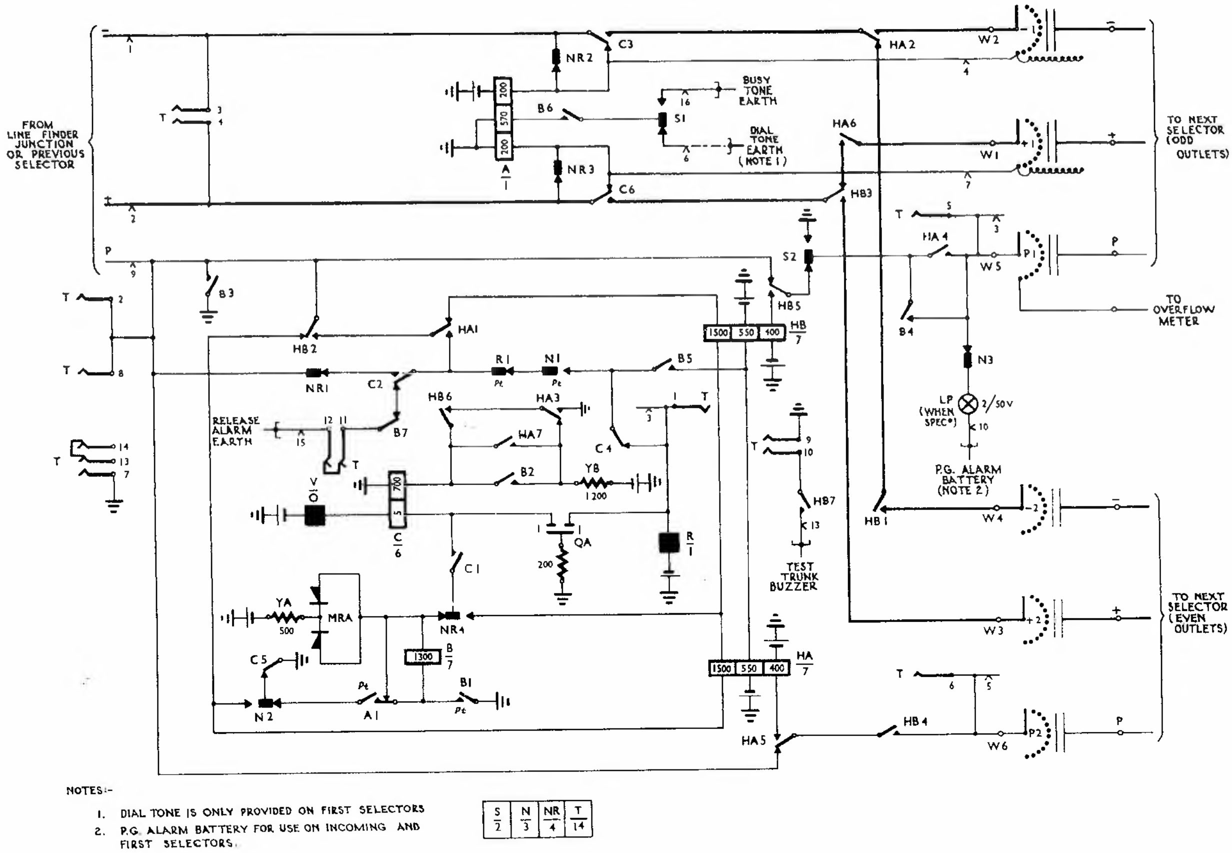
(x) Releases itself when release conditions are applied.

(xi) Provides an alarm should the switch fail to release due to a mechanical defect. (Release alarm.)

(xii) Provides an alarm should the switch be held without dialling longer than 6 minutes (P.G. alarm).

(xiii) Provides a jack to enable the operation of a bell to indicate which of the two outlets on which the wipers are standing has been seized.

3.3 Fig. 6 shows the circuit of a 200 Outlet Group Selector (2000 Type), and a description of the circuit operation follows.



NOTES:-
1. DIAL TONE IS ONLY PROVIDED ON FIRST SELECTORS
2. P.G. ALARM BATTERY FOR USE ON INCOMING AND FIRST SELECTORS.

GROUP SELECTOR, 200 OUTLET (2,000 TYPE).

FIG. 6.

Switch Seized. Relay A operates to the calling loop on the negative and positive wires via NR2 and NR3. A1 completes the circuit of relay B from earth via C5 and N2 to battery via 500 ohm YA and rectifier MRA.

Relay B operates and B1 holds B-operated when C5 subsequently opens. B3 connects a guarding and holding earth to the P wire. If the switch is a first selector, B6 connects dial tone to the 570 ohm winding of relay A, and the caller hears the tone induced into the 200 ohm windings. B4 completes the circuit of the supervisory lamp to earth via S2, HB5 and B3, and, if the switch is not stepped within the specified delay period (6 minutes), the P.G. alarm is given. Further details of the alarm circuits are given in Paper No. 7.

B2 completes the circuit of relay C on its 700 ohm winding to battery via 1200 ohm YB. C operates and C1 prepares the impulsing circuit to the vertical magnet.

/ Vertical

Vertical Stepping. When dialling takes place, relay A releases with each impulse and, on each release, the vertical magnet is operated via the 5 ohm winding of relay C, C1, NR4 and A1 to earth at B1. The wiper carriage is thus raised to the level corresponding to the digit dialled. A1 short-circuits the winding of relay B during impulsing to make that relay slow to release.

On the first vertical step, the off-normal (N) springs operate. Relays HA and HB operate on their 550 ohm windings via B5, N1, R1, C2 and NR1 to earth at B3. The 700 ohm winding of relay C is now short-circuited by earth via HA3 and HB6, making this relay slow to release. Relay C remains operated during dialling by the pulses through its 5 ohm winding and, after the last impulse has been received, C releases slowly.

Rotary Hunting. After its slow release period (80-120 mS) relay C releases and C4 completes the self-drive circuit of the rotary magnet via N1, R1, HA1 and HB2 to earth at B3. The wipers are stepped on to the first pair of outlets on the dialled level. Towards the end of the rotary armature stroke, the rotary interrupter contacts break, opening the circuit of the rotary magnet and also the 550 ohm windings of relays HA and HB.

If the contacts on which the wipers are resting are both busy, relays HA and HB remain operated on their 400 ohm windings to the earths encountered by the P2 and P1 wipers, respectively. The disconnection of the magnet circuit allows the release of the armature and, when the interrupter contacts re-make, the circuit of the magnet and the 550 ohm windings of relays HA and HB is again completed. The wipers are stepped to the second set of bank contacts, this cycle being repeated until a free outlet is reached, when either HA or HB releases and cuts the self-drive circuit of the rotary magnet.

It should be noted that during rotary hunting the rotary magnet is shunted by the 550 ohm windings of relays HA and HB in parallel. This provides a circuit for the high inductive voltage produced by the magnet coil, and the release time of the rotary armature is thus increased. The hunting speed is thereby reduced to approximately 40 steps per second. Relays HA and HB must release very fast in order to stop the drive on a free outlet and, for this reason, are fitted with nickel-iron cores. In addition, the inductive surge from the rotary magnet through their 550 ohm windings reduces the release lags of these relays to between two and three milliseconds.

Odd Outlet Free. Absence of earth on the P1 wiper allows relay HB to release. HB2 cuts the rotary magnet circuit to prevent further stepping. The outlet is immediately busied via the P1 wiper, B4, S2 and HB5 to earth at B3. HB4 opens the circuit of the 400 ohm winding of relay HA, which also releases. HB6 and HA3 remove the short-circuit from the 700 ohm winding of relay C, which reoperates. Relay HA now reoperates on its 1500 ohm winding from battery via the vertical magnet, 5 ohm winding of relay C, C1 and NR4 to earth on the P wire via HB2. HA7 holds relay C operated when relay B subsequently releases.

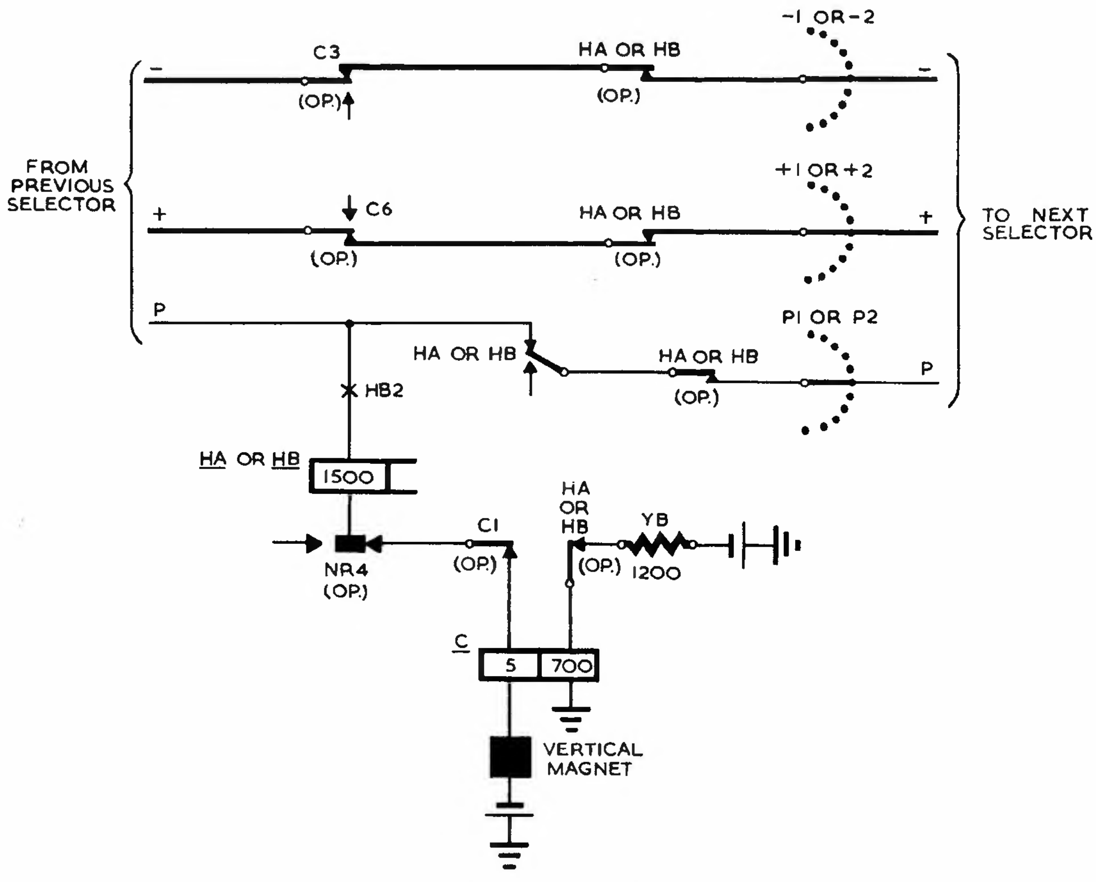
C3 and C6 extend the negative and positive wires via HA2 and HA6 through to the seized outlet, at the same time disconnecting relay A, which releases. A1 short-circuits relay B which, due to its release lag (250-350 mS), remains operated for a period sufficient to ensure that the seized circuit returns an earth to guard and hold the connection.

Even Outlet Free. Relay HA releases due to absence of earth on the P2 wiper and HA1 cuts the drive circuit. In this case, relay HB remains operated on its 400 ohm winding via B4 to the earth on the P1 wiper. HA5 guards the seized outlet with earth at B3. HA3 removes the short-circuit from the 700 ohm winding of relay C, and, when C reoperates, relay HB holds on its 1500 ohm winding from battery via the vertical magnet, 5 ohm winding of relay C, C1 and NR4 to earth on the P wire via HB2 and HA1. The operation of relay C switches the calling subscriber through to the seized outlet, and relays A and B release as described in the previous paragraph. HB7 prepares the circuit for the operation of the test trunk bell when a test plug is inserted in T9-10, thus it is possible to determine which outlet has been seized without removing the switch cover. HB6 holds relay C operated when relay B releases.

/ Both

Both Outlets Free. In this case relays HA and HB both release. The drive circuit is opened at HA1 and HB2, and the odd outlet is immediately guarded by the application of earth via B3, HB5, S2 and B4 to the P1 wiper. The even outlet is not guarded due to the release of HB4. Relay C reoperates as the short-circuit is removed from its 700 ohm winding at HB6 and HA3. Relay HA then reoperates on its 1500 ohm winding as previously described, and the call is switched through to the odd outlet. It will be seen that, in this condition, switching takes place on the P1 outlet, thus giving a definite priority to the odd outlets.

Fig. 7 shows a simplified diagram of the through connections on this switch.



THROUGH CONNECTIONS.

FIG. 7.

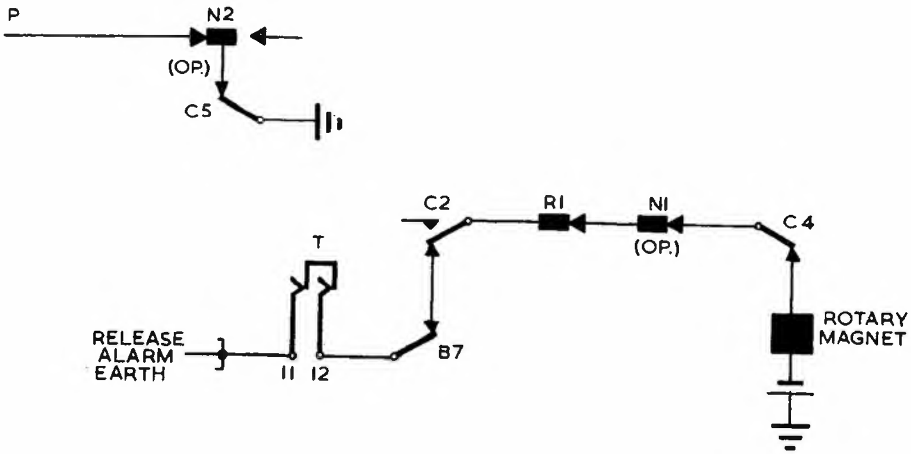
All Outlets Busy. If all outlets in the dialled level are busy, the wipers are stepped to the 11th contacts and the 11th step (S) springs operate. As there is normally no earth on the 11th P contacts, relays HA and HB release and the drive is stopped. Relays C and HA then reoperate as described previously and the calling subscriber is switched to the -1 and +1 wipers. These are resting on the 11th bank contacts which are commoned (but not multipled) and connected to relay A. Thus relay A holds operated to the calling loop and relay B remains operated. B3 maintains the earth on the P wire to hold and guard the connection. S1 connects busy tone to the 570 ohm winding of relay A, whence it is induced into the line windings. S2 connects earth to the P1 wiper for operation of the overflow meter. S2 also opens the testing circuit of relay HB to ensure the release of this relay should an earth be encountered on the 11th P contact. (Due to another selector in the same group standing on this contact.)

/ Release

Release of Connection.

(a) After a Normal Call. The release of the selector is normally effected when the earth is removed from the P wire by the switch ahead. Relay HA (or HB) then releases, followed by the release of relay C. C4 completes a self-drive circuit for the rotary magnet via N1, R1, C2 and B7 to release alarm earth, as shown in Fig. 8. The wiper carriage is thus rotated to the 12th step, where it falls to below the first level and rotates backwards to the normal position. At this position the off-normal contacts restore and N1 opens the release circuit. If, due to a mechanical defect, the carriage does not return to normal within the specified delay period (9 seconds), the alarm circuit operates (see Paper No. 7).

During the release period, the selector is guarded by an earth connected to the P wire via C5 and N2. The selector is unguarded during the combined release lags of relays HA (or HB) and C (a total of approximately 20 milliseconds) but, if it is seized during this brief period, the release action is unaffected since relay B cannot operate until the switch reaches the normal position.



RELEASE CIRCUIT.

FIG. 8.

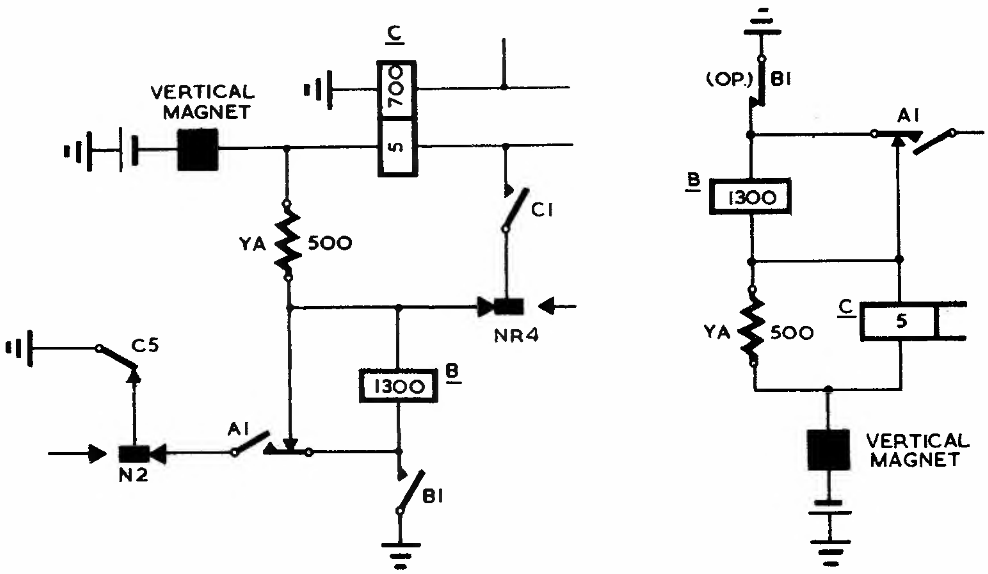
(b) After "All Outlets Busy" Condition. When the caller replaces the receiver, relay A releases and A1 short-circuits the winding of relay B, which releases slowly. B3 removes the earth from the P wire and relay HA releases, followed by the release of relay C. When C releases, the selector releases as described above for the normal call, and the switch is guarded during the release period.

Operation on Faulty Outlet. If the seized outlet is faulty, no earth will be returned on the P wire to hold the switching relay, which releases after the release of relay B. Relay C then releases, completing the release circuit of the selector. Relay A reoperates to the calling loop via C3 and C6, but relay B cannot operate until the switch reaches the normal position. The switch, therefore, releases fully and the call "drops out" back to the first switch in the train.

/ 3.4

3.4 Modifications to Group Selector Circuit. The group selector circuit previously described includes a metal rectifier, type 2N/6A, in the circuit of relay B. Its purpose is to prevent the operating circuit of relay B affecting the release time of the selector magnets.

Recently the rectifier was eliminated by a simple circuit alteration, as shown in Fig. 9.

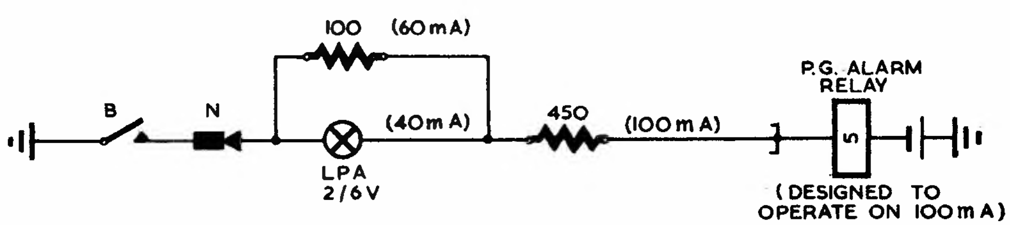


MODIFIED IMPULSING CIRCUIT.

FIG. 9.

The operating circuit for relay B is taken via 500 ohm YA to battery via the vertical magnet. The rectifier is not necessary in this circuit as there is no circuit for the inductive discharge of the magnet, apart from the path through relay B. The impedance of this path, however, is sufficiently high to prevent any appreciable current flow, and the effect on impulsing is negligible. Apart from a reduction in the operate and release times of the magnets of approximately one millisecond, the modification was found to have a negligible effect on the circuit operation.

3.5 Use of 6 Volt Lamps. The group selector circuit shown in Fig. 6 shows a 50 volt lamp in the P.G. alarm circuit. (These lamps are fitted on incoming and first selectors only.) Later switches are fitted with 6 volt metal filament lamps. Originally a 1200 ohm resistance was connected in series with the 6 volt lamp to allow it to operate on 50 volts. However, to ensure correct operation of the P.G. alarm supervisory relay, it became necessary to shunt the lamp with a resistance of 100 ohms, as shown in Fig. 10.



LATER P.G. ALARM CIRCUIT.

FIG. 10.

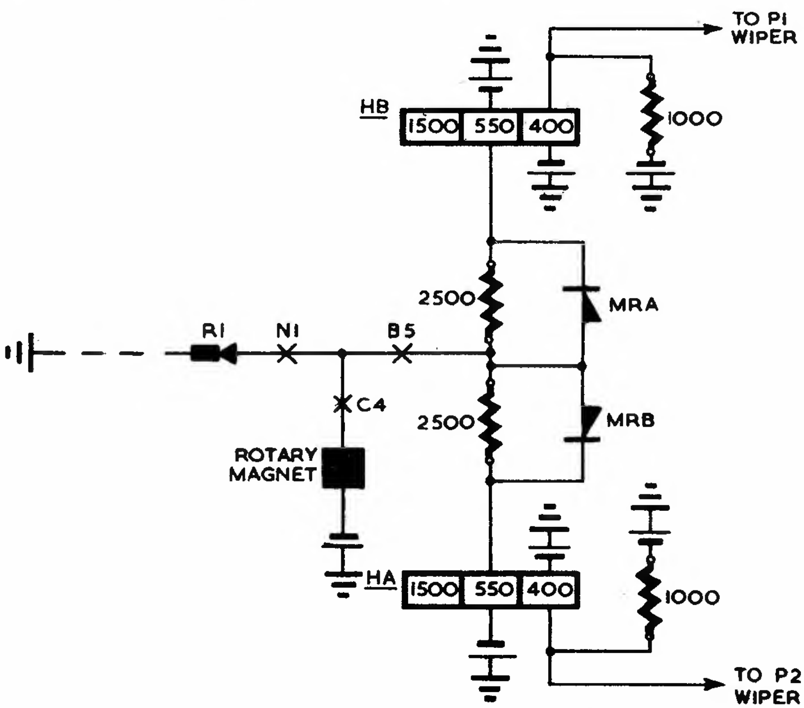
3.6 "Stop on Busy" Trouble. Relays HA and HB are required to hold operated while the wipers are passing over busy contacts and to release immediately a free outlet is reached. These relays are fast releasing and a momentary open-circuit or high resistance condition in the P1 or P2 wiper circuit may allow these relays to release prematurely and switch the caller through to an outlet which is already in use. Some likely causes of this trouble are -

- (i) Faulty alignment of the wipers on the bank contacts.
- (ii) Faulty wiper adjustment.
- (iii) Faulty adjustment of rotary interrupter contacts.
- (iv) "Backlash" in the rotary magnet adjustment, causing "overshoot" of wipers.
- (v) High resistance contacts between wipers and banks. (Dirty bank contacts.)

Careful maintenance, with particular attention to the above points, can reduce the incidence of double connections. Trouble can also be caused by wiper "bounce," but a new type of wiper, now being developed, will minimise this effect.

To give a more positive rotary action on multi-bank selectors, a more powerful rotary magnet than originally used is now fitted to 2000 type switches. This has accentuated the "stop on busy" problem, as the inductive kick from the rotary magnet, due to its increased inductance, tends to cause a faster release of the switching relays.

Recently, with the object of eliminating double connections, modifications have been made to the group selector circuit. To slow down the release of relays HA and HB, 1000 ohm resistances are connected in parallel with their 400 ohm windings. In most cases, provided that the switches are carefully maintained, this measure is quite effective in preventing double connections. The latest development of the group selector circuit includes a further safeguard. The inductive kick from the rotary magnet is attenuated by 2,500 ohm resistances connected in series with the 550 ohm windings of relays HA and HB, as shown in Fig. 11. The metal rectifiers, shunting the resistances, allow the switching relays to be fully operated, but are blocking to the inductive current from the magnet. This has the effect of slightly increasing the release lag of the switching relays and also allows the switch to hunt at a slightly increased speed (approximately 45 steps per second).



MODIFIED TESTING CIRCUIT.

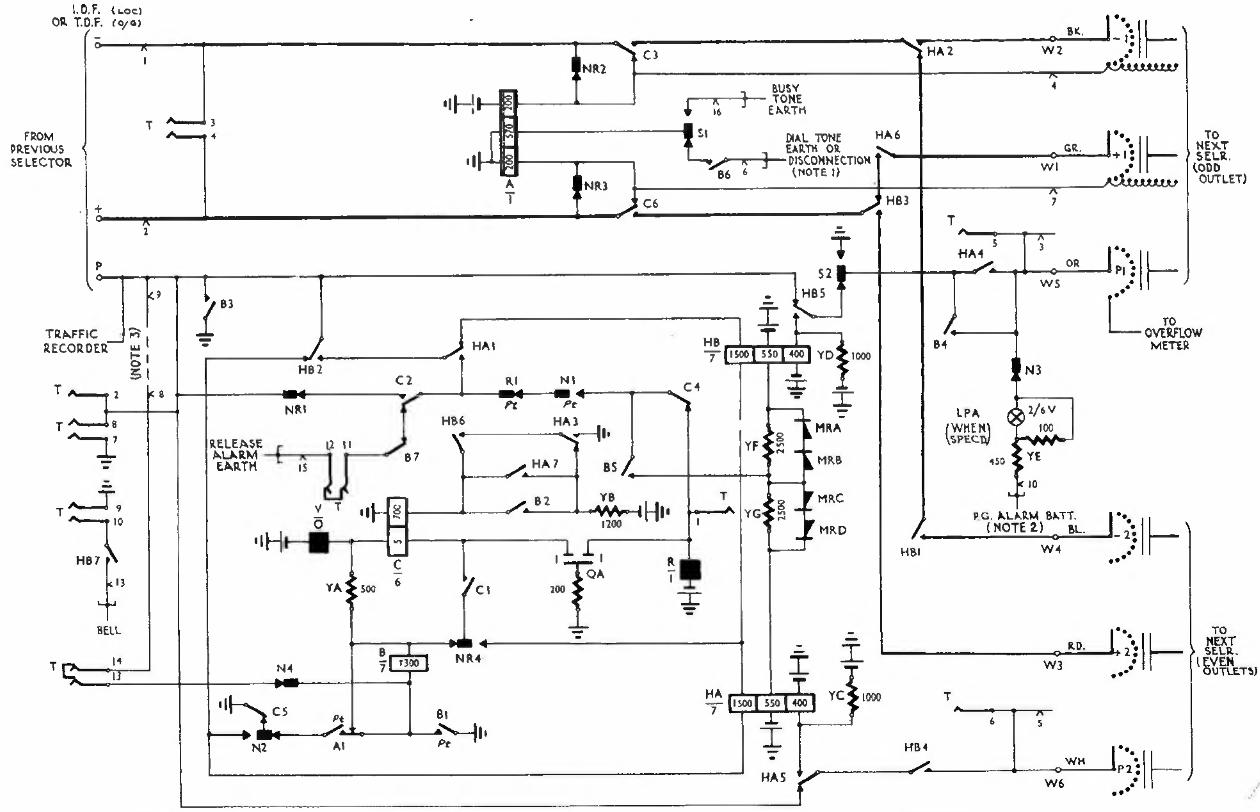
FIG. 11.

3.7 Fast Guard Feature. When a group selector is seized, relay A operates, followed by the operation of relay B. After the combined operate lags of relays A and B, earth is applied to the P wire (at B3) to hold and guard the connection. To cover this period, all selectors must have a slow releasing relay (relay B in the case of a group selector) which maintains the earth on the P wire until it is returned from the switch ahead.

In the case of subscribers' uniselector circuits, the line relay (L) is fitted with a copper slug to give this slow release feature. However, with circuits using 600 type line relays, trouble has been experienced on long lines due to inadequate fluxing of the relay. This causes a reduction of the release lag and, in some cases, the line relay releases before the earth is returned on the P wire from the first selector. The cut-off relay then releases, the line relay reoperates and interaction is set up between these two relays.

To prevent this condition, and allow satisfactory operation on longer lines than previously was possible, the present standard group selector circuit (Fig. 12) incorporates a fast guard feature. Earth is returned on the P wire as soon as relay A operates via C5, N2, A1, N4, T13-14 and shelf strap U8-U9. This strap is only wired on first selectors serving subscribers' uniselectors, as, in all other cases, the fast guard feature is not required.

When it is required to busy the selector, the test plug is transferred from T13-14 to T7-8, thus preventing a current drain via resistance YA and the vertical magnet.



NOTES :-
1. DIAL TONE IS ONLY PROVIDED ON SUBSCRIBERS' FIRST SELECTORS.
2. P.G. ALARM BATT. FOR USE ON FIRST SELECTORS ONLY.
3. SHELF STRAP U8 TO U9 PROVIDED FOR LOCAL FIRST SELECTORS ONLY.

S	N	NR	T
2	4	4	14

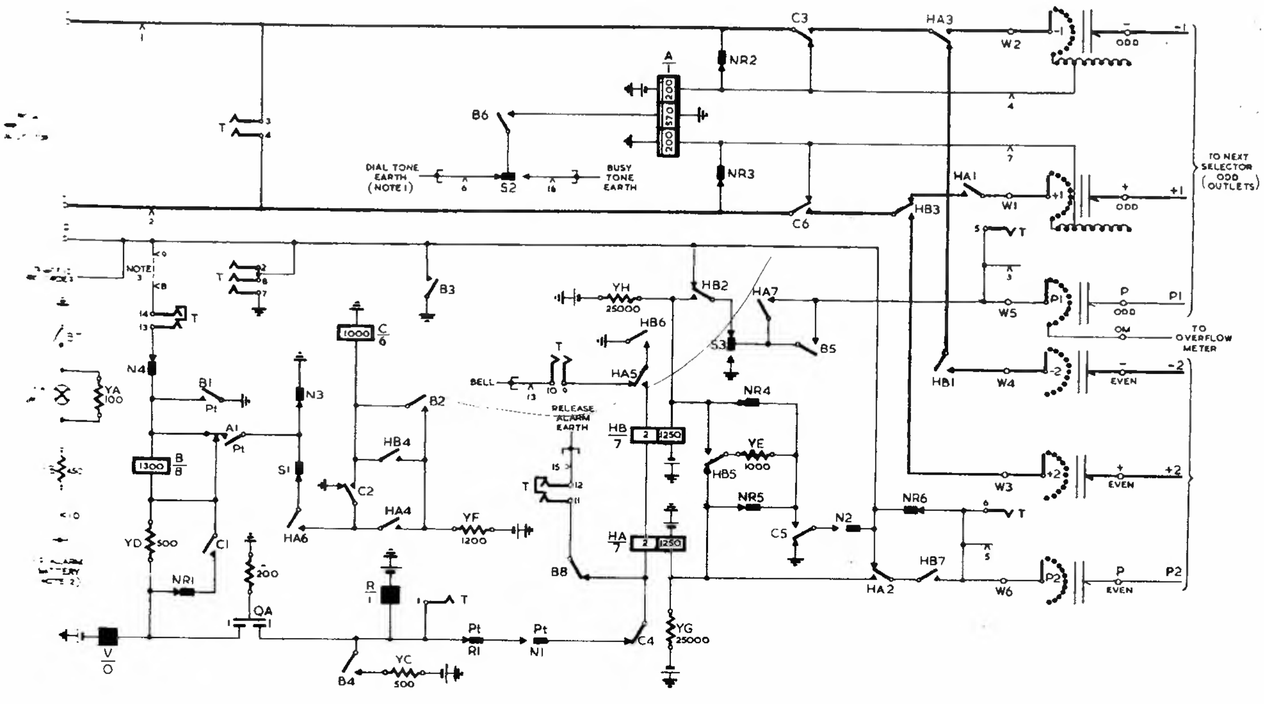
200 OUTLET GROUP SELECTOR (2,000 TYPE).
(Drawing CE-65, Sheet 1, Issue 8.)

FIG. 12.

3.8 Fast Guard Group Selector. Fig. 13 shows the circuit of a 200 outlet group selector which has been developed by the Automatic Telephone and Electric Company, Liverpool, and is at present undergoing extensive field trials in the Commonwealth.

The circuit contains several novel features, particularly in regard to the arrangement of the switching relays, HA and HB. These relays have only two windings and are held during rotary stepping on their two ohm windings in series with the rotary magnet. With this arrangement, the inductive voltage produced by the rotary magnet winding when its circuit is broken has no effect on the release lags of the switching relays. Therefore, there is less possibility of these relays releasing due to the private wiper momentarily overstepping a busy contact, and so there is less liability to double connections than with the earlier circuit. While the interrupter contacts are opened, the outlets on which the wipers are standing are tested by the 1250 ohm windings of relays HA and HB. These relays remain operated while the wipers are passing over busy contacts but release immediately a free outlet is reached. This same winding is used to hold the switching relay operated during the connection, but with a 1000 ohm resistance in series to reduce the current drain.

Another new feature is the arrangement of relay C, which is provided with a single winding. It is preoperated when the switch is seized and, during dialling, is short-circuited by earth via the operated contacts of the impulsing relay. It holds during vertical stepping and releases slowly at the end of the impulsing train to cause the rotary search. As the whole of the winding space is available for the short-circuited winding, its release lag is longer than that of the previous type of relay used, giving an improvement in the impulsing performance of the switch. The circuit operation is described on the following pages.



NOTES
1. DIAL TONE IS ONLY PROVIDED ON LOCAL 1ST SELECTORS
2. P G ALARM BATTERY & LAMP PROVIDED ON LOCAL 1ST & INCOMING SELECTORS ONLY
3. SHELF STRAP UB TO U9 ONLY PROVIDED FOR LOCAL 1ST SELECTORS AT UNISELECTOR EXCHANGES

FAST GUARD GROUP SELECTOR, 200 OUTLET (A.T. AND E. CIRCUIT S.210782).

FIG. 13.

Switch Seized. Relay A operates to the calling loop and A1 completes the circuit of relay B from earth at N3 to battery via the vertical magnet and 500 ohm YD. A1 also applies a fast guard earth to the P wire via N4, T13-14 and shelf strap U8-9 in the case of first selectors serving subscribers' uniselectors.

Relay B operates and B1 holds relay B when N3 subsequently opens. B3 applies a holding and guarding earth to the P wire. On local first selectors B6 connects dial tone to the 570 ohm winding of relay A. B7 closes the circuit of the supervisory lamp to P.G. alarm battery (fitted on local first and incoming selectors only). B8 opens the self-drive release circuit. B2 closes the circuit of relay C to battery via 1200 ohm YF.

Relay C operates and C1 prepares the circuit for impulsing the vertical magnet. C2 prepares for the short-circuiting of relay C during impulsing. C4 opens the rotary magnet circuit and C5 prepares for the operation of relays HA and HB.

Vertical Stepping. On each impulse relay A releases and A1 operates the vertical magnet via NR1 and C1 to earth at B1. Relay B is short-circuited and holds during impulsing. The wiper carriage is raised to the dialled level and, on the first step, the off-normal (N) springs operate.

Relays HA and HB now operate on their 1250 ohm windings via NR5 and NR4, respectively, to earth via C5, N2 and B3. HA6 extends the earth from A1 to short-circuit relay C during impulsing. C holds during the impulse train and releases slowly after the last impulse. HA4 maintains the short-circuit on relay C when C2 releases, so that relay C remains unoperated during rotary hunting. Earth from normal contact C2 ensures this condition in the event of further dialling by the caller. Further operation of the vertical magnet is prevented by the release of C1, and, when C subsequently reoperates, by the operation of NR1. HA and HB are held operated when C5 releases by earth via B3, NR6, HB7 and HA2 (and NR5 and NR4 in the case of relay HB).

Rotary Hunting. When relay C releases, a self-drive circuit is completed for the rotary magnet via its interrupter contacts R1, N1 C4, two ohm windings of relays HA and HB and HA5 to earth at HB6. The wipers are stepped to the first contacts and the rotary off-normal (NR) springs operate. NR6 opens the holding circuit of the 1250 ohm windings of relays HA and HB, and these windings are connected to the P2 and P1 contacts respectively to test the outlets. When the rotary interrupter springs open the circuit of the two ohm windings of these relays, they remain operated on their 1250 ohm windings to the earths on busy outlets, and release immediately a free outlet is reached. The 25,000 ohm resistors YG and YH prevent sparking at the P2 and P1 wipers and give a slightly increased release lag to relays HA and HB to cover the possibility of premature release of these relays due to the private wiper momentarily overstepping a busy contact. B4 connects 500 ohm YC in parallel with the rotary magnet, thus slowing down the hunting speed to approximately 37 steps per second. This is necessary to ensure that the selector will not pass over free outlets.

Odd Outlet Free. The wipers are driven over the bank contacts as described above and, on reaching an odd outlet which is free, relay HB releases, due to absence of earth on the P1 wiper. The outlet is immediately guarded with earth via B3, HB2, S3 and B5. HB7 opens the testing circuit of relay HA, which also releases. HB6 and HA5 cut the rotary magnet drive circuit. HA4 disconnects the short-circuiting earth from relay C, which reoperates. Relay HA now reoperates on its 1250 ohm winding via HB5, 1000 ohm YE, C5 and N2 to earth at B3. The calling loop is disconnected from relay A at C3 and C6 and extended through to the seized outlet via HA3 and HA1. Relay A releases and A1 short-circuits relay B, which releases slowly. A1 also removes the short-circuiting earth from relay C which thus remains operated via C2 and HA4. B3 removes the earth from the P wire, relay HA holding to the earth returned from the seized circuit. The circuit remains in this condition, with relays C and HA operated, until released.

/ Even

Even Outlet Free. In this case, assuming that the P1 wiper has encountered a busy outlet and that encountered by the P2 wiper is free, relay HA releases, but relay HB holds via HB2, S3 and B5 to the earth on the P1 wiper. HA5 cuts the drive circuit and prepares for the operation of the test bell. The seized outlet is immediately busied by earth via B3, HA2 and HB7 applied to the P2 wiper. HA4 disconnects the short-circuit from relay C, which operates. C3 and C6 disconnect the calling loop from relay A and switch through to the seized outlet via HB1 and HB3. Relay A releases and A1 short-circuits relay B, which releases slowly. Relay HB holds via HB5, 1000 ohm YE, C5 and N2 to earth on the P wire when the circuit via the P1 wiper is opened at B5. Resistance YE prevents the extension of a full earth to the P1 wiper during the release time of relay B. Relay C holds via HB4 when B2 opens.

Both Outlets Free. In this case, due to absence of earths on both P1 and P2 wipers, relays HA and HB release together. The subsequent operation is exactly the same as that described for "Odd Outlet Free," and the call is switched to the odd outlet.

All Outlets Busy. If all outlets in the dialled level are busy the wipers are stepped to the 11th contacts and the 11th step (S) springs operate. Relays HA and HB release as there is normally no earth on the 11th P contacts. Since this is the same condition as "Both Outlets Free," relays C and HA reoperate and the calling loop is switched through to the -1 and +1 wipers. The 11th bank contacts, however, are wired to relay A, and this relay remains operated. A1 holds relay B, and B3 maintains the earth on the P wire to hold relay HA. S1 prevents the earth at A1 from short-circuiting relay C. S2 connects busy tone to the tone winding of relay A, which functions as a tone transformer to give the busy signal to the calling party. S3 connects an earth to the P1 wiper for operation of the overflow meter. S3 also opens the testing circuit of relay HB to ensure the release of this relay.

Release of Connection.

(a) After a Normal Call. The removal of the holding earth from the P wire allows the release of relay HA (or HB), followed by the release of relay C. The self-drive homing circuit of the rotary magnet is completed via R1, N1, C4 and B8 to release alarm earth, and the wipers are driven off the bank and restore to the normal position. B4 removes the 500 ohm shunt from the rotary magnet during the release action and the wipers are stepped out of the bank at the rate of approximately 45 steps per second.

During the release action the switch is guarded by the application of earth to the P wire via C5 and N2. The switch is unguarded during the combined release times of relays C and HA, a total of approximately 25 milliseconds. Seizure of the selector during this unguarded period cannot interfere with the release of the selector, as the operating circuit for relay B is broken at N3, N4 and HA6.

When the switch reaches the normal position, the off-normal springs restore and N1 opens the rotary drive circuit. N2 removes the earth from the P wire to free the switch. N3 prepares the operating circuit of relay B and N4 prepares the fast guard circuit.

(b) After Seizure. The calling party replacing the receiver disconnects relay A. A1 short-circuits relay B, and, during the slow release of B, the vertical magnet operates to step the selector and operate the off-normal springs. Relays HA and HB operate. On the release of relay B, HA and HB release, followed by the release of relay C, and the switch releases as described above.

(c) After "All Outlets Busy" Condition. The calling party replacing the receiver releases relay A which releases relay B. Relays HA and C release in turn, completing the release circuit as described.

/ 4.

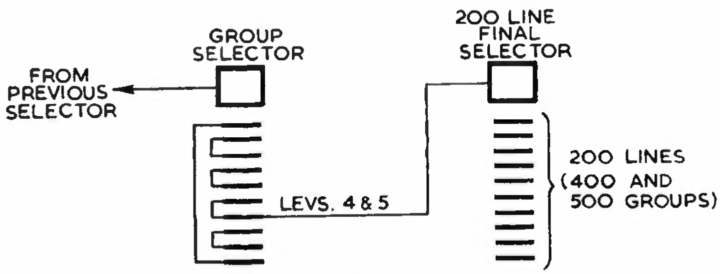
4. ORDINARY FINAL SELECTOR, 200 LINE.

4.1 Prior to the introduction of 2000 type equipment in Australia, final selectors serving 100 lines were used and consequently a separate group of final selectors was required for each 100 lines. The actual number of final selectors provided in each group depends on the maximum number of simultaneous calls likely to be made to the 100 lines to which they have access. This is decided from the average busy hour terminating traffic of the lines concerned. As an example, consider a branch exchange where the average busy hour terminating traffic is 0.02 T.U. per line for ordinary (non-P.B.X.) lines. Traffic capacity tables give the number of final selectors required to give the standard grade of service (0.002) as 8 per 100 line group.

It is shown in Telephony III, Paper No. 8, that the efficiency of a group of switches from the traffic-carrying view-point is increased by increasing the size of the group served. Thus in the example quoted above, if 200 lines were served by one group of final selectors, only 12 switches would be required instead of 16 switches in two separate 100 line groups. The higher traffic occupancy of the 200 line final selectors means that in an average case a reduction in final selectors of 15 per cent. to 20 per cent. can be attained. Although the number of final selectors is reduced, each switch is larger and therefore more expensive. However, there is generally a considerable net saving in favour of 200 line final selectors, and this type of switch is standardised for use in 2000 type exchanges.

To enable final selectors to serve two 100-line groups, it is necessary to interconnect two levels of the banks on the previous rank of switches. In the case of a five-digit system, this interconnection is made at the third selectors and in a six-digit system, at the fourth selectors.

The trunking arrangements are shown in Fig. 14, which shows the standard method of interconnecting the penultimate selector banks.



TRUNKING TO 200 LINE FINAL SELECTORS.

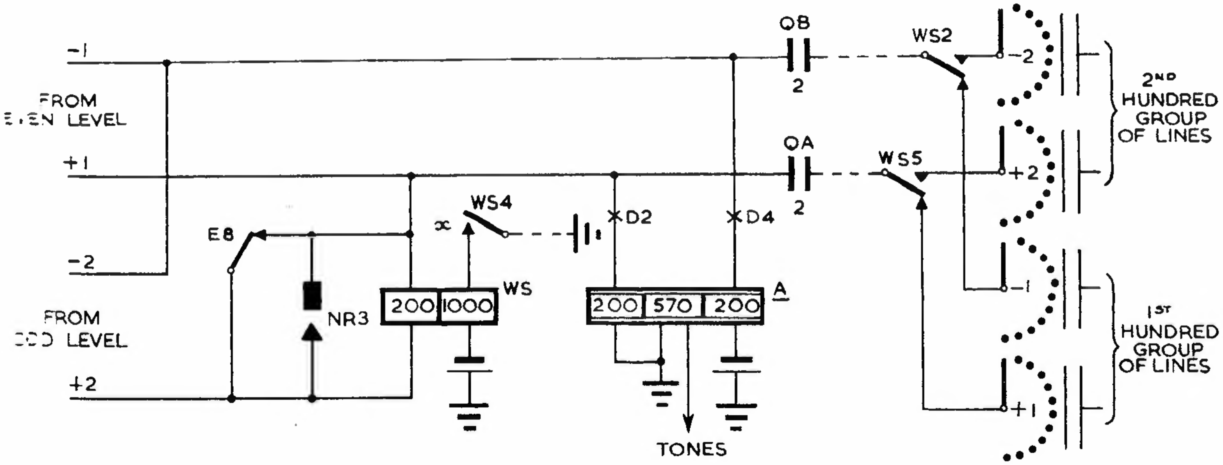
FIG. 14.

To accommodate the 200 lines, the final selectors are fitted with a 600-point bank, made up of three 200-point units. The bottom unit takes the negative and positive wires of the first hundred lines, the middle unit the negative and positive wires of the second hundred lines while the 200 private wires are taken by the upper unit. When the switch is stepped to any position, the wipers have access to two lines and it is necessary to choose between these two. Thus if the wiper carriage is stepped up 4 and in 3 steps, the call may be for either -443 or -543. To effect this discrimination, a wiper switching relay (WS) is included in the final selector circuit, the simplified connections being shown in Fig. 15.

Calls from even levels (0, 2, 4, 6, 8) of the previous selector have no effect on relay WS, and the call is directed via its normal contacts to the lower set of wipers serving the first hundred lines. If, however, the call is from an odd level (1, 3, 5, 7, 9) of the group selector, the positive line circuit is completed via E8. At the end of the first impulse train and after the final selector is stepped to the dialled level, relay E is operated, removing the short-circuit from the 200 ohm winding of relay WS, which operates in series with one winding of relay A. WS locks

/ on

on its 1000 ohm winding to earth via WS4, and the call is switched to the upper set of wipers. During the first rotary step NR3 operates and again short-circuits the 200 ohm winding of WS to prevent distortion of impulses during dialling and interference with transmission.



DISCRIMINATING CIRCUIT OF 200 LINE FINAL SELECTOR.

FIG. 15.

4.2 The functions of the 200 line final selector are -

(i) Returns busying and holding earth to the preceding switches when seized.

(ii) Steps vertically under the control of the first train of impulses received.

(iii) Automatically selects the particular 100 group of lines called, determined by the level of the previous selector from which the call is routed.

(iv) Steps rotarily under the control of the second train of impulses received.

(v) Prevents interference with lines passed over during rotary stepping.

(vi) Tests the called subscriber's line.

(vii) If busy, transmits balanced busy tone to the calling party.

(viii) If free, applies ringing conditions to the called line and ring tone to the caller.

(ix) Guards the seized line against intrusion.

(x) When the called subscriber answers -

(a) Cuts off ringing conditions and ring tone.
(b) Provides a transmission bridge.
(c) Reverses the battery on the incoming lines for supervisory purposes.
(d) Connects positive battery to the P wire for operation of the caller's meter.

(xi) Releases all preceding switches when the calling party clears.

(xii) Provides a supervisory lamp signal and gives an alarm should one party clear and the other fail to release (C.S.H. alarm).

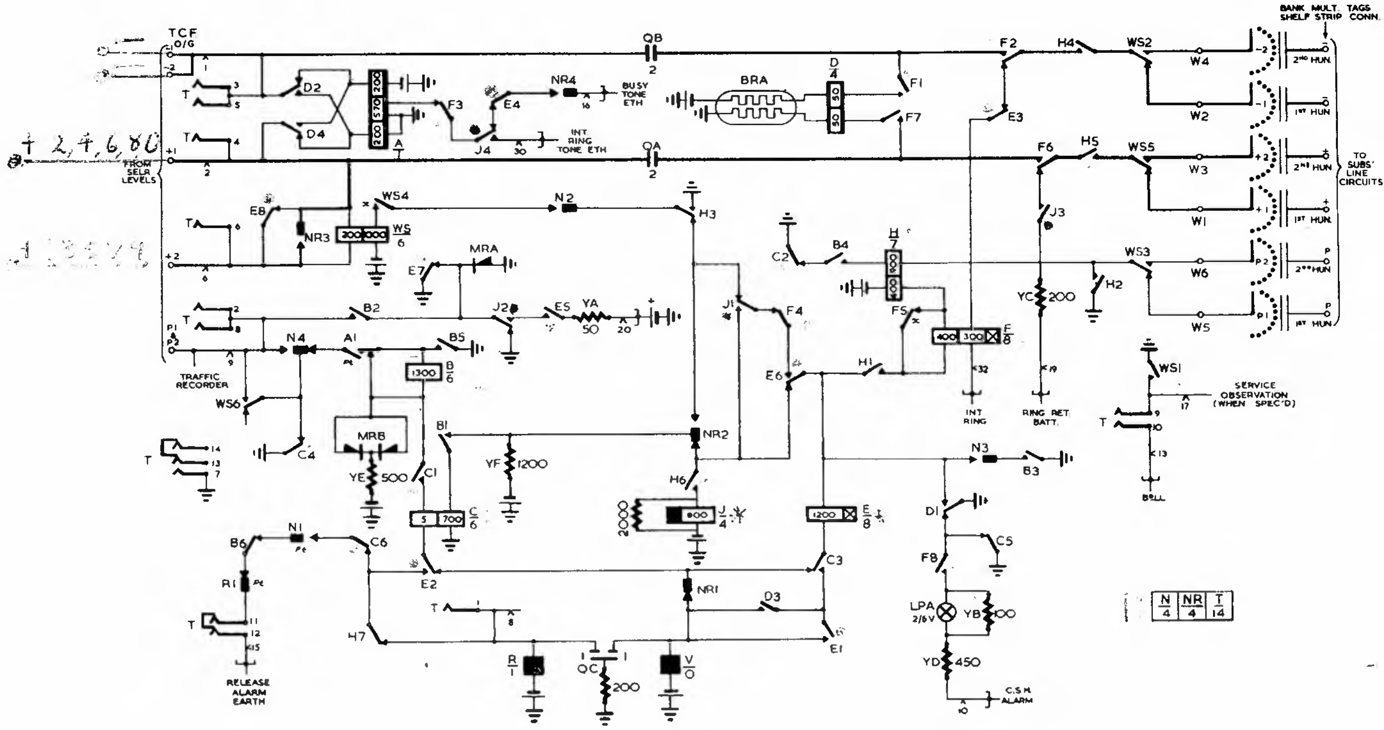
(xiii) Releases itself when both parties clear.

(xiv) Guards itself against intrusion during the release period.

(xv) Provides a supervisory alarm should the switch fail to restore to normal due to a mechanical defect (Release alarm).

/ 4.3

4.3 Fig. 16 shows the circuit of the 2000 Type Ordinary Final Selector, 200 Line and a description of the circuit operation follows.



ORDINARY FINAL SELECTOR, 200 LINE, 2000 TYPE.

FIG. 16.

Switch Seized. The subscriber's loop, extended from the previous selector, operates relay A via D2 and D4. Relay B then operates from battery via 500 ohm YE and rectifier MRB to earth via A1, N4 and C4. B2 connects earth from E7 and J2 to the P wire to guard the switch from intrusion and hold the connection. B5 holds relay B when C4 subsequently opens, and B1 closes the circuit for the preoperation of relay C on its 700 ohm winding to battery via 1200 ohm YF. The operation of relay C prepares the circuit for the operation of the vertical magnet.

1st Impulse Train. When the subscriber dials, relay A releases at each impulse. At each release a circuit is completed for the vertical magnet via NR1, E2, 5 ohm winding of relay C, C1 and A1 to earth at B5 and the wiper carriage is stepped to the dialled level.

During impulsing, relay B remains operated by virtue of the short-circuit placed across its winding by A1, thus making the relay slow to release. The rectifier MRB is included in the circuit to prevent a path for the discharge current of the magnet via resistance YE which would otherwise make the magnet slow to release.

At the first vertical step, the off-normal (N) springs operate and the 700 ohm winding of relay C is short-circuited by earth via B3, N3, E6 and NR2, making the relay slow to release. It is held operated during dialling by the pulses through its 5 ohm winding and releases slowly after the last impulse.

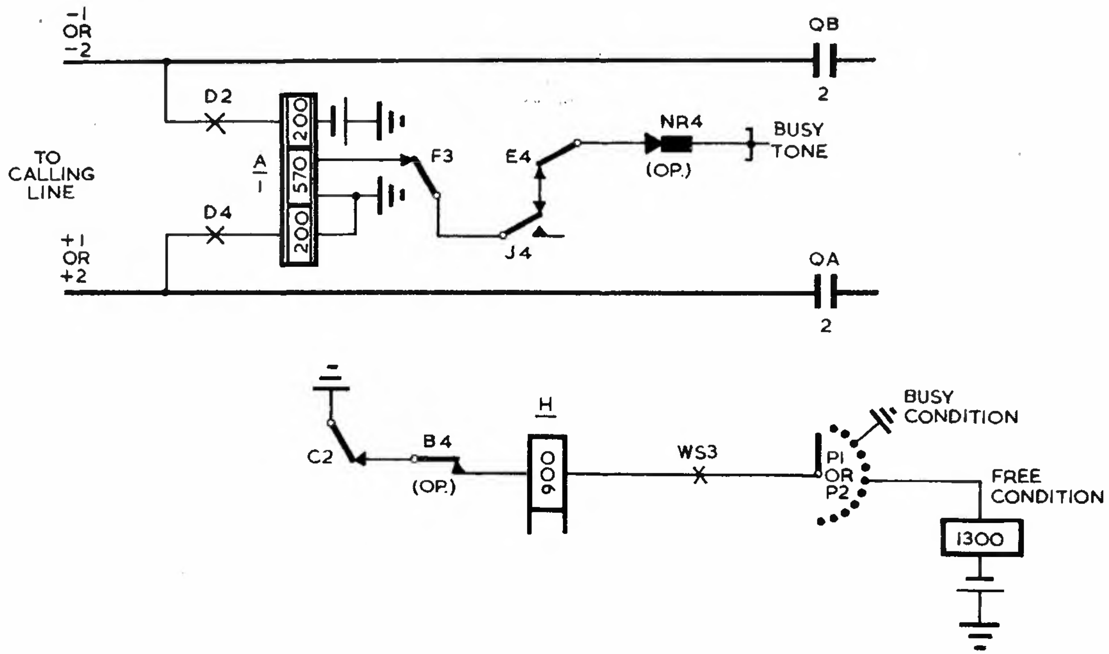
Relay E now operates from battery via the vertical magnet, NR1 and C3 to earth via N3 and B3. E6 removes the short-circuit from the 700 ohm winding of relay C, which reoperates. Relay E holds via E1 when C3 changes-over. Relay E is made slow to operate, which ensures that it is fully saturated before relay C can reoperate. Thus the transit time of C3 contacts has no effect on the operation of relay E. (To improve the operation of relay E, its resistance has recently been decreased from 1500 ohms to 1200 ohms). E2 changes over the impulsing circuit to the rotary magnet.

/ The

The operation of E8 removes the short-circuit from the 200 ohm winding of relay WS. If the incoming call is from an even level the calling loop will be over -1 and +1 wires and relay WS will not operate. If the call is from an odd level, the subscriber's loop will be over -2 and +2 wires and relay WS operates in series with relay A. If WS operates, it locks via WS4 "x", N2, H3, J1, F4, E6 and N3 to earth at B3. The call is then switched to the upper set of wipers via WS2, WS5 and WS3 contacts. WS1 prepares the circuit of the test trunk bell, so that it is possible to determine which set of wipers are in use, without removing the switch cover, simply by inserting a test plug into T9-10.

2nd Impulse Train. With relays A, B, C and E (and possibly WS) operated the switch is now ready to receive the final train of impulses. The rotary magnet is operated via H7, E2, 5 ohm winding of relay C, C1 and A1 to earth at B5 and the wipers are stepped round to the dialled contacts. At the first step the rotary off-normal (NR) springs operate. NR2 short-circuits the 700 ohm winding of relay C via J1, F4, E6 and N3 to earth at B3, making C slow to release. NR3 short-circuits the 200 ohm winding of relay WS to prevent impulse distortion.

At the end of the rotary impulses the wipers rest on the called subscriber's bank contacts. Relay C is held during dialling by the pulses through its 5 ohm winding, and, after the last impulse, C releases slowly, and at C2 the testing circuit is completed for relay H. C3 opens the circuit of relay E which is slow to release and during this release lag (approximately 100 mS) the called line is tested. The testing conditions are shown in Fig. 17.



TESTING CALLED SUBSCRIBER'S LINE.

FIG. 17.

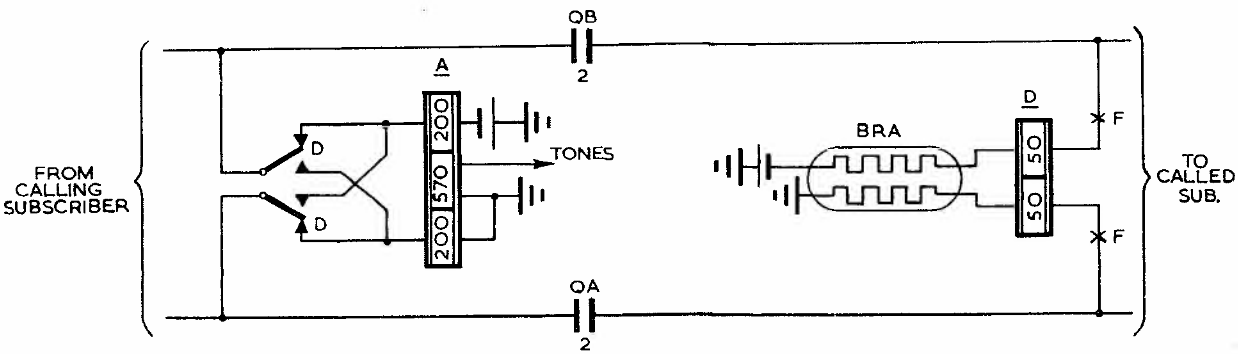
Called Line Busy. The circuit for relay H depends upon the condition on the P wire of the called subscriber's line circuit. If the line is busy the P wire is earthed and, in this case, relay H cannot operate. When relay E releases, E6 removes the short-circuit on the 700 ohm winding of relay C, which reoperates. E4 connects busy tone via NR4, J4 and F3 to the 570 ohm winding of relay A, from which it is induced equally into the line windings and thus connected to the calling party. (This "balanced" application of tones is described earlier in this Paper.) The reoperation of relay C disconnects the testing circuit of relay H at C2.

Called Line Free. If the called subscriber's line is free, when relay C releases at the completion of rotary stepping, relay H operates on its 900 ohm winding over the P1 or P2 wiper (depending on whether relay WS is operated or not) in series with the cut-off relay (K) in the line circuit, which operates and cuts-off the line relay and earth from the called line. Relay H locks on its 400 ohm winding via F5, H1, and N3 to earth at B3. H2 connects a full earth to the P wiper to guard the called line against intrusion. H3 holds relay WS. This is necessary in view of the subsequent release of E6. H4 and H5 prepare for the application of ringing conditions to the called line. H6 prepares the circuit of relay J and H7 opens the circuit of the rotary magnet to prevent further stepping should the caller subsequently operate the dial.

After its release lag, relay E releases and E6, as well as removing the short-circuit from relay C, completes the circuit of relay J. Relays C and J operate. Ringing current is applied to the negative wire of the called line via the 300 ohm winding of relay F, E3, F2, H4, WS2 and the -1 or -2 wiper. The ringing return is to battery via 200 ohm YC, J3, F6, H5, WS5 and the +1 or +2 wiper. J4 connects interrupted ring tone to the "tone" winding of relay A. The delay in connecting the ringing ensures that the called subscriber's relay K has time to operate and disconnect the line relay and earth from the negative and positive lines, respectively. J2 prepares the positive battery metering circuit.

Called Subscriber Answers. When the called subscriber removes the receiver, a loop is connected across the line, which allows relay F to operate on its 300 ohm winding to the ring return battery superimposed on the ringing current. Relay F operates to break its "x" contact (F5) only on this winding, but the 400 ohm winding is then energised in series with relay H and F operates fully.

F1 and F7 connect relay D to the negative and positive lines respectively. These contacts are introduced to prevent impulse distortion due to condensers QA and QB and relay D being across the line during dialling. F2 and F6 disconnect the ringing current and ring return respectively and extend the negative and positive lines through to the transmission bridge. F3 disconnects the ring tone from relay A. F4 prevents relay C being short-circuited when relay E subsequently operates. F8 prepares the C.S.H. alarm circuit. The transmission circuit of the final selector is shown in Fig. 18.



FINAL SELECTOR TRANSMISSION BRIDGE.

FIG. 18.

The called subscriber's loop is now connected to relay D, which operates. D1 disconnects the C.S.H. alarm circuit. D2 and D4 reverse the battery connections on the incoming positive and negative wires for supervisory purposes and for metering conditions when the call is routed from a distant exchange. D3 completes the circuit for the reoperation of relay E from battery via the vertical magnet, D3 and C3 to earth via N3 and B3.

/ Metering.

Metering. The operation of relay E at this stage brings about the metering conditions. E1 holds relay E independent of D3. Any subsequent release or operation of relay D thus has no effect on relay E and, consequently, on the metering circuit.

E5 extends the positive battery via J2 and B2 to the P wire to operate the caller's meter. E7 removes the full earth on the private during the application of the positive battery pulse. E6 opens the circuit of relay J, which releases slowly. After its slow release period (about 250 mS), relay J releases and J2 disconnects the positive battery from the P wire and replaces it with earth. Rectifier MRA is included in the metering circuit to maintain an earth potential on the P wire during the transit time of E and J contacts, and does not shunt the positive battery pulse. It is of interest to note that the separate break (E7) and make (E5) contacts of relay E are used instead of a single change-over contact unit, so that positive battery and earth are not normally connected on the same contact unit. The risk of short-circuiting during testing is thus reduced. The 50 ohm YA resistance is included to guard against such short-circuits, also against short-circuits to earth caused by the bridging private wipers on subscriber's uniselectors.

Prevention of False Metering. It is possible, due to faulty adjustment of relay E contacts, for interaction to be set up between relays C and E. If, on the release of relay E at the end of rotary impulsing, E6 breaks earlier than E1, relay C reoperates and, as the circuit of relay E is still completed at E1, relay E reoperates, reconnecting the short-circuit across relay C, which again releases. This interaction continues and if the line is free relay H operates, followed by the operation of relay J. In earlier circuits, the interaction continues until the called party answers, when F4 prevents relay C from releasing. During the time the called subscriber is being rung, the calling subscriber's meter is operated once for every time relay E reoperates.

In this circuit the interaction is stopped when relay J operates, therefore, no false metering can take place. J1 prevents the short-circuiting of relay C, which remains operated and relay E releases, the call then proceeding normally.

Calling Party Clears. Under this condition, relay A releases and A1 short-circuits relay B. After its release lag (250-350 mS) relay B releases and B1 opens the circuit of relay C. B2 removes the earth from the P wire thus allowing the preceding selectors to release. After the release lag of relay C (15-20 mS), C4 connects earth to the P wire to reguard the switch. C3 opens the circuit of relay E, which releases and at E6 reoperates relay J, but this operation is of no importance.

The final selector is now held by the called subscriber's loop, which holds relay D operated. D1 applies an earth to hold relays F and H and the release of the selector is prevented at H7. C5 closes the C.S.H. alarm circuit via F8 and lamp LPA and, if the condition is maintained for the specified delay period (3 minutes), an alarm is given. The lamp indicates the switch causing the alarm.

Called Party Clears. The replacing of the called subscriber's receiver allows relay D to release. D1 completes the C.S.H. alarm circuit. D2 and D4 replace normal battery conditions on the incoming lines for supervisory purposes. The selector is thus held until the calling party clears, when relay A releases.

The Called Subscriber Held (C.S.H.) feature is introduced to supervise any prolonged holding of the called subscriber's line after the end of the conversation.

Release of Selector. After both parties have cleared, all relays release. H2 allows the called subscriber's relay K to release, H4 and H5 disconnect the negative and positive wipers. H7 completes a self-drive circuit for the rotary magnet via C6, N1, B6 and R1 to release alarm earth. The wiper carriage is rotated until the 12th step is reached when the carriage falls to the normal position. In this position the off-normal (N) contacts restore and N1 opens the release circuit while N4 removes the earth (via C4) from the P wire to free the selector. WS6 guards the selector against seizure should relay WS still be operated.

Last party release has the advantage that, as the final selector is held until both parties replace their receivers, neither party originates artificial traffic to the line finders (or uniselectors) and 1st selectors.

/ 5.

5. 2-10 P.B.X. FINAL SELECTOR, 200 LINE.

5.1 This switch functions in a similar manner to the pre-2000 type switch (Telephony III, Paper No. 5) but is adapted to the special requirements of the 2,000 type mechanism, therefore, the circuit resembles that of the ordinary final selector previously described. An extra 200-point bank is added to effect the necessary discrimination on P.B.X. lines. The contacts corresponding to the first line in a P.B.X. group are connected to battery through a 200 ohm resistance, while the last lines of each group are connected to earth. Intermediate lines and ordinary (non-P.B.X.) lines are left disconnected. P.B.X. groups and ordinary lines can be accommodated in both the first hundred (lower) and second hundred (upper) groups of lines.

5.2 The functions of this switch are -

(i) Returns busying and holding earth to the preceding switches when seized.

(ii) Steps vertically under the control of the first train of impulses received.

(iii) Automatically selects the particular hundred group of lines called, determined by the level of the previous selector from which the call is routed.

(iv) Steps rotarily under the control of the second train of impulses received.

(v) Prevents interference with lines passed over during rotary stepping.

(vi) Tests the called subscriber's line.

(vii) Functions as an ordinary final selector when connected to non-P.B.X. services.

(viii) If the first line of a P.B.X. group is dialled, hunts for and seizes the first free line in the group.

(ix) Transmits busy tone to the caller if all lines in the group are busy.

(x) Should the wanted line be free, applies ringing conditions to the called line and ring tone to the caller.

(xi) Guards the seized line against intrusion.

(xii) When the called subscriber answers -

(a) Cuts off ringing conditions and ring tone.
(b) Provides a transmission bridge.
(c) Reverses the battery on the incoming lines for supervisory purposes.
(d) Connects positive battery to the P wire for metering.

(xiii) Releases all preceding switches when calling party clears.

(xiv) Provides a supervisory lamp signal and alarm should one party clear and the other fail to release (C.S.H.).

(xv) Releases itself when both parties clear.

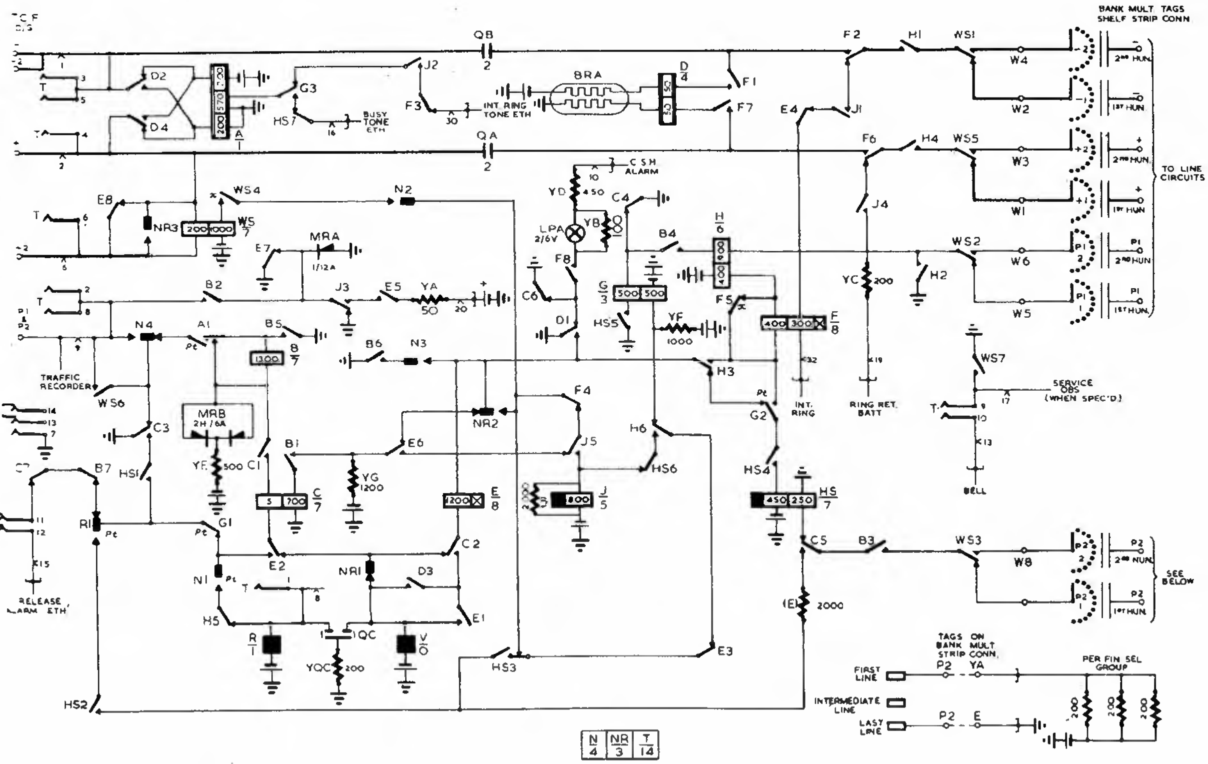
(xvi) Guards itself against intrusion during the release period.

(xvii) Provides a supervisory alarm should the switch fail to restore to normal due to a mechanical defect.

(xviii) Provides night service facilities on any line in a P.B.X. group except the first.

/ 5.3

5.3 Fig. 19 shows the circuit of the 2000 Type 2-10 P.B.X. Final Selector, 200 Line, and a description of the circuit operation follows -



2-10 P.B.X. FINAL SELECTOR, 200 LINE, 2000 TYPE.

FIG. 19.

Switch Seized. Relay A operates to the loop extended from the previous selector and A1 operates relay B from earth via C3 and N4 to battery via 500 ohm YE and rectifier MRB. B2 earths the P wire via E7 and J3 to hold the preceding switches and guard the connection. B5 holds relay B when relay **C** subsequently operates. B1 completes the circuit of relay **C** on its 700 ohm winding to battery via 1200 ohm YG. **C** operates and C1 prepares the circuit for impulsing.

Vertical Stepping. On the receipt of the first impulse train, relay A responds, stepping the wipers to the level corresponding to the digit dialled. During each break period, the vertical magnet is operated via NR1, E2, the 5 ohm winding of relay **C**, C1 and A1 to earth at B5. The off-normal (N) springs operate during the first vertical step and the 700 ohm winding of relay **C** is short-circuited by earth via E6, NR2, N3 and B6, making **C** slow to release. At the end of the impulse train, relays A and B remain operated and relay **C** releases slowly. C2 completes the circuit of relay E from earth via B6 and N3 to battery via the vertical magnet and NR1. Relay E operates slowly and E6 removes the short-circuit from the 700 ohm winding of relay C which reoperates. E1 holds relay E when C2 changes over. If the called line is in the second hundred group, the incoming lines to relay A are via -2 and +2, and, when E8 operates, the short-circuit is removed from the 200 ohm winding of relay WS, which operates, thus switching the call to the upper (second hundred) set of wipers. If, however, the called line is in the first hundred group, WS does not operate and connection is made to the lower (first hundred) set of wipers. E2 changes over the impulsing circuit to the rotary magnet in readiness for the second impulse train.

/ Rotary

Rotary Stepping. Relay A responds to the second train of impulses and the rotary magnet is operated via H5, N1, E2, 5 ohm winding of relay C, C1 and A1 to earth at B5. The wipers are stepped to the dialled contacts and, during the first step, the rotary off-normal (NR) springs operate. The 700 ohm winding of relay C is short-circuited by earth via E6, J5, F4, NR2, N3 and B6, making it slow to release. NR3 short-circuits the 200 ohm winding of relay WS to prevent distortion of the impulses received by relay A. WS holds on its 1000 ohm winding via WS4, N2, NR2 and N3 to earth at B6.

After the last impulse has been received, relay C releases slowly. C2 opens the circuit of relay E, which also releases slowly. During the release period of relay E, two tests are made -

(i) Relay H tests the P1 bank contact via C4, B4, WS2 and the P1/1 or P1/2 wiper.
(ii) Relay HS tests the P2 bank contact via C5, B3, WS3 and the P2/1 or P2/2 wiper.

Called Line Busy. Assuming that the called line is an ordinary line and is busy, neither relay H or HS operates and, when relay E restores, E6 removes the short-circuit from the 700 ohm winding of relay C, which reoperates. Relay G operates via H6, E3, HS3, NR2 and N3 to earth at B6. G3 connects busy tone via HS7 to the 570 ohm winding of relay A, whence it is induced into the calling line circuit.

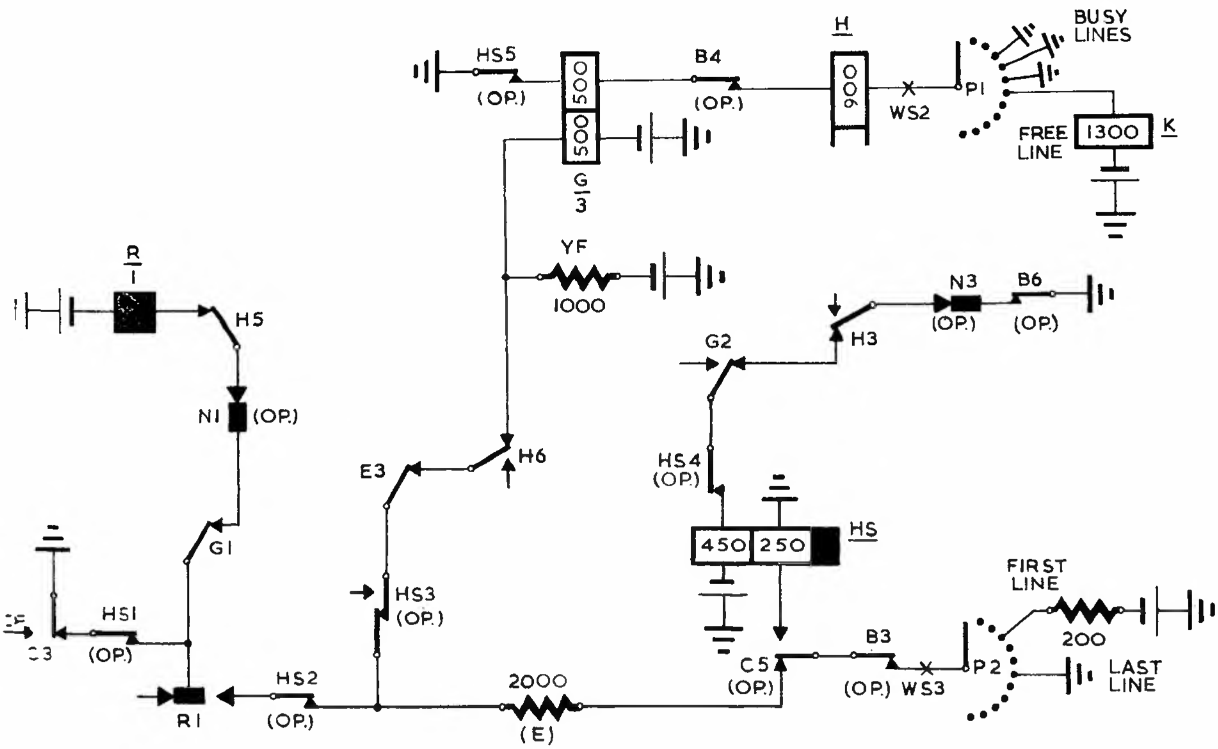
This condition also applies when a line other than the first line in a P.B.X. group is dialled and found busy, thus giving the night service facility. As described later, automatic hunting in the P.B.X. group commences only when the first line in the group is dialled and is found busy.

Called Line Free. On the release of relay C, relay H operates on its 900 ohm winding from battery via relay K in the called line circuit over the P1 bank contact and wiper. H locks on its 400 ohm winding via F5 and N3 to earth at B6. H2 connects earth to the P wiper to guard against intrusion. H1 and H4 prepare for the application of ringing conditions to the called line. On the release of relay E, the short-circuit is removed from the 700 ohm winding of relay C, which reoperates. Relay J operates via HS6, H6, E3, HS3, NR2 and N3 to earth at B6. J1 and J4 apply ringing current and ring return battery, respectively, to the called line, and J2 connects ring tone to the tone winding of relay A. J5 prevents false operation of the caller's meter due to interaction between relays C and E.

Automatic Hunting Over a P.B.X. Group (Fig. 20.) If the first line in a P.B.X. group is dialled and is found busy, relay H does not operate but relay HS operates over the P2 wiper to battery connected to the bank contact via a 200 ohm resistor. HS locks on its 450 ohm winding via HS4, G2, H3 and N3 to earth at B6. On the release of relay E, C reoperates and the rotary magnet is operated via H5, N1, G1 and HS1 to earth at C3. The wipers are stepped to the next line, the interrupter springs close and relay G is operated via H6, E3, HS3, HS2, R1 and HS1 to earth at C3. G1 opens the circuit of the rotary magnet, which releases, opening the operating circuit of relay G. If this line is free, relay G holds and H operates in series with the subscriber's cut-off relay, but if the line is busy, G releases and the rotary magnet operates to step the wipers to the next line. Relay HS holds during rotary stepping because of its copper slug, and releases slowly when relay H operates to a free line. Relay J operates and subsequent operation is as described under "Called Line Free." Further rotary stepping is prevented by H5.

All Lines Busy. When the wipers reach the last line in the P.B.X. group, relay G is held from earth on the P2 bank contact via P2 wiper, WS3, B3, C5, 2000 ohm resistance (E), HS3, E3 and H6. The resistance prevents feed-back during rotary stepping of a full earth to the P2 wiper, which might cause interference with other switches in the same 200 line group. G1 releases the rotary magnet and G2 opens the circuit of relay HS, which releases slowly. On the release of HS, relay G holds via NR2 and N3 to earth at B6, and busy tone is connected to the tone winding of relay A via HS7 and G3.

/ Fig. 20.



AUTOMATIC HUNTING OVER A P.B.X. GROUP.

FIG. 20.

Called Party Answers. When the call is answered, relay F operates to the loop provided and F5 allows F to lock on its 400 ohm winding in series with relay H. F2 and F6 disconnect ringing current and ring return battery, respectively, and connect the called line to the transmission bridge. F1 and F7 connect relay D and the ballast resistance in circuit and D operates to the loop on the called line. F8 prepares the C.S.H. alarm circuit, which is held open by D1.

D2 and D4 reverse the connections of relay A to the calling line. Relay E reoperates in series with the vertical magnet via D3, C2 and N3 to earth at B6. E5 connects positive battery to the P wire to operate the caller's meter and E3 opens the circuit of relay J, which releases slowly. J3 disconnects the positive battery pulse and replaces it with earth. MRA maintains an earth on the P wire during the transit time of J3 contacts.

Calling Party Clears. Relay A releases and A1 short-circuits relay B, which also releases. B2 removes earth from the P wire to release preceding switches and B1 releases relay C. C3 reconnects earth via N4 to the P wire to guard the switch. Relays E, F and H are held by earth at D1 and the switch, therefore, is held by the called party. C6 closes the circuit of the C.S.H. alarm.

Called Party Clears. Relay D releases and D1 closes the C.S.H. alarm circuit. All other relays remain operated and the calling party holds the switch.

Release of Switch. When both parties have cleared, all relays release and a self-drive circuit is completed for the rotary magnet via H5, N1, G1, R1, B7 and C7 to release alarm earth. When the switch reaches the normal position, N1 opens the rotary magnet circuit and N4 removes the guarding earth (from C3) from the P wire. Should the switch fail to restore, an alarm is given after the specified delay period.

6. LARGE GROUP P.B.X. FINAL SELECTOR, 100 LINE.

6.1 In city exchanges, large P.B.X. and P.A.B.X. services having more than 10 exchange lines must be provided for. It is also necessary to accommodate 10-line services so that additional lines can be given without having to change the subscriber's number.

The simplest method of dealing with borderline cases, that is, those having from 10 to 16 lines, is to allot them a level in a 2-10 P.B.X. group, and cut in additional lines as required on the first choices in each shelf of switches. This method is described in Telephony III, Paper No. 5. Only those lines which are common to all switches are available for night service.

To serve P.B.X's and P.A.B.X's with more than, say, 16 exchange lines, use is made of "large group" final selectors. These function similarly to the pre-2000 type switch, that is, each service is restricted to one level and the final selector is operated by a single digit, cuts-in and searches for a free line in the level. Full availability is not given, the final selectors having access to 10 lines in each level. However, the incoming trunks from the previous rank of group selectors are distributed over all the shelves serving the group, and repeated calls, therefore, are given a chance of testing all the lines in a P.B.X. group. This agrees with the standard method of trunking to junction groups of comparable size.

The final selector shelf multiples are terminated on grading strips on a T.D.F. (see Paper No. 6, Page 14), allowing the P.B.X. lines in each group to be graded for greater traffic efficiency. Lines requiring both-way service (incoming and outgoing) are cross-connected to a uniselector circuit. On incoming lines, the uniselector is not required and the P wire is connected to battery through a 1300 ohm resistor. The lines are cabled to the protector side of the M.D.F., the P wires terminating on a busying strip.

As it is a matter of chance which line will be reached, night service cannot be given on lines served by large group P.B.X. final selectors. However, large P.B.X's and P.A.B.X's usually have their exchange lines arranged in separate groups of incoming and outgoing lines, and night service may be arranged by allotting and listing in the Directory lines normally used for outgoing calls during the day. These lines are connected in ordinary final selector groups.

6.2 The functions of the large group final selector are -

(i) When seized, returns an earth on the P wire to busy and hold the connection.

(ii) Steps vertically in response to dialled impulses.

(iii) Cuts-in automatically on the level dialled, and searches for the first free line in the level.

(iv) If all lines in the level are busy, steps to the 11th contacts where it transmits busy tone to the caller.

(v) Applies ringing conditions to the called line, if free, and ring tone to the calling party.

(vi) When the called party answers, removes ringing and ring tone conditions, provides a transmission bridge and applies metering conditions to operate the calling party's meter.

(vii) When the calling party clears, releases preceding switches.

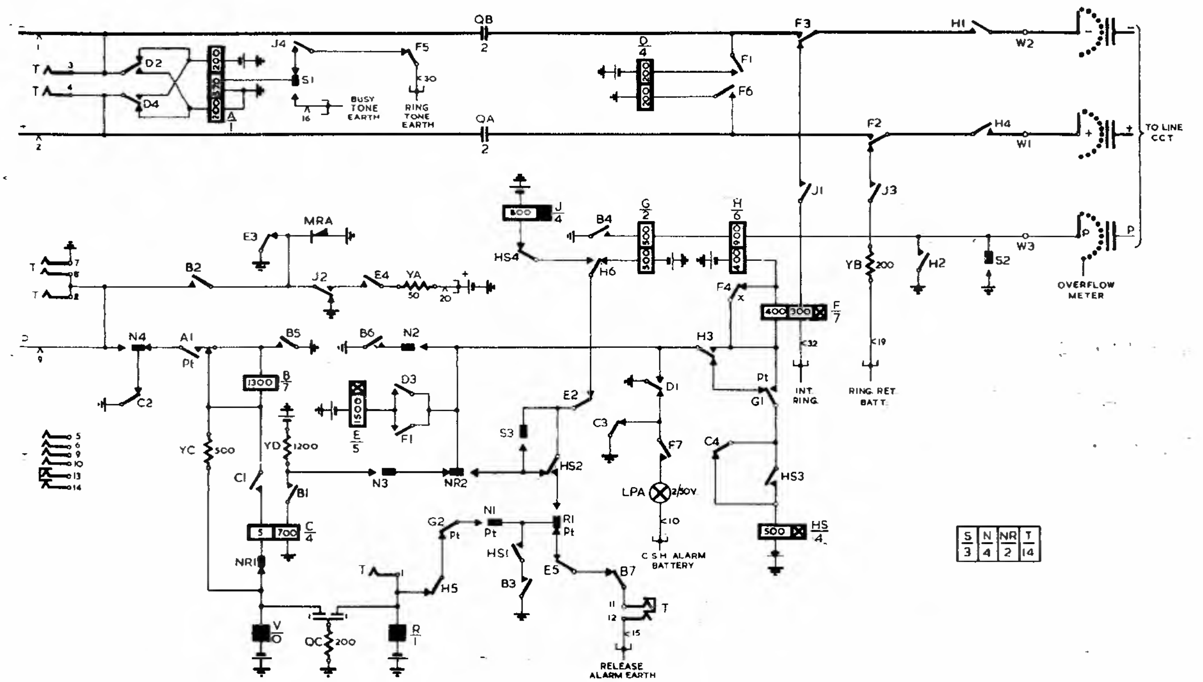
(viii) Releases itself when both parties clear (last party release).

(ix) Provides a supervisory alarm if the calling or called party holds the switch after the other party has cleared (C.S.H. alarm).

(x) Provides a supervisory alarm if the switch fails to restore after release conditions have been applied (Release alarm).

/ 6.3

6.3 Fig. 21 shows the circuit of the 2000 Type Large Group P.B.X. Final Selector, 100 Line, and a description of the circuit operation follows.



LARGE GROUP P.B.X. FINAL SELECTOR 100 LINE, 2000 TYPE.

FIG. 21.

Switch Seized. Relay A operates over the loop extended from the previous selector. A1 operates relay B from earth via C2 and N4 to battery via 500 ohm YC and the vertical magnet. B2 connects the P wire to earth at E3 and J2. B5 holds relay B when C2 subsequently opens. B1 operates relay C on its 700 ohm winding to battery via 1200 ohm YD.

C1 prepares the circuit for impulsing the vertical magnet and C4 opens the circuit of relay HS.

Vertical Stepping. The calling subscriber operates the dial and relay A responds to the impulses. During the break periods, the vertical magnet is energised in series with the 5 ohm winding of relay C via NR1, C1 and A1 to earth at B5. The off-normal (N) springs operate during the first vertical step. N1 prepares the circuit of the rotary magnet, N2 prepares the circuit of relay HS and N3 short-circuits the 700 ohm winding of relay C with earth from B6 and N2.

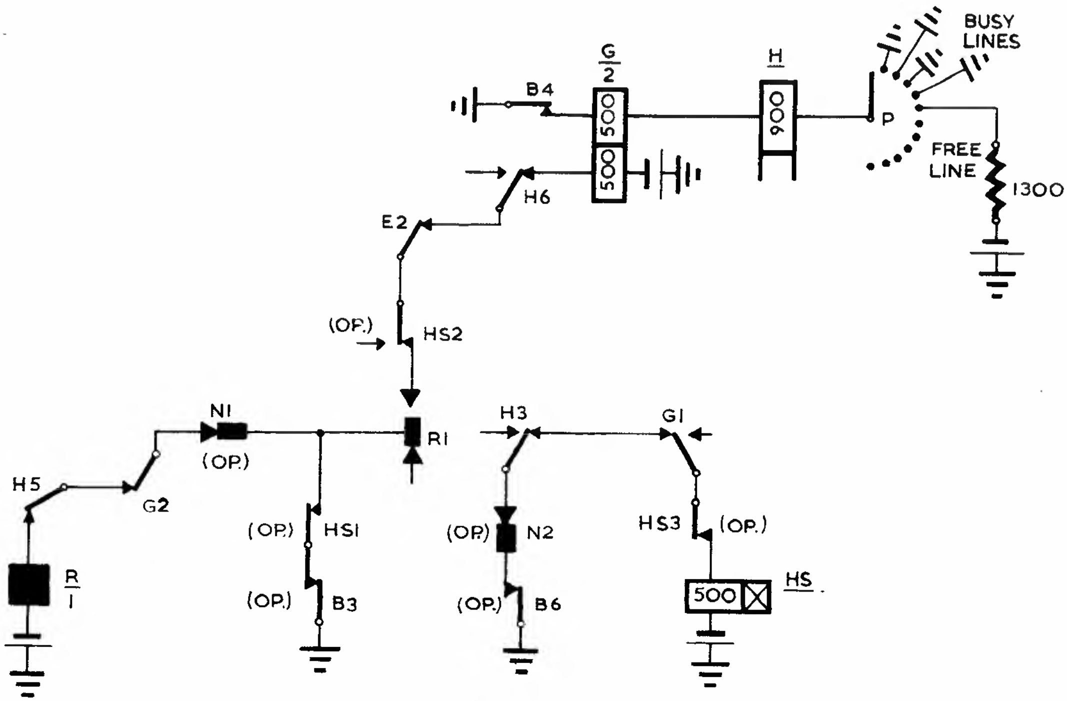
The wipers are raised a number of steps according to the digit dialled, relays B and C remaining operated during impulsing by virtue of their short-circuited windings. At the end of the impulse train, relays A and B remain operated and relay C releases slowly.

/ Cut-in.

Cut-in. On the release of relay C, C4 completes the circuit of relay HS via G1, H3 and N2 to earth at B6. HS operates slowly and holds via HS3. HS4 opens the circuit of relay J and HS2 prepares for the operation of relay G. HS1 completes the circuit of the rotary magnet via H5, G2, N1 and HS1 to earth at B3. The wipers are stepped to the first outlet on the selected level and, during the step, the rotary off-normal (NR) springs operate. NR1 opens the vertical magnet circuit to prevent its operation should the caller continue to dial. NR2 prepares a circuit for the operation of relay J and removes the short-circuit from the 700 ohm winding of relay C, which reoperates. At the end of the rotary magnet stroke the rotary interrupter springs close the circuit of relay G via H6, E2, HS2, R1 and HS1 to earth at B3, and G operates. G2 opens the circuit of the rotary magnet, which releases. G1 opens the circuit of relay HS, which holds because of its copper slug. The elements of the rotary stepping and testing circuits are shown in Fig. 22.

Testing-First Line Busy. A testing circuit is completed on the P wiper via the 900 ohm winding of relay H and the second winding of relay G to earth at B4. As it is assumed for the purposes of this description that the first line is busy, earth will be encountered on the P wiper and relay G will release when the rotary magnet releases and R1 restores to normal. G1 again closes the circuit of relay HS. The copper slug on the armature end of this relay ensures that it is fully saturated before it operates, and, therefore, will hold during the time relay G is operated.

Searching for Free Line. When relay G restores, the rotary magnet circuit is again completed at G2. The rotary magnet operates and the wipers are stepped to the next outlet. Relay G is reoperated and, if this outlet is also busy, relay G again releases and the rotary action continues until either a free line is reached or the 11th contacts are reached. Relay HS remains operated during rotary stepping by virtue of its copper slug.



ROTARY STEPPING AND TESTING CIRCUIT.

FIG. 22.

All Outlets Busy. If no free line is available in the dialled level, the wipers are stepped to the 11th contacts and the 11th step (S) springs operate. S3 holds relay G operated via NR2 and N2 to earth at B6, and G2 opens the circuit of the rotary magnet to prevent further rotary stepping. S1 connects busy tone to the tone winding of relay A and S2 connects earth to the P wiper for the operation of the overflow meter.

Free Line Reached. When the P wiper reaches a free line marked by battery via 1300 ohm resistance, relay G holds on its second winding in series with relay H, which operates. The rotary magnet circuit is opened at G2 and also at H5. G1 opens the circuit of relay HS which releases slowly. H3 locks relay H on its 400 ohm winding via F4, H3 and N2 to earth at B6. H2 earths the P wire to busy the line and operate the cut-off relay in the line circuit (two-way line). This earth also short-circuits the 900 ohm winding of relay H and the holding winding of relay G. Relay H is held on its 400 ohm winding, but relay G releases slowly. Reoperation of the rotary magnet and relay HS when relay G restores is prevented by H5 and H3, respectively. H1 and H4 prepare for the application of the ringing circuit to the called line, but this is delayed until relay J operates. After the release of relay HS, J operates via HS4, H6, E2, HS2, NR2 and N2 to earth at B6.

Ring Cut-on. J1 connects ringing current via the 300 ohm winding of ring trip relay F, J1, F3 and H1 to the negative line wire and the ring return is to battery via 200 ohm YB, J3, F2 and H4 to the positive line wire. J4 connects ring tone via F5 and S1 to the 570 ohm tone winding of relay A, and ring tone is induced into the line windings and transmitted to the calling party. J2 prepares the positive battery metering circuit.

Called Party Answers. When the P.B.X. operator answers, the line is looped and relay F operates. F4 "x" operates first and removes the short-circuit from the 400 ohm winding of relay F, which holds in series with relay H. F5 disconnects the ring tone from the tone winding of relay A. F3 and F2 disconnect the ringing current and ring return battery, respectively, from the called line and extend the called line to the transmission bridge. F1 and F6 connect relay D in circuit and D operates to the loop on the called line. F7 prepares the C.S.H. alarm circuit, which is opened at D1.

D2 and D4 reverse the connections of relay A to the calling line. D3 completes the circuit of relay E, which operates slowly and locks via E1. E3 removes earth from the P wire and E4 connects positive battery to operate the caller's meter. E2 opens the circuit of relay J, which releases slowly. During the slow release period of relay J, positive battery is applied to the P wire via 50 ohm YA, E4, J2 and B2 and, when J restores, positive battery is disconnected and earth is reconnected at J2. Rectifier MRA maintains an earth on the P wire during the transit time of J2 contacts, but does not shunt the positive battery pulse.

Called Line Clears. Relay D releases and the C.S.H. alarm circuit is completed from earth at D1 via F7, LPA to C.S.H. alarm battery. If this condition is maintained for a specified period (3 minutes) an alarm is given. The lamp indicates the faulty switch.

Calling Party Clears. Relay A releases, followed by the release of relay B. B1 opens the circuit of relay C, which also releases. B2 removes earth from the P wire, allowing the preceding switches to release, but when C restores, C2 reconnects earth to the P wire to busy the switch. As relay D is held by the loop on the called line, D1 holds relays E, F and H operated and the busy condition is maintained on the called line at H2. The C.S.H. alarm circuit is completed by earth from C3.

Release of Switch. When both parties clear, all relays release and the self-drive rotary magnet circuit completed via H5, G2, N1, rotary interrupter contact R1, E5 and B7 to release alarm earth. The switch restores to normal, when N1 breaks the homing circuit. If, for any reason, the switch fails to restore within the specified time (9 seconds), the release alarm is given.

7. TEST QUESTIONS.

1. Pre-2000 type group selector circuits use a relay interaction hunting circuit, whilst 2000 type circuits have a self-interrupted drive. With the aid of simple circuit diagrams, compare the two arrangements, giving the advantages of the 2000 type circuit.

2. What is the reason for the adoption of 200 outlet group selectors in preference to 100 outlet switches?

3. How are 2000 type group selectors guarded against seizure during the release of the switch?

4. List three likely causes of a 200 outlet group selector (2000 type) switching through on busy outlets.

5. How does a 200 line final selector discriminate between the two 100 line groups?

6. Show how busy tone is returned to the caller from a 2000 type final selector, if the called line is busy.

7. How is discrimination obtained on P.B.X. groups in the 2-10 P.B.X. final selector?

8. Draw a circuit diagram of the special rotary action of a large group P.B.X. final selector (2000 type) and explain, with the aid of the diagram, how the switch searches for a free line in a P.B.X. group.

8. REFERENCES.

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Telephony, Vol. II - J. Atkinson - Chapter XI.

END OF PAPER.

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COURSE OF TECHNICAL INSTRUCTION.

LINE FINDER SYSTEM.

[CON]TENTS.

1. INTRODUCTION.

2. BASIC LINE FINDER SYSTEM.

3. LINE FINDER SYSTEM WITH FULL SECONDARY WORKING.

4. LINE FINDER SYSTEM WITH PARTIAL SECONDARY WORKING.

5. PRIMARY LINE FINDER - CIRCUIT OPERATION.

6. DELAYED ALARMS AND FAULT CONDITIONS.

7. CHANGE-OVER TO INDIRECT FINDERS.

8. ROUTINE TESTING OF PRIMARY FINDERS.

9. SECONDARY FINDERS.

10. ROUTINE TESTING OF SECONDARY FINDERS.

11. TEST QUESTIONS.

12. REFERENCES.

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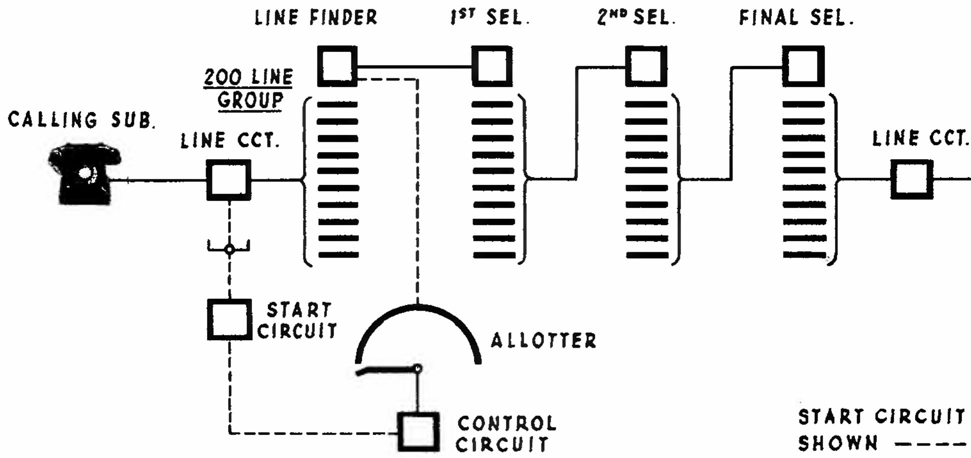
1. INTRODUCTION.

1.1 The provision of a uniselector per subscriber's line, as explained in Telephony III, Paper No. 2, is economically justified owing to the consequent reduction in the number of first selectors required. Subscribers' telephones, however, and thus the individual equipment of the lines (uniselectors, etc.), are idle for most of the time, and any reduction in the amount of equipment individual to subscribers' lines must prove economically sound. The object of all Line Finder systems is to reduce the amount of apparatus required in an exchange. This is achieved mainly by a reduction in the individual equipment. Paper No. 2 of Telephony III also explains how uniselectors may be used as line finders, allowing a small number of uniselectors to serve a group of 25 lines.

1.2 The telephone traffic carrying efficiency of a group increases with the size of the group (see Telephony III, Paper No. 8), and thus it is an advantage for each group of subscribers' lines in a line finder exchange to be as large as possible. The two-motion selector mechanism with a 200 point bank has been adopted to meet this requirement, and such a switch is shown in Fig. 2 of Paper No. 1. This switch provides for groups of 200 subscribers' lines, resulting in satisfactory traffic carrying efficiency on the first selectors. The use of the two-motion selector as a 200 line finder has been developed, therefore, to give a very economical arrangement for groups of subscribers with medium or low calling rates.

2. BASIC LINE FINDER SYSTEM.

2.1 The basic trunking arrangement for a 4-digit line finder exchange is shown in Fig. 1.



BASIC LINE FINDER TRUNKING DIAGRAM.

FIG. 1.

This diagram shows how each line of a group of 200 lines is connected via the line circuit to contacts in the line finder bank multiple. A number of line finders is available to each 200 line group, and a free finder is preselected by the allotter in readiness for an originated call. When the calling subscriber lifts the receiver, the line is marked on the multiple bank contacts of all line finders in the group, and a start signal is connected to the start circuit. The control circuit operates and causes the selected line finder to search for the calling line and switch it through to a first selector from which dial tone is given. The allotter then preselects another finder in readiness for the next call.

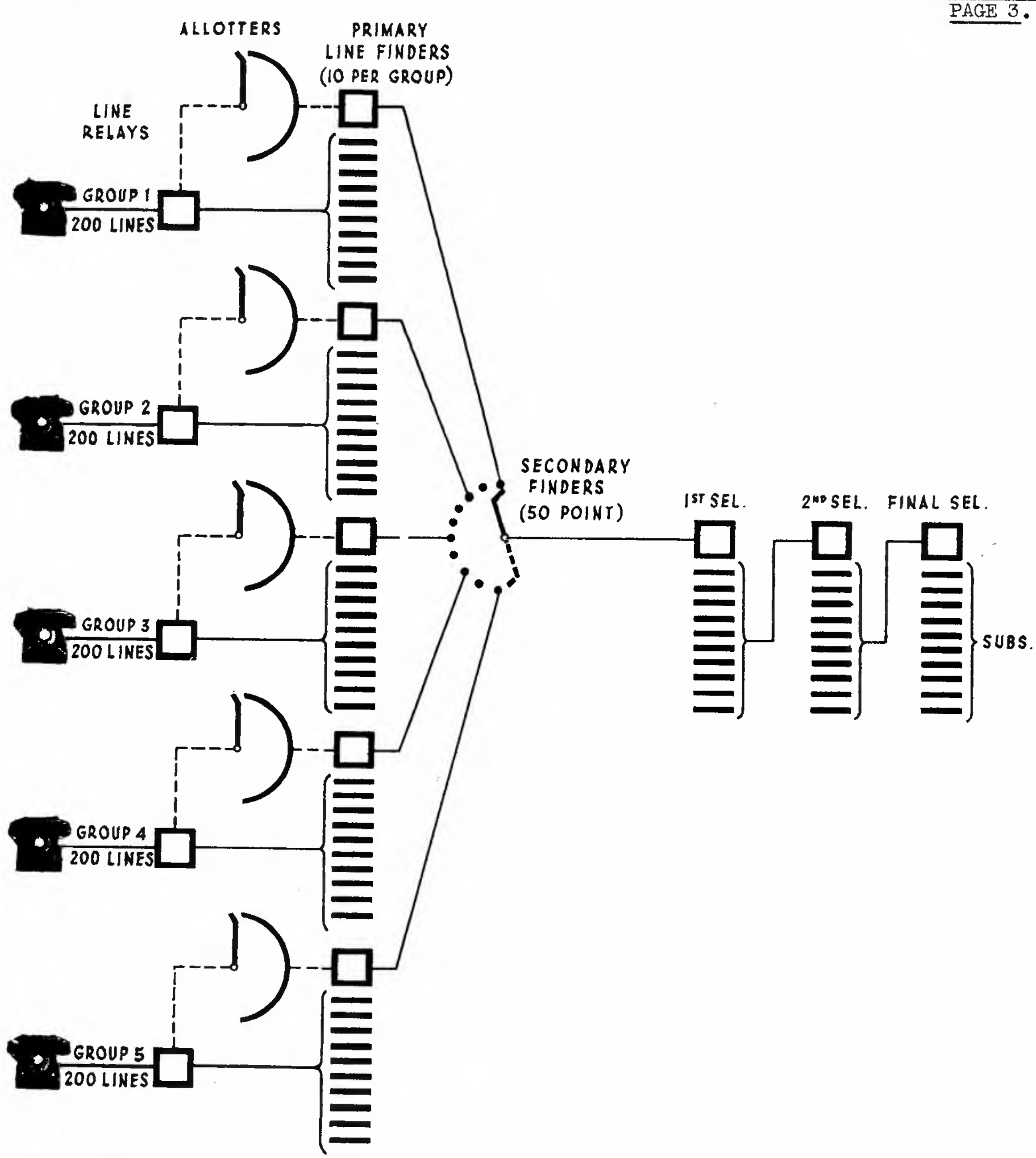
2.2 The line finders in this scheme are known as Direct Finders, as each one is permanently and directly connected to a first selector. Consequently, the number of first selectors must equal the number of line finders. The availability of the first selectors is limited to the 200 subscribers' lines in one line finder group with a resultant limitation in the traffic carrying efficiency of the selectors. The efficiency can be improved by increasing the availability of the selectors, and the use of a Secondary Line Finder Scheme gives this effect.

3. LINE FINDER SYSTEM WITH FULL SECONDARY WORKING.

3.1 The principles of secondary working are given in Paper No. 8 of Telephony III, and these are now applied to line finder working. Assume that a 1,000 line exchange has five groups of 200 lines and that each group has 10 line finders connected directly to 10 first selectors in order to carry the originating traffic. The connections are as shown in Fig. 1, and there are five similar groups. Conditions may arise with this arrangement when all first selectors in some groups are busy while there are free selectors in other groups, since subscribers in one group have access to 10 first selectors only.

If, however, each first selector is connected via a 50 point Secondary Finder (usually a uniselector), as shown in Fig. 2, so that any one of the two-motion finders can connect to each first selector, then the incoming traffic can find its way to any free selector and a much more efficient arrangement results. Any subscriber in the exchange has access to any free first selector, and this is the condition of "Full Availability". The arrangement is known as "Full Secondary Working" and requires a minimum number of first selectors. In the example quoted, the number required would be considerably less than the 50 necessary if secondary working is not used.

/ Fig. 2.



1,000 LINE FINDER EXCHANGE WITH FULL SECONDARY WORKING.

FIG. 2.

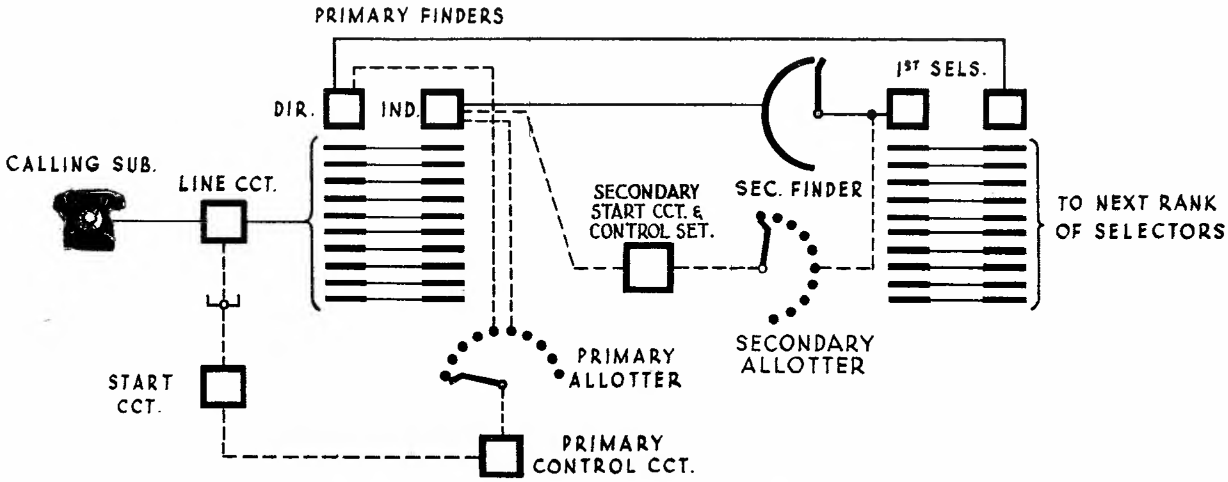
3.2 Consideration will show, however, that while the number of first selectors has been reduced, extra equipment in the form of secondary finders has been added, and the cost of this equipment tends to offset the savings in first selectors. A compromise between the two conditions of all Direct Finders and a Full Secondary Scheme provides an economical and efficient arrangement.

3.3 Line finders connected via a secondary scheme are called Indirect Primary Line Finders. The word "Indirect" indicates that the finders are connected to first selectors not directly but via secondary finders, while "Primary" indicates the rank of line finders used.

4. LINE FINDER SYSTEM WITH PARTIAL SECONDARY WORKING.

4.1 In practice, each primary line finder group contains a certain number of directly connected finders and the remainder are indirectly connected, that is, some finders are connected directly to first selectors and the others are connected to first selectors via secondary finders. This is called "Partial Secondary" working.

In a typical group of 20 primary line finders, the traffic carried by the ten finders first selected averages 0.78 traffic unit for each finder, and this is highly satisfactory. Consequently, no useful purpose would be served by combining the traffic from these finders into larger groups by means of secondary finders. On the other hand, the average traffic carried by the ten finders last selected is only 0.22 traffic unit per finder, and it is therefore of great advantage to concentrate the traffic from the later choice finders into a common group of first selectors via secondary finders. The arrangements are such that the direct finders are used first and, when all these are busy, the indirect primary finders are brought into use. Although full availability conditions are not possible, the results achieved are practically as good, and a very considerable saving in secondary apparatus is effected.



LINE FINDER SYSTEM WITH PARTIAL SECONDARY WORKING.

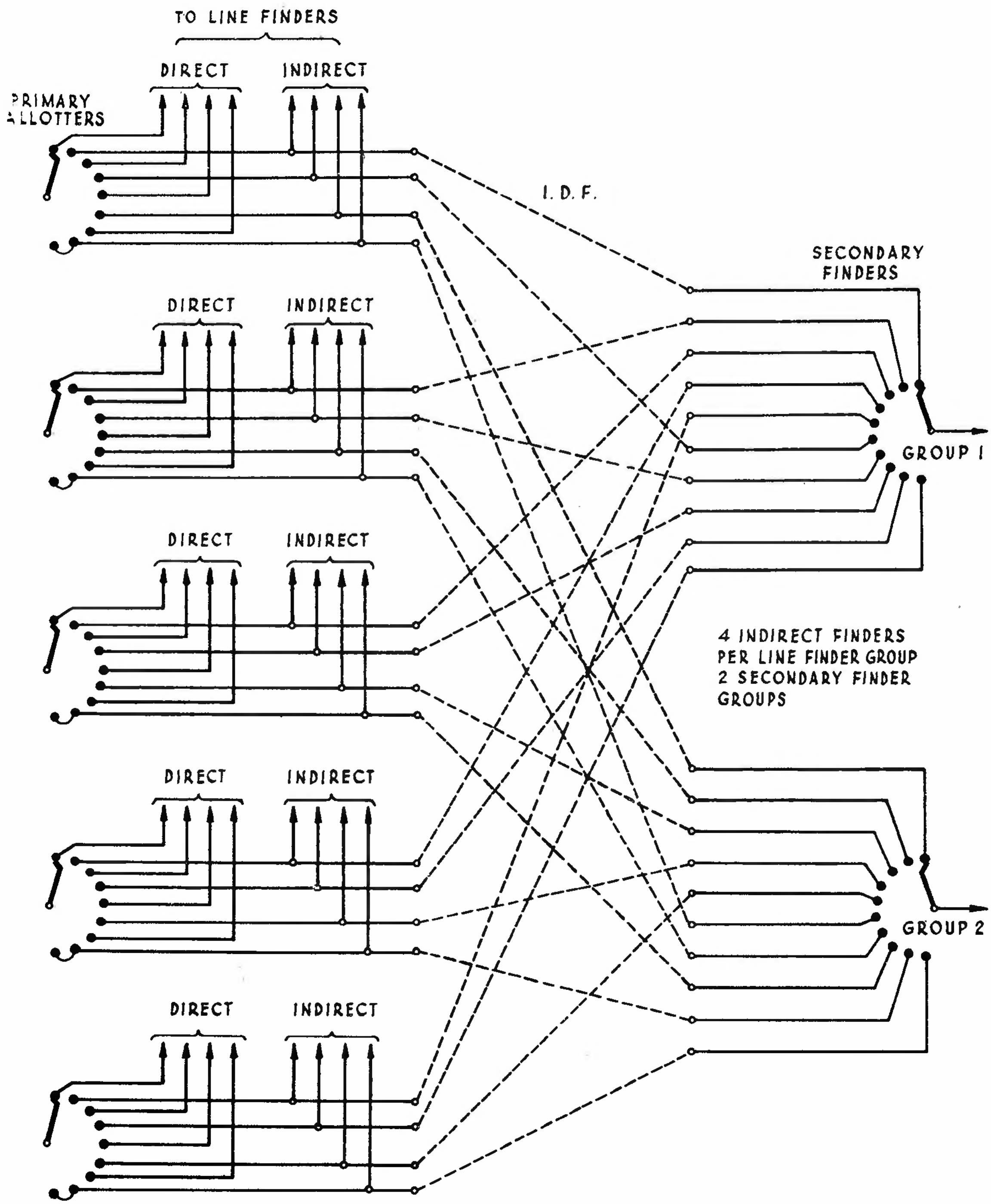
FIG. 3.

Fig. 3 shows the trunking arrangements, and it will be seen that the direct primary finders are connected directly to first selectors while the indirect primary finders are trunked to a common group of selectors via secondary line finders. This diagram shows only one group of finders, but an exchange consists of a number of such groups, and the indirect finders of all groups share the first selectors trunked via secondary finders.

In practice, a number of secondary finder groups is used and the indirect finders from each primary group are staggered over the various secondary groups. This is to avoid the possibility of congestion in a primary group should all first selectors connected to a particular secondary group be in use simultaneously. A typical cross-connection arrangement between primary line finders and the secondary finder banks is shown in Fig. 4.

It is essential in the line finder system that the traffic originated in each primary group be approximately the same. To achieve this condition the busier lines are distributed evenly over all the groups in the exchange. This is done without altering the directory number of the lines concerned by a rearrangement of the jumper wires on the Intermediate Distributing Frame (I.D.F.). For further details see Paper No. 6, Paragraph 2.2.

/ Fig. 4.



TYPICAL CROSS-CONNECTIONS FROM INDIRECT PRIMARY FINDERS TO SECONDARY FINDER BANKS.

FIG. 4.

4.2 A more detailed trunking diagram of a line finder system with partial secondary working is shown in Fig. 5. To explain the connections between primary finders, secondary finders and 1st group selectors, two groups each of primary and secondary finders are shown. In actual practice, the direct and indirect primary line finders are connected to alternate contacts of the allotter, as shown in Fig. 4. The connections of the primary line finders to the allotter bank contacts shown in Fig. 5 are for the purpose of simplicity. The three directly connected finders in Primary Group 1 are connected to 1st group selectors 1, 2 and 3, and those in Primary Group 2 to 1st group selectors 5, 6 and 7. From the indirectly connected primary finders connections are made to the secondary finder groups as follows -

(i) Connection to the secondary finder bank contacts for bank marking and switching through purposes.

(ii) Connection via the start lead to the secondary start relay-set in order to start the secondary finders searching for the marked contact.

For the purpose of starting the line finders searching, the 200 lines are divided into five sub-groups of 40 lines, and from each sub-group there are two wires leading to Start Relays. Thus, from each group of 200 lines there are 10 wires which terminate on five start relays. The contacts of these start relays send a start signal to an appropriate Control Relay-set. Associated with each control set is an Allotter (a 25 point uniselector) which preselects a free line finder in readiness to search for the calling line. Thus, five start relays may be in use at once in a 200 line group, but the number of line finders searching simultaneously is limited by the number of control sets and associated allotters provided. This number depends on the calling rate of the group, and is usually two or three. When one control set and associated allotter is held by a fault condition, the start leads to that control set are transferred to another control set.

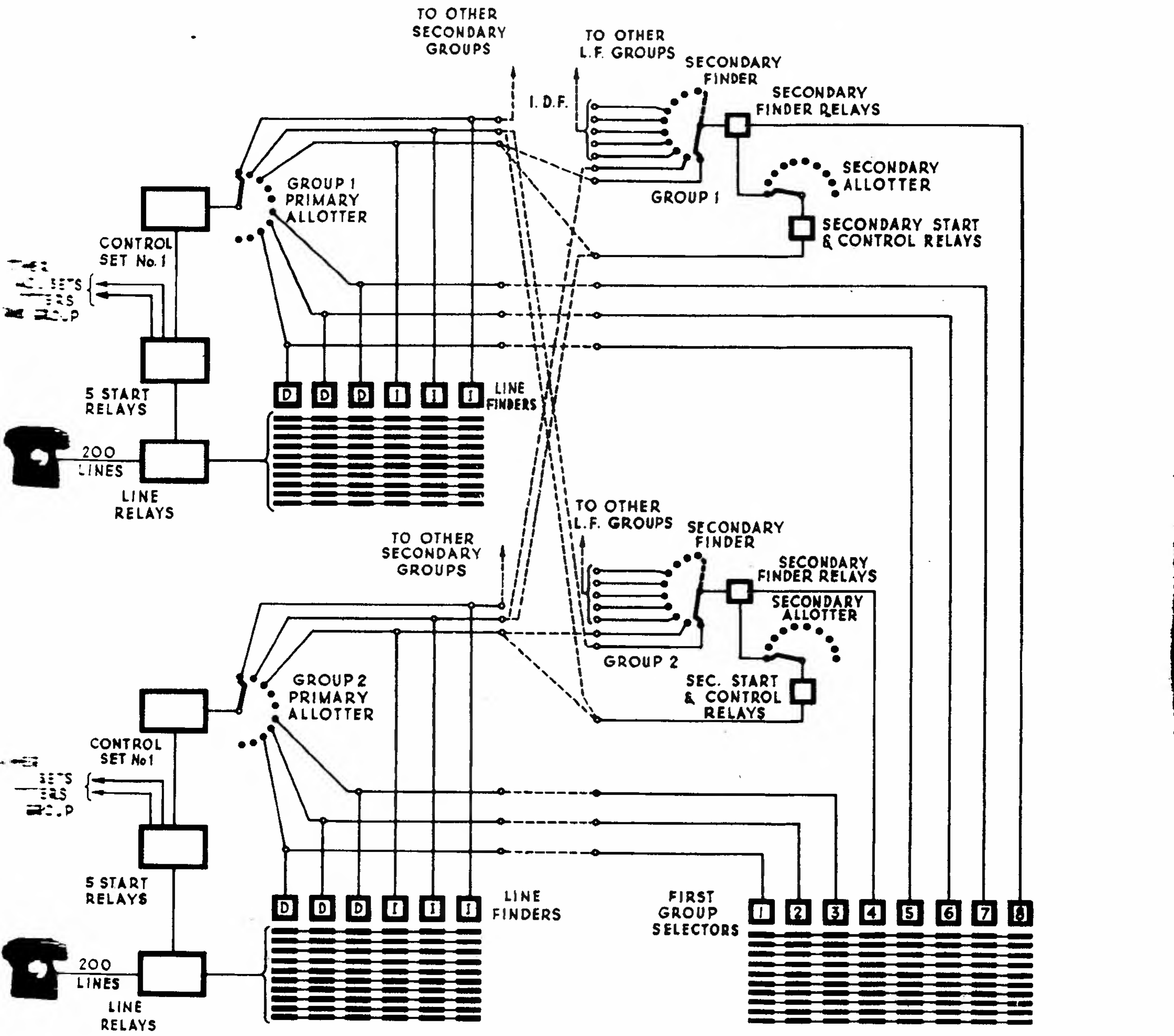
4.3 Referring to Fig. 5, the operation of a call is traced as follows -

When the subscriber lifts the receiver, a start relay, which is common to the 40 lines in the sub-group, operates and a primary control set is seized. The wipers of the associated allotter are standing on contacts leading to a free Direct Primary Finder which searches for the calling line and, when found, connects the line through to the first selector. When this is done, the primary control relay-set and primary start relay-set are disconnected and the allotter steps its wipers to find another free finder in readiness for the next call. Dial tone sent out from the first selector indicates that dialling can commence.

When all the direct primary finders are busy, the wipers of the primary allotter are stepped to contacts leading to an Indirect Primary Finder. As before, the call operates a start relay to seize the primary control relay-set and primary allotter (the contacts of which now lead to the indirect primary finder) and a start signal is sent to the secondary start set. This seizes the secondary control set and associated secondary allotter, which will have preselected a free secondary finder. The secondary finder searches to find the marked contact in the secondary finder bank leading to the indirect primary finder allotted to the calling subscriber. After the indirect primary finder has been found by the secondary finder, the primary finder commences to search for the calling line, and the subscriber is connected through the banks of the primary finder and the secondary finder to the associated first selector. Dial tone is returned to the subscriber to indicate that the call may proceed.

If the primary finder is indirectly connected, the secondary finder must complete its finding action before the primary finder starts searching. This sequential operation is necessary to ensure that there is no interruption in the battery supply to the subscriber's line. This would cause false supervision if the calling line was from a P.B.X. switchboard.

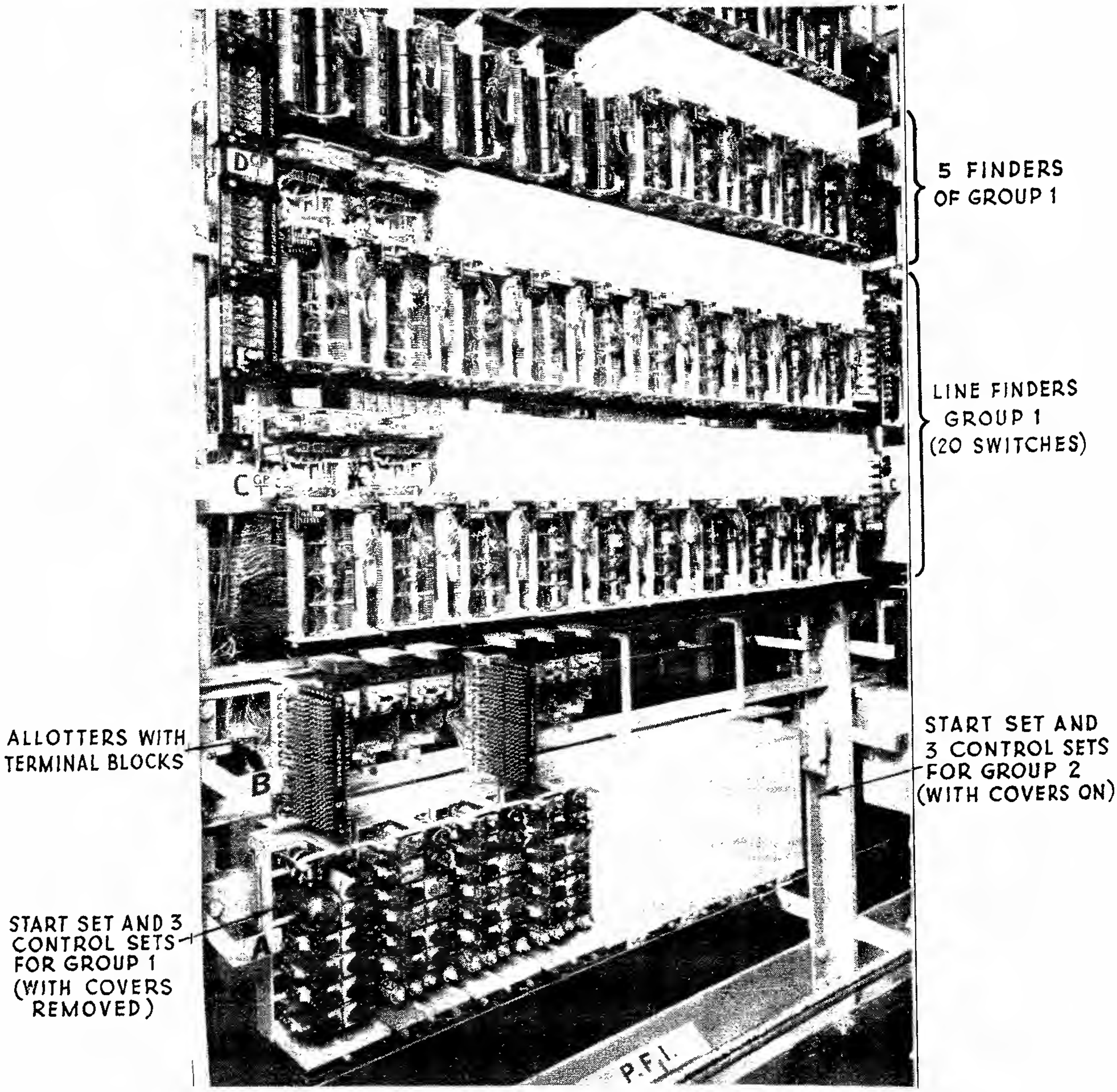
/ Fig. 5.



TRUNKING DIAGRAM OF 200 POINT LINE FINDER SYSTEM WITH PARTIAL SECONDARY WORKING.

FIG. 5.

4.4 Fig. 6 shows the equipment provided for a 200-line primary line finder group. Although the 2000 type switch has been used in all major line finder exchanges in Australia, it should be noted that the use of 200 point line finders is not necessarily restricted to 2000 type equipment. There are, in fact, exchanges in England using line finders of the pre-2000 type. Another system uses a 200 point uniselector as a line finder.



TYPICAL 200 POINT PRIMARY LINE FINDER GROUP.

FIG. 6.

5. PRIMARY LINE FINDER - CIRCUIT OPERATION.

5.1 From Fig. 6, it will be seen that each primary finder has only two relays, HA and HB. These relays are necessary to hold the call, but all other relays necessary to control the functions of the finder are placed in the control relay-set and are used in turn for every finder to which the control set is connected. This arrangement gives a considerable economy of apparatus. In dealing with the operation of a finder, therefore, it is necessary to consider the circuit of line finder, allotter, control relay-set, start relay-set, and subscriber's line circuit as a whole, rather than as completely separated circuits. Fig. 7a attached shows the complete circuit, and the functions performed by this circuit are as follow -

(i) Connects the calling line to the primary finder.

(ii) Connects the normal traffic direct from the primary finder to the associated first selector.

(iii) Connects peak traffic via the primary finder and secondary finder to a first selector.

(iv) Regulates the primary control relay-sets so that one or more primary finders hunt simultaneously dependent on the traffic conditions.

(v) Operates a congestion meter when no outlet to a first selector is available to the group.

(vi) Busies out faulty equipment.

(vii) Operates an alarm should a control set develop a fault.

(viii) Removes the fault busying condition should all controls be affected, thereby allowing a fresh chance for calls to originate.

(ix) Provides for positive battery metering.

(x) Gives a release alarm should a primary finder fail to restore.

(xi) The allotter steps on to ensure a different primary finder being used on repeated calls.

(xii) Prevents the continuous rotation of allotters when all primary finders are busy.

(xiii) Provides for self-routining of the apparatus.

(xiv) Provides a "camp on" facility to enable the continuous routine testing of any particular primary finder.

(xv) Routine testing causes no interference to normal calls.

(xvi) Should the control set seized by a calling subscriber develop a fault during operation, transfers the start signal to a second control set.

(xvii) Gives equal loads to control sets.

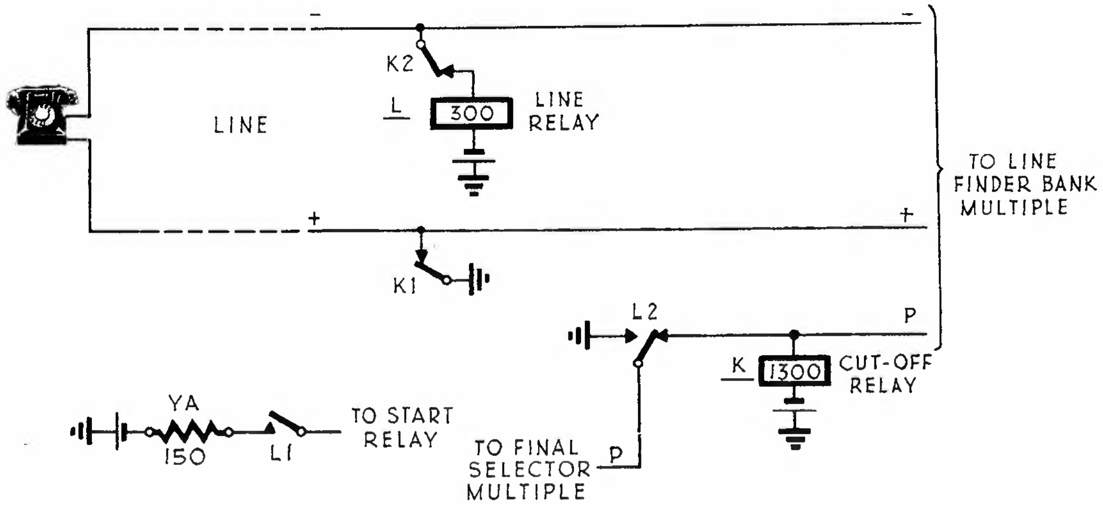
(xviii) Provides a test trunk buzzer to indicate which of two outlets is seized by the finder.

/ 5.2

5.2 Line Circuit and Finder Bank Marking. The basic requirements of the line circuit in a line finder exchange are similar to those for the uniselector exchange described in Telephony III. These requirements are -

(i) A Line Relay connected to battery and through a contact of the cut-off relay to the negative line.
(ii) Earth connected through a contact of the cut-off relay to the positive line.
(iii) A Cut-off Relay operated over the private wire from the line finder and the final selector.
(iv) A subscriber's meter.

In addition, the line relay contacts must mark the particular level and the particular contact in that level in the line finder bank multiple to enable the particular line to be found when a call is originated. The elements of the line circuit are shown in Fig. 8.



ELEMENTS OF THE LINE CIRCUIT.

FIG. 8.

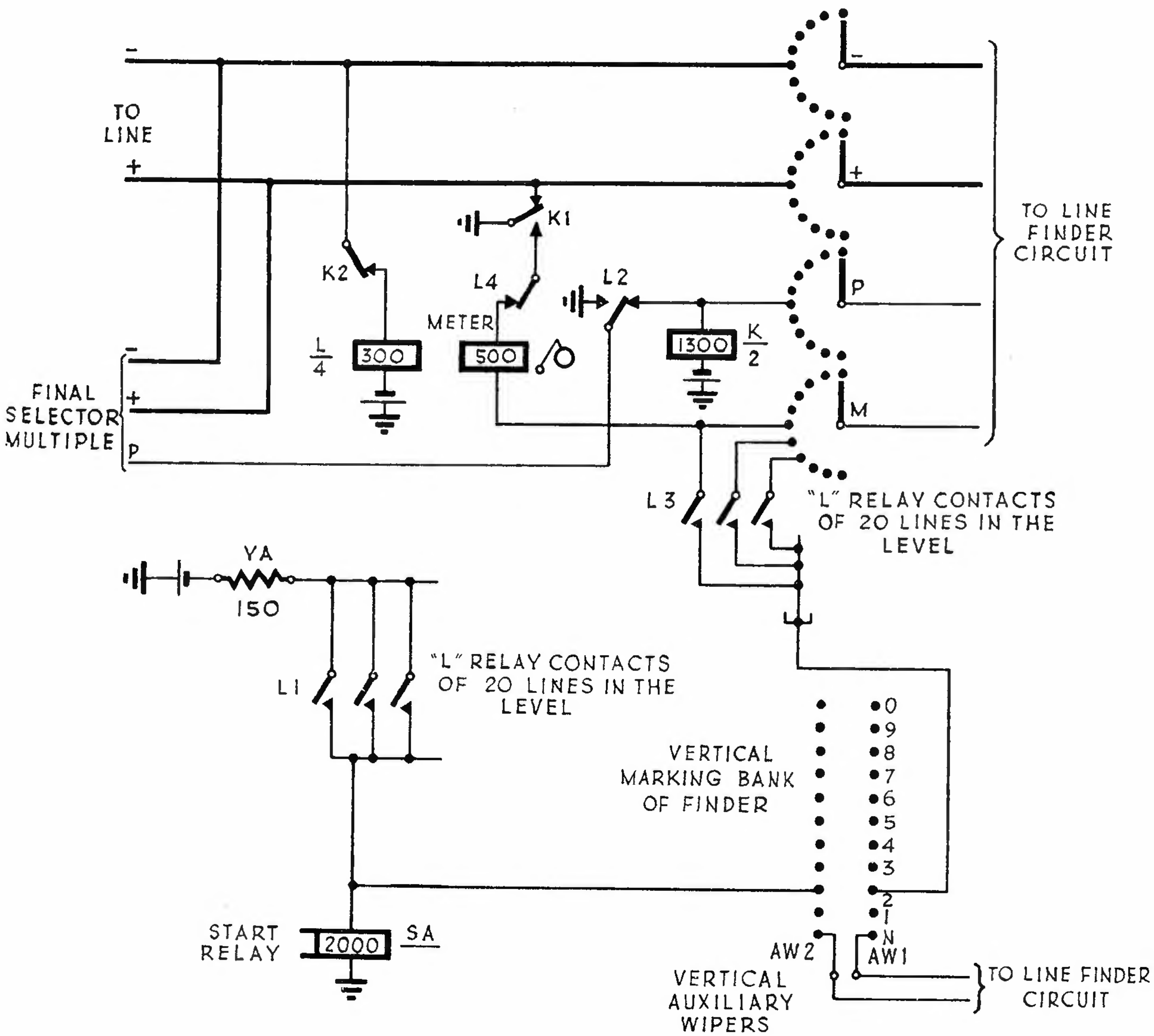
When the receiver is lifted, the line relay operates over the circuit shown in Fig. 8. Contact L2 earths the P wire to the final selector to busy the line to incoming calls. Contact L1 operates the start circuit by extending battery via 150 ohms YA to one of the start relays in the primary start circuit. Change-over contacts of relay K, as used in the uniselector line circuit, are not needed in this circuit as the wires to the line finder banks are open-circuited at the bank contacts. For comparison, see change-over contacts K1 and K2 in Fig. 2, Paper No. 4.

5.3 Referring now to the more detailed line circuit in Fig. 9, the start lead (via L1) also connects marking battery to the appropriate level contact on the vertical auxiliary marking bank of all finders in the group. Battery via resistance YA is connected to the particular start relay winding (in this case SA) by the operation of any one L1 contact from the 20 line circuits connected to that level. The operation of the start relay sets up a train of operations (explained later) and a line finder is stepped vertically, searching for the level in which the calling line is connected. The finder has an auxiliary contact bank with two columns of ten contacts, as shown in Fig. 9. As the finder carriage rises, the vertical wipers AW1 and AW2 contact each column separately. The normal condition on AW2 contacts is earth through the 2000 ohm winding of the particular start relay. Operation of an L1 contact, however, connects battery via 150 ohm YA to the auxiliary bank contact and, when the vertical wiper finds this battery, a relay in the control set operates to stop the vertical search. The finder wipers are stopped, therefore, opposite the level in which the calling line is connected. The finder wipers then automatically commence the rotary search for the calling line which is

/ marked

marked on the M bank. Contact L3 has closed a circuit from the marked contact on the M bank to the level contact on AW1 bank. As the other circuits connected to the level are open-circuited on the M bank, the finder passes over them. However, when the finder locates the contact which is marked, a circuit is completed for temporarily locking the rotary magnet of the finder to stop the search. A relay in the line finder operates and applies an earth over the P bank in order to operate the cut-off relay K. The line relay L and earth are removed from the line at contacts K2 and K1, respectively. The final selector P bank contact is busied by the earth from the line finder, and the subscriber's meter is connected from earth over K1 and L4 to the M bank contact of the finder.

The L and K relays used in the line circuit are of the 600 type, and their mounting and cabling is shown in Paper No. 6.

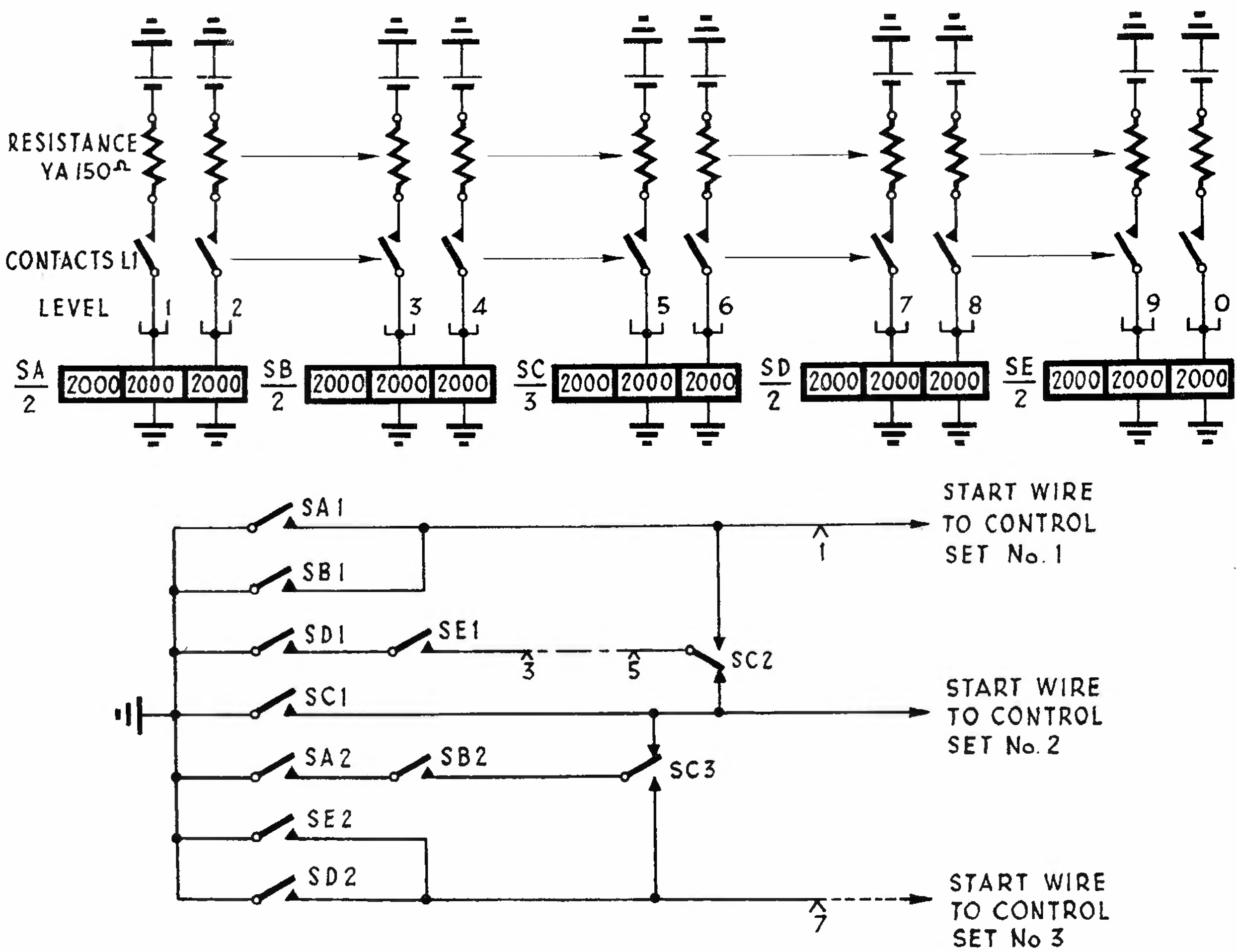


LINE CIRCUIT AND FINDER BANK MARKING.

FIG. 9.

5.4 Start Conditions. An adverse feature of earlier line finder systems was that only a single finder in each group could hunt for calling lines. This is a serious disadvantage in groups of 200 lines for, although normally any single call is switched through in one or two seconds, it is to be expected that, at times, several calls will be originated simultaneously from the group of 200 subscribers. If these simultaneous calls were dealt with in turn, the delay in some instances would be excessive. To reduce this delay as much as possible, the system now used incorporates the "Plurality Hunting" feature. This enables two or three line finders to search simultaneously for lines in the same group, provided that subscribers in different sub-groups of the 200 line group originate the simultaneous calls.

The 200 contacts of the line finder bank are divided into 10 levels, each having 20 subscribers' lines connected. There is a start wire common to the 20 subscribers' line circuits of each level, and this leads to the winding of a relay in the Primary Start Relay-set, the essential connections of the starting arrangements being given in Fig. 10. The start wire from each level is shown, and two such commons are connected to two separate windings of each start relay. These relays are operated, therefore, when any subscriber connected to a contact of two levels originates a call. These two levels form the sub-group of 40 lines referred to previously.



ESSENTIAL CONNECTIONS OF THE START RELAY-SET FOR THREE CONTROL SETS.

FIG. 10.

As shown in Fig. 10, triple-wound relays SA, SB, SC, SD and SE are provided, one relay for each two levels of the line finder multiple. Only two windings of each relay are normally in use, the third windings being used for routine testing (explained later). In each line circuit there is a make contact of the line relay (L1) which, when operated, connects battery through 150 ohm resistance YA to a winding of one of the relays, as shown. In Fig. 10 the circuit of one such connection in a line circuit is shown, but it should be understood that there are 20 such connections commoned to two windings of each start relay. Hence, each start relay is controlled by any of the L1 contacts of the line relays of the 40 subscribers in a sub-group.

Contacts of these start relays (SA to SE) are connected, as shown in the lower part of Fig. 10, and, when a start relay operates, these contacts connect an earth to the control sets of the particular line finder group. As there may be two or three control sets in the one group, the contacts must be so arranged that, when one start relay operates, one control set is taken into operation and, when a second start relay operates, another control set is seized. The contact system of the start relays is arranged so that a call initiated in one of the five 40-line groups earths the start wire of one of the three control sets. Calls initiated simultaneously in any two sub-groups earth the start wires of two control sets, whilst calls initiated simultaneously in any three sub-groups earth the start wires of three control sets. If a call is initiated from a subscriber on level 2, for example, then relay SA is operated and earth from SA1 is connected to Control Set No. 1. If, at this time, another call were initiated on level 4, relay SB would be operated and an earth extended to control set No. 2 via contacts SA2 and SB2. It will be appreciated that two simultaneous calls in the same sub-group will not seize two control sets and, therefore, two finders will not commence hunting. In this case, one call uses the control set and the finder, and, when this line is found, the allotter steps on. The next finder then operates to find the second calling line, and thus simultaneous calls are dealt with one after the other. When two or more simultaneous calls are made in the one sub-group, therefore, there may be an appreciable time from the lifting of the receiver to the connection of the line to a first selector. This is one reason why dial tone becomes very important in a line finder system.

An allotter is associated with each control set and, as has been mentioned previously, the allotters are 25 point non-homing uniselectors which preselect the line finder. When the line finder has found the calling line and switched it through to a first selector, the allotter steps to preselect a free line finder in readiness for the next call. It will be realised that, as the start wire to two or three control sets can be earthed simultaneously, the above action can be taking place in one, two or three finder of the group at the same time.

The principles given above could be extended to provide for the simultaneous hunting of more than three line finders. In practice, however, it is found that not more than three control sets need be provided. Only one start relay-set is employed whether two or three control sets are used, and the connections from the contacts of the start relays (see Fig. 10) are arranged by strapping on the shelf jacks to cater for both cases.

5.5 Control Set Seized. (See Fig. 7a, attached.) As previously explained, when a subscriber lifts the receiver to originate a call, the line relay L operates and L1 extends marking battery to the vertical bank contact of the primary finders and causes a start relay to operate, the relay which is operated being governed by the level on which the calling subscriber's line is terminated.

Assume that relay SA operates, then SA1 extends an earth via OFZ5 to Primary Control Relay-set No. 1 and relay ST operates via TB5 to battery via resistance YG.

If the allotter is already standing on contacts associated with a free primary finder, relay LK operates on its 11 ohm winding from earth at ST1, via VR3, Test Jacks T5-6, RFZ1, allotter wiper and bank R2, N2 and HA2 to battery via 150 ohm YA. (Assuming that the finder is directly connected.) Should the allotter still be finding a free line finder when the control set is seized, relay LK does not operate until it has found one. The operation of the allotter is described later.

When relay LK operates, earth from LK1 completes the circuit of relay VR in series with the allotter magnet. Relay VR operates but the allotter magnet does not.

Relay SF operates on its 500 ohm winding from earth at ST7, via RS5, 8 ohm winding of relay LK, VR6, allotter wiper and bank R4 to battery over the negative wire from the first selector A relay. This also causes the pre-operation of relays A and B in the first selector, and earth is returned on the P wire.

Line finder relay HA operates on its 2000 ohm winding from earth at SF1, via relay VT (which does not operate), allotter wiper and bank R5, vertical wiper AW2 and normal auxiliary bank contact, S1, NR2 and N1 to battery via the line finder rotary magnet. HA2 disconnects the 11 ohm winding of relay LK, which is required to hold on its 8 ohm winding in series with relay SF. In earlier circuits, it was sometimes found that relay LK failed to hold under these conditions. The addition of 1000 ohm non-inductive resistance YH across the 500 ohm winding of relay SF allows the current to rise more rapidly in relay LK and it holds satisfactorily.

Relay SFR operates on its 2000 ohm winding from earth at SF3 via allotter wiper and bank R7, 10 ohm winding of relay HA, HB8, HA1 and N1 to battery via the rotary magnet. SFR6 provides a holding circuit to battery via 200 ohm YB for relays SFR and HA when the line finder subsequently steps off-normal.

5.6 Indirect Primary Finder. When a primary finder is indirectly connected, that is, when a secondary finder is used to connect the primary finder to the first selector, the secondary finder must complete its finding action before the primary finder starts searching. This is to ensure that there is an A relay connected to the subscriber's line before the battery and earth in the subscriber's line circuit are cut off by the operation of relay K. Should relay K operate - due to the primary finder having switched - but with the secondary finder still searching, then a temporary disconnection would occur on the subscriber's line. If the calling line is from a P.B.X. switchboard, this could cause false supervision.

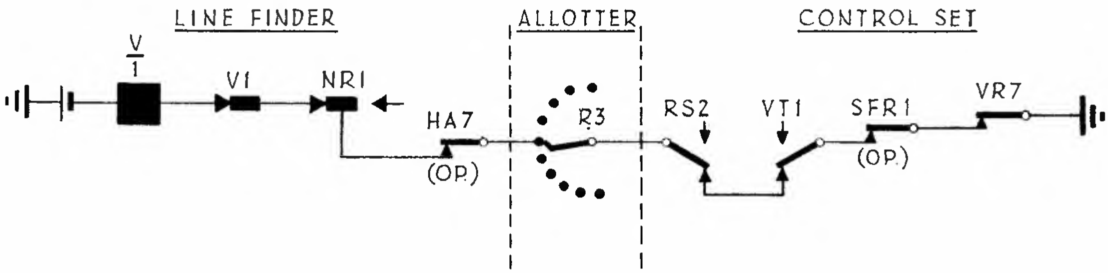
Sequential operation of the finders is therefore necessary and, when the secondary finder reaches the chosen primary finder, the secondary switching relay (SK) operates and connects the primary finder to a first selector. Relay SF then operates in series with the selector A relay to bring about the subsequent operation as described previously.

The operation of relay SFR in either case causes the primary finding action to commence as follows -

/ 5.7

Vertical Stepping. The operation of relay SFR causes the wipers to be stepped vertically until the level marked by the calling line is reached. The circuit is shown in simplified form in Fig. 11. The operation of the magnet breaks its own circuit, so that it alternately releases and reoperates to step the wipers vertically.

During the first vertical step, the off-normal (N) springs operate and, consequently, the initial operating circuit of relay HA is broken at N1 and by the auxiliary wiper AW2 (see paragraph 5.5). HA holds, however, from battery via 200 ohm YB, SFR6, allotter wiper and bank R7, 10 ohm winding, HB8, HA1, NR2, 2000 ohm winding to earth returned on the P wire from the first selector. Under these conditions the two windings of relay HA are in opposition, but the effect of the 10 ohm winding is slight and HA holds.

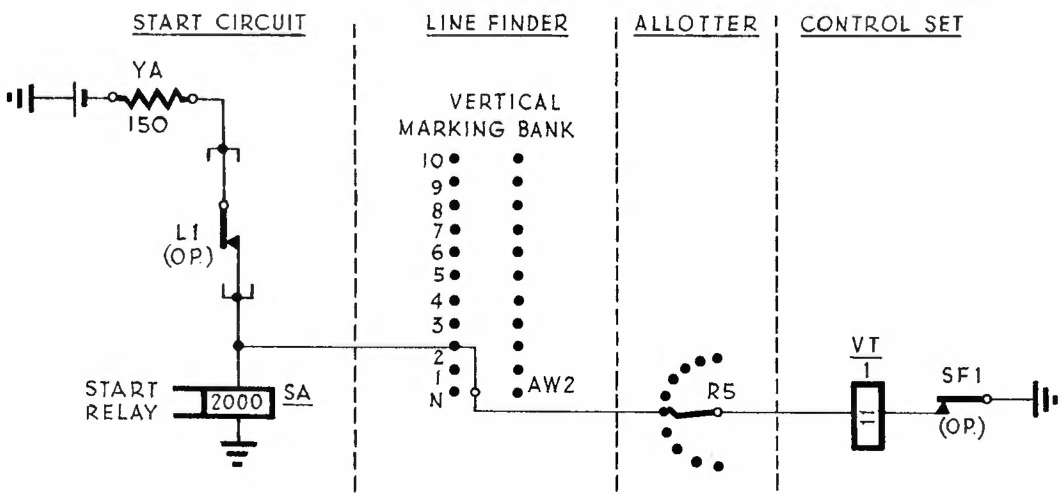


VERTICAL SELF-DRIVE CIRCUIT.

FIG. 11.

It has been explained, in Paragraph 5.3, how a level is marked by battery via a 150 ohm YA resistance connected to a contact of the vertical marking bank. Therefore, the auxiliary wiper AW2, moving over these bank contacts, is searching for this marked condition.

When the wipers reach the marked vertical bank contact, relay VT operates over the circuit shown in Fig. 12. VT1 breaks the vertical self-drive circuit (Fig. 11) and the vertical stepping is arrested. To reduce "line stealing," earth via the winding of relay VT "busies" the vertical contact and prevents other finders from cutting in on this level. The start relay is shunted by this low resistance earth, and may or may not release under this condition. This release, however, has no significance, as relay ST in the control set is held operated (at VR4) independent of the initial start earth.



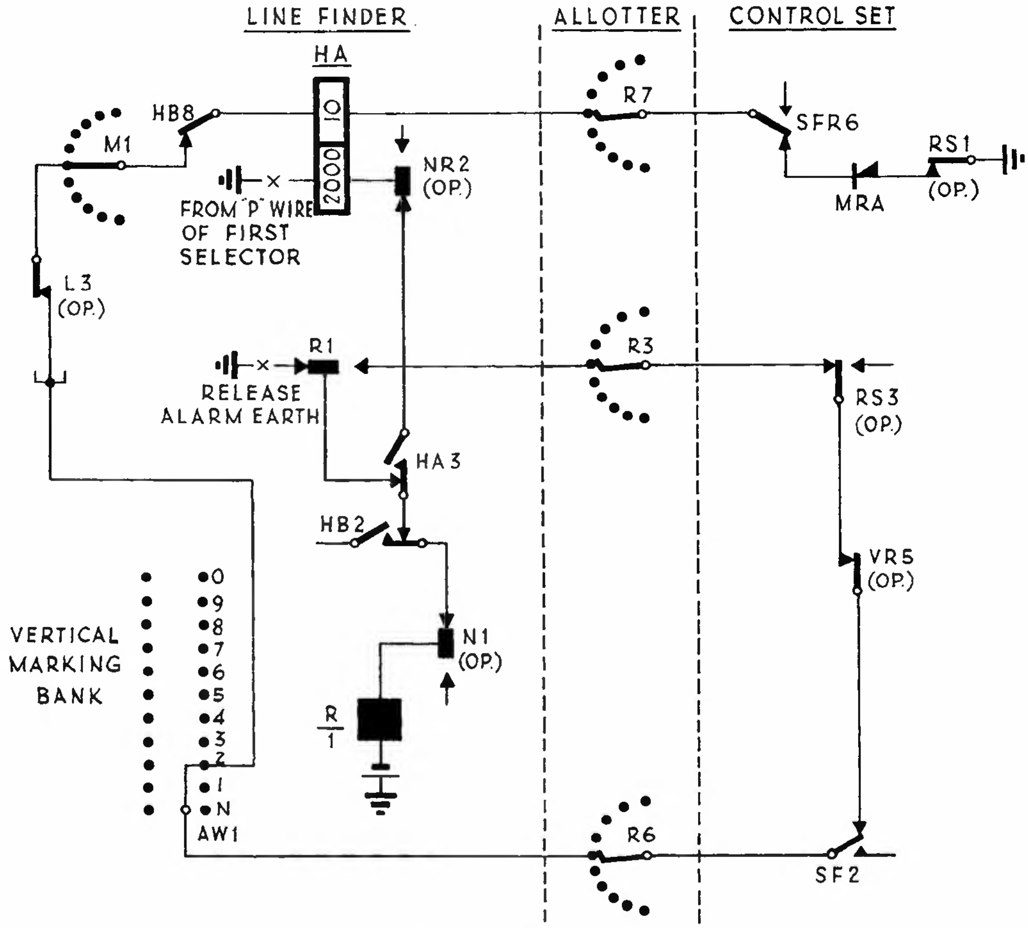
VERTICAL TESTING CIRCUIT.

FIG. 12.

Relay RS operates via VT1 and SFR1 to earth at VR7 and locks via RS6. RS5 short-circuits the 500 ohm winding of relay SF, but includes 500 ohm YD in place of SF. Relay SF releases, therefore, unless held on its 1000 ohm winding. (This is a fault condition and is described in Paragraph 6.7.) Relay SFR releases, followed by the release of relay HA in the line finder.

/ 5.8

5.8 Rotary Stepping. When HA restores, a self-drive circuit is completed for the rotary magnet via N1, HB2, HA3 and R1 to release alarm earth. The rotary magnet drives the wipers over the bank contacts until the marked contact is reached, when relay HA or HB operates on its low resistance winding in series with the rotary magnet, which is thus held operated and prevented from making any further rotary steps. Fig. 13 shows the self-drive circuit and testing and holding circuits for relay HA.



TESTING CIRCUIT FOR RELAY HA.

FIG. 13.

The operating circuit for relay HA is via the rotary magnet, N1, HB2, HA3, operated rotary interrupter contact R1, allotter bank and wiper R3, RS3, VR5, SF2, allotter wiper and bank R6, auxiliary wiper AW1 and vertical bank contact, operated L3 contact in the calling subscriber's line circuit, M1 bank and wiper, HB8, 10 ohm winding of HA, allotter bank and wiper R7, rectifier MRA to earth at RS1. The operation of HA3 breaks the rotary magnet circuit and closes the holding circuit of HA on its 2000 ohm winding in series with the rotary magnet.

The high searching speed of approximately 50 steps per second attained by a line finder necessitates a positive means of tripping the drive. This is obtained by ensuring that, at the completion of the last stepping operation, the magnet is locked until the operating circuit is disconnected. Thus, when the line finder wipers reach the marked contact, the rotary interrupter change-over contact breaks the operating circuit of the magnet and almost simultaneously completes the circuit for the 10 ohm winding of relay HA in series with the magnet. The magnet remains locked in series with the 10 ohm winding of relay HA until HA3 opens the low resistance circuit and completes its high resistance holding circuit. The magnet then releases but cannot reoperate as the original operating circuit is disconnected at operated HA3 contacts.

/ 5.9

5.9 The operation of relay HA previously described assumes that the calling subscriber's line is connected to the even hundred group, that is, to the lower set of bank contacts. However, the caller may be situated in the odd hundred group and, in this case, relay HB operates to stop the rotary drive and switch the call through to the upper set of bank contacts. The testing and holding circuits for relay HB are shown in Fig. 14, and it will be seen that these are similar to those for relay HA, but using bank M2 and allotter bank R8 in lieu of M1 and R7, respectively.

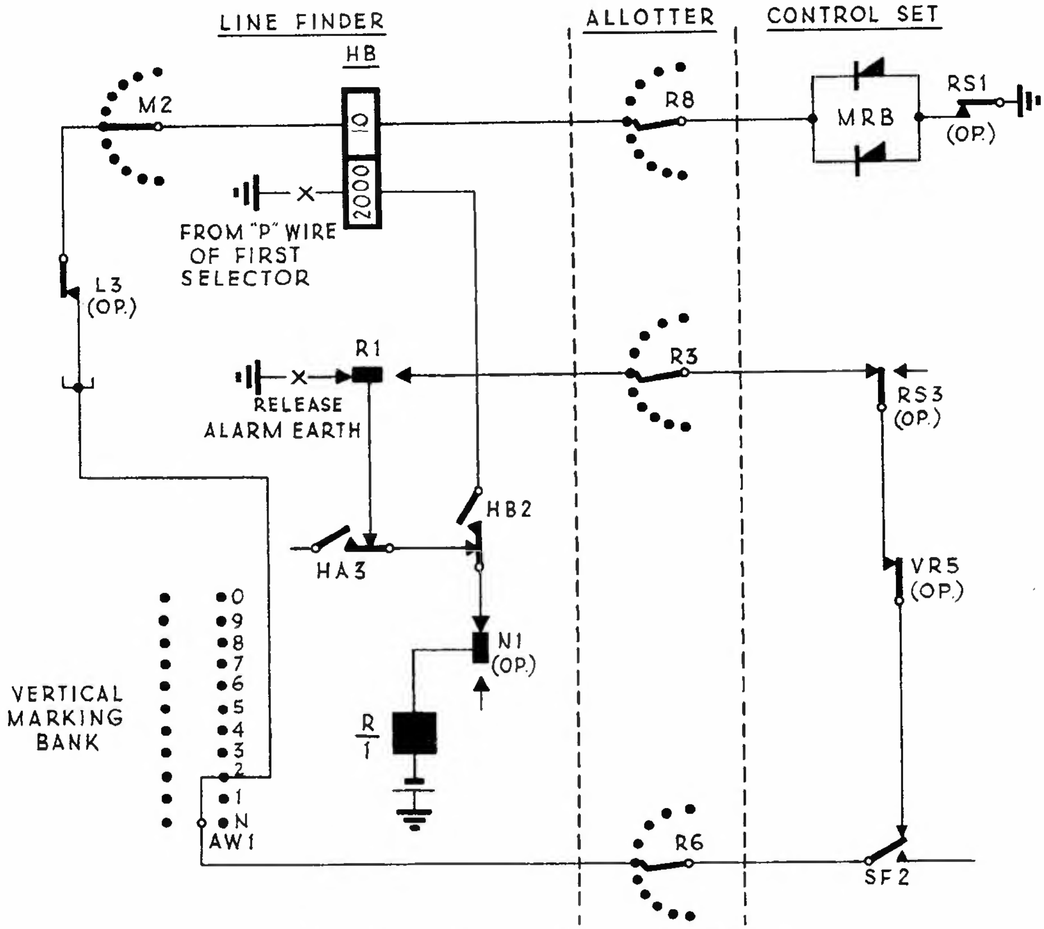


FIG. 14. TESTING CIRCUIT FOR RELAY HB.

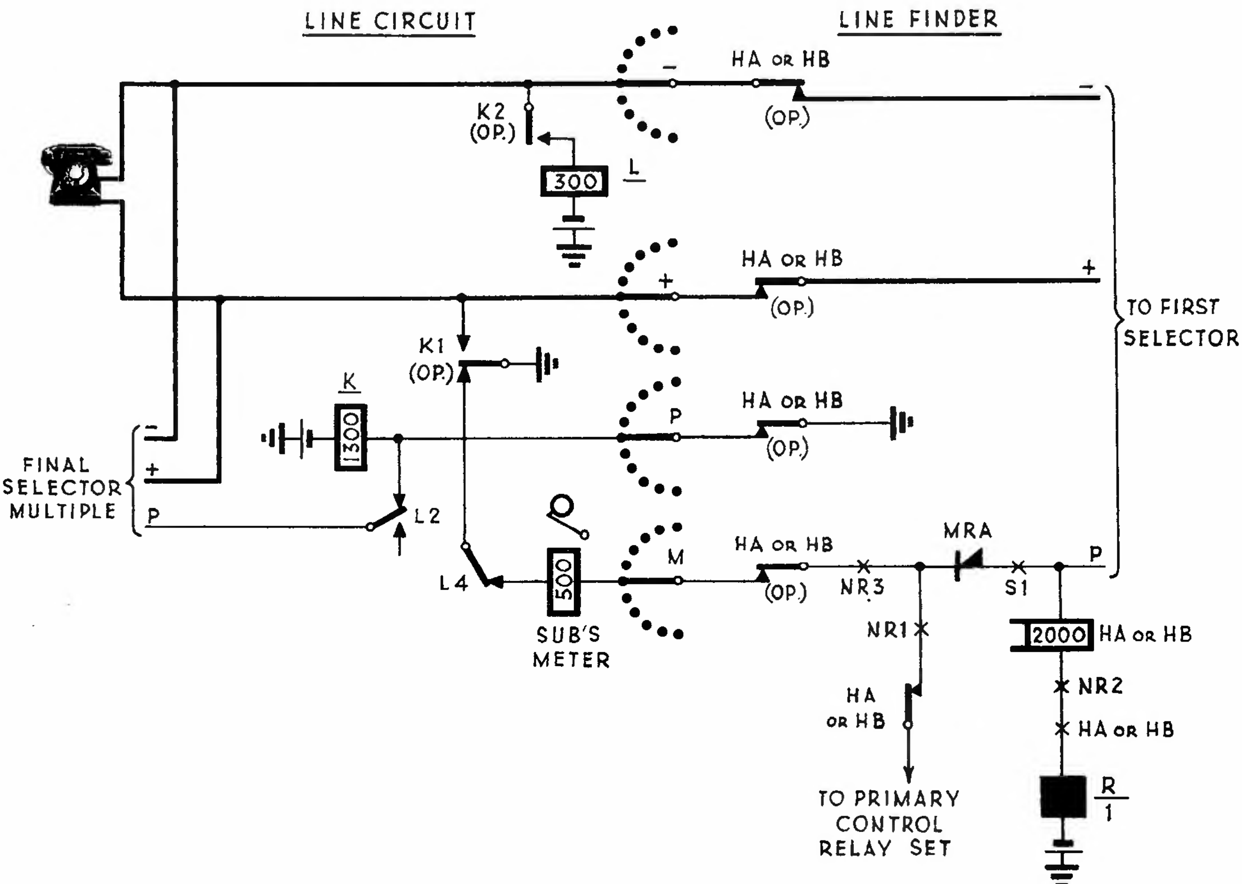
The operating circuit for relay HB is via the rotary magnet, N1, HB2, HA3, operated rotary interrupter contact R1, allotter bank and wiper R3, RS3, VR5, SF2, allotter wiper and bank R6, auxiliary wiper AW1 and vertical bank contact, operated L3 contact in the calling subscriber's line circuit, M2 bank and wiper, 10 ohm winding of HB, allotter bank and wiper R8, rectifier MRB to earth at RS1. The operation of HB2 breaks the rotary magnet circuit and closes the holding circuit of HB on its 2000 ohm winding in series with the rotary magnet.

5.10 It is possible that corresponding contacts in both lower and upper banks may be marked simultaneously, for example, should subscribers WA 1026 and WA 1126 initiate calls at the same time. In such cases, priority of operation is given to the odd hundred group and relay HB operates. This is arranged as follows -

(i) The operating circuit for relay HB is via two metal rectifiers (MRB) in parallel, while the operating circuit for HA is via a single rectifier MRA. Thus, the resistance in the circuit of relay HB is less than that of HA, and HB therefore operates faster than HA.

(ii) Relay HB, in operating, breaks the operating circuit of relay HA at HB8, and the holding circuit of relay HA at HB2. Thus, only relay HB can operate.

5.11 Switching Through. The operated contacts of relay HA or HB extend the negative and positive lines through to the first selector; connect earth to the P1 or P2 wiper to operate relay K in the subscriber's line circuit; connect the P wire from the selector to the M1 or M2 wiper; and extend the earth on the P wire to the primary control relay-set in order to release the latter. When relay HB is operated, HB4 prepares the circuit of the test trunk bell, which is completed when a plug is inserted in test jacks T9-10. Dial tone is now heard by the calling party. The through connections are shown in Fig. 15.



THROUGH CONNECTIONS.

FIG. 15.

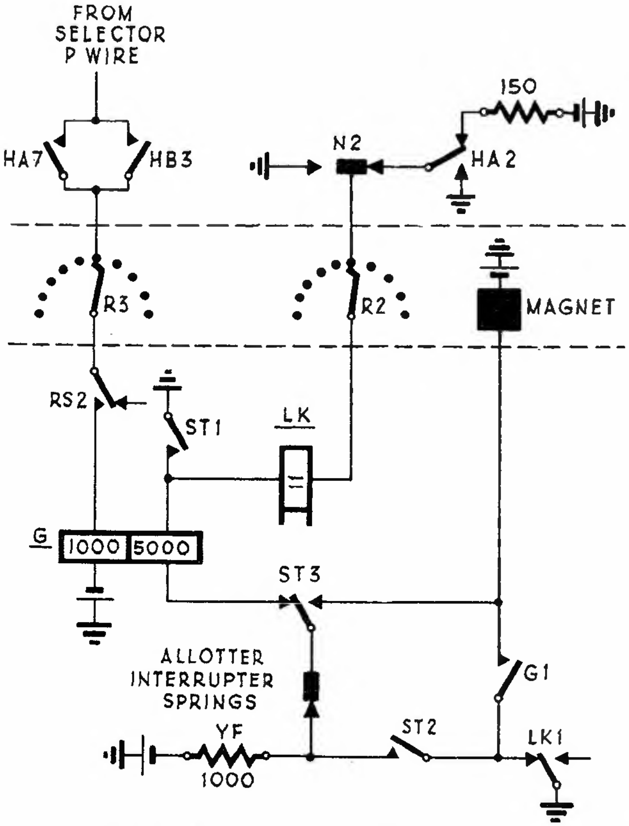
Operation of relay K in the line circuit releases relay L and gives a clear line for the speaking pair. Earth from the P wire is extended via L2 to busy the final selector multiple.

The subscriber's meter is eventually operated by a pulse of positive battery returned on the P wire from the final selector or relay-set. The circuit is via S1, MRA, NR3, HA1 or HB1, M1 or M2 wiper and bank, 500 ohm meter and L4, to earth at K1.

5.12 Release of Primary Control Relay-set. Relay G operates via RS2 when earth on the P wire from the first selector is extended by HA7 or HB3 over allotter bank and wiper R3. G2 in series with VR1 short-circuits relay ST, which releases and allows relay LK to restore. This in turn causes relay VR to release and VR7 releases relay RS. RS2 breaks the circuit of relay G, which also releases. Thus, the control set relays are all released, including the alarm relay TA, whose function is described later.

/ 5.13

.13 Preselection of a Free Outlet. The elements of the allotter circuit are shown in Fig. 16. On the operation of relay G and the release of relay LK, the allotter magnet is energised and, when relay RS releases, the circuit of relay G is disconnected. Relay G releases, causing the allotter wipers to be stepped to the next outlet. If this outlet is busy, earth is encountered on allotter bank R2 from operated N2 or HA2, and relay G operates on its 5000 ohm winding to battery via 1000 ohm YF and the allotter interrupter springs. The allotter magnet is again energised and the interrupter springs open to disconnect the circuit of relay G, which releases to step the allotter. This interaction continues until a free outlet is reached by the allotter wipers when, due to the absence of earth on the R2 contact, relay G does not reoperate.



ELEMENTS OF THE ALLOTTER CIRCUIT.

FIG. 16.

Although the allotter is stepped to a free outlet after the control set is released, there is a second, and possibly a third, allotter with the banks multipled and leading to the same group of line finders. Consequently, there may be two or three allotters standing on the same outlet, and this outlet may be seized and "busied" by another of the control sets. In this case, the allotter again steps as described above until another free outlet is reached.

Before the allotter has stepped to a free outlet, relay ST may be operated due to the origination of another call. In order to decrease switching time, the allotter is self-driven via its own interrupter springs via ST3 and ST2 to earth at LK1, and continues to step until a free outlet is reached, when relay LK operates. LK1 disconnects the self-drive circuit and operates relay VR, and the call proceeds as previously described.

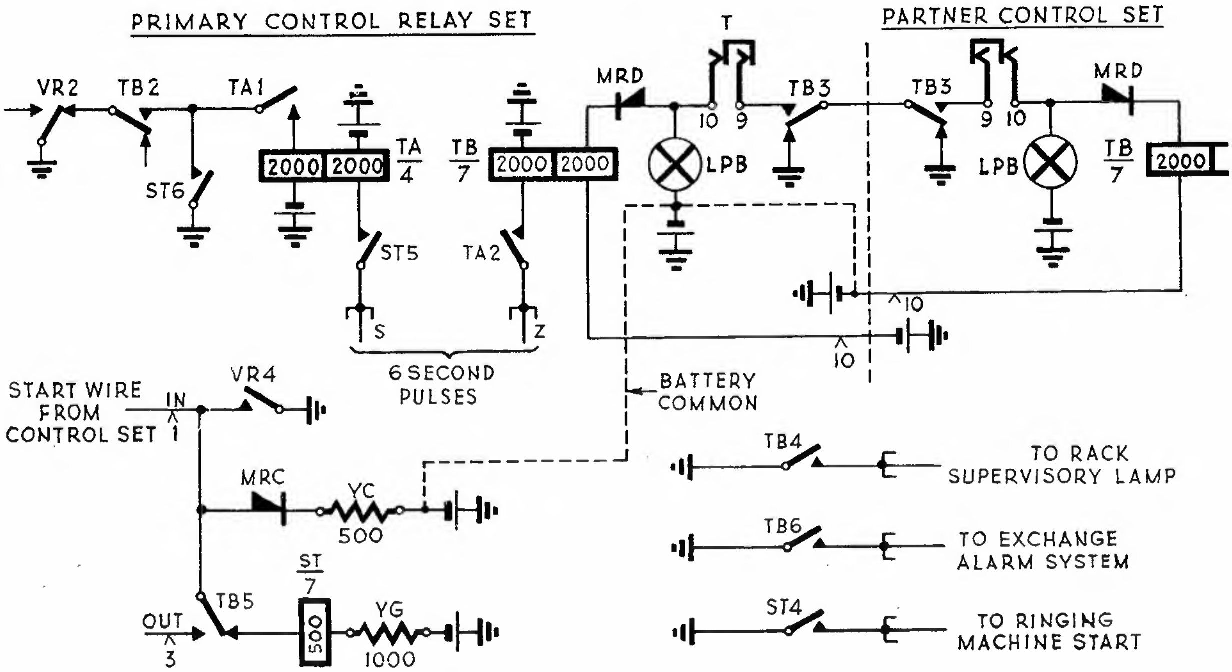
With two allotters simultaneously searching for a free outlet, a double connection is guarded against by the operating characteristics of the test-in relay LK. The free condition of a line finder is battery via 150 ohm resistance. Two LK relays will not operate in parallel to this condition, but a relay holds once operated. Therefore, two allotters testing the same outlet step on until they are sufficiently out of step for one relay to operate at a free outlet before the other arrives at the particular contact. Since the operating time of the relay is approximately three milliseconds, in practice the allotters seldom take more than two or three steps to become sufficiently out of step.

.14 Release of Primary Finder. When the calling party replaces the receiver, the holding earth on the P wire is removed and relay HA (or HB) releases. A self-interrupted drive circuit is completed for the rotary magnet via N1, HB2, HA3, R1 to release alarm earth. The wipers are stepped off the bank and the carriage restores to normal, when the off-normal springs release, and disconnect the rotary magnet circuit.

/ 6.

6. DELAYED ALARMS AND FAULT CONDITIONS.

6.1 Delayed Alarm Circuit. As each call is initiated, the start wire to a primary control set is earthed to operate relay ST, which remains operated until the call has been switched through. When, for any reason, the call is not switched through within a few seconds, an alarm is given, the start signal is diverted to another control set and the faulty control set is locked out of service. In certain circumstances, the particular line finder is also busied out. The operation of the delayed alarm circuit is shown in Fig. 17.



ELEMENTS OF DELAYED ALARM CIRCUIT.

FIG. 17.

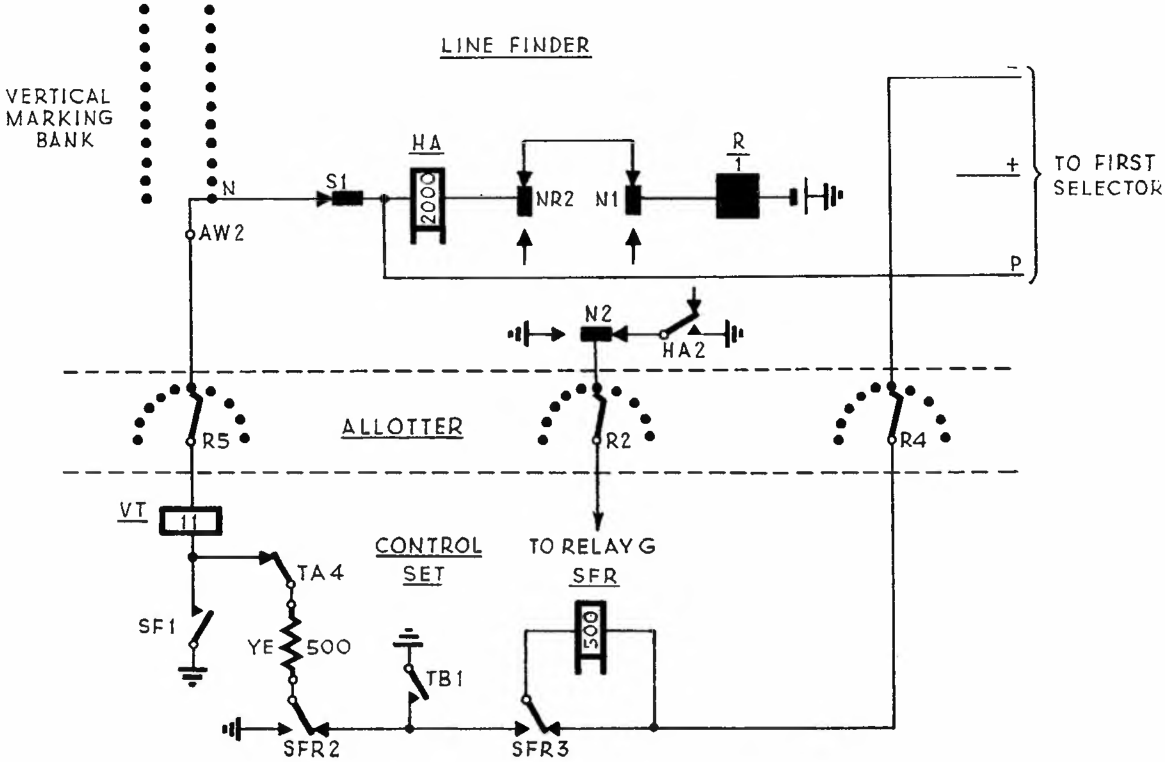
Operation of relay ST, besides initiating the control set relay operation and line finding action, closes the circuit at ST5 of relay TA to the "S" pulse lead. The "S" and "Z" pulses consist of short impulses at regular intervals of 6 seconds, the S pulse occurring a few milliseconds after the completion of the Z pulse. (Details of the generation and distribution of these pulses are given in Paper No. 7.) Hence, when the S pulse is received, relay TA operates and locks on its second winding to earth at ST6. TA2 prepares a circuit for relay TB, and should the call not be switched through by the time the Z pulse occurs (six seconds later), relay TB operates and locks on its second winding via TB3 to earth from TB3 on the other control sets in the group. Note that there can be a period of up to six seconds' delay before the first pulse on the S lead, so that the total delay period is anything between 6 and 12 seconds.

Operation of relay TB lights the rack supervisory alarm at TB4 and extends an earth to the exchange alarm system at TB6 (see Paper No. 7 for further details of the alarm system). Lamp LPB in parallel with the second winding of relay TB glows and indicates the particular control set causing the alarm. TB5 disconnects the start relay ST and diverts the start wire to another control set.

Should the call not be switched through in the specified time, therefore, visual and audible alarm signals are given, the call is given an opportunity of being completed via alternative apparatus, while the circuits in which the abnormal condition exists are locked out of service. The failure of a call to be switched through in normal line-finding time may be due to a defective line finder or a defective control set and the alarm circuit is arranged to discriminate between these two conditions.

/ 6.2

6.2 Faulty Line Finder. When a control set is seized, relays ST, LK and VR operate to initiate the finding action of a preselected line finder. If, for any reason, the line finder fails to switch through and release the control set within the 6-12 seconds' delay period then, when relay TB operates, the particular line finder is "busied" out of service as well as the particular control set. Operation of relay TB gives the alarm indications, redirects the start signal to another control set, and releases relay ST, as described in the previous paragraph. ST6 opens the locking circuit of relay TA, which releases, as relay ST restores before relay VR. The arrangements for busying the line finder are shown in the simplified circuit of Fig. 18.



ARRANGEMENTS FOR BUSYING THE LINE FINDER.

FIG. 18.

When the line finder has stepped off-normal, it is busied on the allotter bank R2 from earth at N2. If it has not stepped, a circuit for operating relay HA is completed via the rotary magnet, N1, NR2, 2000 ohm winding of HA, S1, normal vertical marking bank contact and auxiliary wiper AW2, allotter bank and wiper R5, 11 ohm winding of relay VT (which does not operate), TA4, 500 ohms YE, SFR2 to earth at TB1. Operation of relay HA busies the finder on the allotter banks with earth at HA2.

6.3 Faulty Control Set. If the primary control relay-set fails to switch to a free primary finder within 6-12 seconds of receiving the start signal, relays LK and VR will not be operated when relay TB operates to the Z pulse. In this case, when ST6 breaks the locking circuit of relay TA, that relay holds via TB2 to earth at VR2. As the fault is in the control set or allotter, it is not necessary to busy a line finder, and operated contact TA4 opens the operating circuit for relay HA shown in Fig. 18.

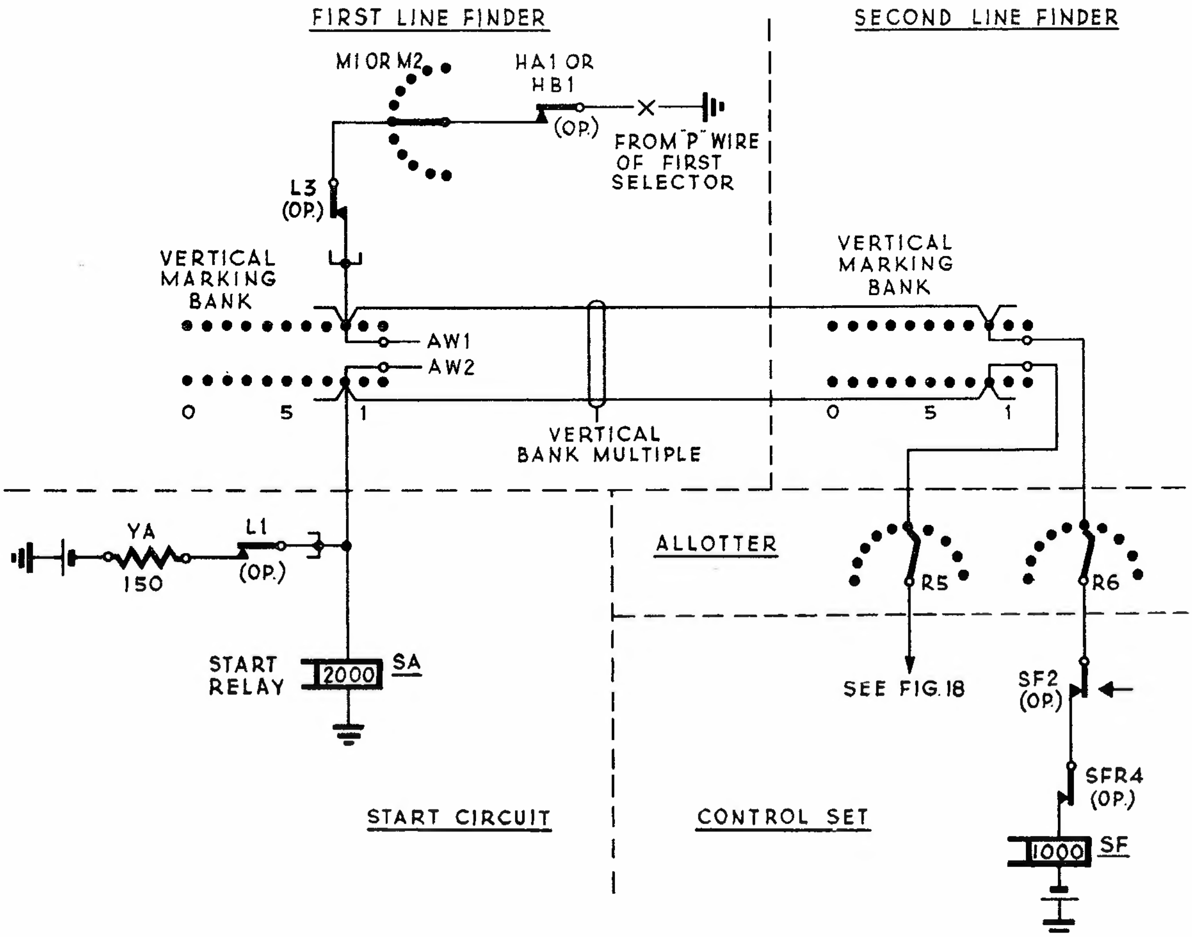
6.4 Operation of Control Set Fuse. The locking winding of relay TB is fused with the partner control set (see Fig. 17), and, in the event of a control set fuse operating, the next start earth to the disabled control set operates relay TB via MRC, 500 ohm YC, over the battery common to LPB, MRD, and the 2000 ohm winding of TB to battery from the partner control set. The call is then transferred to another control set, and an alarm is given. (Note. LPB does not glow.) Rectifier MRD prevents false operation of relay TB in the partner control set under this condition. Rectifier MRC prevents a permanent start condition being given to the second control set over the battery common when the fuse on the first control set operates, and relay TB locks up.

/ 6.5

6.5 All Control Sets Faulty. It might appear from the foregoing that there is a possibility of all control sets in a group being locked out, unless prompt attention is given to faults. Circuit arrangements are made, however, to ensure that a TB relay cannot lock unless at least one of the TB relays in a group is normal (see Fig. 17). When the last TB relay operates, therefore, the others release, thus bringing the remaining control sets back into service and giving calls a chance to be switched through, in case the faults have cleared in the meantime.

6.6 First Selector "Busied" Out. When the selector is busied during testing, etc., an earth is returned over the P wire to operate relay HA over the circuit shown in Fig. 18. HA2 busies the finder on the allotter bank contacts.

6.7 Operation of Primary Finder Under Fault Conditions. An adverse feature of earlier line finder systems was that if relay L in the subscriber's line circuit failed to release when the line finder switched, the start relay remained operated and a number of line finders would switch to the calling line. Due to the paralleling of circuits in the finders, damage was caused by the excessive current flow. This condition is prevented in the present circuit, the simplified circuit conditions being shown in Fig. 19.



FAULT CONDITION WHEN RELAY L FAILS TO RELEASE.

FIG. 19.

Should a line finder switch to a calling line but, owing to a fault, is unable to operate the line circuit relay K, then relay L remains operated. The start relay, therefore, remains operated, and a second line finder commences to search immediately after the allotter has stepped on. Earth from the private wire of the first selector is extended over M1 or M2 wiper and bank and operated L3 contact to the corresponding vertical marking bank contacts of all line finders in the group, since these are multipled. When the second line finder reaches the marked level, relay VT operates normally, but, on the operation of relay RS, relay SF does not release but holds via SFR4 and SF2 to this earth. Relays SFR and HA are also held (see Paragraph 5.7) and the line finder is thus prevented from entering the level. Since the finding action is not completed, with the arrival of the "Z" pulse, relay TB operates. The alarm is given and the start signal transferred to another control set which may cause a third finder to search for the calling line. However, earth via 11 ohm relay VT and SF1 busies the level and prevents other line finders from seizing the faulty level. This earth may or may not cause the release of the start relay, and, if this relay remains operated, line finders are stepped to level 0 where they cut-in and switch through (see Paragraph 6.8).

The conditions now are that the first line finder is standing on the contacts of the calling line and the second line finder is standing with its wipers outside the marked level. It should be noted, however, that the fault is in the calling subscriber's line circuit. The second line finder indicates the level in which the faulty line is situated, and it is necessary to examine the other finders in the group, or the L and K relays of that level, to find the faulty line circuit. This examination must be carried out promptly because, when the calling subscriber replaces the receiver, the first line finder releases and the fault is cleared. Relay SF now releases, but relay SFR holds on its 500 ohm winding from earth at TB1 to battery on the negative wire from the first selector (see Fig. 18). Thus, the line finder is held in position opposite the level to indicate the nature and location of the fault. On the release of SF1, the shunt on the start relay is increased to 511 ohms (11 ohm relay VT plus 500 ohm YE), allowing this relay to operate should other calls be originated from the level on which the fault has occurred.

6.8 Permanent Marking Battery via 150 ohm YAO is connected to the tenth contact of the vertical marking bank to ensure the normal release of line finders under the following conditions -

(i) When a subscriber removes the receiver and then replaces it without making a call.

(ii) Intermittent short-circuit or contact fault on a line.

(iii) Fault on a line circuit, and the level busied out, as described in Paragraph 6.7.

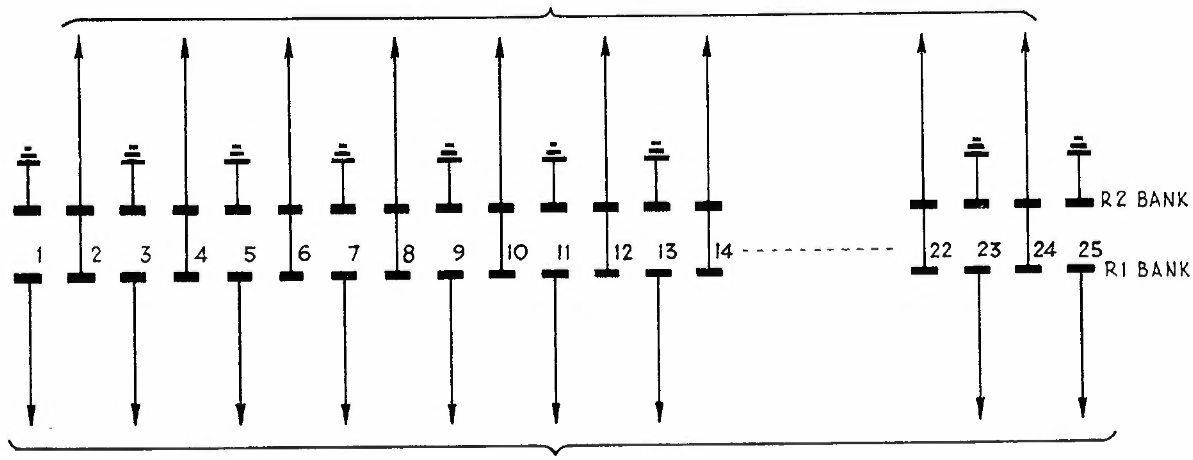
In such circumstances the line finder steps vertically to level "O", where the drive is tripped by the permanent marking battery, and rotary stepping commences. The 11th contacts of M1 and M2 banks are permanently connected to the respective vertical marking bank contacts, the line finder switches to this contact and the control set is released. There being no loop to hold the first selector, the line finder is released.

6.9 If the fault described in Paragraph 6.7 occurs on level 0, it will be seen that, while the fault persists, the level is busied by earth via the 11 ohm winding of relay VT, and it is not possible for another finder to test-in on this level. To provide for the release of line finders under the conditions described in Paragraph 6.8, relay NM is connected in parallel with the 150 ohm resistance YAO on level 0. Relay NM operates whenever level 0 is busied and NM1 transfers the permanent marked condition to level 9, so that finders can test-in on this level and release.

/ 7.

7. CHANGE-OVER TO INDIRECT FINDERS.

7.1 Method of Connection of Direct and Indirect Primary Finders. The directly connected primary finders are wired to a number of positions on the allotter banks, and the indirectly connected primary finders are wired to the remainder of the positions. Fig. 20 shows a typical arrangement of direct and indirect primary finders on the allotter banks R1 and R2. All the directly connected finder test-in leads are connected to bank R2 and the remaining contacts on this bank are earthed. All the indirectly connected finder test-in leads are connected to bank R1 and the remaining contacts on this bank are strapped across to the R2 bank contacts.



TYPICAL ARRANGEMENT OF PRIMARY FINDERS ON THE ALLOTTER BANK.

FIG. 20.

To reduce the searching time of the allotter to a minimum, the appearance of direct and indirect primary finders on the allotter bank should be as near as possible in alternate order. Where there are less than 25 line finders in a group, the spare bank contacts on the allotter banks are multipled. For example, with a total of 20 line finders per group, bank contacts 21 are connected to 1, 22 to 2, and so on.

The connections shown in Fig. 20 are not actually made directly on the allotter bank, but the banks are wired to the line finder shelf jacks and the connections made there. With both direct and indirect line finders, the switches are identical, and the discrimination is made by means of local straps on the line finder shelf jacks. It is possible to change a line finder from direct to indirect connection, or vice versa, by the simple expedient of altering these straps and the jumpering on the I.D.F.

In cases where there are more than 25 primary finders serving a group, two allotters are used. The direct finders are connected to the regular allotter banks and the indirect finders to the auxiliary allotter banks. Unallotted positions on both banks are earthed. However, in most cases, the number of line finders serving a group of 200 lines is 25 or less, and the circuit description in this Paper is confined to such cases.

/ 7.2

7.2 Change-over to Secondary Working. When all directly connected primary finders in a group are busy, then that group changes over to secondary working and the indirectly connected primary finders are used. The change-over is automatic and immediate, and its operation is shown in Fig. 21.

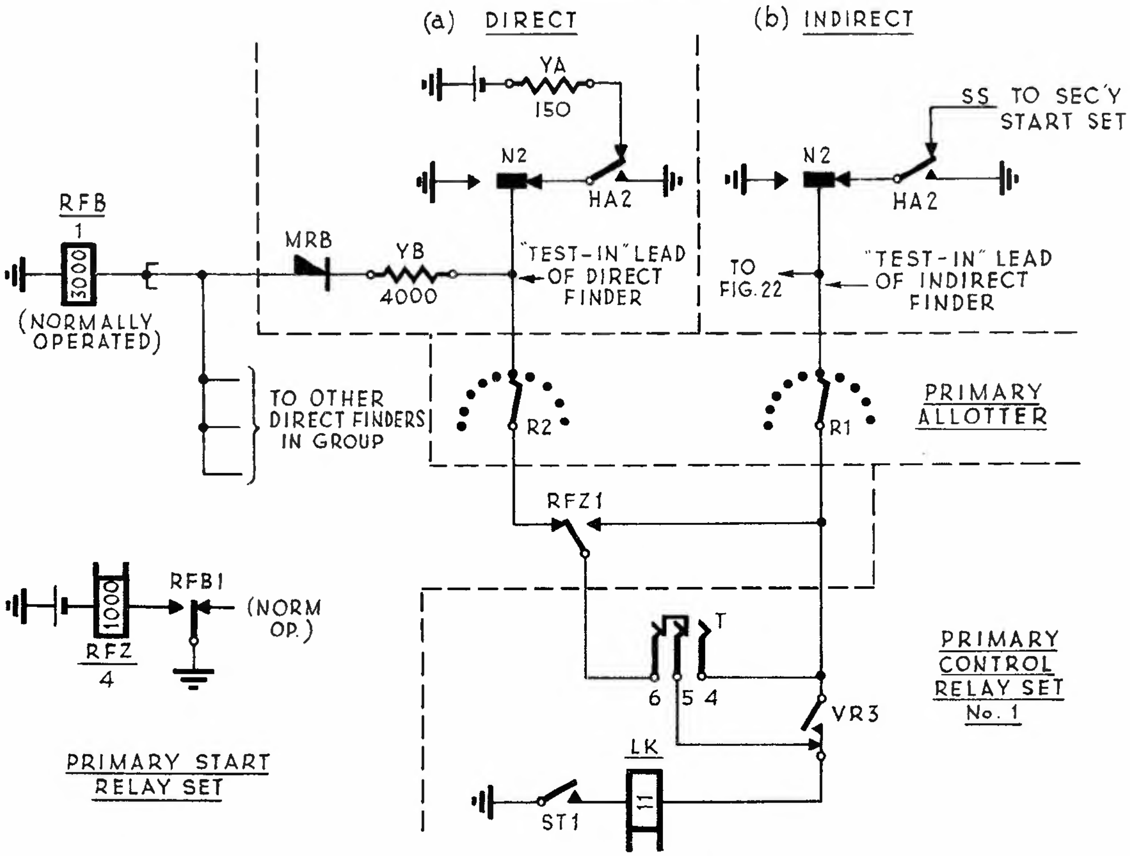


FIG. 21. CHANGE-OVER TO SECONDARY WORKING.

Relay RFB is used to detect the condition of all direct finders in the group busy. The "test-in" lead of each direct primary finder is connected via 4000 ohm YB and rectifier MRB to relay RFB. The rectifier prevents the busying earth on busy finders from shunting (via the RFB common) the 150 ohm battery condition on free finders. Resistance YB limits the current through the rectifier to a safe value.

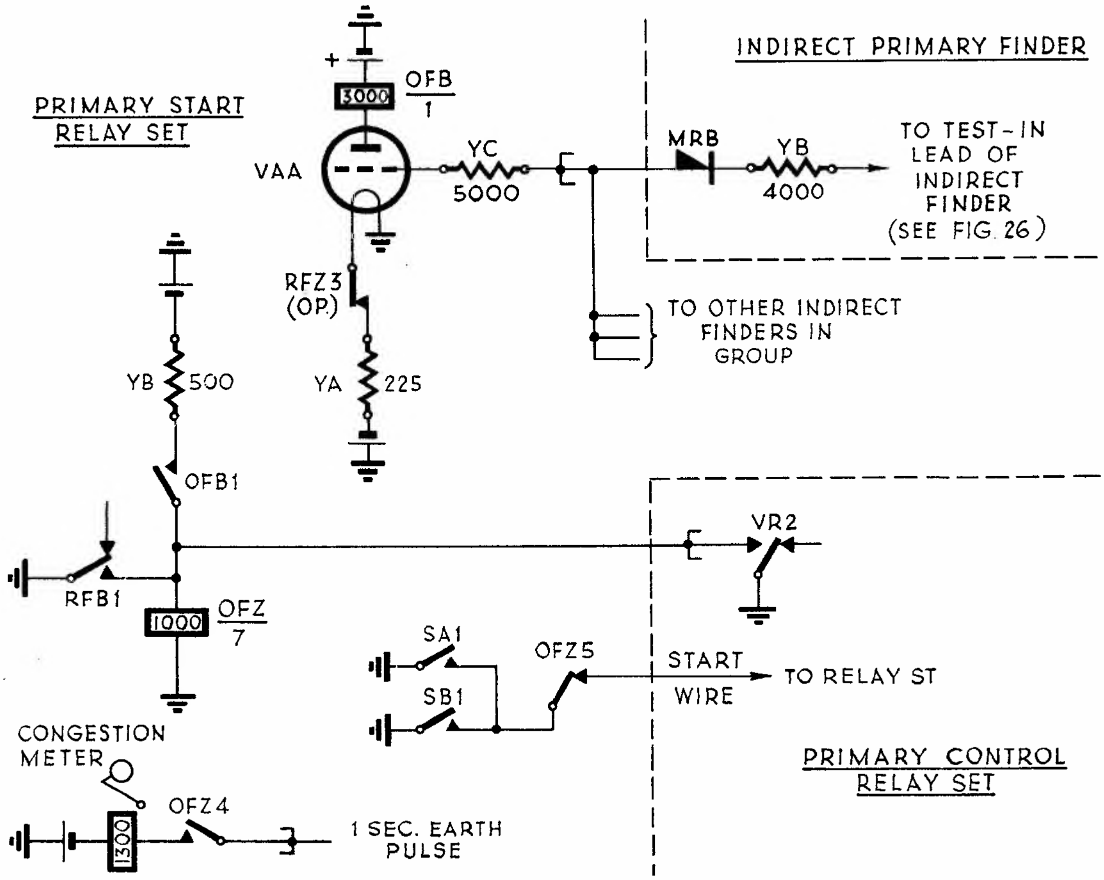
Normally, relay RFB is operated by battery over this circuit from at least one direct finder. As each direct finder is taken into use, however, the individual battery feed from that finder is disconnected and, when the last direct finder is busied on the allotter bank R2, relay RFB releases. RFB1 completes the circuit of relay RFZ, which operates.

RFZ1 changes the operating circuit for relay LK in Primary Control Relay-set No. 1 from allotter bank R2 to bank R1, to which the indirectly connected primary finders are wired. RFZ2 and RFZ4 perform similar functions in Primary Control Relay-sets 2 and 3, respectively. As relay RFZ can operate before the last direct line finder has switched through, VR3 delays the change-over from R2 to R1 until the primary control set is released.

On the origination of a call, relay LK switches to battery in the secondary control relay-set over the "SS" lead, and the 11 ohm earth placed on this lead by relay LK constitutes a start signal for the secondary finder equipment.

/ 7.3

7.3 All Primary Finders Busy. When all the line finders of a primary group are busy, the circuit ensures that calling subscribers in that group do not seize a control set and so cause operation of the delayed alarm. Continuous rotation of the allotters in the busy group is prevented and a congestion meter is operated. A thermionic valve in the Primary Start Relay-set (see Fig. 6) is used to detect this condition, and the circuit elements are shown in Fig. 22.



PRIMARY FINDER GROUP BUSYING ARRANGEMENT.

FIG. 22.

Operation of relay RFZ when all direct finders in the group are busy (see Paragraph 7.2) completes the filament circuit of the valve at RFZ3. The anode is connected to 50 volt positive battery via relay OFB, but this relay is normally prevented from operating, as the valve is biased to "cut-off" point by a 50 volt negative potential on the grid. This potential is supplied by at least one of the indirect primary finders in the group (from the associated secondary equipment) and is removed from any particular finder -

(i) When the indirect finder is taken into use;
(ii) When the associated secondary control relay-set is busy; or
(iii) When all secondary finders in the associated secondary group are busy.

Should any of these conditions occur on the last free indirect primary finder, or its associated secondary group, the negative potential on the grid of the valve is removed, allowing anode current to flow, and relay OFB operates. OFB1 prepares a circuit for relay OFZ which, however, is prevented from operating by earth from VR2, until the release of the Primary Control Relay-set after the last indirect primary finder has switched through.

/ With

With VR2 normal, relay OFZ operates via OFB1 and 500 ohm YB to battery.

OFZ1, 2 and 3 open the operating circuits of relays G in all primary control sets of the group to prevent continuous stepping of the primary allotters.

OFZ5, 6 and 7 disconnect the start wires from the primary control relay-sets to prevent callers from seizing a primary control set and causing false operation of the delayed alarm.

OFZ4 connects the Group Congestion Meter to the one second earth pulse supply. These meters indicate the time (in seconds) that each group has no free outlets, and are used to check that the traffic originated from each primary group in the exchange is approximately equal.

Since there are fewer secondary finders than indirect primary finders, it will be seen that conditions may arise when indirect finders are not in use, but the secondary access system is in use with other groups. If it so happens that the access equipment only is busy, that is, start set, control set and allotters, but there are secondary finders free, it is not necessary to meter congestion as, directly the access equipment becomes free, calls may proceed. Relay OFZ, therefore, is prevented from operating until the primary control set has been released and VR2 opens. This limits the metering of congestion to periods when all outlets from the group are busy.

7.4 Directly Connected Finder Becomes Free. Immediately a directly connected primary finder becomes free, battery is reconnected to relay RFB, which operates. RFB1 opens the circuit of relay RFZ and short-circuits relay OFZ, so that both relays release. The contacts of OFZ reconnect the start wires to the primary control relay-sets and re-establish the primary allotter stepping circuits. RFZ contacts connect the test-in relay LK to allotter wiper R2, and the allotters are stepped to preselect a free primary finder.

7.5 Indirectly Connected Finder Becomes Free. The release of an indirectly connected primary finder and the associated secondary finder after the "All Outlets Busy" condition reconnects negative battery via rectifier MRB to the grid of the valve, causing relay OFB to release. OFB1 releases relay OFZ, whose contacts function as described in Paragraph 7.4.

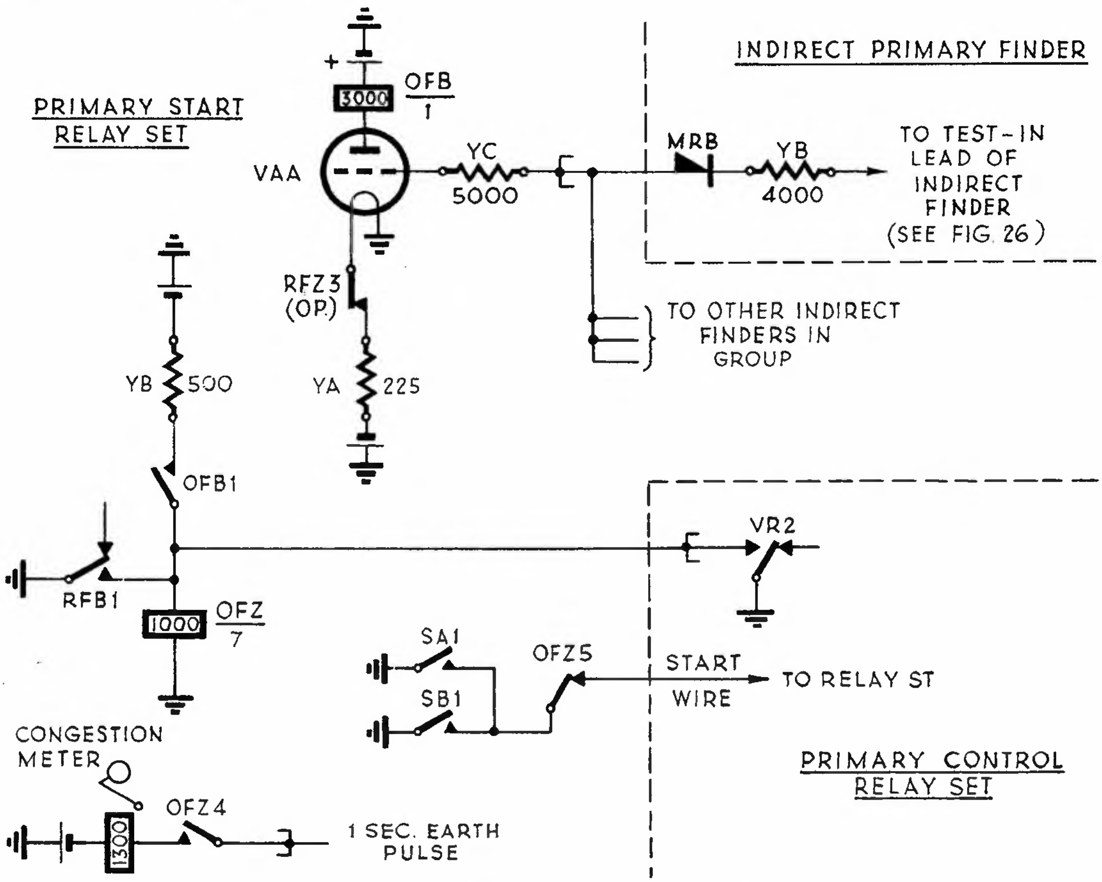
7.6 Reason for Use of a Thermionic Valve. In this circuit, a thermionic valve has the advantage, as compared with a relay, of operating to potential only and drawing negligible current via the grid circuit. It will be seen that the valve is associated with the indirectly connected finders only, while the connection for direct finders is to relay RFB. In the latter case, the direct finders have no association with other finder groups, therefore the 3000 ohm relay gives an almost negligible shunt on the line finder "test-in" battery.

In the case of indirect finders, the testing battery is derived from the secondary equipment, and, since this is common to all primary finder groups in the exchange, if a relay were used instead of a thermionic valve, the testing battery would be shunted not by 3000 ohms but by the paralleling effect of 3000 ohms per line finder group. For example, a 4000 line exchange would have 20 relays in parallel. There would be a considerable current drawn from the testing battery in this case, and the testing conditions of the secondary finder group would not be stable.

Using a thermionic valve in this circuit, the current passed by the grid of the valve, or a number of valves in parallel, is negligible, and there is normally no current drawn from the secondary finder equipment testing battery.

/ 8.

7.3 All Primary Finders Busy. When all the line finders of a primary group are busy, the circuit ensures that calling subscribers in that group do not seize a control set and so cause operation of the delayed alarm. Continuous rotation of the allotters in the busy group is prevented and a congestion meter is operated. A thermionic valve in the Primary Start Relay-set (see Fig. 6) is used to detect this condition, and the circuit elements are shown in Fig. 22.



PRIMARY FINDER GROUP BUSYING ARRANGEMENT.

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(i) When the indirect finder is taken into use;
(ii) When the associated secondary control relay-set is busy; or
(iii) When all secondary finders in the associated secondary group are busy.

Should any of these conditions occur on the last free indirect primary finder, or its associated secondary group, the negative potential on the grid of the valve is removed, allowing anode current to flow, and relay OFB operates. OFB1 prepares a circuit for relay OFZ which, however, is prevented from operating by earth from VR2, until the release of the Primary Control Relay-set after the last indirect primary finder has switched through.

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OFZ1, 2 and 3 open the operating circuits of relays G in all primary control sets of the group to prevent continuous stepping of the primary allotters.

OFZ5, 6 and 7 disconnect the start wires from the primary control relay-sets to prevent callers from seizing a primary control set and causing false operation of the delayed alarm.

OFZ4 connects the Group Congestion Meter to the one second earth pulse supply. These meters indicate the time (in seconds) that each group has no free outlets, and are used to check that the traffic originated from each primary group in the exchange is approximately equal.

Since there are fewer secondary finders than indirect primary finders, it will be seen that conditions may arise when indirect finders are not in use, but the secondary access system is in use with other groups. If it so happens that the access equipment only is busy, that is, start set, control set and allotters, but there are secondary finders free, it is not necessary to meter congestion as, directly the access equipment becomes free, calls may proceed. Relay OFZ, therefore, is prevented from operating until the primary control set has been released and VR2 opens. This limits the metering of congestion to periods when all outlets from the group are busy.

7.4 Directly Connected Finder Becomes Free. Immediately a directly connected primary finder becomes free, battery is reconnected to relay RFB, which operates. RFB1 opens the circuit of relay RFZ and short-circuits relay OFZ, so that both relays release. The contacts of OFZ reconnect the start wires to the primary control relay-sets and re-establish the primary allotter stepping circuits. RFZ contacts connect the test-in relay LK to allotter wiper R2, and the allotters are stepped to preselect a free primary finder.

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7.6 Reason for Use of a Thermionic Valve. In this circuit, a thermionic valve has the advantage, as compared with a relay, of operating to potential only and drawing negligible current via the grid circuit. It will be seen that the valve is associated with the indirectly connected finders only, while the connection for direct finders is to relay RFB. In the latter case, the direct finders have no association with other finder groups, therefore the 3000 ohm relay gives an almost negligible shunt on the line finder "test-in" battery.

In the case of indirect finders, the testing battery is derived from the secondary equipment, and, since this is common to all primary finder groups in the exchange, if a relay were used instead of a thermionic valve, the testing battery would be shunted not by 3000 ohms but by the paralleling effect of 3000 ohms per line finder group. For example, a 4000 line exchange would have 20 relays in parallel. There would be a considerable current drawn from the testing battery in this case, and the testing conditions of the secondary finder group would not be stable.

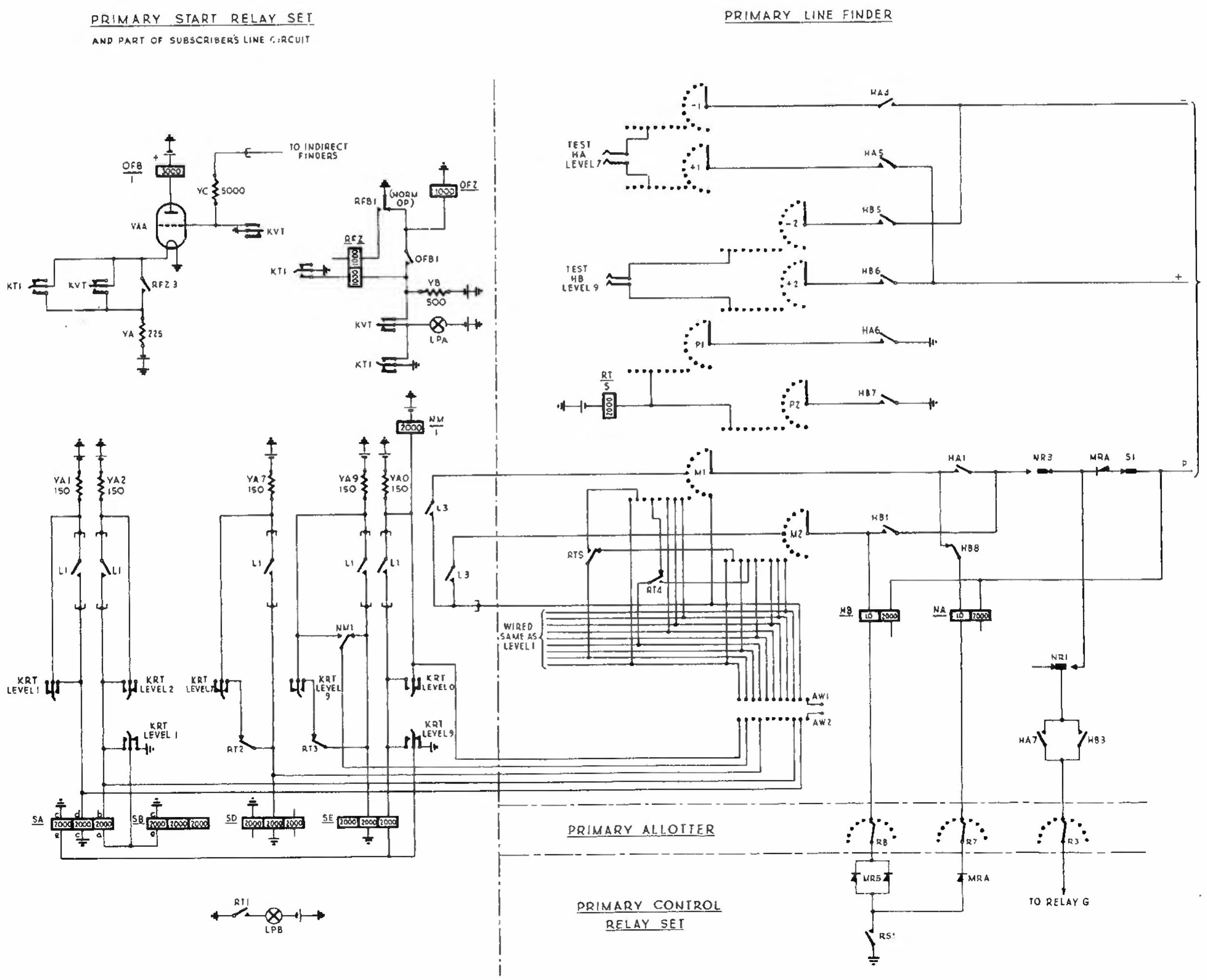
Using a thermionic valve in this circuit, the current passed by the grid of the valve, or a number of valves in parallel, is negligible, and there is normally no current drawn from the secondary finder equipment testing battery.

/ 8.

8. ROUTINE TESTING OF PRIMARY FINDERS.

8.1 General. Comprehensive routining and testing facilities are incorporated in the line finder equipment, and enable the entire equipment to be effectively and rapidly tested at any time without interference with subscribers' service.

Associated with each primary finder group are five two-way Routine Testing Keys (KRT), together with one two-way Test Indirect (KTI) and Valve Test Key (KVT). The latter key is locking on the KTI side and non-locking on the KVT side. The locking KTI side, in conjunction with the KRT keys, provides for the routining of the indirect finders, whilst the non-locking KVT side is for testing the operation of the thermionic valve. Test jacks are provided for each control relay-set and line finder. In addition, two test jacks (HA Lev. 7 and HB Lev. 9) are wired to the eleventh contacts on levels 7 and 9, respectively, and are used for dial tone tests. These jacks are mounted either on the start relay-set or, in later equipment, on the rack. The routine testing equipment may be seen in Fig. 6, and the elements of the circuit arrangements for routine testing are shown in Fig. 23 which, for the purpose of simplicity, deals mainly with levels 1, 2, 7, 9 and 0.



CIRCUIT ARRANGEMENTS FOR ROUTINE TESTING.

FIG. 23.

8.2 Routine Testing of Direct Finders. Operation of the KRT keys exercises the direct finders over any desired level, and tests the control relay-sets and other equipment of the group. The sequence of operation in a typical case is described below -

Assuming that the tests are being carried out on level 2, then KRT2 operates the start relay SA and causes a start signal to be directed to Primary Control Relay-set No. 1. KRT2 also connects marking battery to the appropriate contact of the vertical marking bank. The control set and line finder function as previously described, and the line finder steps to the marked level where it cuts-in and begins its rotary search. Referring to Fig. 23, it will be seen that the eleventh contact on level 2 of bank M2 is permanently connected to the vertical bank, therefore the line finder relay HB switches to this contact and further rotary stepping is prevented. Operation of relay HB releases the primary control set (see Paragraph 5.12) and the allotter preselects the next free direct finder. Since no loop is provided to hold the first selector, relays A and B release, removing earth from the P wire, and the line finder releases. The start condition is maintained as long as KRT2 remains operated, and the free direct finders are seized in turn, stepped to the 11th contacts of level 2 and released.

8.3 Use of Other KRT Keys. It should be noted that, in the foregoing typical case of testing on level 2, that all free direct primary finders can be tested rapidly in succession. However, they are only tested in level 2 (switching with relay HB), and primary control relay-set No. 1 only is used. By using the full set of keys, the line finders can be routined on all levels, both HA and HB relays can be checked and all control sets can be exercised. Routine testing takes place in a definite sequence, for example, if KRT1 is operated, the first control set is taken into use and relay HA is operated. The same control set is used for testing levels 2, 3 and 4, and on level 2 relay HB is operated, while on levels 3 and 4, operating circuits are provided for both HA and HB, in which case relay HB has priority of operation. This sequence is carried out over the other levels, as shown in the following table -

Key KRT No.	Control Relay-set Used	Level Routined	Switching Relay Operated
1	1	1	HA
2	1	2	HB
3	1	3	HA or HB
4	1	4	HA or HB
5	2	5	HA
6	2	6	HB
7	3	7	HA
8	3	8	HB
9	3	9	HB
10	3	10	HA or HB

These varied and comprehensive tests are supplemented by certain special facilities, which include -

(i) Dial tone tests on levels 7 and 9.

(ii) Test for local guarding earth on banks P1 and P2.

(iii) Continuous routining of any single line finder.

(iv) Routining of indirect line finders.

(v) Test for operation of the thermionic valve.

/ 8.4

8.4 Calls Originated During Routine Testing. The circuit ensures that when routining is proceeding on any odd level, any calls initiated on the companion even level are not delayed but are immediately put through via another control set and line finder. Without such an arrangement, calls initiated on the companion even level could not otherwise be put through when routining on the odd level. There is, of course, no delay in switching through calls initiated on a level that is being routined, since the particular finder in use will stop on any marked contact and switch through the waiting call encountered on its normal passage to the 11th contacts.

As previously explained, the start relays SA-SE each cater for two adjacent levels. It will be seen that the third winding of each relay is normally short-circuited by the normal contacts of an odd-numbered KRT key. When routining on an odd level, however, the start relay winding corresponding to the companion even level is short-circuited, and the short-circuit is removed from the third winding of the next start relay. Calls initiated from the companion even level, therefore, operate the next start relay, allowing the calls to proceed via another primary control set and line finder. For example, referring to Fig. 23, if routining is proceeding on level 1, KRT1 removes the short-circuit from the c-e winding of relay SB and short-circuits the a-b winding of relay SA. Now, if a call is initiated from level 2, relay SB is operated and primary control set No. 2 is seized.

The permanent marking condition applied to the 11th contacts of the M1 and M2 banks (see Fig. 23) is necessary for routining purposes, and also to complete the operating cycle of line finders which fail to find a marked bank contact. To prevent interference with normal calls initiated during routining, contact S1 in the line finders prevents earth from the first selector P wire being fed back to the M1 or M2 bank contacts. This earth normally causes the release of the control set by operating relay G, but the alternative circuit via the 10 ohm winding of HA or HB, allotter bank and wiper R7 or R8, rectifier MRA or MRB to earth at RS1 is used during routining.

8.5 Dial Tone Tests. These tests are made by plugging a buttinski into the test jacks associated with levels 7 and 9, and operating the appropriate KRT key. When the line finder under test switches on the eleventh contact of these levels, the buttinski loop holds the first selector and enables dial tone to be heard. By momentarily breaking the loop circuit upon the completion of each routine, the line finders can be subjected to this test in rapid succession.

Interference to normal calls originated on levels 7 and 9 during these tests is prevented by relay RT. The operation of relay HA is tested on level 7, while relay HB is tested on level 9. Relay RT is operated over the P1 or P2 bank by operated HA or HB contacts, respectively, and the contacts of RT transfer the permanent marking condition on the eleventh contacts of the M1 and M2 banks to the other bank. For example, while testing level 7, and relay HA is held over the P1 bank, RT4 transfers the permanent marking condition to the M2 bank contact. If now, a second finder is caused to search over level 7 and fails to find a marked contact, it steps to the eleventh contact and relay HB operates over bank M2 and operated RT4.

Similarly, while testing level 9, the permanent marking condition is transferred from bank M2 to bank M1 by RT5.

RT2 and RT3 open the operating circuits of start relays SD and SE, respectively, so that the respective start relay releases (unless operated by normal calls) while the line finder is held by the loop on level 7 or 9.

In conjunction with the dial tone tests, a test is made for the local guarding earths returned over the P1 or P2 banks to operate relay K in the subscriber's line circuit. If this test is satisfactory, relay RT operates and RT1 closes the circuit of lamp LPB, which glows steadily.

/ 8.6

8.6 Routine Testing of Indirect Finders. The indirect line finders can be routined in succession by operating the Test Indirect Key (KTI) in conjunction with the KRT key. Operation of KTI causes lamp LPA to glow, and relay RFZ to operate. RFZ contacts change the primary control set test-in leads from allotter bank R2 to bank R1, so that all free finders, direct and indirect, may be seized and tested in turn.

Note that while KTI is operated, normal calls may seize indirect finders, even though direct finders are available. It is possible, therefore, that all indirect finders in the group may be taken into use while direct finders remain free. Under these conditions, relay OFB operates, but relay OFZ is shunted by earth at operated RFB1 and does not operate. Relay RFZ is also shunted by this earth and releases. KTI contacts maintain the circuit of the valve filament when RFZ3 opens.

8.7 Valve Test. This test may be performed while the direct finders are in use by simply operating and holding the Valve Test key (KVT). This changes the potential at the grid of the valve from 50 volts negative to earth potential at KVT contacts. Under this condition, relay OFB in the anode circuit should operate and light lamp LPA via KVT contacts, OFB1 and RFB1 to earth. This test should only be used when direct finders are actually available. The 5000 ohm resistance YC prevents the earth at the grid of the valve being fed back to the indirect finders.

8.8 Continuous Routining of a Line Finder. To continuously routine any particular direct line finder it is necessary to -

(i) Open the allotter magnet circuit by removing the test link from T7-8 in the respective primary control relay-set.

(ii) Set the allotter wipers by hand on the desired contact, and

(iii) Operate the appropriate KRT key.

Any indirect line finder can be continuously routined by transferring the test link from T5-6 to T5-4 on the primary control set and then proceeding as above for a direct finder.

8.9 Use of Test Jacks on Primary Finder Equipment. Test jacks are provided on each of the switches and relay-sets. As previously mentioned, the test jacks associated with the primary start relay-set are used for dial tone tests on levels 7 and 9. On these tests, the glowing of the lamp LPB proves the local guarding earths returned over the P1 and P2 banks. Lamp LPA is for checking the functioning of the thermionic valve when KVT is operated and also glows during the time that key KTI is operated.

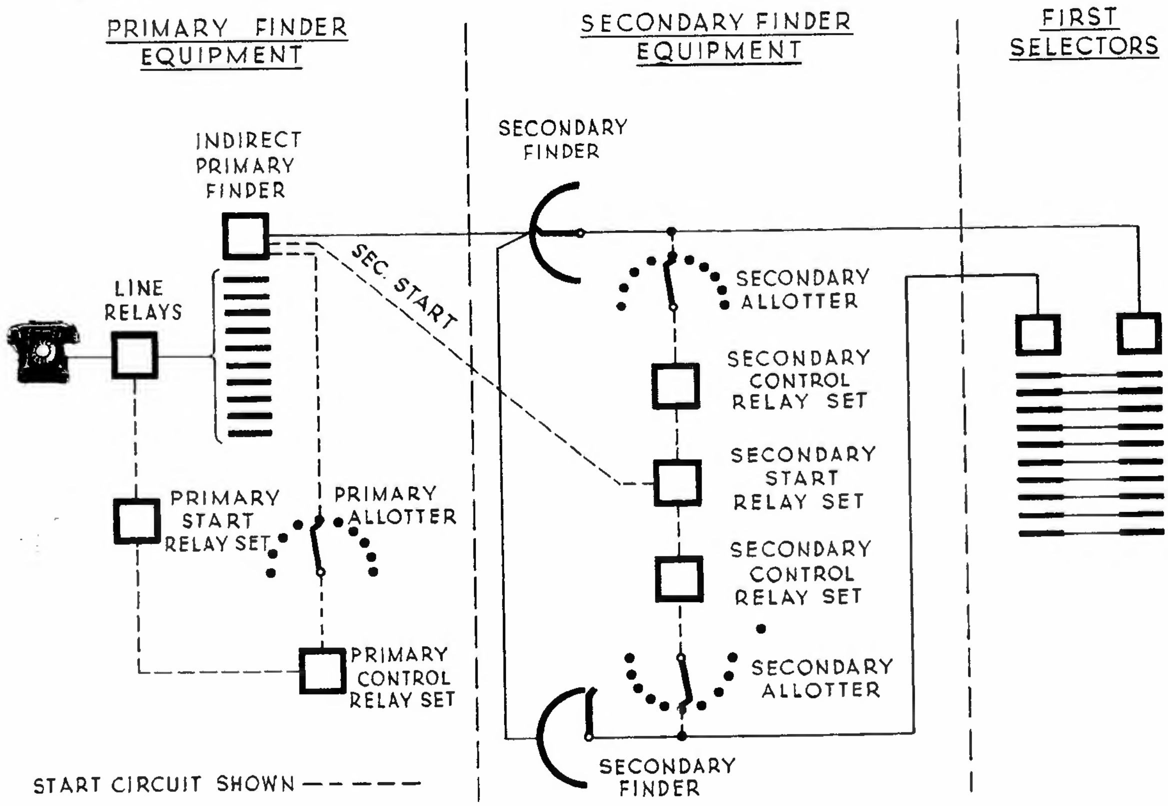
In the primary control relay-set, test links are normally inserted to bridge T5-6, T7-8 and T9-10. By transferring the link from T5-6 to T4-5 the indirect finders are introduced and, by moving the link from T7-8 to T1-2, the running of the allotter can be tested by short-circuiting the allotter test jack. Should the delayed alarm function and lock-up relay TB, this may be cleared down by momentarily withdrawing the test link from T9-10 after the cause of the fault has been investigated.

The test jack of the line finder normally has two test links inserted, one in T11-12 and the other in T13-14. By transferring the latter to T7-8, the particular line finder is busied out of service and relay HA is operated. A direct finder can also be busied by busying the associated first selector (see Paragraph 6.6). The test link in T11-T12 normally completes the finder release circuit so that, by withdrawing this link the finder can be operated manually for inspection purposes. The test jack points T9-10 are used for determining, without removing the switch cover, which of the two relays, HA or HB, has switched through. The test trunk buzzer operates when a test link is placed in T9-10 if relay HB has switched through, but remains silent if relay HA has switched.

9. SECONDARY FINDERS.

9.1 When all the directly connected primary finders in a group are busy, the group changes over to secondary working. A subscriber originating a call is connected to a first selector via an indirectly connected primary finder and a secondary finder. The first selector is permanently connected to the secondary finder, and these are available to the indirect finders of several primary groups.

The secondary finders are 50 point non-homing type uniselectors and are preselected and controlled (in a similar manner to the primary finders) by a secondary control relay-set and associated secondary allotter. The general arrangement is shown in Fig. 24.



SECONDARY FINDER TRUNKING DIAGRAM.

FIG. 24.

When an indirectly connected primary finder is seized, a start condition is extended from the primary control relay-set to the secondary start relay-set, which serves two secondary control relay-sets and their associated allotters. The two secondary finders, which have been preselected by the secondary allotters, proceed to search simultaneously for the marked outlet to which the indirect primary finder is connected. As the wipers of one secondary finder may be on the first bank contact while the other may be standing on the centre of the bank, dual searching reduces the finding time of the secondary finders as well as providing a factor of safety against faults. The secondary finding action ceases when one of the secondary finders reaches the marked bank contact and switches the first selector through to the indirect primary finder. This allows the primary finder to commence its search for the calling line, as previously explained. The secondary start and control relay-sets are released and the allotters preselect free secondary finders in readiness for the next call.

/ 9.2

9.2 The functions performed by the secondary finder equipment are as follow -

(i) Provides for preselection of a free secondary finder by the secondary allotter.

(ii) To reduce finding time, provides for simultaneous searching by two secondary finders.

(iii) Connects the first selector associated with the secondary finder to the appropriate indirect primary finder.

(iv) Releases the secondary start and secondary control relay-sets when the secondary finder has switched through.

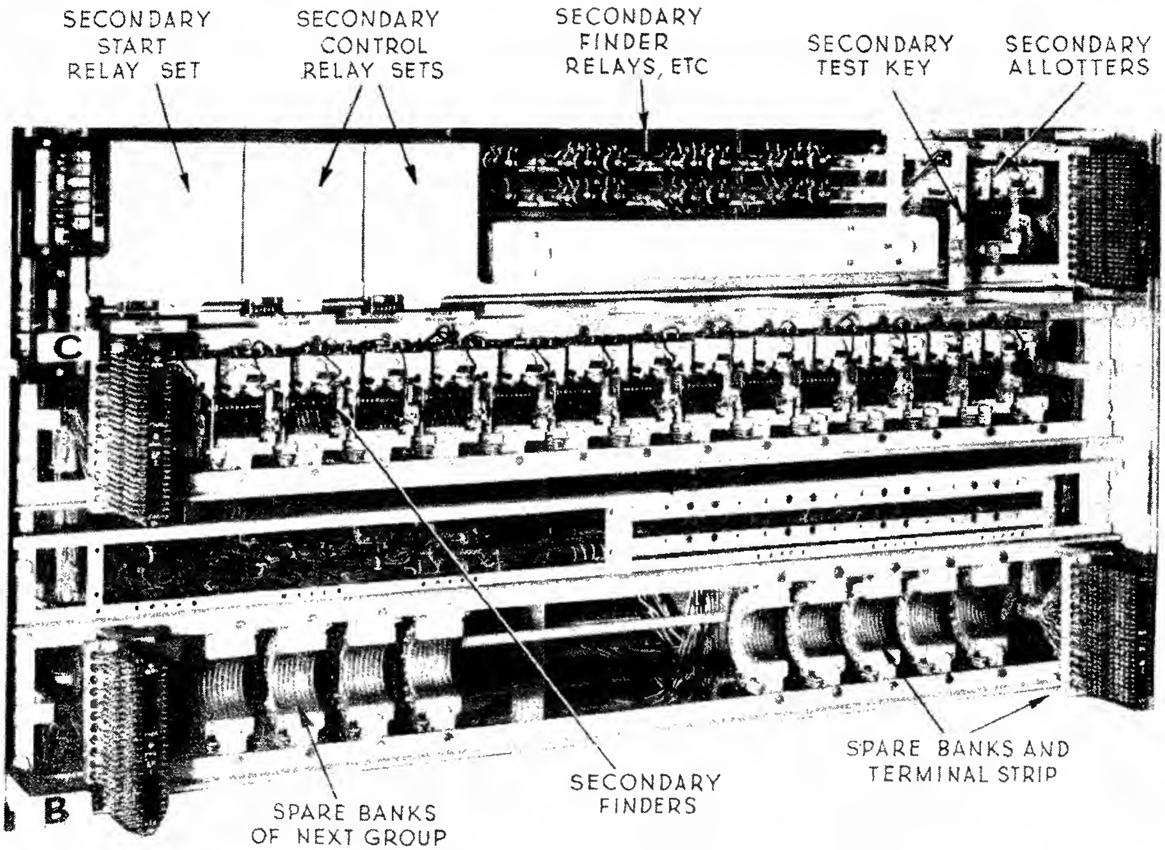
(v) Busies the secondary start relay-set when all secondary finders in the group are busy.

(vi) Provides for routine testing of equipment.

(vii) Busies the secondary control relay-set during routine testing.

(viii) Provides for testing the running of allotters.

Fig. 25 shows the equipment provided in a typical secondary finder group. In this case, 14 secondary finders are fitted and banks are available for the addition of six additional switches to cater for the growth of the exchange.

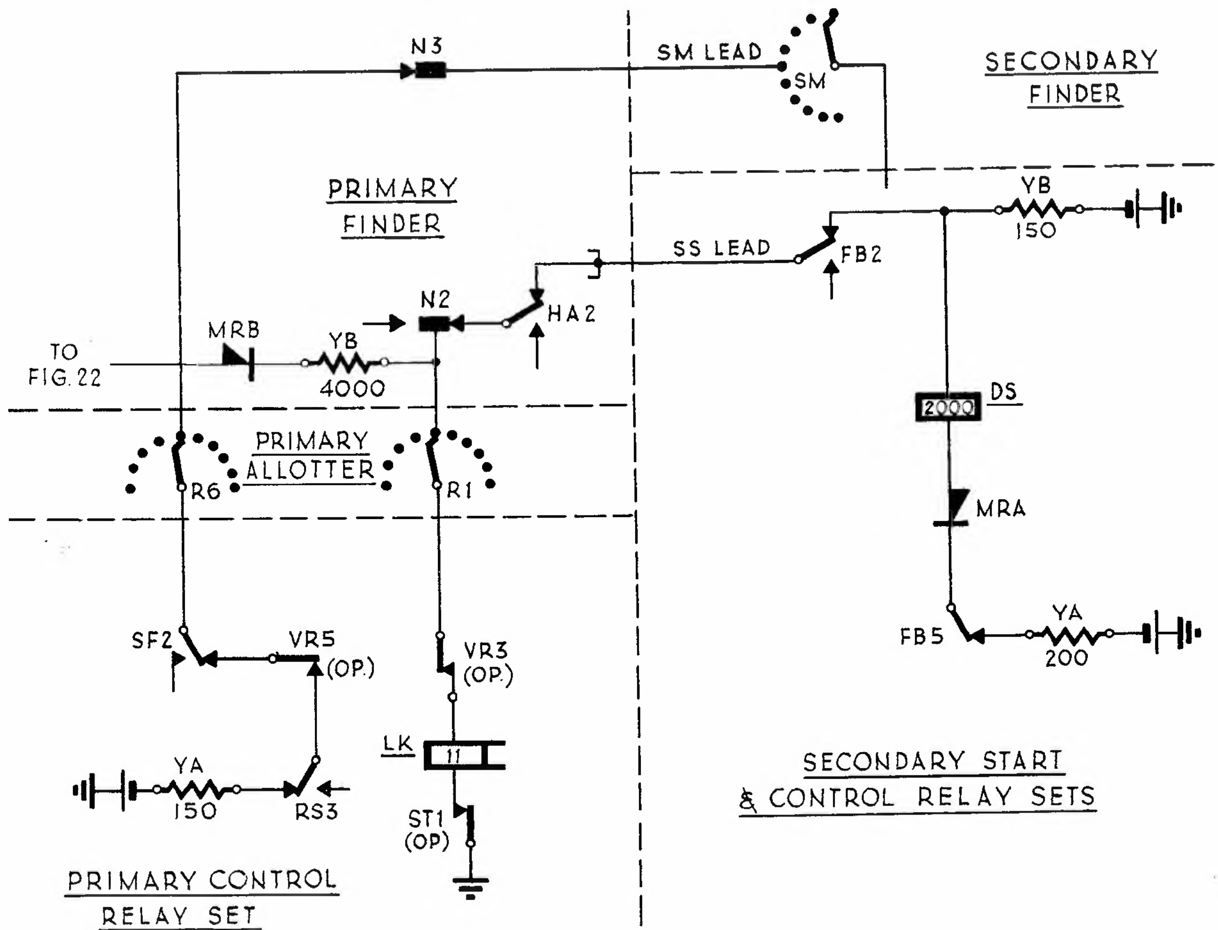


SECONDARY FINDER GROUP.

FIG. 25.

9.3 Circuit Operation. In this explanation, it is convenient to consider the operation of the secondary start relay-set, secondary control relay-sets and the secondary finders as a whole. The complete circuit is shown in Fig. 7(b) attached.

9.4 Circuit Seized. The secondary start relay-set has two start leads, namely, S1 and S2. When the circuit is seized, earth via the 11 ohm winding of relay LK in the primary control relay-set is applied to one of these leads, and 150 ohm marking battery via the SM lead is applied to the secondary finder bank multiple SM contacts associated with the indirect primary finder. Fig. 26 shows the circuit conditions, assuming that the start condition is applied to the S1 lead.



SECONDARY EQUIPMENT SEIZED.

FIG. 26.

The 11 ohm earth, which constitutes a busy condition on the lead, is extended via FB2 to battery via 150 ohm YB. A parallel circuit is also provided via relay DS, rectifier MRA, FB5 and 200 ohm YA to battery, and relay DS operates. DS3 holds DS operated independent of FB2, and DS1 completes the circuit of relay DR via FB1 and FR6. DR operates and holds via DR4 independently of FR6. The operation of relay DR causes the secondary finder, which has been preselected by the associated allotter, to commence its search for the marked bank contact. DR2 extends the earth from DS1 via KST contacts to operate relay DR in the partner control set.

/ Assuming

Assuming that the secondary allotter has completed its preselecting action, relay DK operates to 150 ohm marking battery YA in the secondary finder over allotter bank and wiper SA1 and DR5. The operation of DK1 removes the short-circuit from relay FR, which now operates via DR3, allotter interrupter contacts SAdm and DR1 to battery via the allotter magnet. DK1 also completes the secondary finder magnet circuit via its interrupter contacts SFdm, allotter bank and wiper SA3 and DK1 to earth at FK1. The magnet circuit is self-interrupted at SFdm and the secondary finder wipers are stepped around the bank.

FR2 completes a circuit to earth via 500 ohm YC for the pre-operation of the first selector A relay over the negative wire. FR1 completes the testing circuit of relay FK. The 500 ohm resistance YB in the secondary finder prevents the earth returned on the P wire from the first selector from short-circuiting relay DK.

9.5 Operation of Partner Control-set. Assume that the allotter associated with the partner control set has also preselected a free secondary finder. The operation of relay DR, as explained previously, operates relay DR in the second control set. The sequence of operations in this control set is the same as that in the first control set, namely, relays DK and FR operate, the self-interrupted drive circuit of the secondary finder is completed and relay A in the associated first selector is pre-operated. As the S2 lead is unaffected, a second indirect primary finder may seize the circuit during this operation.

9.6 Dual Searching of Secondary Finders. Both secondary finders, therefore, search simultaneously for a marked primary finder, each with its wipers in a different position on the bank. When one of the secondary finders finds a primary finder marked by 150 ohm battery on the SM bank contact, relay FK in the associated control set operates. Relay FK, which is fast to operate, cuts the self-interrupted drive circuit of the secondary finder and operates relay SK over allotter wiper and bank SA2. SK holds via SK5 to earth returned on the P wire from the first selector.

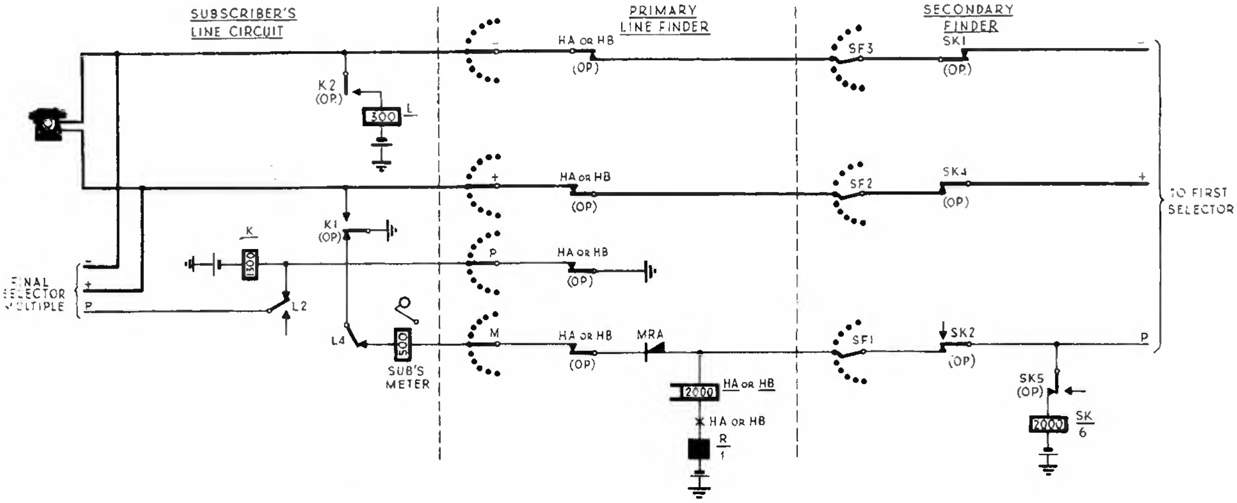
9.7 Switching Through. SK1, 4 and 2 extend the negative, positive and P wires, respectively, from the first selector through to the primary finder. This allows the operation of relay SF in the primary finder, which then -

(a) Disconnects the 150 ohm marking battery from the SM lead.

(b) Disconnects the earth from the SS lead, and

(c) Proceeds to search for the calling line circuit.

A simplified diagram of the connections on a call through an indirect primary finder and secondary finder is shown in Fig. 27.



CONNECTIONS OF CALL THROUGH A SECONDARY FINDER.

FIG. 27.

Operation of relay SK opens the circuit of relay DK at SK3 and applies a guarding earth to the SA1 allotter bank contact. SK6 prepares the test bell circuit. It is possible to determine which secondary finder has switched, without removing the relay cover, by bridging the secondary finder test jack springs.

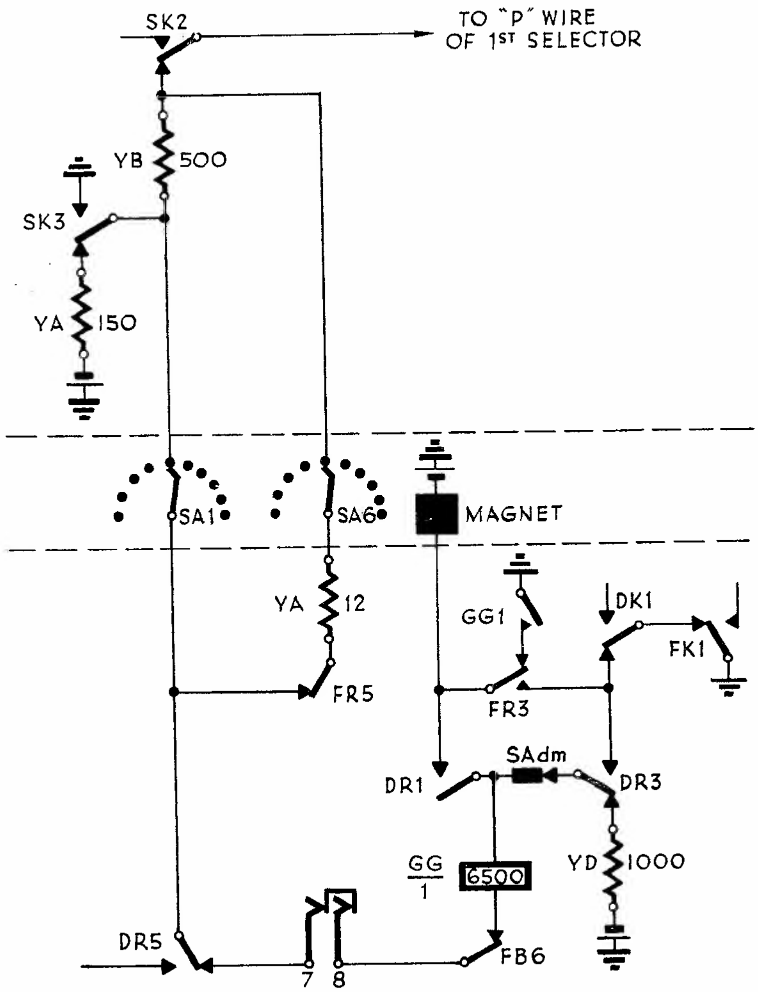
9.8 Release of Control and Start Relay-sets. The following relays release -

(i) Relay DK, whose circuit is opened at SK3.
(ii) Relay FK, when the 150 ohm marking battery is removed from the SM lead by the primary finder.
(iii) Relay DS, when the earth condition is removed from the SS lead by the operation of relay HA in the primary finder.

DS2 releases relay DR, and DS1 releases relay DR in the partner control set. At this stage, the secondary finder associated with the second control set ceases to step. Earth is extended via FK1 and DK1 to short-circuit relay FR, which releases slowly. During the releasing time of FR, the same earth is extended via FR3 to operate the allotter magnet, and, when FR restores, the magnet releases, stepping the wipers on to the next outlet. FR2 opens the original operating circuit of relay A in the first selector, but this relay is held by the primary finder until the subscriber's loop is subsequently extended.

9.9 Preselection of Free Secondary Finder. As described above, after the secondary finder has switched, the allotter wipers are stepped to the next outlet. If this outlet is busy, earth is encountered on the SA1 allotter bank contact and extended over the circuit shown in Fig. 28 to operate relay GG. GG1 completes the allotter magnet circuit via FR3, and the interrupter springs SAdm open the circuit of relay GG, which releases. The allotter magnet circuit is disconnected and the wipers step to the next outlet. This cycle of operations continues until a free secondary finder is reached, when relay GG does not operate due to absence of earth on the SA1 allotter bank contact, and the allotter ceases to step.

If the secondary control set is seized while the allotter is still searching for a free secondary finder, the allotter is self-driven over the busy outlets via DR1, its own interrupters, DR3 and DK1 to earth at FK1. A reduction in hunting time is thus effected, and when a free outlet is reached, relay DK operates to cut the self-drive circuit. The call then proceeds in the normal manner.



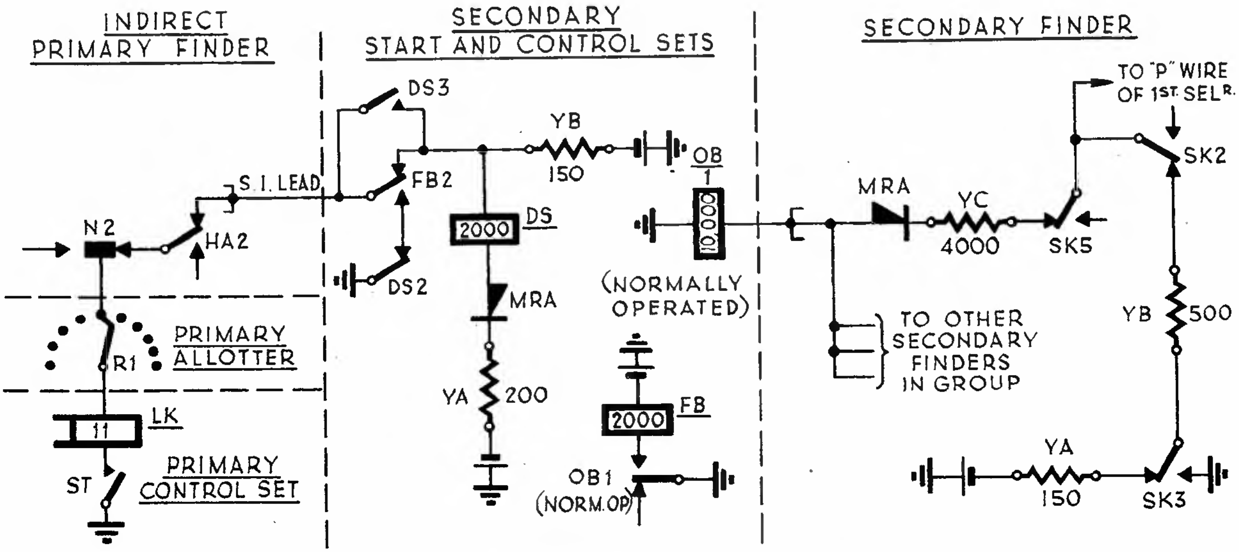
SECONDARY ALLOTTER STEPPING CIRCUIT.

FIG. 28.

/ 9.10

9.10 Release of Secondary Finder. At the completion of the call, earth is removed from the P wire and relay SK releases. SK3 removes the busying condition from the allotter bank SA1 and the circuit restores to normal, the secondary finder wipers remaining on the outlet used (non-homing).

9.11 All Secondary Finders Busy. Fig. 29 shows the elements of the group busying arrangement for a secondary finder group. Provided that there is at least one secondary finder free, relay OB remains operated to battery from 150 ohm YA over the circuit shown in Fig. 29.



GROUP BUSYING ARRANGEMENT FOR SECONDARY FINDER GROUP.

FIG. 29.

Immediately the last secondary finder is seized, relay OB releases and relay FB operates to earth at OB1. When the call has switched through and relay DS releases, FB2 opens the circuit of the S1 lead and connects it to earth at DS2. This busies the secondary start relay-set, and the associated indirect primary finders, although free themselves, will be passed over by the primary allotter in searching for a free outlet. FB3 performs a similar function to busy the S2 lead. FB6 and 7 open the circuits of relays GG in each secondary control relay-set, continuous stepping of the allotters thus being prevented.

Rectifier MRC prevents the earth from busy secondary finders from shunting relay OB and 4000 ohm YC limits the current through the rectifier to a safe value.

9.12 Secondary Finder Throw-out. The circuit ensures that the delayed alarm is only caused to function under genuine fault conditions and not due to traffic congestion. Assume the case when two separate calls simultaneously seize the two start leads (S1 and S2) and only one secondary finder is free. As soon as one control set seizes this finder, relay OB releases, followed by the operation of relay FB. FB5 opens the operating circuit of relay DS in the second control set, relay DS in the first control set being maintained by FR4, relay FR having operated. In the second control set, therefore, relay DS releases and the start lead (assume it is S2) is busied at FB3 and DS2, as described above.

In the primary control set associated with the indirect primary finder which has failed to find a free secondary finder, relay LK releases. If channels are available via indirect finders associated with other secondary groups, the primary allotter will hunt for one of these finders and the second call can be completed. Should, however, all outlets from the primary group be busy, relays OFB and OFZ operate, and the subsequent operation is described in Paragraph 7.3. In either case, the fault alarm is prevented from operating.

/ 10.

10. ROUTINE TESTING OF SECONDARY FINDERS.

10.1 For routine testing purposes, a two-way non-locking Secondary Test Key (KST) is provided for each secondary group. The 50th contacts on the secondary finder banks are used for testing and are multipled and wired to a test jack on the secondary start relay-set. A buttinski plugged into this jack enables the secondary equipment to be tested when the key is operated.

10.2 Operation of KST -

(i) Connects 150 ohm marking battery to the 50th SM bank contact.

(ii) Connects earth to the appropriate start lead (S1 or S2, depending on the direction KST is operated), and

(iii) Disconnects the partner control set.

The secondary start and control relay-sets function in the normal way. The first selector relay A is preoperated and the secondary finder searches for the marked SM bank contact. On the 50th contact relay FK operates, disconnects the stepping circuit and operates relay SK. SK holds to the earth returned on the P wire from the first selector and extends the buttinski loop to the first selector. Dial tone is heard in the receiver, and lamp LPA is caused to glow by the earth on the P wire. The connection is maintained until KST is restored, when relay FK is disconnected and releases. FK1 short-circuits relay FR, and, during its release period, the allotter magnet is energised. The wipers step to the next set of bank contacts and the secondary finder and first selector are released. The secondary finders may be tested in turn by reoperation of KST.

10.3 Running of Uniselectors. To test the running of the allotter mechanism, the test link is transferred from T7-8 to T1-2 on the associated secondary control relay-set. The self-drive circuit is completed by bridging the allotter test jack springs.

Should a call be originated while the allotter mechanism is being tested, relay DR operates to disconnect the continuous stepping circuit. The allotter connects to a free secondary finder, when relay DK operates and the call proceeds normally.

The secondary finder mechanism may be tested by bridging its test jack springs SFt. If the circuit is in use, the switch does not step and an indication is given on the Test Trunk bell.

10.4 First Selector Busied. When the first selector is artificially busied for testing purposes, earth is returned over the P wire and extended via SK2, allotter bank and wiper SA6, 12 ohm YA and FR5 to operate relay GG and so busy the secondary finder (see Fig. 28). The 500 ohm resistance YB in the secondary finder circuit prevents excessive heating of 150 ohm YA under this condition. Resistance YA in the control set is of such a value (12 ohms) that it does not cause the release of relay DK when earth is returned on the P wire from the first selector on a normal call. However, its resistance is low enough to prevent operation of relay DK to a secondary finder, of which the associated first selector is artificially busied. (Note that under these conditions relay SK does not operate.)

/ 11.

11. TEST QUESTIONS.

1. Why are some line finders connected directly to first selectors and others connected through secondary finders?

2. Sketch a block schematic diagram of the route of a call using an Indirect Primary Line Finder.

3. Sketch the subscriber's line circuit of the line finder scheme, showing how the circuit operates and how the line is marked for selection by a line finder.

4. When two subscribers in the same 200 line finder group originate a call at the same time, discuss the general operation of the circuits concerned.

5. Describe, with the aid of a sketch, the metering circuit used in the Line Finder System.

6. Discuss the reason for placing the MRA rectifier in the P lead of the primary line finder. What would be the advantage of placing the MRA rectifier in the M lead in the line circuit?

7. In the allotter circuit there are different stepping circuits. Give sketches to show each action. Why are the different actions used?

8. What method of bank marking is used for the finding action on the following -

   (i) primary allotter,
   (ii) primary line finder during vertical search.

9. In a primary finder circuit provision is made for relay HB to operate before relay HA when testing corresponding bank contacts on M1 and M2 banks which are marked simultaneously. State briefly how this is arranged.

10. Sketch the Test-In Circuit of the Secondary Finder and compare this with the test-in arrangements for -

    (i) primary allotter,
    (ii) secondary allotter.

    From this information, show a circuit which can be regarded as the standard method of testing for line finder circuits.

11. What is the purpose of the Time Delay Circuit? State briefly how it operates and the time of action.

12. A primary line finder is found standing with the wipers standing outside the bank contacts of level 0. State two possible causes of this fault condition.

13. What is the method of testing the Primary Finder Units for correct operation?

14. What is the purpose of relay NM associated with a primary line finder group?

15. State the purpose of the thermionic valve in the start relay-set.

12. REFERENCES.

"Telecommunication Journal of Australia" -

Vol. 1, No. 4 "The British Post Office Type 2000 Line Finder System" - W. A. Phillips.

"Strowger Journal" -

Vol. 5, No. 3 "Type 32A Line Finder Circuit" - J. W. McClew.

"Tele-Technician" -

Vol. XXX, No. 2 "Faults on 2000 Type Finder Equipment" - E. Whitely.

/ Notes.

NOTES.

(a) Primary Finder.

(1) When line finder is directly connected, strap U9-U17, U20-U24 and U27-U29.

When line finder is indirectly connected, strap U11-U17 and U29-U31.

(2) Five KRT keys provide level test facilities, in conjunction with key KTI, for changing over to indirect line finders, when desired. Key KVT tests the operation of the valve, in which case lamp LPA should glow. This test should only be employed when directly connected line finders are actually available.

(3) The jack points U1 and U3 are adjusted to make contact when the control relay-set is removed.

(4) Any spare positions on the allotters are multipled; for example, 13 to 1, 14 to 2, etc.

(5) In cases where only two control relay-sets are required, the shelf wiring shown in broken lines is omitted and jack points U1-U3, U5-U7 and U57-U59 require to be strapped.

(6) To test the running of the allotter uniselector from the test jack, transfer U-link from T7 and T8 to T1 and T2 on the associated control relay-set.

(7) To routine continuously any particular directly connected line finder, transfer U-link from T7 and T8 to T1 and T2, set the allotter by hand and operate the appropriate KRT key.

To routine continuously any particular indirectly connected line finder, transfer U-link from T5 and T6 to T4 and T5 and proceed as for a directly connected line finder.

(8) For line-finder groups having directly connected line finders only, strap U31 to earth.

(9) For dial tone tests on levels 7 and 9, insert a telephone in the appropriate test jack associated with the primary start relay-set and operate the appropriate KRT key. The telephone loop should hold the connection and lamp LPB should glow.

(10) For directly connected finders, connect SM lead to +. SS lead not connected. For indirectly connected finders, connect (i) SS lead to S1 or S2, and (ii) connect SM lead to SM lead of secondary apparatus.

(11) When only two controls are fitted per group, fuse No. 1 with No. 2 and No. 2 with No. 1.

When three controls are fitted per group, fuse No. 1 with No. 3, No. 2 with No. 1 and No. 3 with No. 2.

(b) Secondary Finder.

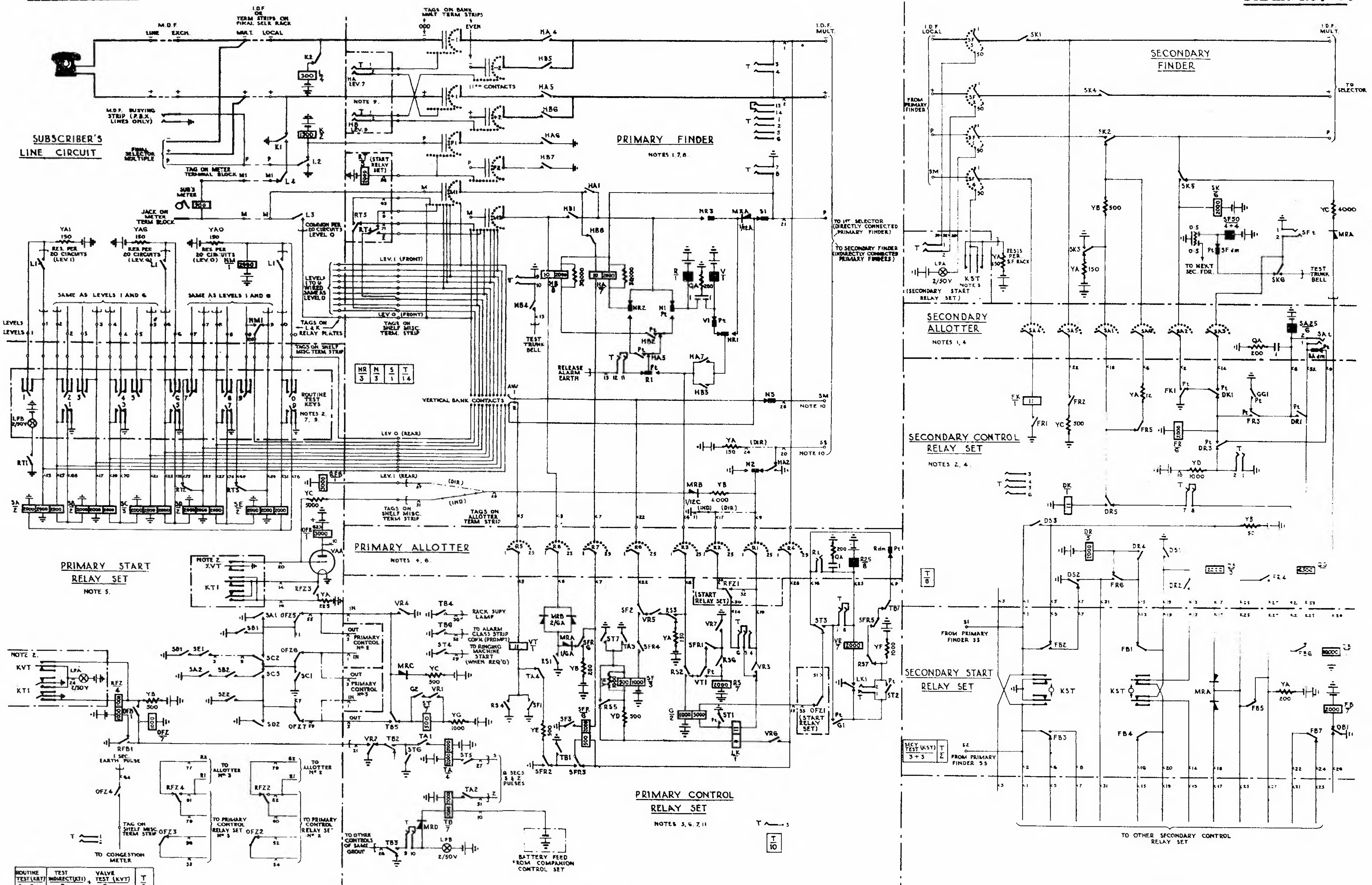
(1) Any spare positions on the secondary allotters to be multipled; for example, 13 to 1, 14 to 2, etc.

(2) Shelf jack points 1 and 3 to "make" contact when a control relay-set is removed.

(3) One KST key is provided for each secondary start relay-set and is two-way, non-locking.

(4) To test the running of the allotter uniselector from the test jack, transfer the test U-link from T7 and 8 to T2 and 1 on the associated control relay-set.

END OF PAPER (Fig. 7 attached).



(a) Primary Finder (CE.49.)

(b) Secondary Finder (C.1185).

FIG. 7. LINE FINDER CIRCUITS.

COMMONWEALTH OF AUSTRALIA.

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Postmaster-General's Department,
Treasury Gardens,
Melbourne. C.2.

COURSE OF TECHNICAL INSTRUCTION.

LINE CIRCUITS.

CONTENTS.

1. INTRODUCTION.

2. SUBSCRIBERS' UNISELECTOR LINE CIRCUIT.

3. NON-METERING CIRCUIT.

4. DUPLEX SUBSCRIBERS' LINE CIRCUIT.

5. TEST QUESTIONS.

6. REFERENCES.

1. INTRODUCTION.

1.1 The economic advantage of the line finder system diminishes as the average calling rate of the exchange increases. For this reason, line finder installations in Australia have been limited to exchanges with a medium to low calling rate, that is, where a maximum of 25 line finders serve a group of 200 lines. It has been found that the line finder system using partial secondary working is easily blocked by an increase in the originating traffic from one primary group. In addition, the circuits are complex, in some cases making the tracing of faults very difficult.

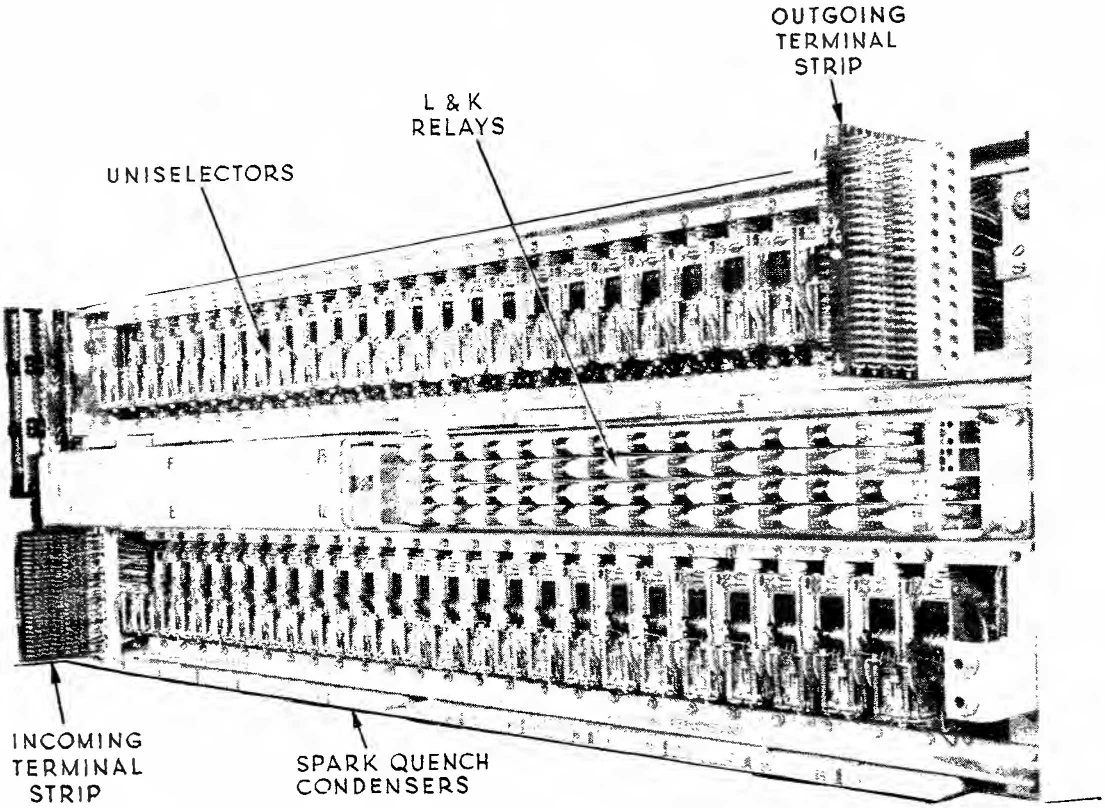
For these reasons, it is now the policy of the Department to install line finder equipment only in exchanges having a low calling rate. Partial secondary working is not used, all primary finders being directly connected to first selectors. In busier exchanges, homing type uniselectors, having an availability of 23, are installed, the outlets being graded to suit the traffic requirements.

The circuit operation of the subscriber's uniselector is described in Telephony III, Paper No. 3, and further details of this circuit are given in this Paper. Information is also given on the Non-Metering Circuit for use on certain Departmental lines, also on the Duplex Subscribers' Line Circuit.

This last circuit is designed to provide telephone service to applicants in localities where there is a shortage of line plant. In the duplex service two subscribers are given service on one line.

2. SUBSCRIBERS' UNISELECTOR LINE CIRCUIT.

2.1 Subscribers' uniselectors of the A.P.O. type are mounted in units of 50, consisting of two shelves of 25 uniselectors, with an intermediate mounting plate containing 50 sets of L and K relays of the 600 type. The general arrangement is shown in Fig. 1. The switches have two spring mounting points to the frame and the spark quench condensers are mounted below the switches. Six units of 50 switches, that is, a total of 300 uniselectors, mount on a standard rack (see Paper No. 6, Page 11).



MOUNTING OF SUBSCRIBERS' UNISELECTORS.

FIG. 1.

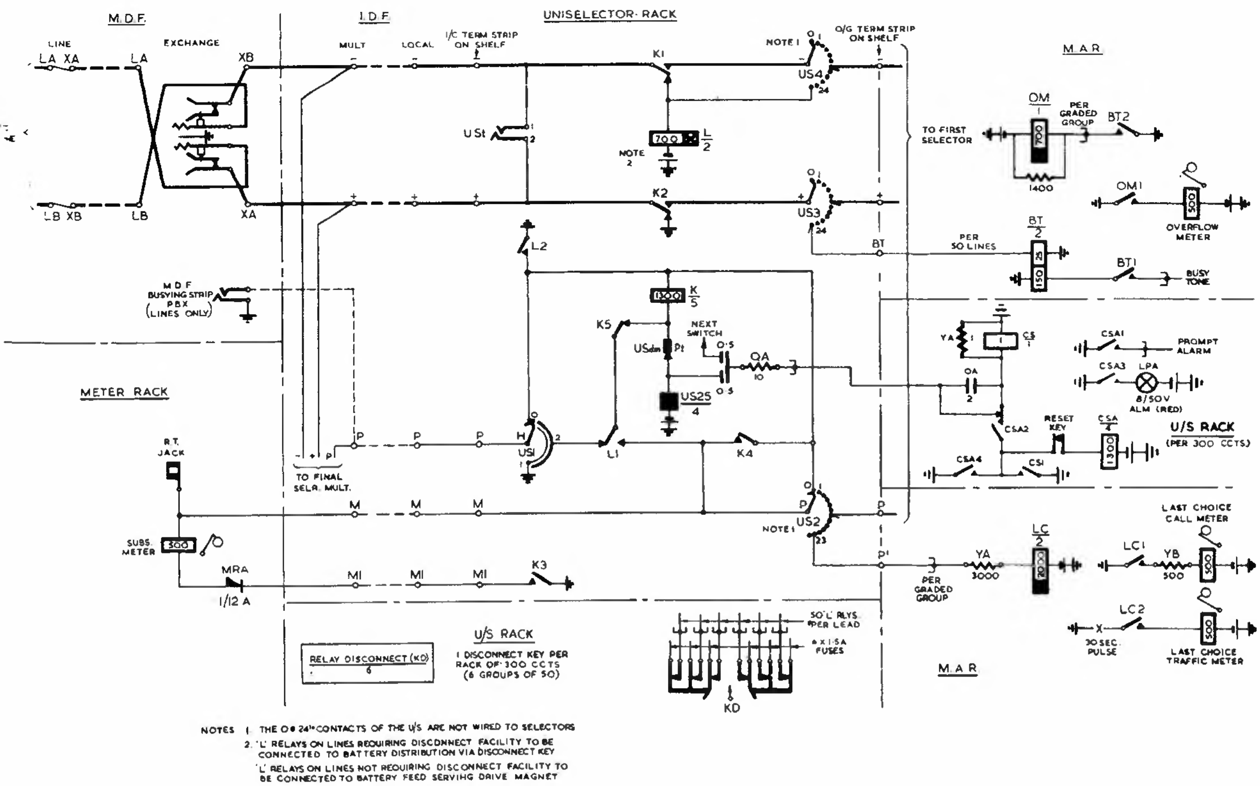
The incoming line wires from the I.D.F. terminate on the incoming terminal strip shown at the lower left-hand side of Fig. 1, the back set of tags being the terminals for the lower shelf of switches and the front tags for the upper shelf. The outgoing multiple wires from the bank contacts terminate on a second terminal strip, shown at the upper right-hand corner of the figure. On this block, the wires from each shelf of 25 switches are arranged to facilitate commoning of the two shelves by bridging adjacent tags.

As the switches are of the homing type, the outgoing cables from the uniselector rack are taken to a T.D.F., where the outlets are graded, thus increasing the average traffic occupancy of the first selectors by approximately 20 per cent. The number of cables to the T.D.F. depends on the trunking scheme, as also does the number of shelf-to-shelf tie cables.

2.2 A description of the A.P.O. type uniselector is given in Telephony III, Paper No. 3. Originally the switches were fitted with five bank levels, but recently the circuit was amended to allow the use of four-level switches.

/ 2.3

2.3 The subscriber's line circuit is shown in Fig. 2. The circuit is arranged for positive battery metering, metal rectifiers MRA, used for this purpose, being mounted on the meter rack. This arrangement uses more rectifiers, but enables four-level uniselectors to be used, and also reduces the possibility of false metering. When all 23 outlets are busy the switch stops on the 24th contacts and returns busy tone to the caller.



SUBSCRIBER'S LINE CIRCUIT. (CE.292, SHEET 2.)

FIG. 2.

2.4 Traffic Meters. Relay BT operates to supply busy tone to the calling line. Operation of BT2 closes the circuit of relay OM, which is common to the group of 50 or 100 lines, and OM1 operates the Overflow Meter. Relay OM is fitted with a copper slug, so that it does not respond to dialled impulses.

To obtain a more accurate indication of the traffic carried by each graded group, a Last Choice Call Meter and a Last Choice Traffic Meter are operated each time the 23rd outlet is taken into use. Relay LC operates to the earth on the P wire, and is fitted with a copper slug, so that it holds during the brief unguarded period prior to the release of the first selector. The last choice call meter is operated once, therefore, for each time the 23rd outlet is taken into use, while the last choice traffic meter is connected to the 30 second pulse supply, and operates every half minute that the outlet is in use. These readings can be used to calculate the traffic carried by the last choice trunk, and, by comparison with the overflow readings, the efficiency of the grading can be determined.

2.5 Condenser Alarm. This circuit incorporates an alarm indication in the event of failure of a uniselector spark quench condenser. Operation of the alarm circuit is described in Paper No. 7.

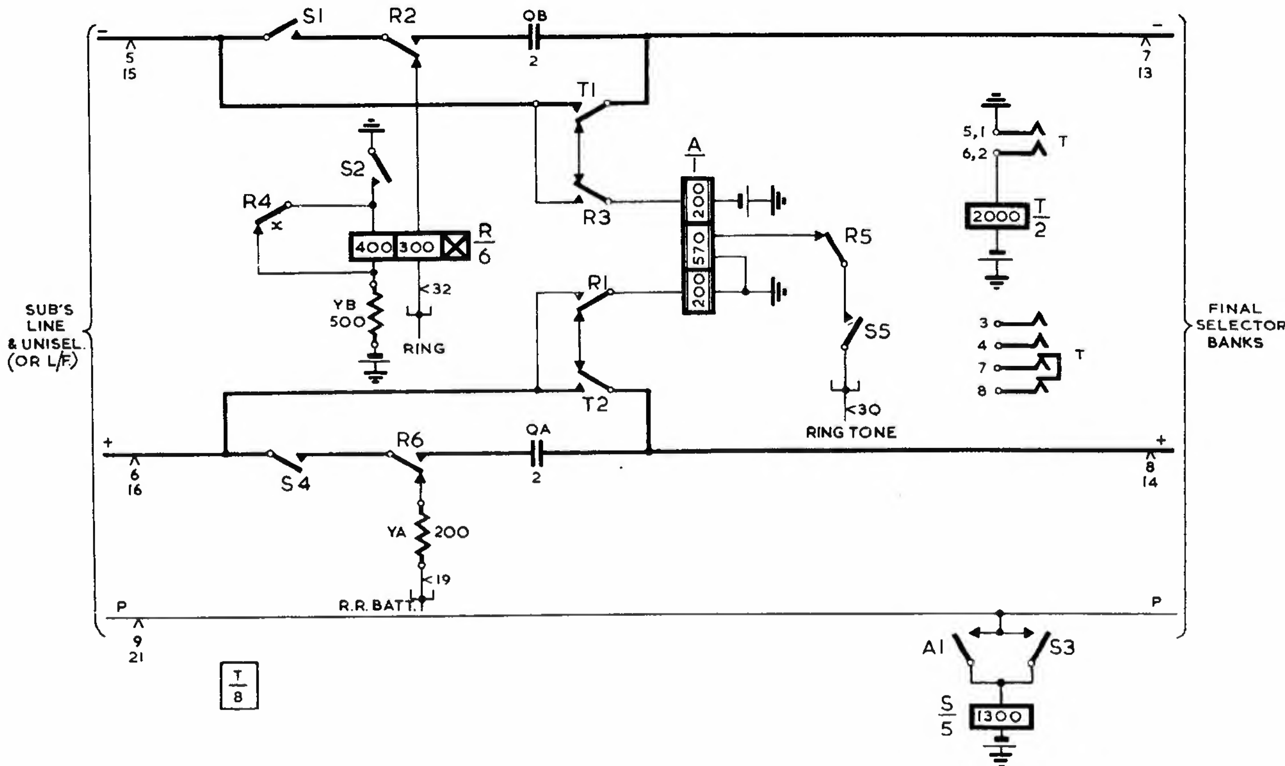
2.6 "Disconnect" Facility. A key is now provided on each uniselector rack to disconnect the battery feed from the line relays in times of emergency, when service is restricted to urgent services. This is arranged by wiring the battery feed to the urgent services' line relays from the drive magnet battery feed, instead of via the disconnect key.

/ 3.

3. NON-METERING CIRCUIT.

3.1 This circuit is provided on certain Departmental lines, for example, Line Foremen, to enable calls to be made to such telephones without operating the calling party's meter. Thus a lineman or cable jointer may make these calls by connecting his buttinski to a working line, without the necessity of rebating the call to the subscriber. As no reversal of current is given on the calling line, calls to lines connected via a non-metering circuit may be made from a public telephone without inserting coins.

The apparatus is mounted in relay-sets (two circuits per base), the circuit connections being shown in Fig. 3.



NON-METERING CIRCUIT. (CE.381.)

FIG. 3.

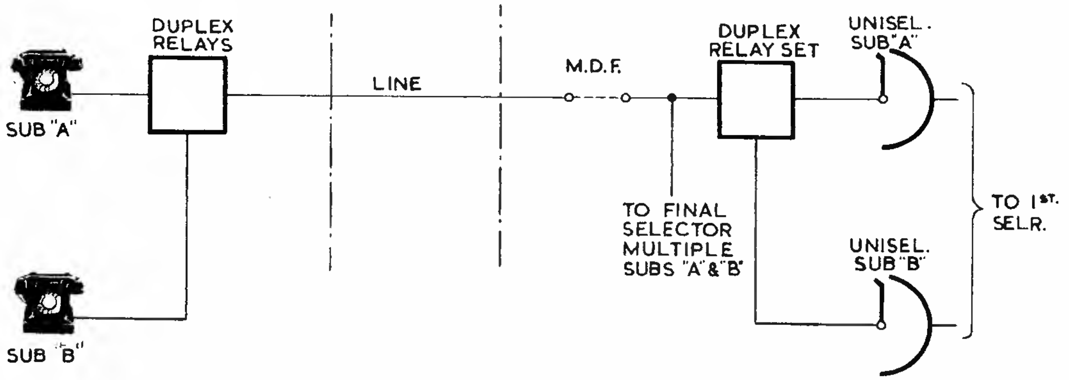
3.2 Circuit Operation. When the non-metering circuit is seized by a calling final selector, relay A operates via R1 and T2 to the ring return battery applied to the positive wire. The ring is tripped by the battery from the second winding of relay A applied via R3 and T1 to the negative wire. Relay S operates via A1 to the earth on the P wire and holds via S3. S1 and S4 connect ringing current and ring return battery respectively to the line wires and S5 connects ring tone to the tone winding of relay A, from which it is given to the calling party. When the called party answers relay R operates, disconnecting the ringing current and tones and connecting the two parties together for conversation. Condensers QA and QB prevent the operation of the final selector relay D, thus metering of the call does not take place. The transmitter battery for the called telephone is supplied via relay A in the non-metering circuit.

Outgoing calls are completed in the normal manner, and there is no operation in the non-metering circuit. To test the line, it is necessary to insert a test plug into T1-2 (or T5-6), operating relay T, and connecting the line wires through at T1 and T2.

/ 4.

4. DUPLEX SUBSCRIBERS' LINE CIRCUIT.

4.1 This service has been introduced in order to provide telephone service to applicants in localities where there is a shortage of line plant. It gives exchange service to two subscribers via one cable or overhead pair, as shown in Fig. 4. The service is made available only to subscribers with a low calling rate, that is, residential subscribers.

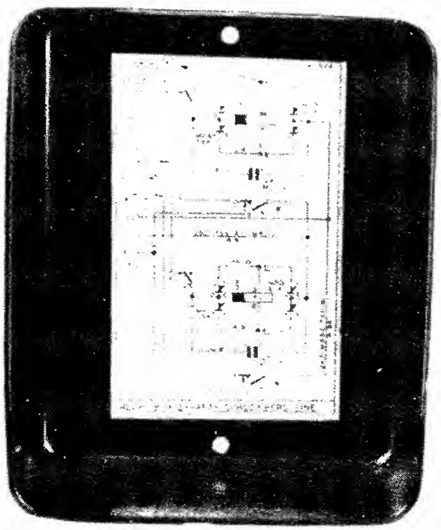


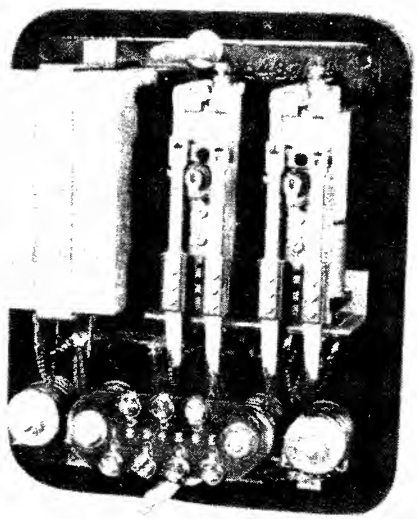
BLOCK DIAGRAM OF DUPLEX SERVICE.

FIG. 4.

Each subscriber has a separate exchange number, but only one subscriber can use the service at any one time. The service is secret, and selective ringing ensures that only the wanted subscriber's bell rings on incoming calls. Separate meters are provided in each individual line circuit.

Secrecy is preserved by automatically disconnecting one subscriber while the other is using the line. The switching medium is a special relay-set mounted at the subscriber's premises (see Fig. 5). When the two duplex subscribers are in separate buildings the relay-set is installed at the "A" subscriber's premises. At the exchange a further relay-set is used for the selection of the appropriate line circuit. The arrangement of the relay-set at the exchange is designed to simplify the ultimate change-over to exclusive services when cable pairs are available to the subscribers concerned.





DUPLEX RELAYS.

FIG. 5.

(For additional information about Duplex Services see Telephone Engineering Instruction General E 0101).

4.2 Circuit Operation. (Refer to Fig. 6.)

(i) Outgoing Calls. In the case of subscriber "A" originating a call, relay LA operates over the negative line wire and the telephone loop to earth at A1. Relay A does not operate in series with 5000 ohm relay LA. LA1 operates the line circuit relay L via 500 ohms YA. Earth returned on the P wire from the line circuit operates relay LC. LC1 and LC3 disconnect relays LA and LB respectively and switch the line through to the "A" subscribers line circuit. LC2 earths the final selector P wire of the number associated with subscriber "B" to busy that line. The increased current on the negative line allows relay A to operate and A1 completes the loop dialling circuit for subscriber "A" who receives dial tone. A2 disconnects subscriber "B" from the line. When the reversal of current is received on the line, the metal rectifiers prevent relay A from flicking out and opening the loop circuit.

Calls from subscriber "B" operate in a similar manner to the above, except that relays LB, LD and B operate in lieu of LA, LC and A respectively and the line is connected to the "B" subscriber's line circuit.

(ii) Incoming Calls. Assuming that the "A" subscriber is called, relay LC operates to the earth on the P wire from the final selector. Ringing current from the final selector flows over the negative line to operate the "A" subscriber's bell to earth at A1. When the subscriber answers, relay A operates to the ringing current and A1 closes the loop on the line to trip the ring. Subscriber "B" is disconnected at A2.

On calls to subscriber "B", relay LD operates. Ringing current flows over the positive line to operate the "B" subscriber's bell and operate relay B.

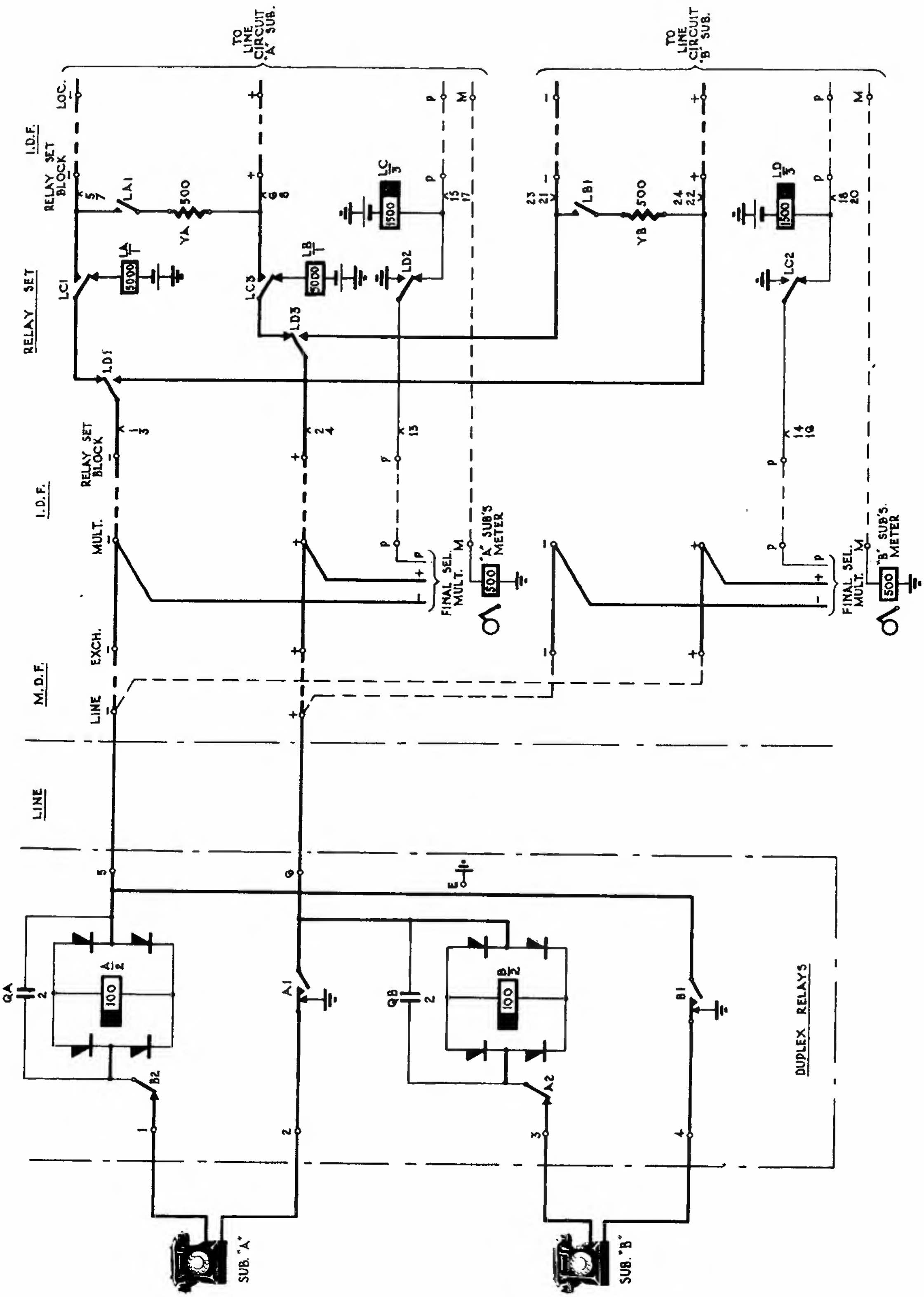
4.3 Standard telephones are used, but it is necessary to fit bias springs to the bells to reduce the possibility of tinkling of the idle subscriber's bell which would otherwise occur when a duplex subscriber lifts and replaces the receiver.

Duplex subscribers should be instructed to listen carefully for dial tone before proceeding to make a call. Absence of dial tone almost certainly indicates that the other subscriber is using the service. In the unusual event of one subscriber lifting the receiver to make a call while the other subscriber is being called, the ring is tripped and the call is taken by the wrong subscriber. If it is convenient, the other subscriber should be requested to take the call. Otherwise the caller should report obtaining a wrong number to "Complaints", who will connect him to the correct number without charge.

4.4 Transmission. The insertion of the relay unit introduces an additional loss of 0.2 db in sending and receiving efficiency in each line and, in addition, causes a greater reduction in sending efficiency owing to the effect of the added resistance on the transmitter current. The resistance of the unit consists of the 100 ohms of the relay plus the resistance of the bridge rectifier which varies from approximately 65 ohms with a current of 70 milliamps to 105 ohms at 30 milliamps.

It is necessary, therefore, to reduce the normal line allowance by an amount which covers the above losses. This need not be as great as the resistance of the unit since the line losses consist of attenuation plus feeding current loss. The amount which should be subtracted is 100 ohms for automatic services. To simplify the limiting conditions, and since the limits for a solid back transmitter would be very short in some cases, this type of service must be fitted with an inset type of transmitter (Inset No. 13 or equivalent).

/ Fig. 6.



DUPLEX SUBSCRIBERS' LINE CIRCUIT. (CE.399, SHEET 1.)

FIG. 6.

5. TEST QUESTIONS.

1. Discuss the practical disadvantages of the line finder system using partial secondary working. What alternative systems are now preferred for the connection of subscriber's lines to a 2000 type automatic exchange?

2. What is the availability of uniselectors used in the subscriber's line circuit shown in Fig. 2? Describe the method used to connect the outlets to the next rank of switches.

3. What are the advantages and disadvantages of the method of connecting the metal rectifier in the subscriber's meter circuit in Fig. 2?

4. Observation of the traffic meters associated with a subscriber's uniselector grading during the exchange busy hour indicates that the Last Choice Call Meter is operated 3 times and the Last Choice Traffic Meter 12 times.

   Calculate -

   (i) The traffic carried by the last choice trunk. (Answer 0.1 T.U.)

   (ii) The average holding time of the originated calls. (Answer 2 minutes.)

5. Where is the Non-Metering Circuit used and what are the advantages of its use?

6. What special instructions should be given to a subscriber connected to a Duplex service? Give the reasons for your answer.

7. In a Duplex service explain how one subscriber is called without operating the second subscriber's bell. Why is it necessary to bias the bells?

8. Explain the effect on transmission of changing an exclusive service to Duplex working. In this respect, what precautions must be taken in order to ensure a satisfactory standard of transmission performance?

6. REFERENCES.

Telecommunication Journal of Australia.

Vol. 2, No. 2, "The City West Uniselector. (G.E.C. Type C.3100)" - H. G. Kuhn.

Vol. 6, No. 6, "Two Party Line Subscriber's Automatic Service with Secrecy and Selective Ringing and Metering." - J. S. Silvester.

END OF PAPER.

COMMONWEALTH OF AUSTRALIA.

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Treasury Gardens,
Melbourne, C.2.

COURSE OF TECHNICAL INSTRUCTION.

JUNCTION WORKING.

CONTENTS:

1. INTRODUCTION.

2. RELAY-SET REPEATER.

3. RELAY-SET, JUNCTIONS TO SPECIAL SERVICES.

4. DISCRIMINATING SELECTOR REPEATER (D.S.R.).

5. TEST QUESTIONS.

6. REFERENCES.

1. INTRODUCTION.

1.1 The special requirements necessary for junction working in a multi-exchange network are described in Telephony III, Paper No. 6. In 2000 type exchanges, the arrangements are the same as those described in that Paper for exchanges of the pre-2000 Strowger type. However, as 2000 type group selectors have an availability of 20 outlets per level, the use of junction hunters is not economically justified.

2. RELAY-SET REPEATER.

2.1 These are connected between the group selector levels and the junction, as shown in Fig. 1.

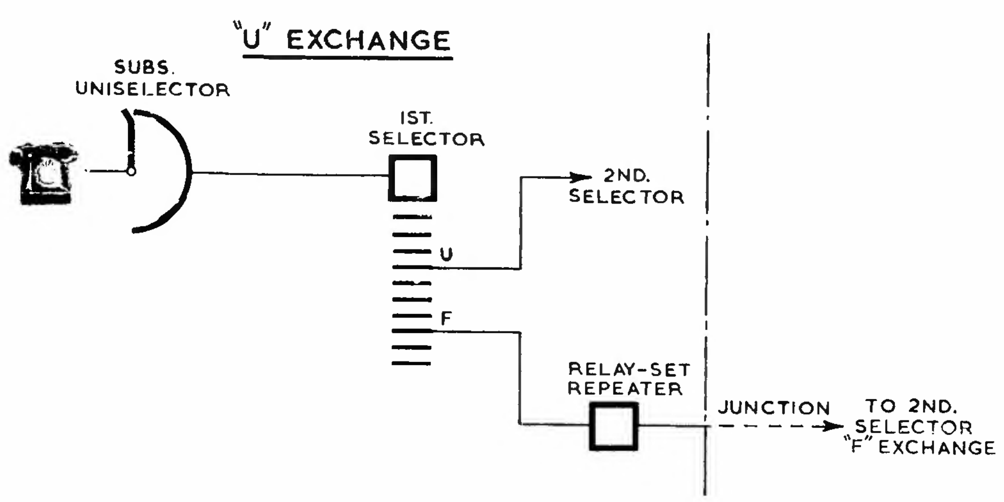
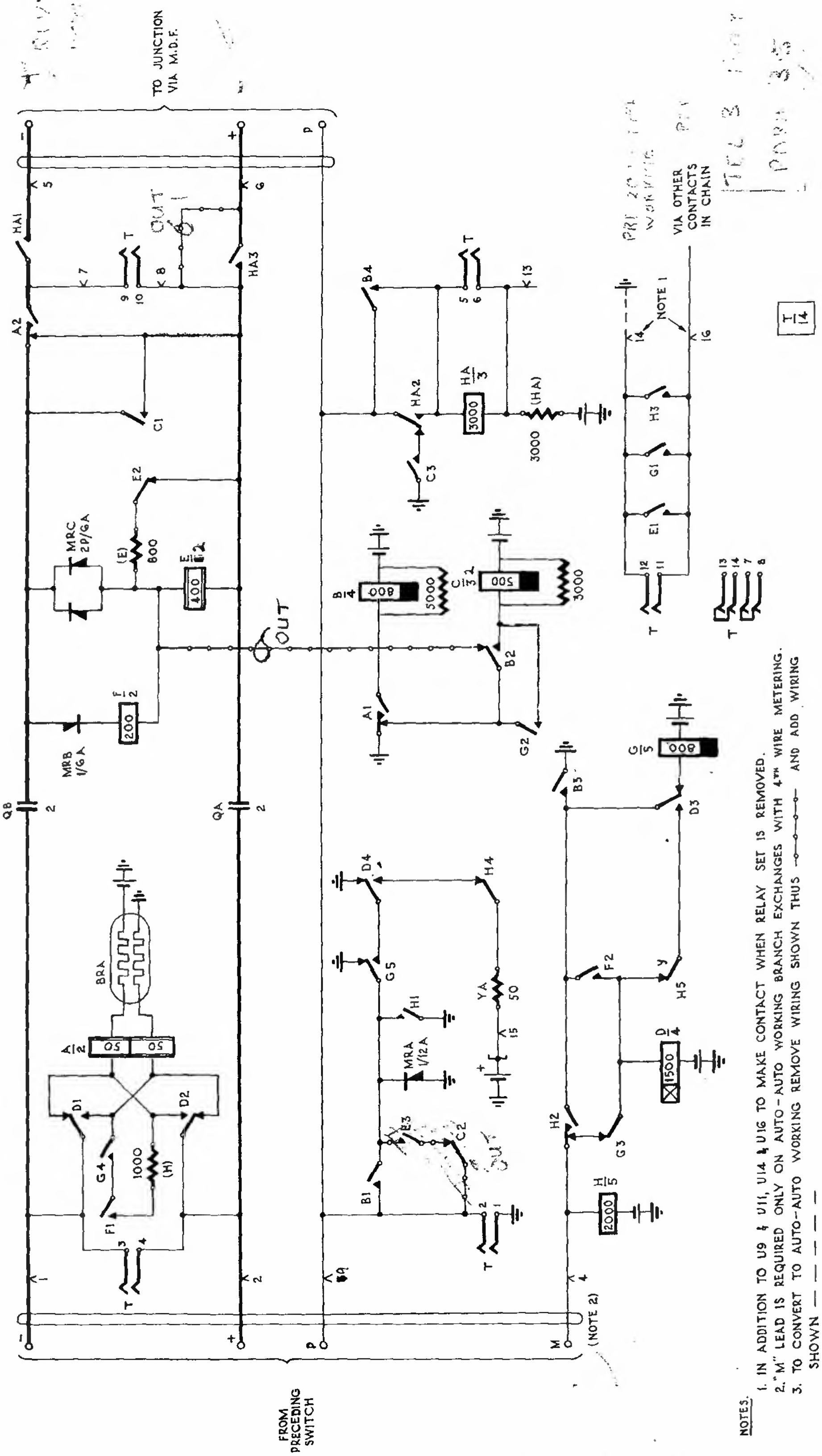


FIG. 1. TRUNKING DIAGRAM OF RELAY-SET REPEATERS.



NOTES.
1. IN ADDITION TO U9 & U11, U14 & U16 TO MAKE CONTACT WHEN RELAY SET IS REMOVED.
2. "M" LEAD IS REQUIRED ONLY ON AUTO-AUTO WORKING BRANCH EXCHANGES WITH 4TH WIRE METERING.
3. TO CONVERT TO AUTO-AUTO WORKING REMOVE WIRING SHOWN THUS —o—o— AND ADD WIRING SHOWN — — — —

FIG. 2. REPEATER AUTO-MANUAL CONVERTIBLE TO AUTO-AUTO. (2000 TYPE)

2.2 The functions of a relay-set repeater, auto-auto, are given in Telephony III, Paper No. 6, Paragraph 3.2, and the additional functions performed by the circuit convertible from auto-manual to auto-auto working are given in Paragraph 6.2 of that Paper. Fig. 2 shows the connections of the 2000 type version of this latter circuit. The circuit is identical with that of the pre-2000 type relay-set except for the inclusion of contacts of relay HA in the junction loop. This is to enable automatic routining of the relay-sets. Earth from the routiner short-circuits relay HA to disconnect the junction during testing. The provision of test jacks is in accordance with standard 2000 type practice.

3. RELAY-SET, JUNCTIONS TO SPECIAL SERVICES.

3.1 On junctions to special services, such as Information, Time Service, Trunk Inquiries, etc., a simplified relay-set is used. As no reversal is given on calls to these services, the polarised relay is omitted from the circuit, as also is the metering facility.

3.2 The circuit connections are shown in Fig. 3, and a description of the circuit operation follows.

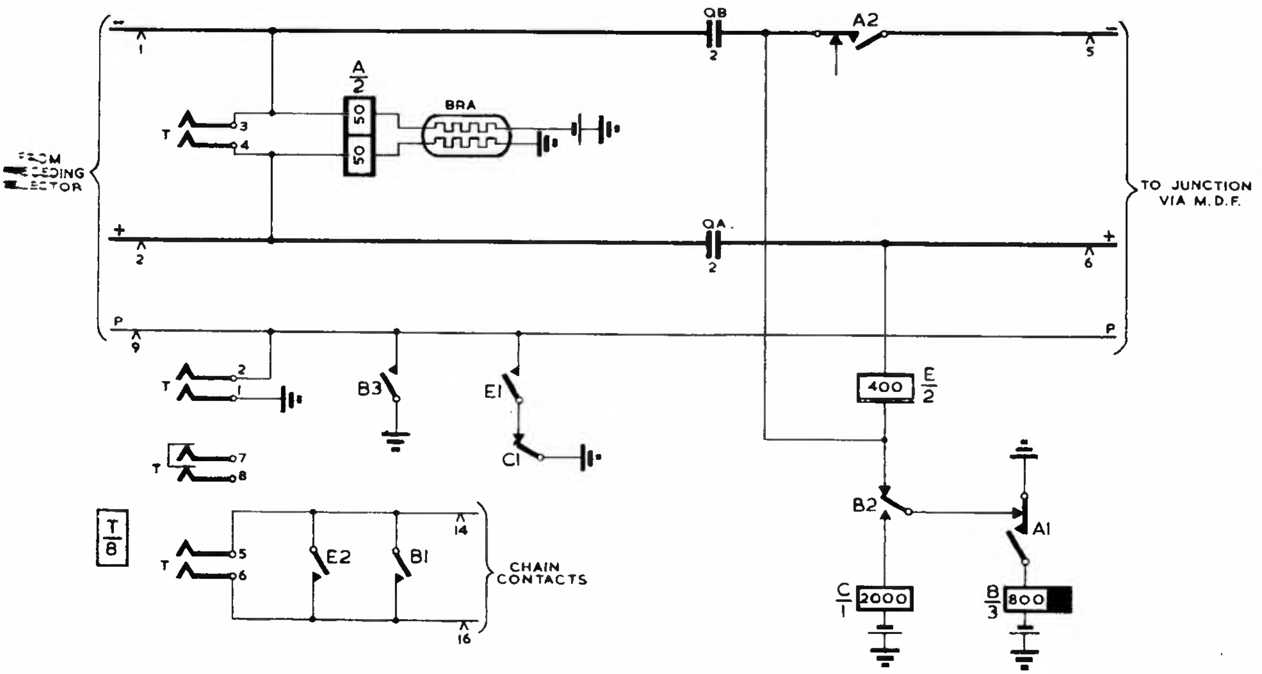


FIG. 3. RELAY-SET, JUNCTIONS TO SPECIAL SERVICES.

3.3 When the circuit is seized from the selector level, relay A is operated over the calling subscriber's loop in series with the ballast resistance. A1 operates relay B and B3 applies an earth to the P wire to hold the connection. A2 completes the junction loop circuit via relay E to signal the distant switchboard. The circuit remains in this condition during conversation.

When the caller replaces the receiver, relay A releases, followed by the release of relay B. Relay C is operated during the release time of relay B and releases after the release of B2. The preceding switches are released when B3 removes the earth from the P wire. Should the junction still be held by the switchboard operator, relay E will be held over the positive line to earth via B2 and A2. In this case, the relay-set is re-guarded by earth via C1 and E1 when relay C releases. The release time of relay C (approximately 20 mS) allows the preceding switches to release before the circuit is re-guarded. On the release of relay E, the circuit restores to normal.

/4.

4. DISCRIMINATING SELECTOR REPEATER (D.S.R.).

4.1 The reasons for the use of this switch in branch exchanges are given in Telephony III, Paper No. 6, Paragraph 2.7. Briefly, D.S.R's are used to enable a reduction to be made in the number of junction circuits required to the parent main exchange and also in the number of 1st and 2nd selectors required at that exchange. Fig. 4 shows the trunking arrangements for D.S.R's at a typical branch exchange (MB). A junction hunter is associated with each D.S.R. to enable a saving in junctions to the parent main exchange to be made. Forty D.S.R's and the associated junction hunters are mounted on a standard rack, as shown in Paper No. 6, Fig. 5.

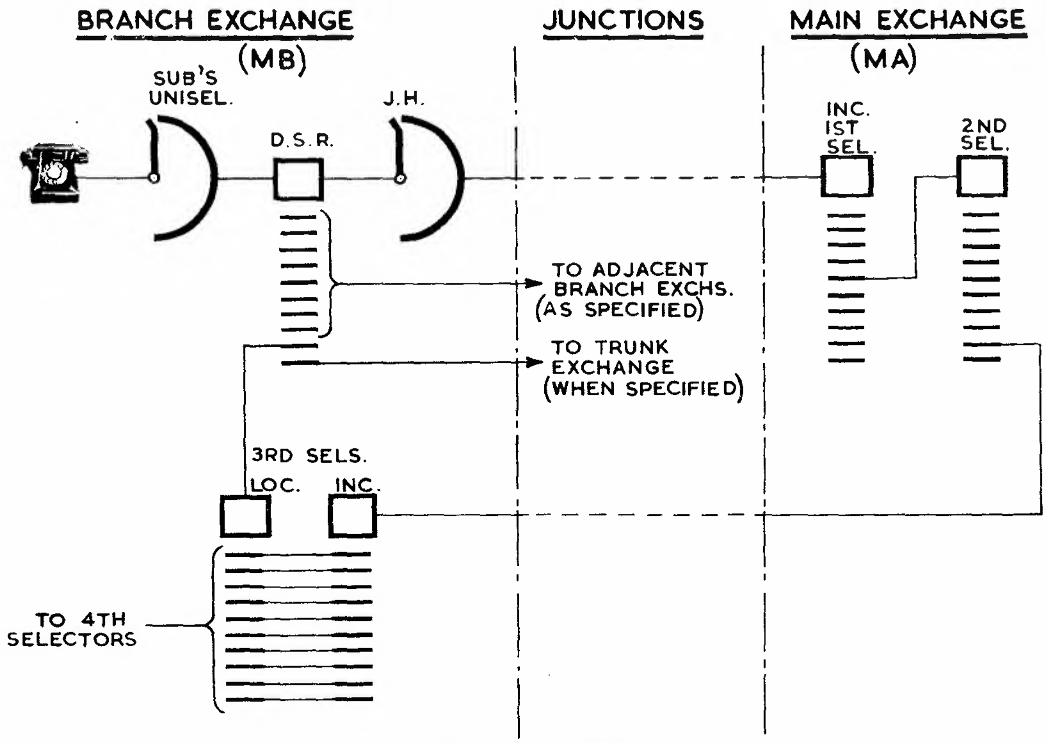


FIG. 4. TRUNKING FROM D.S.R's.

4.2 The 2000 type D.S.R. differs from the pre-2000 type switch in the following respects -

(i) 2000 type mechanism is used.

(ii) Because of the longer releasing time of the 2000 type switch (see Paper No. 1, Paragraph 7.4), different arrangements are made for the absorption of digits.

(iii) The switch automatically steps to the first level when seized. The first train of impulses steps the wipers into the first level.

(iv) Discrimination is given on all the P2 bank contacts of the first level, and on the first P2 bank contact of other levels.

(v) The junction hunter is a 25-point homing type uniselector.

(vi) The relays controlling the junction hunter are incorporated in the D.S.R.

(vii) The switch functions as a group selector instead of a selector-repeater on local calls.

/4.3

4.3 Outline of Operation. (Refer to Fig. 4.)

(i) Call to Other Main Exchange Group. When the D.S.R. is seized via the subscriber's uniselector, the associated junction hunter searches for a free junction to the parent main exchange, the D.S.R. wipers are automatically stepped to the first level and a rotary stepping circuit is prepared. Dial tone is given to the caller and, when the first digit is dialled, the D.S.R. rotary magnet is operated to step the wipers round the first level and the impulses are repeated over the junction to operate the first selector at the parent main exchange.

As this call is for a main exchange group other than that of the parent main exchange, the first digit dialled will be a number other than the first digit of the parent main exchange (in this case, some digit other than 6 or M). The condition encountered on the P2 bank contact determines that the D.S.R. shall continue to function as a repeater. Further impulse trains, therefore, are repeated over the junction to the main exchange and thence to another main exchange in the network, thereby establishing the connection.

(ii) Call to Parent Main Exchange. When the subscriber dials as a first digit the number corresponding to the first digit of the parent main exchange prefix (in this case, 6), the D.S.R. is caused to restore to normal from the sixth contact of the first level, but the main exchange first selector is held on the sixth vertical level.

The D.S.R. and second selector both respond to the second train of impulses, the D.S.R. being stepped vertically and cuts-in on the dialled level. As this does not correspond with the local branch exchange prefix (MB), the D.S.R. continues to function as a repeater and the call is set up in the main exchange in the usual manner.

(iii) Local Call. If a call is made to a number in the same branch exchange, the preliminary operation of the D.S.R. is similar to that described above for a call to the parent main exchange.

However, when the D.S.R. wipers cut-in after the receipt of the second train of impulses, the condition encountered on the P2 bank contact enables the D.S.R. to function as a selector. The switch hunts for a free outlet in the level, which is wired to local 3rd selectors. The call, therefore, is completed in the branch exchange and the junction to the parent main exchange is disconnected.

(iv) Call to Adjacent Exchange. An "adjacent" branch exchange is one to which direct junctions are provided. In this case, supposing the calling subscriber dials "MF" as the first two digits of the required number, the operation of the D.S.R. is similar to that on a local call, described above.

The second digit, however, steps the D.S.R. to the level corresponding to an adjacent branch exchange and the D.S.R. subsequently functions as a selector-repeater. The switch hunts for a free outlet in the level, which is connected via direct junctions to incoming 3rd group selectors at the adjacent branch exchange. The call is completed over the direct junction and the junction to the main exchange and the first and second selectors are released.

(v) Call to Trunk Exchange. The D.S.R. circuit provides for direct access to the trunk exchange by dialling the single digit "0". If provided, direct junctions to trunks are wired to the first level of the D.S.R. bank multiple.

When seized, the D.S.R. automatically takes a vertical step, and the wipers are stepped to the tenth contacts of level 1 when the subscriber dials. The condition encountered by the P2 wiper causes the wipers to be restores to normal, and the switch takes another vertical step, cuts-in and searches over the first level for a free outlet to the trunk exchange. The D.S.R. functions as a selector-repeater on trunk calls and the junction to the main exchange is disconnected.

/4.4

4.4 Discrimination between Local Calls and Calls to other Exchanges. Discrimination between local calls, calls to adjacent branch exchanges, the trunk exchange or to other exchanges is determined by the condition encountered by the P2 wiper. The P2 contacts of level 1 are tested at the end of the first train of impulses and, if the first digit is absorbed, the switch cuts-in at the completion of the second impulse train and makes a further test on the first P2 contact of the dialled level. The P2 contacts are wired individually on each D.S.R. to an auxiliary switch jack placed above the normal jacks, as shown in Fig. 5. The P2 bank contacts are not multipled.

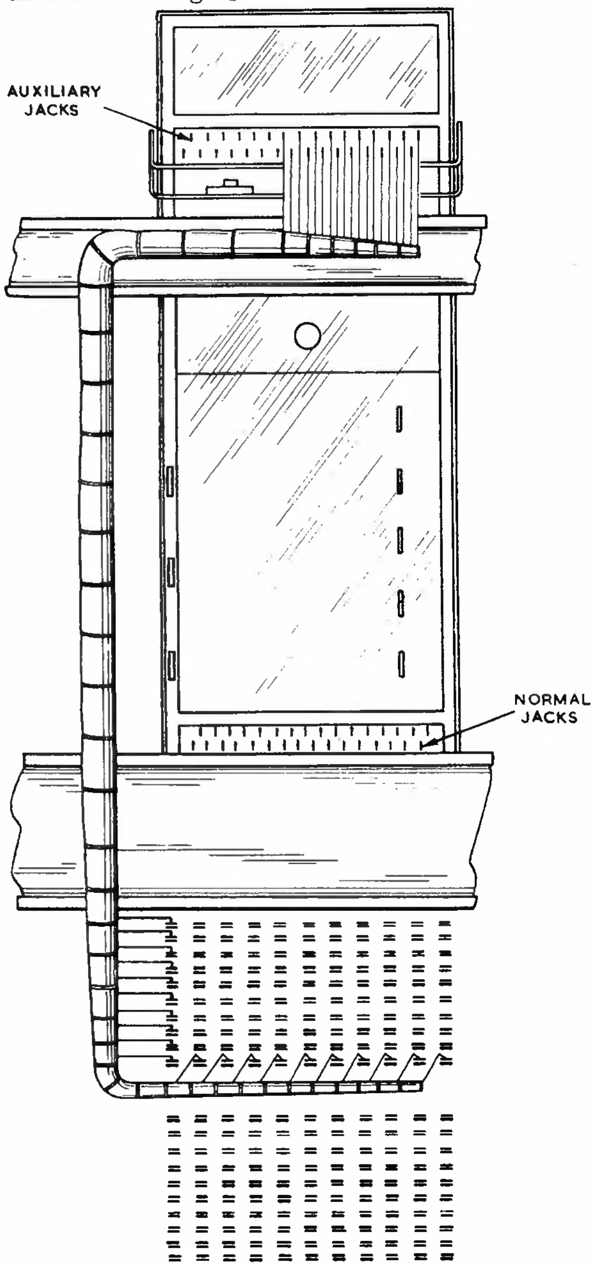


FIG. 5. REAR VIEW OF D.S.R. SHOWING WIRING TO P2 BANK.

Connections are made to the discriminating relays in the D.S.R. by means of straps on the auxiliary switch jack, as follows -

(i) Tag "a" is strapped to the rotary contact corresponding to the first digit of the local exchange numbers. When this number is dialled as the first digit, earth extended over the P2 wiper and bank contact causes the operation of relay DA (Digit Absorbing), the switch is restored to normal and the circuit is prepared for vertical stepping.

(ii) Tag "h" is connected to the vertical contact corresponding to the second digit of the local exchange numbers. When the second digit of a local number is dialled, relay LD (Local Discriminating) operates, followed by the operation of relay LS (Local Switching). The D.S.R. functions as a selector on local calls, as the transmission bridge is not required.

(iii) Tag "k" is connected to the vertical contact corresponding to the second digit of adjacent branch exchanges. Relays LD and LT (Branch Discriminating) operate together on calls to these exchanges, allowing the D.S.R. to function as a selector-repeater.

(iv) Tag "b" is connected to the tenth rotary contact of the P2 bank to provide for direct access to the trunk exchange. When the first digit "O" is dialled, relay OL ("O" Level Discriminating) operates to make the necessary circuit changes.

(v) Tag "c" is connected to all other rotary and vertical P2 bank contacts. When a call is made to an exchange other than the local exchange, an adjacent branch exchange or the trunk exchange, earth extended over the P2 wiper and bank contact via tag "c" operates relay JD (Junction Discriminating). Further stepping of the D.S.R. is prevented and the call proceeds over the junction to the parent main exchange.

(vi) When the first digit is "A", strap tag "e" to tag "a" for local and branch exchanges and "e" to "c" for main exchanges.

(vii) When the second digit is "A" or "1", strap tag "g" to tag "c", "k" or "h" for main branch or local exchanges, respectively.

/4.5

4.5 Functions of D.S.R. The circuit connections of the 2000 type D.S.R. are shown in Fig. 6 attached, and the functions of this circuit are listed below -

(i) When seized, returns a busying and holding earth on the P wire.

(ii) Selects a free junction to the main exchange via the junction hunter.

(iii) Transmits dial tone to the caller.

(iv) Automatically steps the wipers to the first level.

(v) Repeats the first dialled impulse train to the main exchange first selector and steps the wipers round the first level.

(vi) On outgoing junction calls, repeats all succeeding impulse trains over the junction to the main exchange.

(vii) On calls for local or adjacent branch exchanges -

(a) Restores the wipers to normal.

(b) Repeats second impulse train over the junction to the main exchange and steps the wipers vertically.

(c) Hunts for and seizes the first free outlet in the level.

(d) Releases the junction to the main exchange.

(e) All succeeding impulse trains are directed via switch wipers and bank.

(viii) On calls to the trunk exchange -

(a) Restores the wipers to normal.

(b) Automatically steps the wipers to the first level, hunts for and seizes the first free outlet to the trunk exchange.

(c) Releases the junction to the main exchange.

(d) Provides an "operator hold" facility.

(ix) Provides a transmission bridge on all calls except local calls.

(x) Provides metering conditions on calling subscriber's line when called party answers.

(xi) If all junction hunter outlets are busy, allows the call to proceed and, if call is for outgoing junction, transmits busy tone to the caller.

(xii) Restores wipers and releases junction (if in use) when release conditions are applied.

(xiii) Provides release and P.G. alarms.

4.6 Circuit Operation. (Refer to Fig. 6 attached.)

D.S.R. Seized. The caller's loop, extended from the preceding switch, operates relay A via LS1, LS4, MD3, MD6 and 150 ohm resistors YB and YC. A2 prepares the junction loop circuit and A1 closes the circuit of relay B to earth at N2. Relay B operates and holds to earth at B1. A guarding and holding earth is applied to the P wire via MD4, B3 and LS2. B5 further prepares the junction loop circuit and B4 closes the circuit of relay BA, which operates.

BA1 connects earth via LD6, K2, J6 and MD2 to operate relay J, which holds via MD2 and J6 independent of K2 and LD6. J5 completes the circuit of the supervisory lamp via JG7, JD6, LD2, LS3 and 1200 ohm YF to supervisory alarm battery. The lamp glows and, if the circuit is held without dialling for the specified delay period (6 minutes), an alarm is given.

J3 extends the junction hunter to the JH2 bank and, if the first junction outlet is busy, the junction hunter drive magnet operates via its interrupter contacts JHdm, K8, J3 and LD3 to the earth encountered by the JH2 wiper. The junction hunter wipers are stepped around the bank until a free outlet is reached. During hunting, relay K is short-circuited by the earth on the busy outlets and operates when a free outlet is reached from battery via the junction hunter drive magnet, JHdm, J1, JG6 and LD6 to earth at BA1. K8 disconnects the operating circuit of the junction hunter and prevents relay K being short-circuited when K7 applies an earth to the JH2 wiper to guard the seized junction. Junction release guard relays JA and JB now operate but have no function at this stage. K3 and K4 complete the junction loop circuit (see Fig. 7) and relay I operates. As the current is in the non-operate direction, relay D does not operate. K2 provides a holding circuit for relay K independent of J1 and JG6, but dependent on LD6. K5 connects dial tone via JG3 and JD3 to the tone winding of relay I where it is induced into the transmission circuit and heard by the caller.

At the same time, earth from BA1 is extended via DA2, OA6 and N3 to operate the vertical magnet. The wiper carriage is raised one step and the off-normal (N) springs operate. N3 opens the circuit of the vertical magnet.

The operation of relays B and BA and the N springs prepares the circuit of the rotary magnet in readiness to accept the first train of impulses dialled by the caller.

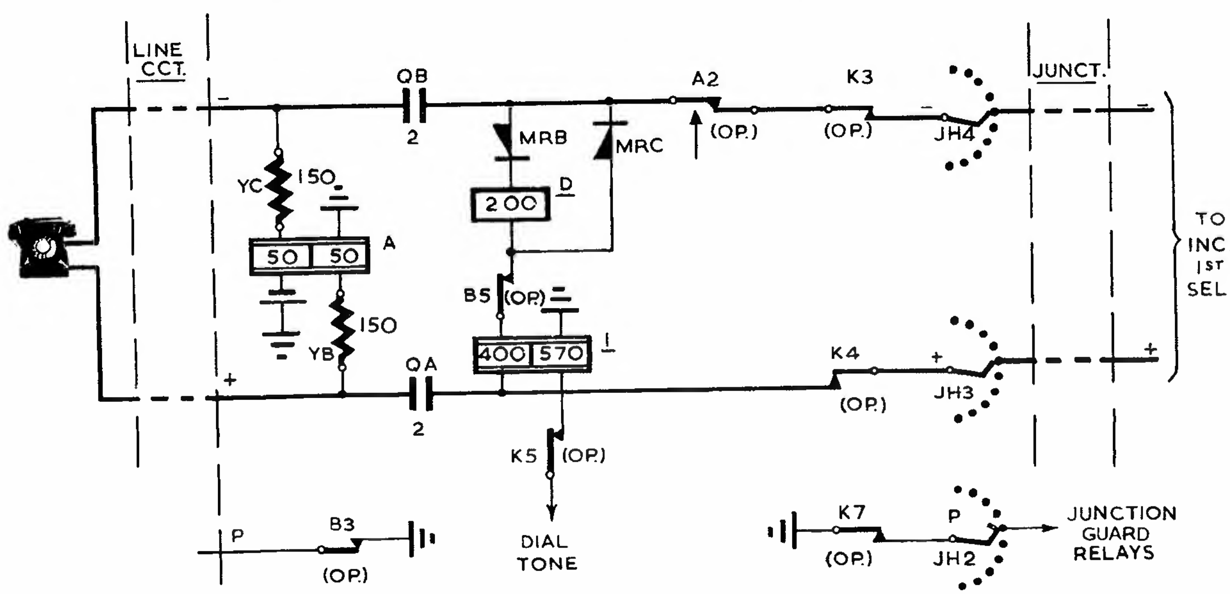


FIG. 7. JUNCTION LOOP CIRCUIT.

Local Call - First Digit Dialled. On receiving dial tone, the calling subscriber dials the first digit of the local number (M, or 6, in this case). Relay A responds to the dialled impulses and, during the break periods, earth is extended via B1, A1 and BA4 to relay C and is further extended via BA3, JD2, OA2, DA3 and N1 to the rotary magnet (see Fig. 8). Relay C operates and C1 places a short circuit across its second winding, making C slow to release, so that it holds during impulsing. C4 short-circuits relays D and I to give a low resistance impulsing loop to the main exchange. The dialled impulses are repeated to the main exchange selectors by A2.

Relay JG operates from earth via N2, C5 and OA7 and locks via JG2 and K6 to earth at JD5. JG7 opens the circuit of the supervisory lamp and JG3 disconnects the dial tone from relay I.

The rotary magnet is impulsed according to the digit dialled (in this case 6) and the wiper carriage and wipers are stepped to the sixth rotary contacts of level 1. This P2 bank contact is strapped to tag "a". At the end of the first train of impulses, relay C releases and earth is extended via BA1, DA4, JG4, C3 and RT6 to the P2 wiper.

Relay DA, which is connected to tag "a" via OA5, operates to the earth over the P2 wiper and bank contact and locks via OA5 and DA4 to earth at BA1. DA1 extends earth via K1, JG1, R1, C2 and N1 to the rotary magnet, which is thus energised in series with the rotary interrupter springs, R1, and automatic rotation of the wipers takes place to restore the D.S.R. to normal. Earth from DA1 also operates relay H, which has no function at this stage.

When the switch restores to the normal position, the N springs release and N1 breaks the rotary magnet circuit. N4 completes the circuit of relay OA to earth via DA2 and BA1. OA operates and locks via OA4 to earth at BA1. OA5 opens the circuit of relay DA, which releases. Relay H holds on its 500 ohm winding via OA1 and R1 to earth at H5. OA6 opens the original operating circuit of the vertical magnet and OA2 changes over the impulsing circuit from the rotary magnet to the vertical magnet in readiness for the second train of impulses. At this stage of the call, relays A, B, BA, J, K, I, JG, H and OA are operated and the switch is in the normal position.

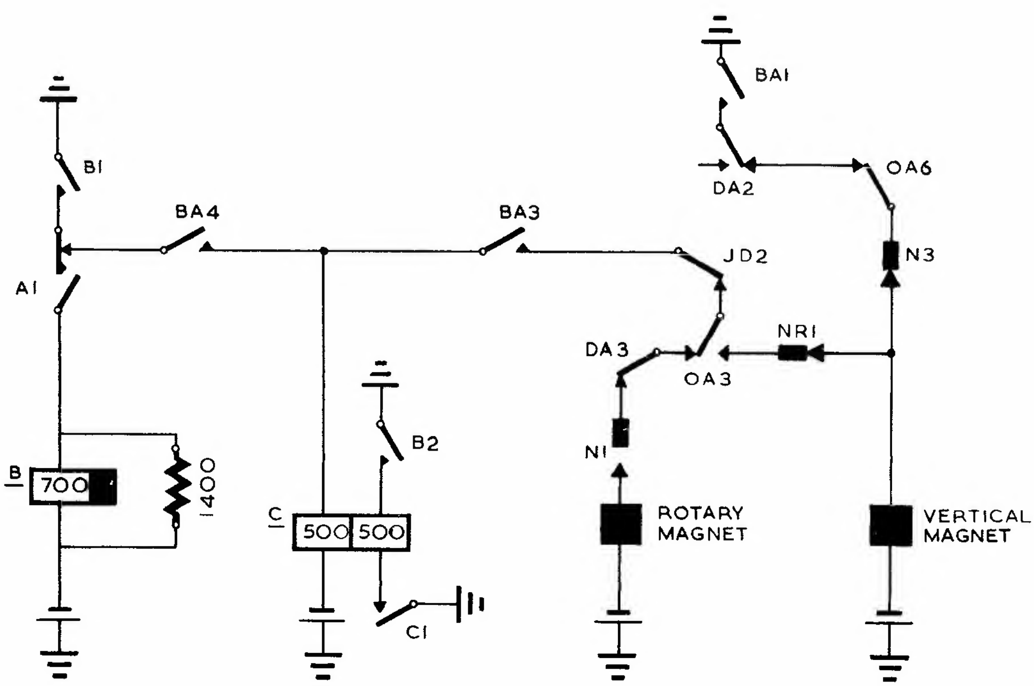


FIG. 8. D.S.R. IMPULSING CIRCUIT.

Local Call - Second Digit Dialled. Relay A responds to the second train of impulses, which are repeated over the junction by A2. A1 operates relay C and the vertical magnet (see Fig. 8). The vertical magnet operates with each impulse, and the wiper carriage is raised to the dialled level. At the end of the impulse train, relay C releases and the circuit of the rotary magnet is completed via N1, C2, OA1, K1 and JG1 to earth at H5. The wipers are stepped to the first rotary contacts and the P2 bank contact, being on the level associated with the second digit of the local number (in this case B or 2), is strapped to tag "h". A circuit is then completed for relay LD via tag "h", P2 bank contact and wiper, RT6, C3, JG4 and DA4 to earth at BA1. Relay LD operates and locks via LD4 to earth at BA5.

LD6 opens the circuit of relay K, which releases, and disconnects the junction loop to the main exchange, and also opens the circuit of relay JG. During the slow release period of relay JG, earth is applied via JG5 and LD3 to the P wiper and bank contact of the junction hunter to hold the junction guard relays operated. After the release of relay K, the junction is busied during the combined release lags of relays JG, JA and JB (approximately 600 milliseconds). This allows sufficient time for the release of the selectors at the main exchange before the junction is made available for other calls.

K1 removes the short circuit from the rotary interrupter contacts, R1, completing the rotary hunting circuit. The wipers are driven over the bank contacts, and relay H tests the outlets on its 2000 ohm winding via H4, S2 and LD1 to the P1 wiper. While the wipers are passing between contacts, relay H is held on its 500 ohm winding in parallel with the rotary magnet and holds on its 2000 ohm winding to the earth on busy P1 contacts.

On reaching a free outlet, relay H releases when the interrupter contacts open and H5 cuts the rotary magnet circuit before the interrupter contacts re-make. The seized outlet is immediately guarded by the application of earth via BA5 and H4 to the P wire. This earth operates relay LS via S1, LD5, LT4 and H3. LS contacts extend the calling line through to the local 3rd selector, which returns an earth on the P wire to hold relays LD and LS. Relays A, B, BA, OA and J release and the junction hunter homing circuit is completed via JHdm, K8 and J3 to the JH1 wiper and bank.

Subsequent digits operate directly to the succeeding switches, the D.S.R. functioning in this case as a selector. The through connections are shown in Fig. 9.

All Outlets Busy. Should all outlets in the level be busy, the D.S.R. wipers are stepped to the eleventh bank contacts and the eleventh step (S) springs operate. S2 opens the circuit of relay H, which releases and prevents further rotary stepping. S2 also applies an earth over the P1 wiper for operation of the overflow meter. S1 prevents the operation of relay LS and S3 connects busy tone to the tone winding of relay I, whence it is transmitted to the caller.

Release of Local Call.

(a) After Effective Call. After the calling subscriber has replaced the receiver, earth is removed from the P wire (by the final selector) and relays LS and LD release. A self-interrupted drive circuit is completed for the rotary magnet via N1, C2, R1, H5, BA6 and LD7 to release alarm earth as shown in Fig. 10. The circuit is broken at N1 when the D.S.R. reaches the normal position. The switch is guarded during the release period by earth via N2, C5, B3 and LS2 to the P wire.

(b) After All Outlets Busy Condition. When the caller replaces the receiver, relay A releases, followed by the release of relays B, BA, OA, LS, LD and J and the D.S.R. and junction hunter complete their respective homing actions as previously described.

/Fig. 9.

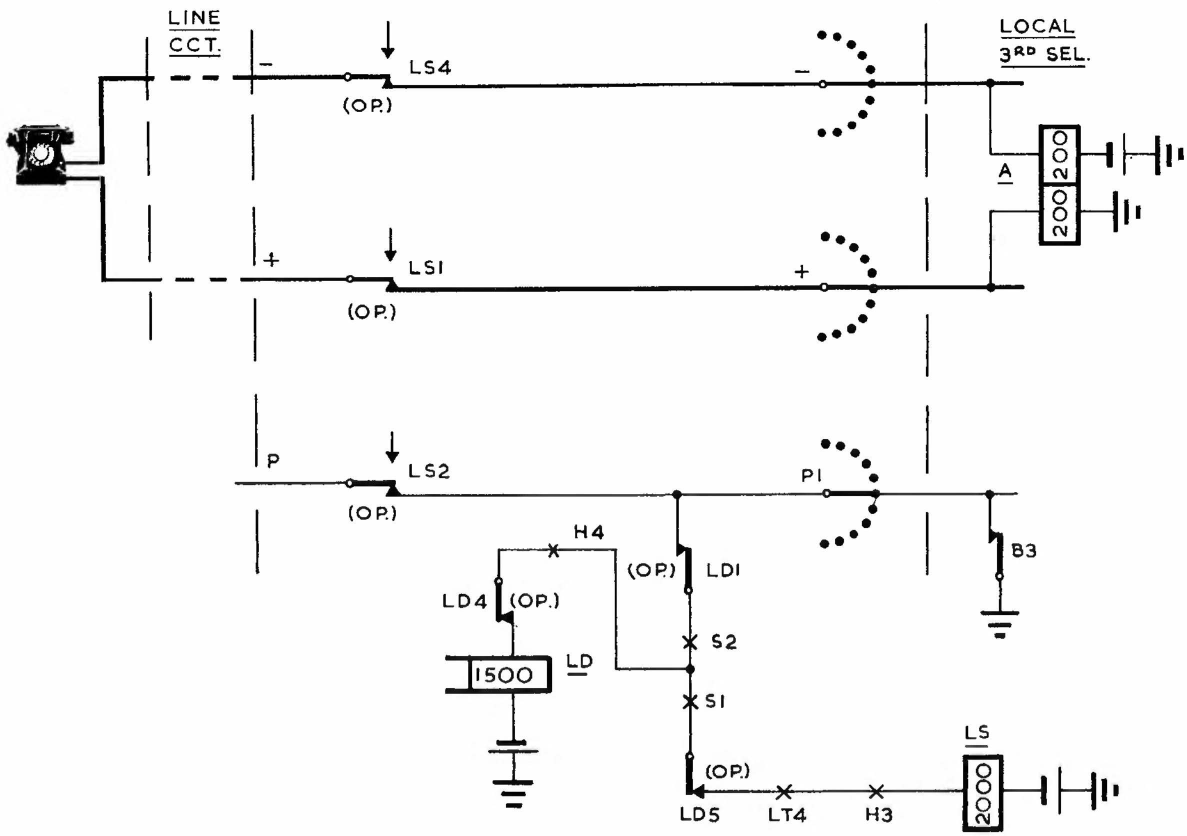


FIG. 9. LOCAL CALL-THROUGH CONNECTIONS.

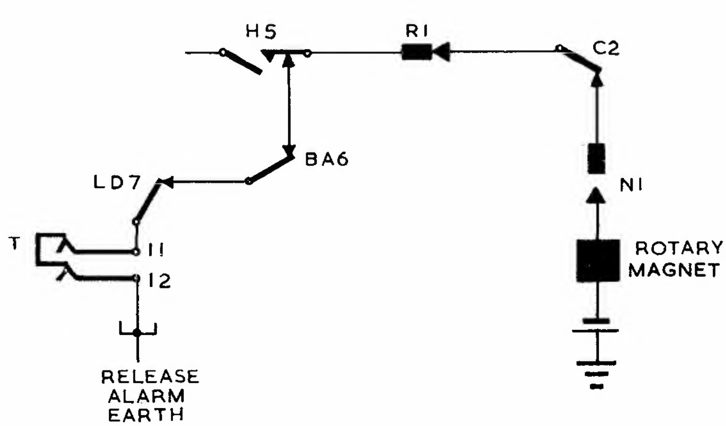


FIG. 10. D.S.R. RELEASE CIRCUIT.

Call to Adjacent Branch Exchange (MF). When the D.S.R. is seized, the caller receives dial tone and proceeds to dial the first digit (M) of the branch exchange number. Since this is the same as the first digit of the local number, the operation of the circuit is identical with that described for a local call on pages 8-9. The digit is absorbed and the D.S.R. restores to normal in readiness for the receipt of the second impulse train, with relays A, B, BA, J, K, I, JG, OA and H operated. At the parent main exchange, a second selector is seized during the dial interdigital pause.

Relay A responds to the second train of impulses and A2 repeats the impulses over the junction to the main exchange. During the first break period, A1 operates relay C and the vertical magnet. The magnet operates with each impulse and the D.S.R. is stepped to the dialled level. Relay C remains operated during impulsing and releases slowly at the end of the impulse train. A circuit is then completed for the rotary magnet via N1, C2, OA1, K1 and JG1 to earth at H5, and the wipers are stepped on to the first bank contacts of the dialled level. The P2 contact, being on the level associated with the second digit of the adjacent branch exchange numbers, is strapped to tag "K". Relays LD and LT operate in parallel via tag "K", P2 bank contact and wiper, RT6, C3, JG4 and DA4 to earth at BA1. LT2 locks the two relays directly to earth at BA1. LT1 and LT3 prepare for the extension of the junction loop circuit to the D.S.R. wipers and LT4 prevents the subsequent operation of relay LS.

LD6 opens the circuit of relay K, which releases, disconnecting the junction loop circuit and relay JG, as in the case of a local call. K1 removes the short circuit from the rotary interrupter contacts, allowing the D.S.R. to hunt for a free outlet. Relay H remains operated during hunting and releases when a free outlet is reached, cutting the drive circuit at H5 and extending the junction loop circuit at H1 and H2 to the incoming 3rd selector at the adjacent branch exchange.

Subsequent impulse trains are repeated by relay A via the D.S.R. wipers and bank to the junction, and relay C operates on each train to give a low impedance impulsing loop to the adjacent branch exchange selectors. The switch thus functions as a selector-repeater. The call proceeds with relays A, B, BA, I, J, LT, LD and OA operated, the through connections being shown in Fig. 11.

Called Party Answers. When the called party answers, the direction of current over the junction is reversed (by the final selector), allowing relay D to operate in series with rectifier MRB. D2 closes the circuit to earth at BA1 of relay MD, which operates slowly. (MD is made slow operating so that it does not respond to "flick" operations of relay D due to line surges, etc.) The operation of relay MD reverses the current on the calling line at MD6 and MD3. MD4 removes the earth on the P wire and MD1 replaces it with positive battery via 50 ohm YA for operation of the calling subscriber's meter. MD2 opens the circuit of relay J, which releases slowly. Positive battery is connected to the P wire during the release time of relay J (approximately 300 milliseconds) and, when J releases, is replaced by earth at J2. Rectifier MRA maintains an earth on the P wire during the transit time of MD and J contacts but does not shunt the positive battery pulse. Relay MD locks via MD2 and J6 to earth at BA1 but, when J releases, is again placed under the control of relay D.

As the ballast resistor is not usually required for transmission until a current reversal is given, it is replaced by 150 ohm resistors YB and YC until relay MD operates, when the ballast resistor filaments are connected in series with relay A. This guards against failure of ballast resistors in service as a result of a subscriber's line contacting a power line. In the event of failure of a ballast resistor filament, 1000 ohm resistors YD and YE, connected across each filament, will prevent the release of relay A when reversal takes place. D1 and J4 short-circuit A2 to prevent the possibility of transmitting a false impulse if relay A flicks during reversal.

The release of relay J completes the homing circuit of the junction hunter via K8 and J3 to the homing arc.

/Called

Called Subscriber Held (C.S.H.). The release of relay J prepares the circuit of the supervisory lamp at J5 and, when the called subscriber replaces the receiver, relays D and MD release and the circuit of the lamp is completed via MD5, LD2, LS3 and 1200 ohm YF to supervisory alarm battery. The lamp glows and, if the condition is maintained for the specified delay period (6 minutes) an alarm is given.

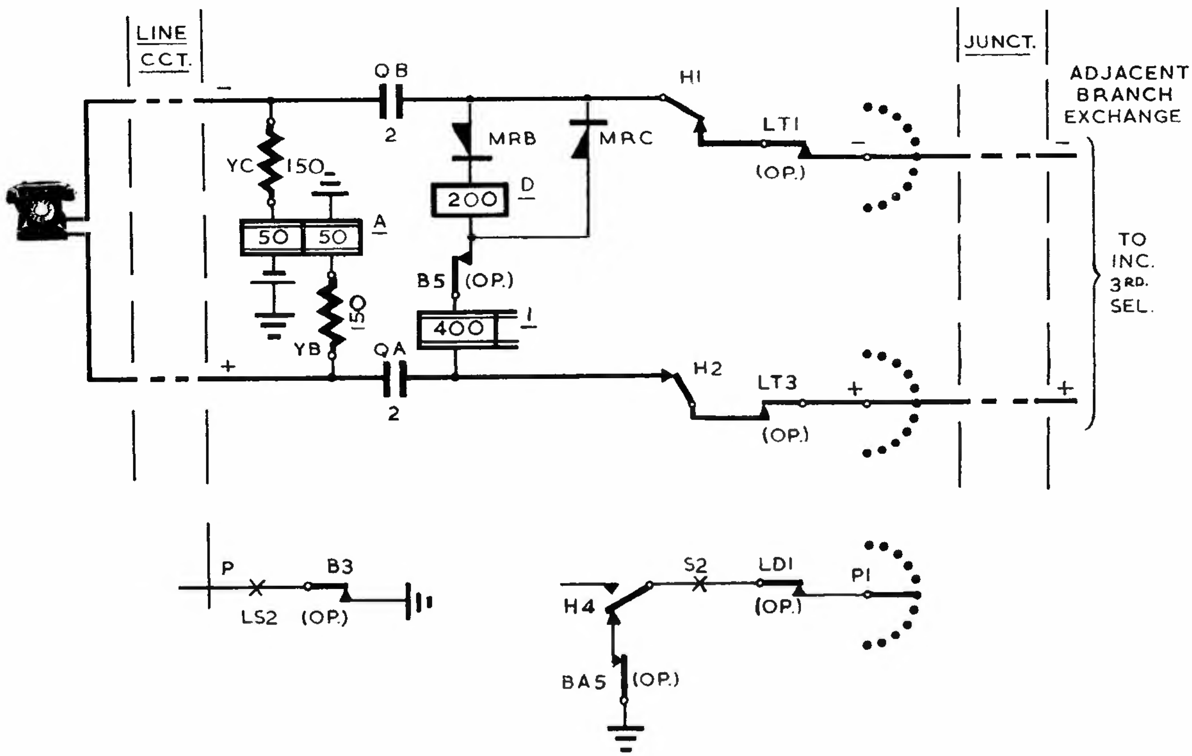


FIG. 11. BRANCH CALL - THROUGH CONNECTIONS.

All Outlets Busy. The operation, if all outlets in the dialled level are busy, is the same as on a local call, as described on page 10. The wipers rotate to the eleventh bank contacts and busy tone is given to the caller.

Release of Branch Call. When the calling subscriber replaces the receiver, relay A releases, followed by the release of relays B and BA. At the same time, A2 opens the junction loop circuit, allowing the release of the selectors at the branch exchange. Earth via BA5, H4, S2 and LD1 is maintained on the P1 bank contact during the combined release lags of relays B and BA to cover the complete release of the incoming 3rd selector. The release of relay BA allows relays LT, LD and OA to release completing the release circuit of the D.S.R. as shown in Fig. 10.

Relay C is operated from earth via B1, A1 and BA4 during the release time of relay B and, when B releases, earth is removed from the P wire to allow the calling subscriber's line circuit to restore to normal. After the release time of relay C (approximately 20 mS) the D.S.R. is again guarded with earth via N2, C5, B3 and LS2 during the release of the switch.

/Call

Call to Another Main Exchange. When the calling subscriber lifts the receiver, the operation of the D.S.R. is as described on page 8. Relays A, B, BA and J operate and the D.S.R. is stepped to the first level. At the same time, the junction hunter hunts for a free junction to the parent main exchange, and relay K operates, connecting dial tone to the subscriber, who commences to dial the required number.

Relay A responds to the dialled impulses and the rotary magnet steps the wipers into the first level. Relay C operates during the impulse train, which is repeated over the junction by A2. At the end of the impulse train, relay C releases and a test is made on the P2 bank contact on which the wiper is resting.

The contacts corresponding to the discriminating digits for calls to main exchanges other than the parent main exchange (all contacts other than M or 6 in this case) are strapped to tag "c". Thus, after the first digit is dialled, the P2 wiper is resting on a contact which is strapped to tag "c" and, when relay C releases, a circuit is completed for relay JD via tag "c", P2 bank contact and wiper, RT6, C3, JG4 and DA4 to earth at BA1. JD operates and locks via JD1 to earth at BA1. JD2 disconnects the D.S.R. magnet circuit to prevent further stepping and JD5 opens the circuit of relay JG which releases slowly. JD6 prepares the C.S.H. alarm circuit.

Subsequent impulse trains are repeated over the junction to the parent main exchange, relay C operating on each train to give a low impedance impulsing loop.

Call to Parent Main Exchange. In this case, the first digit dialled corresponds with the first digit of the local exchange numbers (M), and the operation when the calling subscriber dials the first digit is the same as for a local call, as described on pages 8-9. Relays A, B, BA and J operate and the D.S.R. is stepped to the first level. The junction hunter hunts for a free junction and relay K operates and connects dial tone to the calling subscriber. The first digit rotates the wipers into the first level and, as this digit corresponds to the first digit of the local exchange numbers, relay DA operates via tag "a" and the P2 bank contact and wiper. The operation of relay DA energises the rotary magnet in series with its interrupter contacts, and the D.S.R. restores to normal. Relays H and OA operate and DA releases.

When the second digit is dialled, the wipers are stepped to the dialled level and relay C operates. At the end of the impulse train, relay C releases and the rotary magnet operates to step the wipers to the first contact of the level. A test is made on the P2 bank contact and, as all levels other than the levels corresponding to the local exchange or adjacent branch exchanges are strapped to tag "c", relay JD operates. The subsequent operation is as described under "Call to Another Main Exchange," the D.S.R. functioning as a repeater.

Where the second digit of the main exchange numbers is "A" or "1" (for example, MA), tag "g" is strapped to tag "c". Relay JD then operates after the second digit is dialled via tag "c", tag "g", OL5, OA3, first P2 bank contact and wiper, RT6, C3, JG4 and DA4 to earth at BA1.

All Junction Outlets Busy. If all junction outlets to the main exchange are busy, the junction hunter rotates to the 25th contacts. As these are not multipled, relay K operates in series with the junction hunter drive magnet. Despite the lack of a free junction to the main exchange, dial tone is connected to the calling line. Busy tone, indicating the junction congestion condition, is not given until the routing of the call has been decided. If the junction to the parent main exchange is necessary for the completion of the call, relay JD will operate after the first or second digit has been dialled. Busy tone is connected to the tone winding of relay I via JD3 and I1. As the 25th contacts of the junction hunter are not wired to a junction, relay I cannot operate. JD4 extends the earth from K7 for operation of the overflow meter.

If the digits dialled indicate that a junction to the main exchange is not necessary, relay JD does not operate and the call to the local exchange or adjacent branch exchange may proceed normally. In this case, busy tone is not given and the overflow meter is not operated.

/Call

Call to Trunk Exchange. If direct access to the Trunk Exchange is required, the direct junctions are connected to the first level of the D.S.R. Access to these lines is obtained by dialling the single digit "0" and, to effect the necessary discrimination, the tenth P2 contact of level 1 is strapped to tag "b". The digit is absorbed and the D.S.R. is arranged to hunt automatically over level 1 for a free junction to the trunk exchange as described below.

When the D.S.R. is seized, relays A, B and BA operate as previously described. The junction hunter searches for a free outlet and relay K operates when a free junction is reached. The vertical magnet operates to step the wipers to the first level.

The calling subscriber receives dial tone when relay K operates and, when dialling takes place, the rotary magnet steps the wiper carriage according to the digit dialled (in this case, "0"). Relay C operates in parallel with the rotary magnet and C5 operates relay JG, which locks via JG2 and K6 to earth at JD5.

At the end of the impulse train, relay C releases and, as the tenth contact of level 1 is strapped to tag "b", relay OL operates via tag "b", P2 bank contact and wiper, RT6, C3, JG4 and DA4 to earth at BA1. OL locks on its second winding via OL1 to earth at BA1 and OL2 completes the circuit of relay DA which also operates and locks. The operation of relay DA causes the D.S.R. to restore to normal, as previously described. Relay H operates and, when the wipers reach the normal position, relay OA operates and releases relay DA.

The vertical magnet is connected via N3 and OL3 in series with the second winding of relay C to earth to B2. Relay C operates but the vertical magnet does not operate in series with 500 ohms relay C. However, C1 connects a full earth to the vertical magnet, which operates and steps the wipers to the first level. N3 breaks the circuit of the vertical magnet and relay C releases slowly, being short-circuited by the earth at C1. When relay C releases, the circuit of the rotary magnet is completed via N1, C2, OA1, K1 and JG1 to earth at H5, and the wipers are stepped to the first contacts of level 1. As this circuit does not include the rotary interrupter contacts, there is no automatic hunting at this stage.

The first contact of level 1 is permanently connected to OA3 and, as relays OA and OL are operated, relays LD and LT operate over the P2 wiper and bank contact. The subsequent operation is similar to that for a call to an adjacent branch exchange. LD6 releases relay K, and the junction to the parent main exchange is released. K1 removes the short-circuit from the rotary interrupter springs, allowing the rotary magnet to drive the wipers over the contacts of level 1. Relay H tests on the P1 contacts and, on reaching a free outlet, relay H releases. The rotary drive circuit is cut and the call is switched through to the junction to the trunk exchange. The call proceeds with relays A, B, BA, I, J, OA, OL, LD and LT operated.

Operator Hold Facility. When the call is answered, the direction of current over the junction is reversed and relay D operates. Relay MD operates and relay J releases. The calling subscriber's meter is operated during the release time of relay J, as described under "Called Party Answers" on page 12. Should the calling subscriber replace the receiver before the trunk operator clears the connection, the junction is guarded as follows -

When the subscriber replaces the receiver, relay A releases, followed by the release of relay B. Relay C is operated during the release time of relay B, and B3 removes the earth from the P wire, allowing the subscriber's line circuit to release. After the release of relay C, the D.S.R. is again guarded by earth via N2, C5, B3 and LS2. Until the operator clears the connection, the battery condition on the junction is reversed and relay I is held by the negative battery over the positive wire of the junction to earth via B5 and OL4. I2 holds relay BA, thus preventing the release of the switch.

When the operator clears the connection, relay I releases, followed by the release of relays BA, OA, OL, LD and LT, and the D.S.R. restores to normal as previously described.

/5.

5. TEST QUESTIONS.

1. (a) Draw the circuit of a relay-set suitable for use on junctions from an automatic exchange to a manual Information desk, assuming that calls to the desk are not to be metered against the calling subscriber.

   (b) Explain how the junction is guarded when the calling subscriber has replaced the receiver but the manual desk operator has not cleared the connection.

2. Explain the conditions when D.S.R's are used in preference to relay-set repeaters at an automatic branch exchange. State the advantages of their use.

3. State the differences between the 2000 type D.S.R. and the pre-2000 type switch.

4. List the functions of a 2000 type D.S.R. installed in a branch exchange which is one of the exchanges in a larger Australian metropolitan network.

5. Give a short description of the operation of the D.S.R. during the setting-up of a call to an adjacent branch exchange, that is, a cross-switched call.

6. Assuming the junction seized by a junction hunter associated with a 2000 type D.S.R. to be open-circuit, explain the effect on the operation of the circuit under the following conditions -

   (a) Call to parent main exchange.

   (b) Local call.

7. Explain the reason for the use of junction release guard relays with junctions to the parent main exchange from a branch exchange using 2000 type D.S.R's.

8. Why are junction release guard relays not required on direct junctions from the branch exchange to an adjacent branch exchange?

6. REFERENCES.

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END OF PAPER.

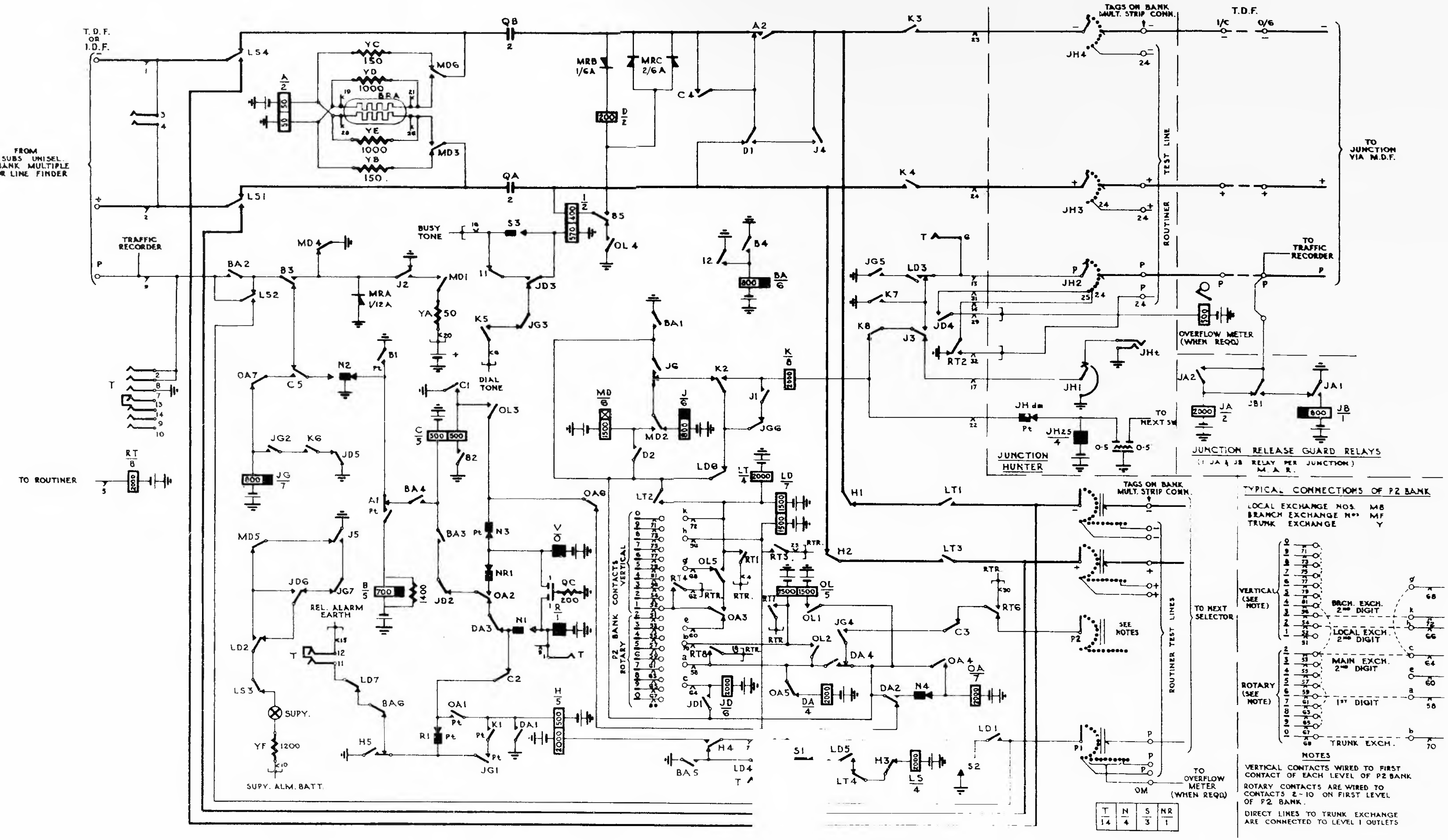

FIG. 6. DISCRIMINATING SELECTOR RE 2000 TYPE (CE.133).

COMMONWEALTH OF AUSTRALIA.

Engineering Services,
Postmaster-General's Department,
Treasury Gardens,
Melbourne, C.2.

COURSE OF TECHNICAL INSTRUCTION.

2000 TYPE EXCHANGE.

CONTENTS.

1. MOUNTING OF APPARATUS.

2. CABLING ARRANGEMENTS.

3. LAYOUT OF EXCHANGE SWITCHROOM.

4. POWER DISTRIBUTION.

5. RING AND TONE DISTRIBUTION.

6. TEST QUESTIONS.

7. REFERENCES.

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1. MOUNTING OF APPARATUS.

1.1 All apparatus in 2000 type exchanges is mounted on open or single-sided racks. Details of the method of mounting are given in Paper No. 1. The 10 ft. 6-1/2 in. rack is the only size in common use in Australia, and is usually 4 ft. 6 in. wide. These racks accommodate a number of shelves of selectors, or relay-sets, each shelf mounting 10 switches at 4-3/4 in. centres. Other rack widths are used for miscellaneous apparatus.

1.2 Apparatus is mounted on one side of the rack only (the apparatus side), while the reverse side is called the wiring side. Racks are installed in rows, or "suites." Gangways, or "aisles," open at both ends, are left between the suites. It is usual to arrange the suites so that they face alternate directions, and this results in aisles giving access to apparatus and wiring sides respectively, as shown in Fig. 1. It is necessary to make provision for a travelling ladder in the apparatus aisle, and also to allow sufficient space for introducing portable test sets, etc. The apparatus aisle generally gives a clear space of 2 ft. 6 ins., while the wiring aisle allows 1 ft. 6 in.

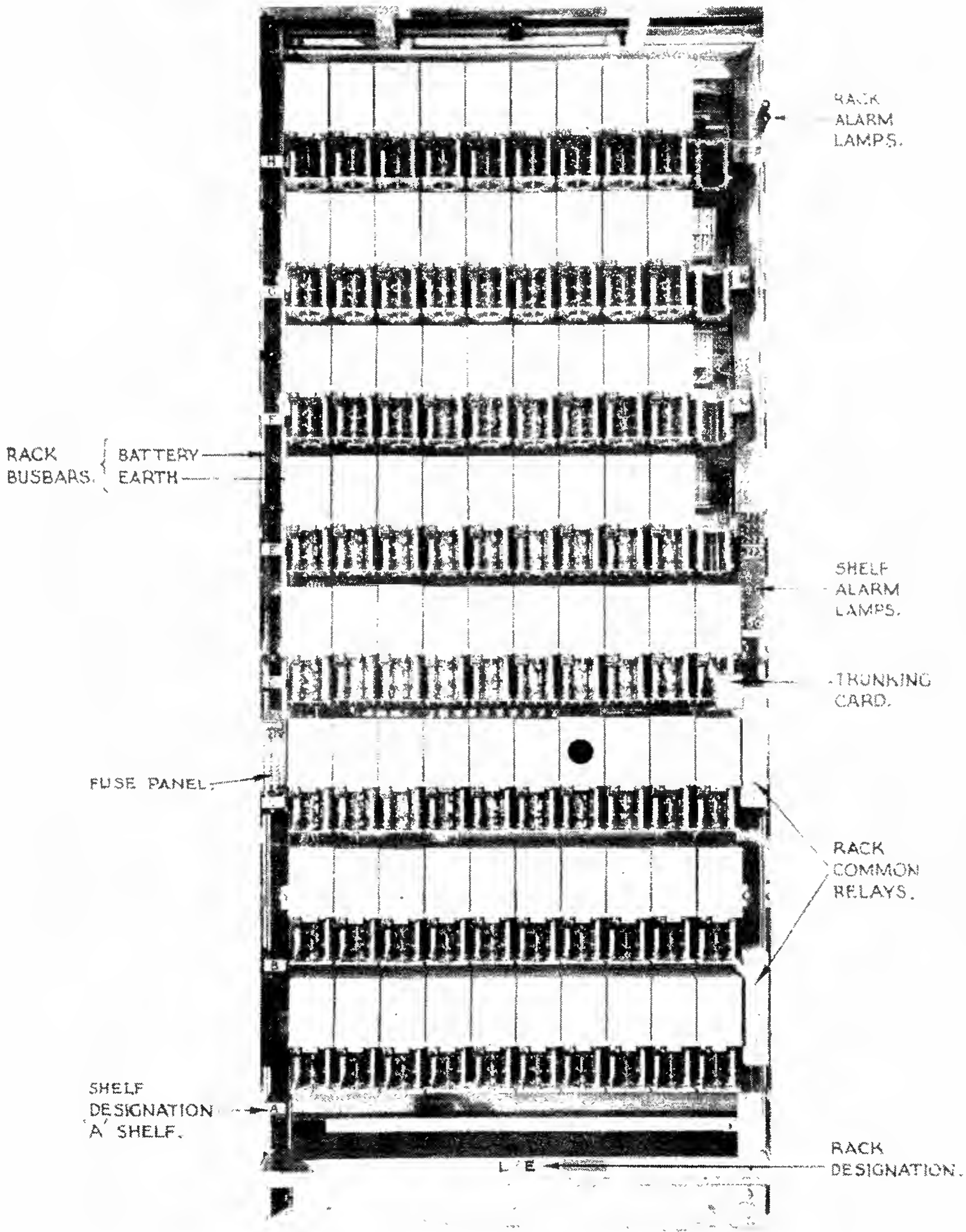
1.3 The single-sided rack provides flexibility in trunking and layout, economy in floor space, even weight distribution over the floor and easy access to apparatus for maintenance purposes. In addition to the mechanical advantages claimed for the 2000 type selector, the reduction in the size of the switch has made it possible to accommodate an increased number of selectors on a given size of rack. For example, the number of 2000 type 200 outlet group selectors which can be fitted on a 10 ft. 6-1/2 in. rack is 80, as against 60 for the equivalent pre-2000 type selector. Compared with the earlier type switches and mounting arrangements, a 10-15 per cent. saving in floor space is possible with single-sided racks and 2000 type apparatus.

1.4 The following paragraphs describe typical racks, and details of the various types of racks are now given.

SUITES OF FINAL SELECTORS SHOWING WIRING AND APPARATUS AISLES.

FIG. 1.

(i) Group Selector Racks. Fig. 2 shows a rack of 200 outlet group selectors. The rack carries eight shelves of ten switches, or a total capacity of 80 group selectors. The shelves are designated A, B, C, etc., as shown in Fig. 2. Racks are designated according to the switch rank, that is, according to the digits dialled to reach the switches on that rack. Thus, the rack shown is a 2nd selector rack at the "L" exchange, as it is designated L/E. The "E" indicates that it is the fifth rack in that particular rank. 1st selector racks are designated 1st A, 1st B, etc. Thus, the switch marked in the figure is the seventh switch on C shelf on rack L/E, or simply C7 on L/E.

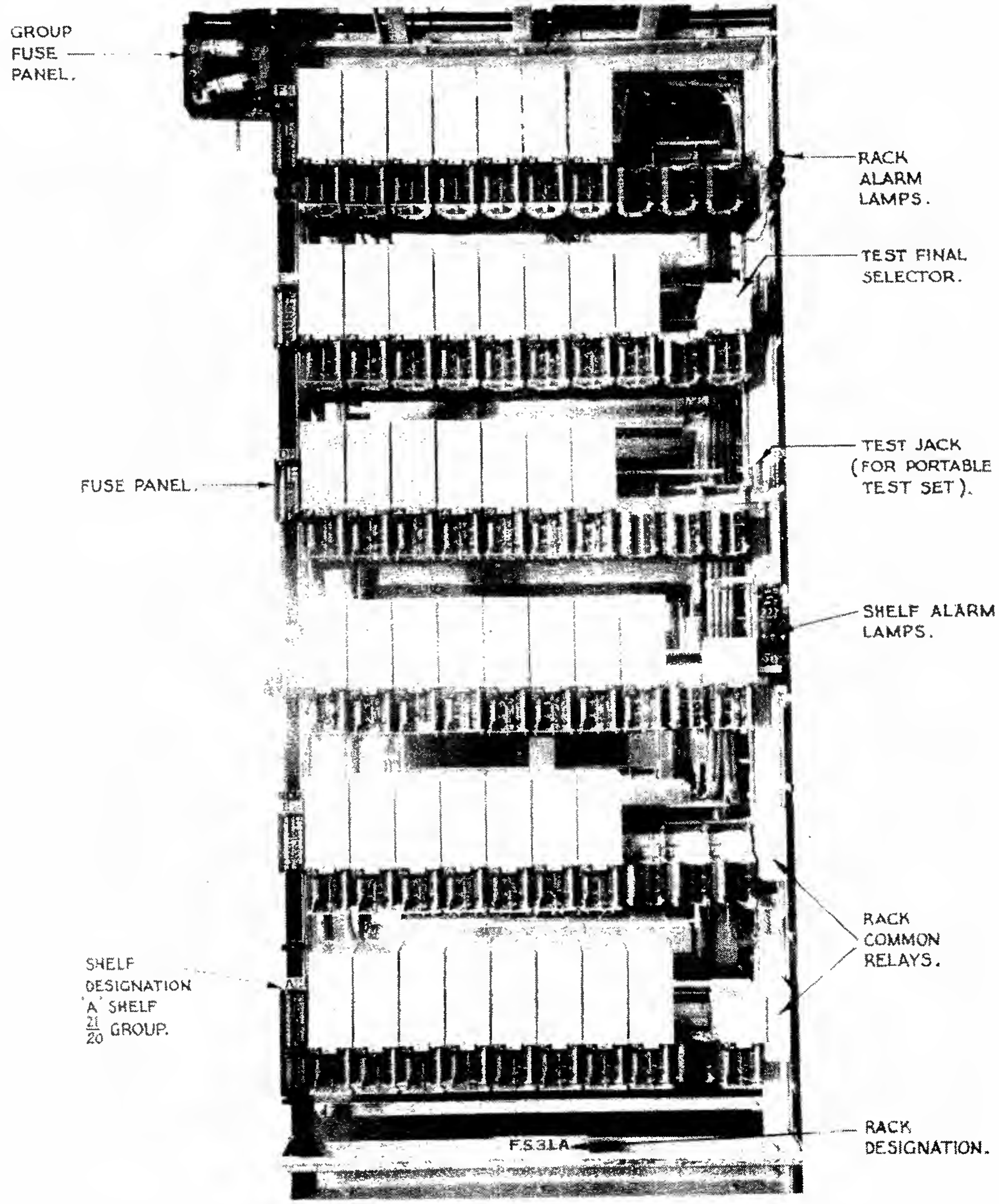


RACK OF 200 OUTLET GROUP SELECTORS.

FIG. 2.

(ii) Final Selector Racks. (Fig. 3). Six shelves of ordinary or P.B.X. final selectors are mounted on a standard rack. The number of switches and banks for each 200 line group varies according to the traffic requirements of the group. In Fig. 3, the rack carries three groups, each having 20 banks, with 15 switches in place. A test final selector is provided for each group.

The shelf designation gives the shelf number and the group which the switches serve. It is usual to designate P.B.X. groups in red. Racks are numbered FS1, FS2, etc., and the suffix (LA) gives the letter prefix of the exchange numbers.

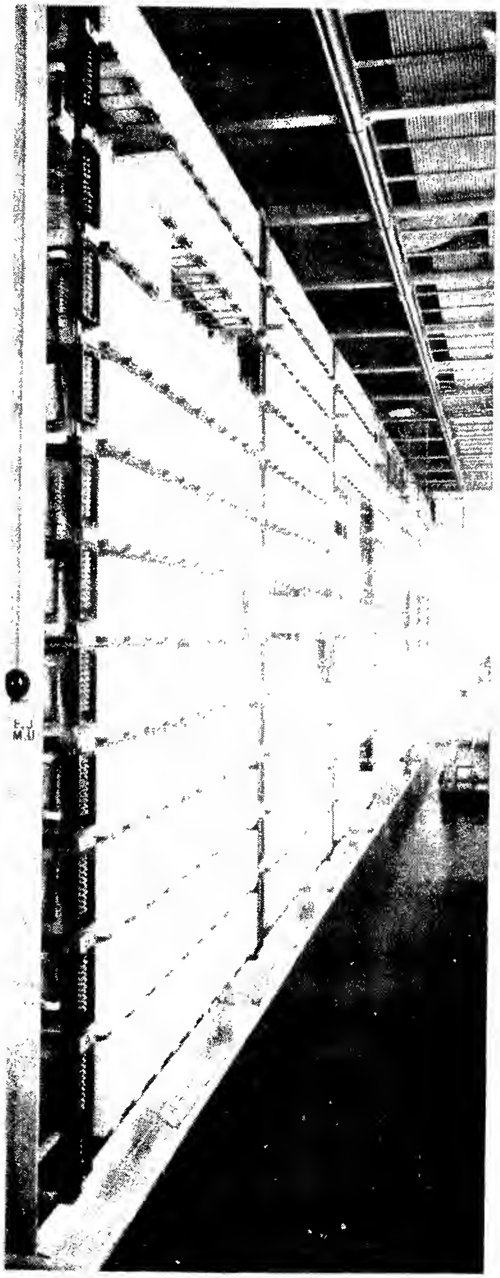


FINAL SELECTOR RACK.

FIG. 3.

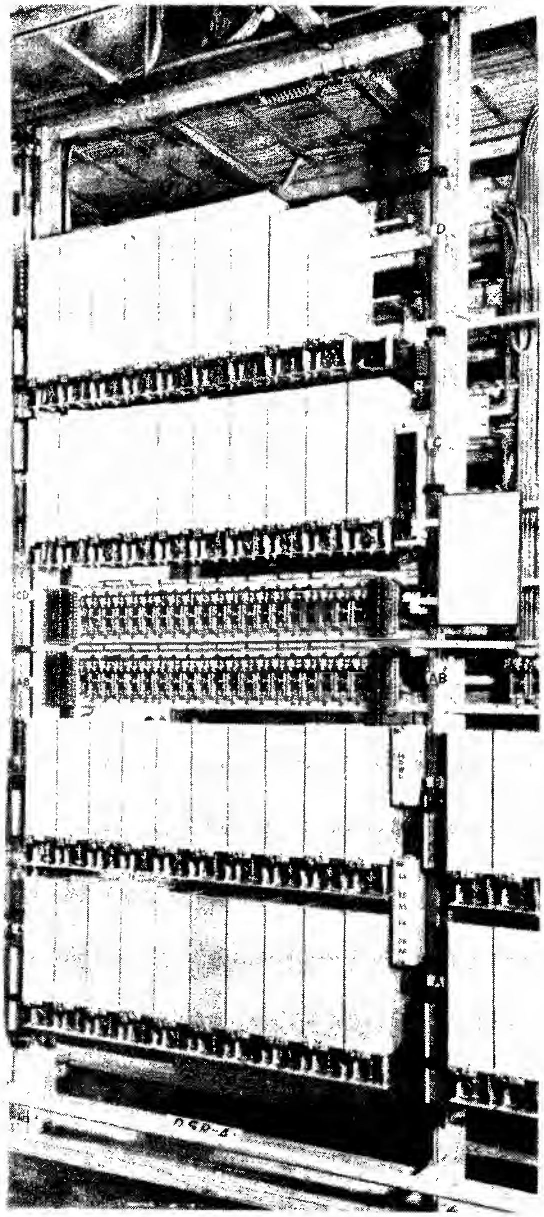
(iii) Relay-set Racks. Fig. 4 shows a suite of relay-set racks. Each rack accommodates 12 shelves of relay-set repeaters, or a total of 120 switches. For miscellaneous relay-sets, the number of shelves depends on the size of each relay-set. Relay-set racks are designated R.S.R.1, R.S.R.2, etc.

(iv) D.S.R. Racks. Four shelves of D.S.R's and the associated junction hunters are mounted on a rack, as shown in Fig. 5. D.S.R. racks are designated DSR-A, DSR-B, etc.



SUITE OF RELAY-SET RACKS.

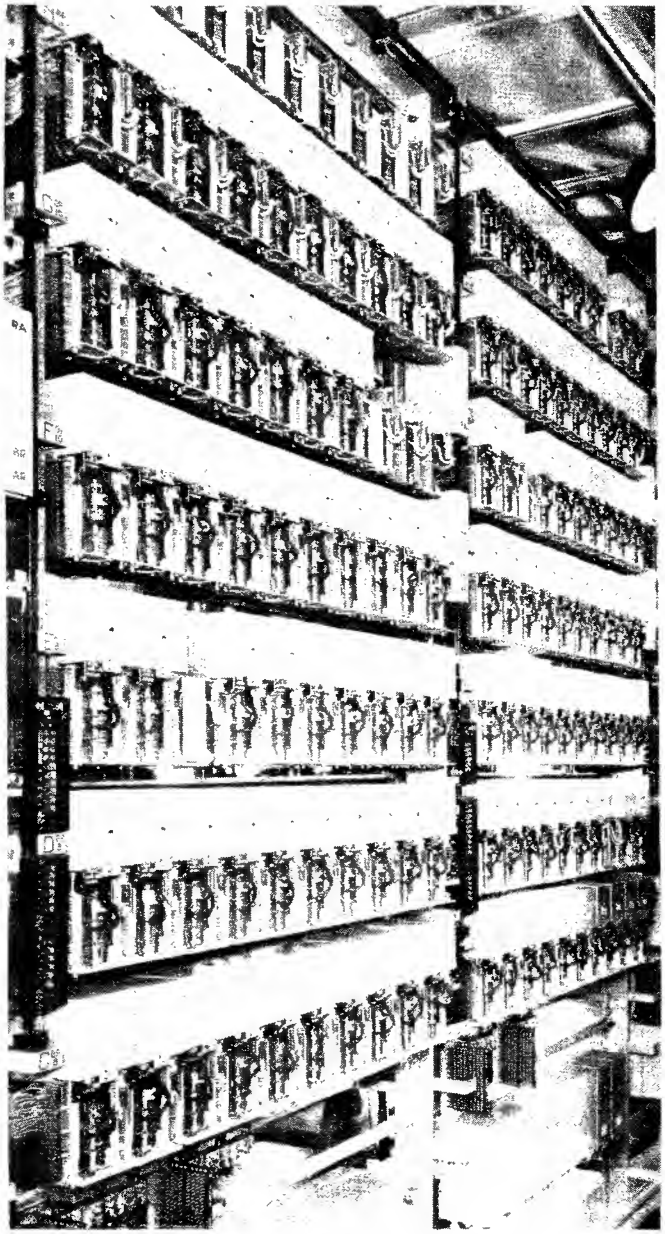
FIG. 4.



D.S.R. RACK.

FIG. 5.

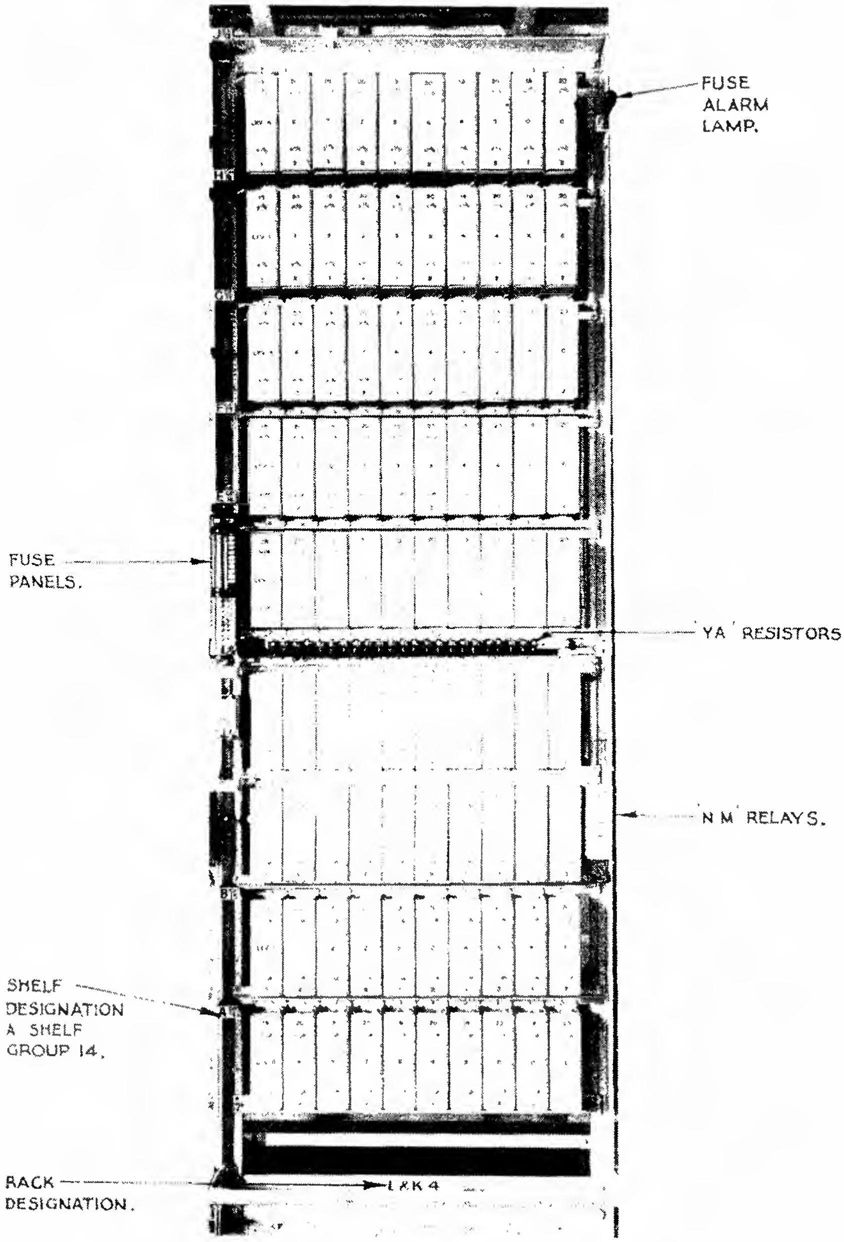
(v) Line Finder Racks. (Fig. 6.) The line finder rack equipment varies with the number of line finder banks per group. As the primary start relay-sets, primary control relay-sets and primary allotters are also fitted on this rack, the maximum number of shelves available for mounting primary finders is seven. Except where 25 finders are provided per group, each rack accommodates a number of complete groups including all the control apparatus for these groups. When 25 finders are provided per group, a suite of three racks accommodates eight complete groups, there being 70 finders on the first rack, 60 on the second and 70 on the third. The start and control relay-sets, together with the allotters, are mounted on special shelves below the primary finders.



200 POINT PRIMARY LINE FINDER RACKS.

FIG. 6.

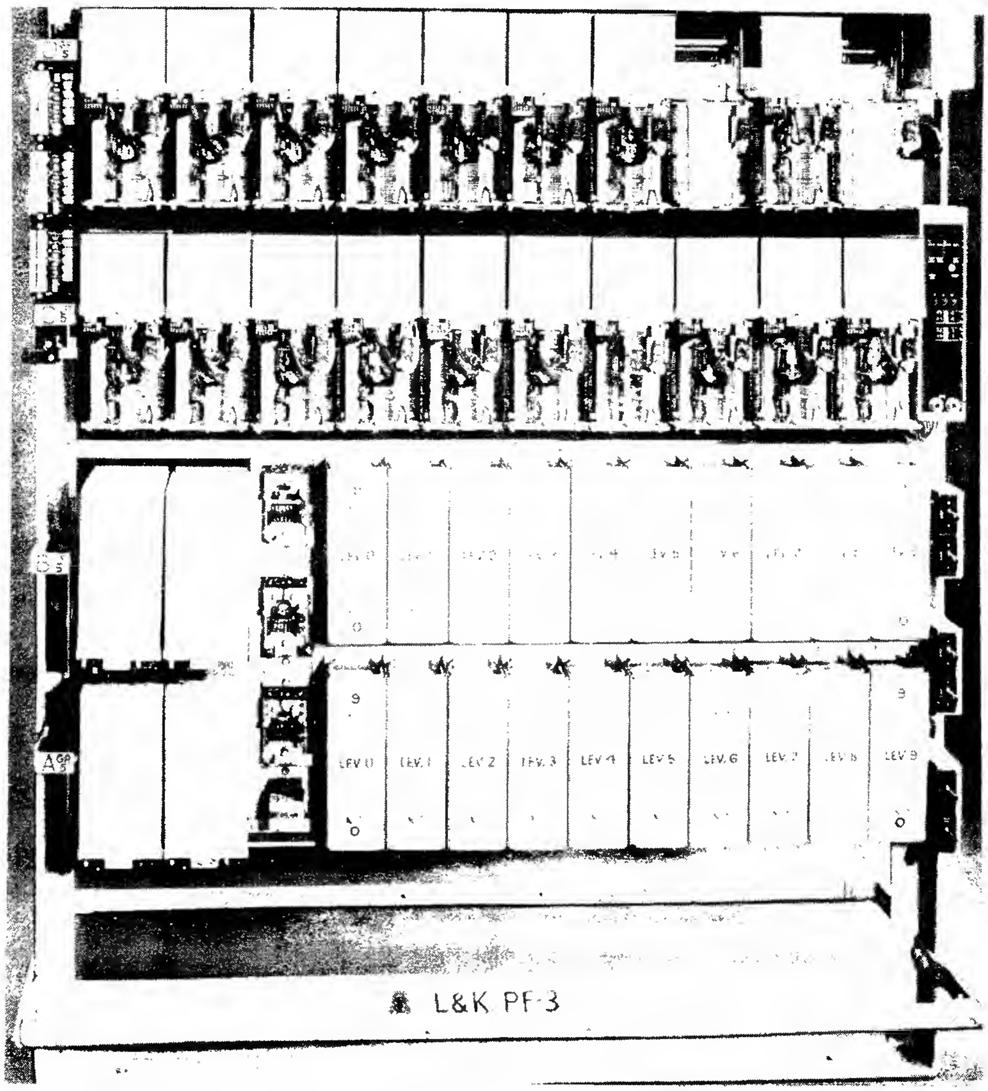
(vi) L and K Racks. Subscribers' line and cut-off relays are mounted on racks 3 ft. 6 in. wide, which accommodate 900 pairs of relays, that is, four and a half 200 line groups (see Fig. 7). The relays are mounted in two vertical rows on plates which cater for 10 line circuits each. Ten of these plates are bolted to the shelf which thus carries 100 line circuits, two shelves constituting one group. The NM relays and 150 ohm YA resistors (see Paper No. 3) are also mounted on this rack.



L AND K RACK.

FIG. 7.

(vii) Composite Primary Finder/L and K Rack. Latest practice is to mount the L and K relays on the same rack as the primary finder equipment. One size of multiple only is used (25 banks per 200 line group) and two complete groups are mounted on each rack. This standardisation has the advantage of making it possible to transfer racks without modification from one exchange to another, and to keep in stock a type of rack which can be used in any area. Installation is facilitated, as the L and K relays are wired to the finder banks on the rack and no cabling is necessary between these items. Fig. 8 shows the lower half of a composite rack, carrying the L and K relays, allotters, start and control relay-sets and primary finders for Group 5. The upper half of the rack carries similar apparatus for Group 6.



PART OF A COMPOSITE LINE FINDER/L AND K RACK.

FIG. 8.

(viii) Meter Racks. Subscribers' meters (100 A type) are mounted on plates, as shown in Fig. 9. Each plate carries 100 meters and a test jack. The meter rack (Fig. 10) has a width of 3 ft. 6 in. and carries 1200 meters.

/ Fig. 9.

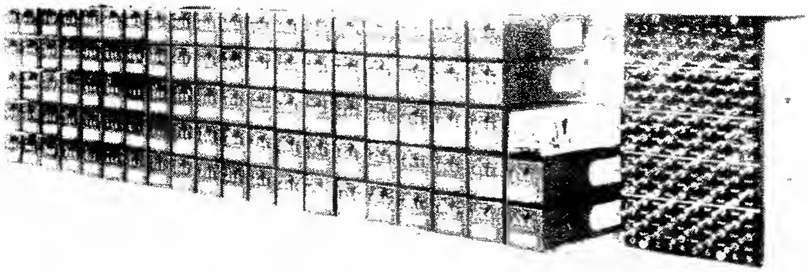


FIG. 9. 100 SUBSCRIBERS' METERS.

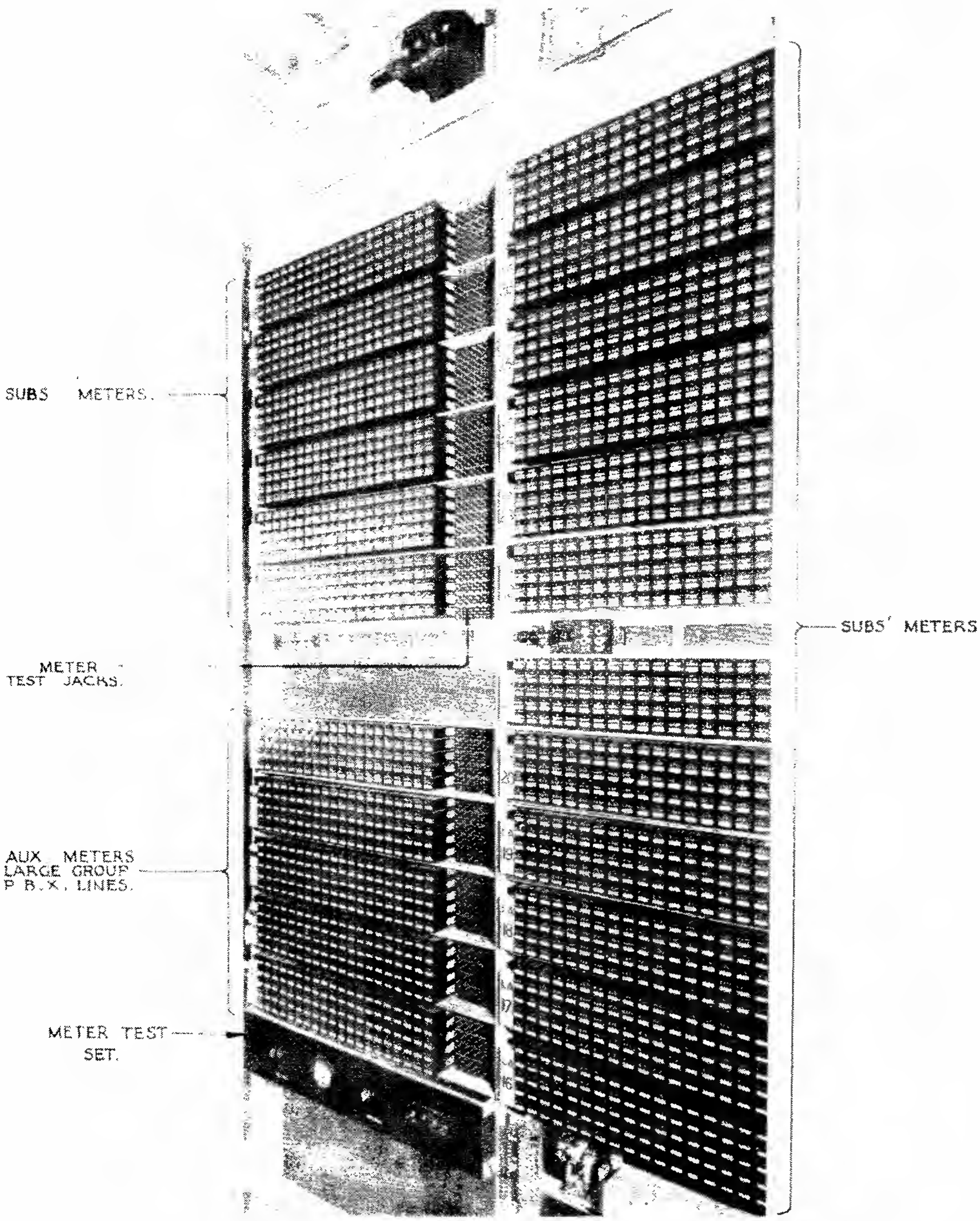
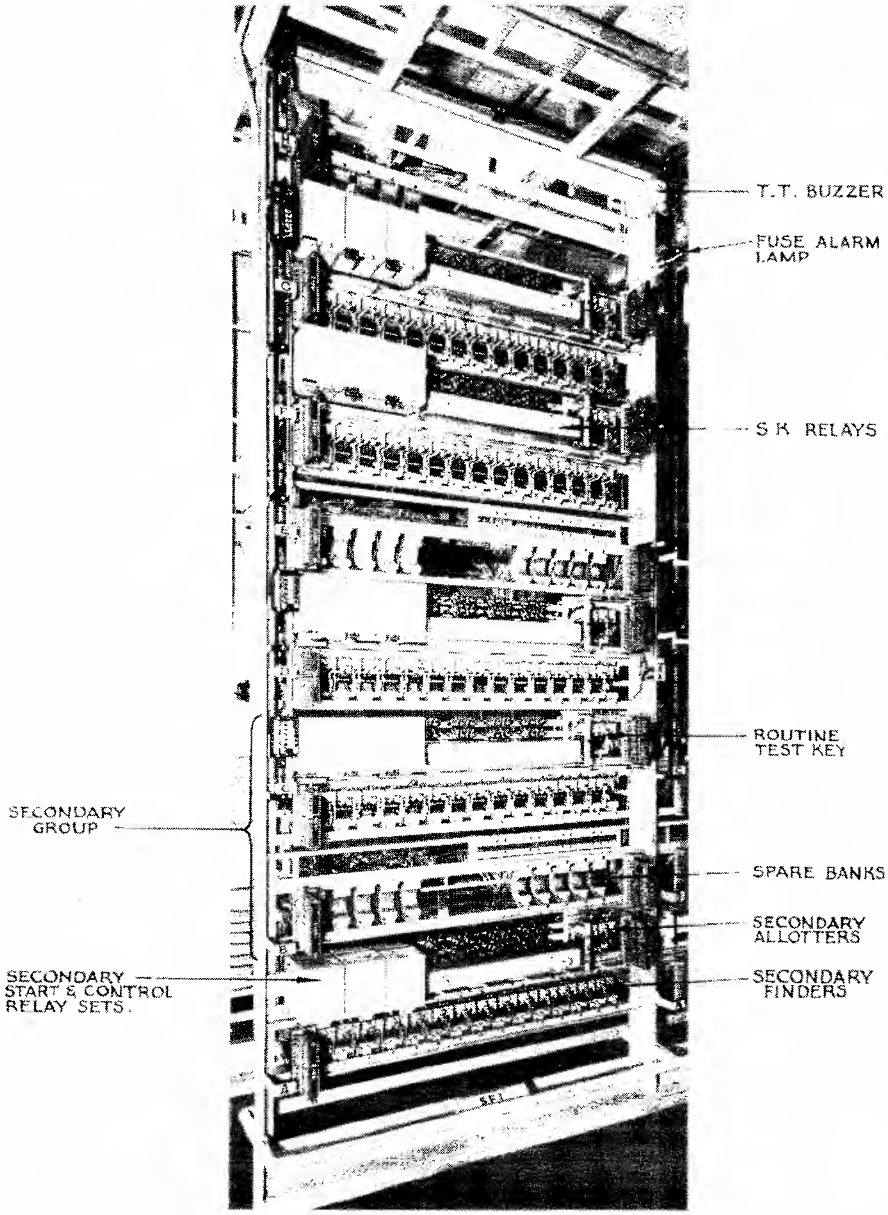


FIG. 10. METER RACK.

(ix) Secondary Finder Racks. (Fig. 11.) Each secondary finder rack can accommodate a maximum of seven shelves, each carrying 15 secondary finders, together with associated secondary allotters, start and control relay-sets. Where not more than 15 finders are provided per secondary group, such a rack would cater for up to seven secondary groups. In many cases, however, this number of finders in a group is exceeded, and one rack may carry five groups of 20 finders per group, or four groups of 25 finders per group.

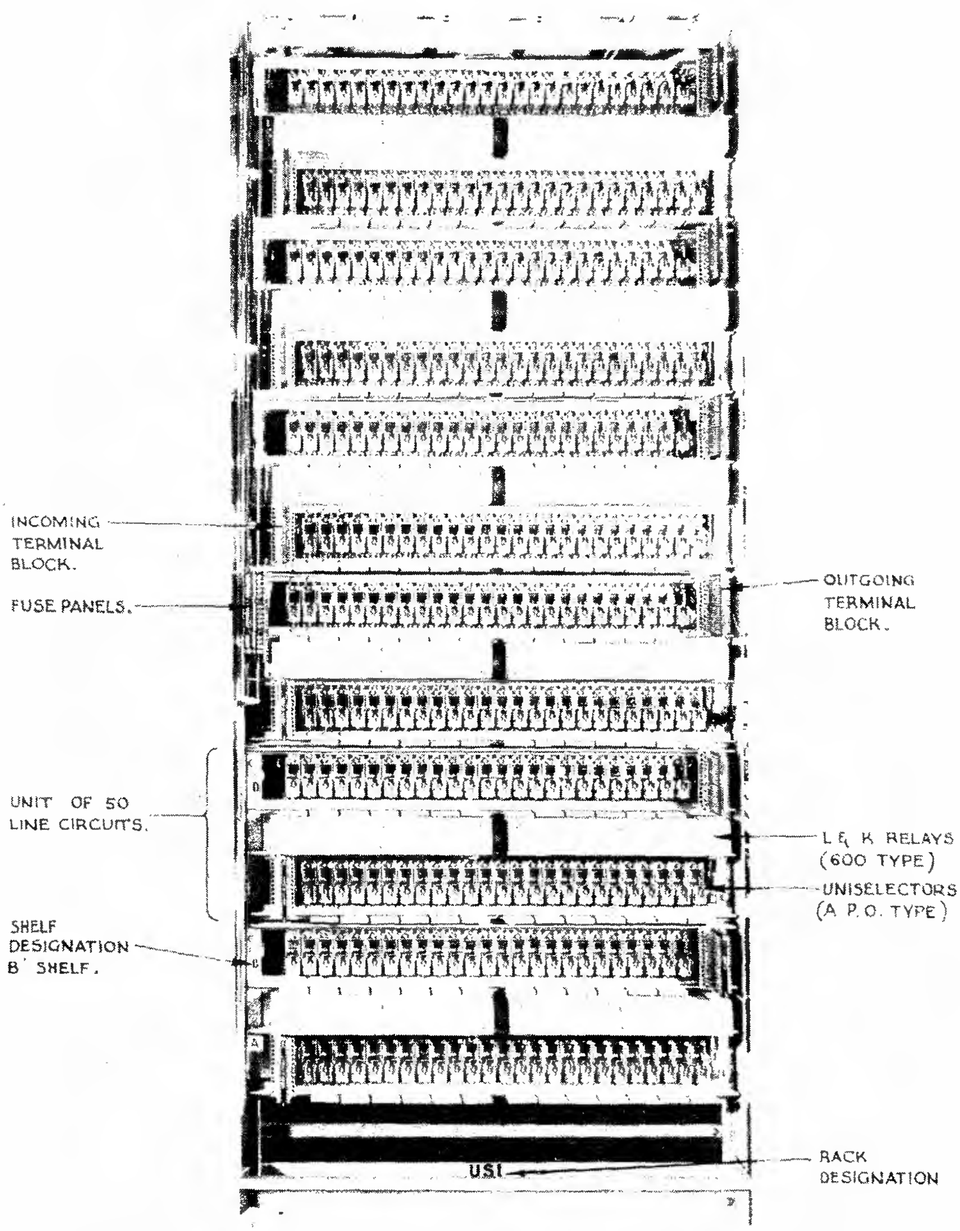


SECONDARY FINDER RACK.
(5 groups of 20 banks with 14 Secondary Finders.)

FIG. 11.

(x) Uniselector Racks. At exchanges where the calling rate necessitates more than 25 finders per group, it is now the practice to install subscribers' uniselectors in lieu of line finder equipment. Subscribers' uniselectors are mounted on units consisting of two shelves of 25 uniselectors and the associated L and K relays. Each unit is provided with a terminal block for the 50 subscribers' lines and a second terminal block for the outgoing trunks. On the latter block, separate terminals are provided for each shelf of 25 uniselectors.

Six units are mounted on a standard rack (10 ft. 6-1/2 in. × 4 ft. 6 in.), that is, 300 line circuits are mounted on each rack. Fig. 12 shows a typical uniselector rack.

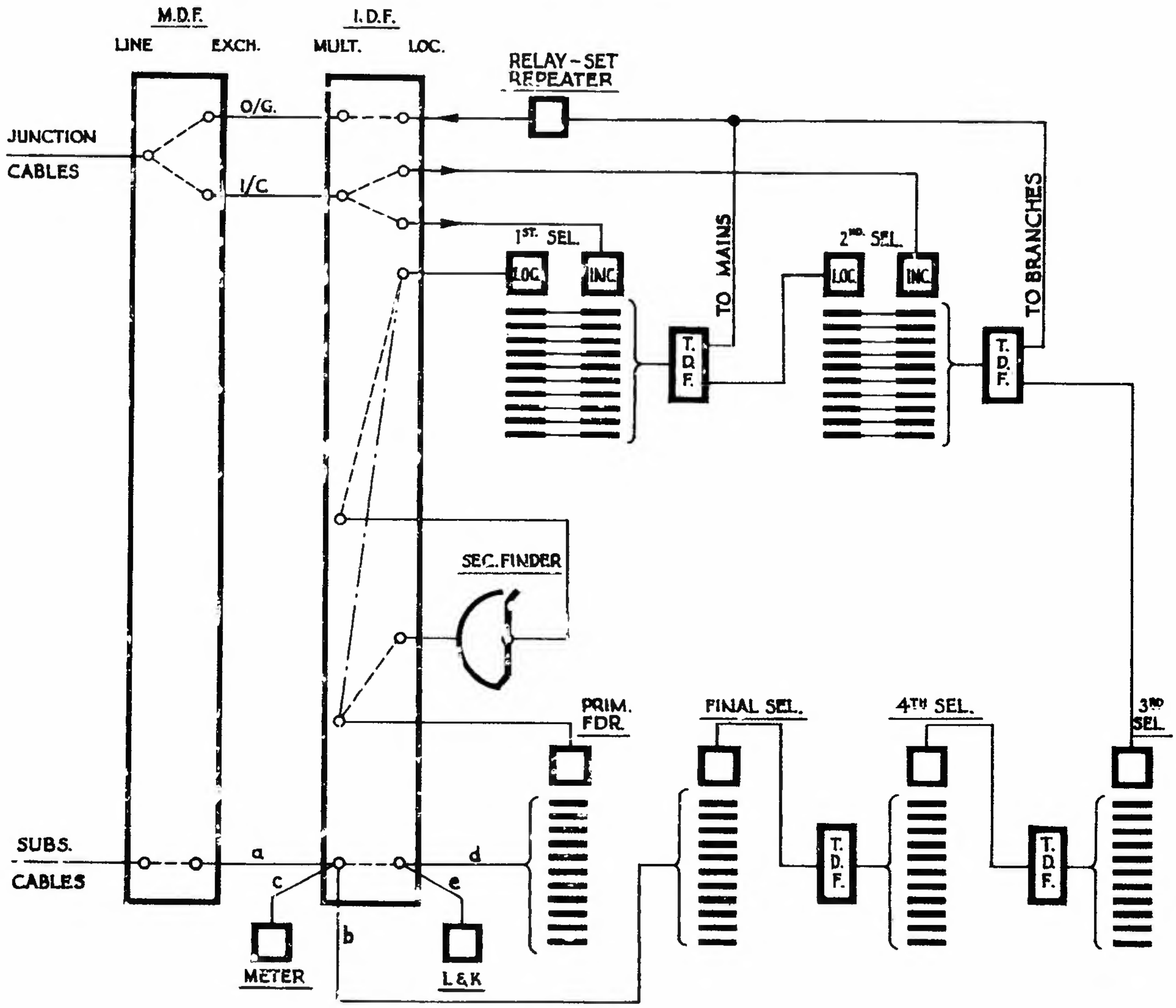


UNISELECTOR RACK.

FIG. 12.

2. CABLING ARRANGEMENTS.

2.1 In earlier 2000 type exchanges, the cabling from a large part of the apparatus is concentrated at a central I.D.F., as shown in Fig. 13. The main object of such an arrangement is flexibility, as it is possible to interconnect various pieces of apparatus by means of jumper wires on the I.D.F.



SCHEMATIC CABLING DIAGRAM OF MAIN EXCHANGE WITH FULL I.D.F.

FIG. 13.

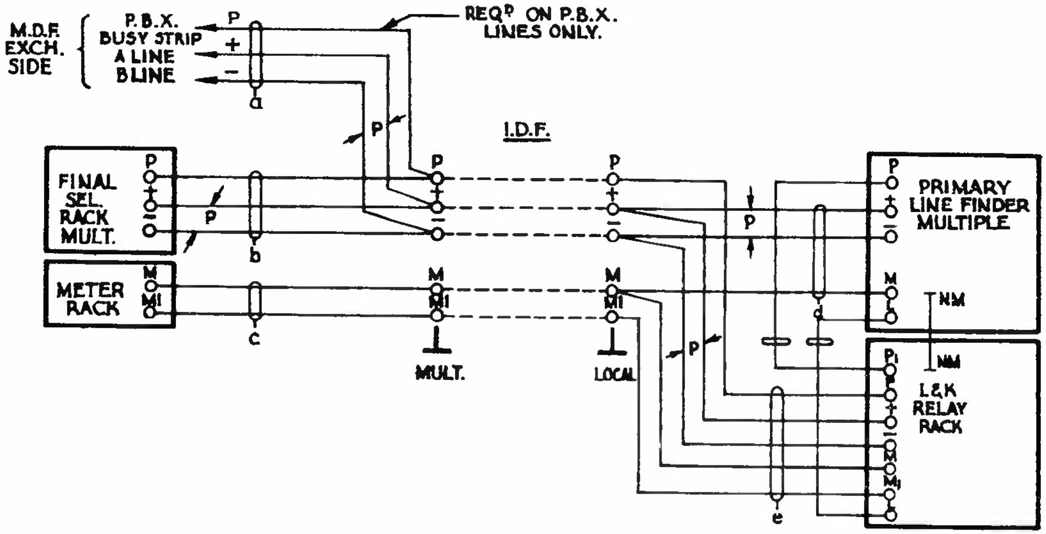
2.2 Cabling of Subscribers' Line Circuits. The cabling of a subscriber's line circuit in a line finder exchange shows the function of the I.D.F. This is shown in detail in Fig. 14. Cables from the M.D.F., final selector bank multiple and meter rack are terminated on the multiple side of the I.D.F., whilst the cables from the L and K relays and the line finder bank multiple are terminated on the local side. The multiple and local sides of a subscriber's line circuit are connected together by means of a 5-wire jumper.

With this arrangement, it is possible to connect a subscriber to any line finder group and to any position in the line finder multiple without changing the position in the final selector multiple, that is, the directory number. This makes it possible to

/ distribute

distribute the subscribers over the line finder groups in such a way that the traffic originated by each group is approximately the same. For example, the subscribers having comparatively high individual calling rates are distributed evenly over all line finder groups in the exchange, and connected to the lower levels of the line finder bank multiples.

The I.D.F. cables in Fig. 14 are designated a, b, c, d and e, respectively, and are to be compared with the corresponding cables in Fig. 13.



LINE FINDER EXCHANGE.

CABLING OF SUBSCRIBER'S LINE CIRCUIT USING FULL I.D.F.

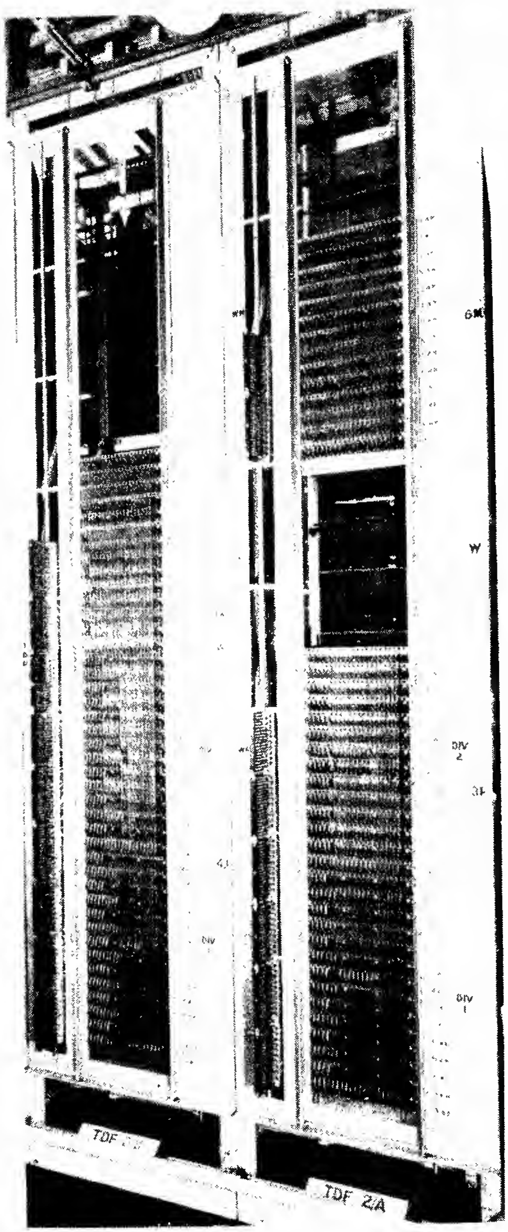
FIG. 14.

2.3 Use of Local I.D.F. The concentration of cabling at the I.D.F. in order to obtain flexibility is a very desirable feature, but is expensive due to the heavy cabling involved. The present tendency is to make direct connections between items of apparatus instead of cabling via the I.D.F. As a contribution to a reduction in costs, combined L and K/Primary Finder racks are used (see Page 8), and cables from the composite rack are taken directly to the final selector rack. This arrangement sacrifices flexibility in regard to the connection of subscribers' lines within line finder groups.

It is possible to retain some degree of flexibility by the use of a small cross-connecting unit (termed a local I.D.F.) on each final selector rack. The wiring from the final selector banks to the multiple connection strips at the rear of the shelves is carried out in the normal manner, and additional tags are fitted, on which the meter cables are terminated. A duplicate set of tags, adjacent to those on which the final selector multiple and meter cable are terminated, are fitted and cabled to the line finder multiple (or uniselector rack). Normally, the duplicate tags are strapped to the final selector bank multiple tags by bare wire straps. When it is desired to transfer a subscriber's line to use line equipment in a different finder group, the straps are removed, and the multiple tags are jumpered to the duplicate tags associated with the chosen line equipment. Jumper rings are provided in order to keep the jumper wires clear of the rack wiring and cabling.

2.4 Cabling of Primary and Secondary Finders. These are cabled to the I.D.F., as shown in Fig. 13. The connections between primary finders, secondary finders and 1st selectors are made by jumpers on the I.D.F. A directly connected finder is cross-connected to a 1st selector with a 3-wire jumper, and an indirectly connected finder is cross-connected to an outlet from a secondary finder with a 5-way jumper. The secondary finders are cross-connected to 1st selectors by 3-wire jumpers.

2.5 Cabling of Group Selector Banks. As shown in Fig. 13, the cabling from group selector banks is taken to a Trunk Distributing Frame (T.D.F.). Here the cables are connected to grading strips and are jumpered from these to terminal blocks cabled to the next rank of selectors, or to the I.D.F. Each grading strip carries the 20 outlets for one particular level only, and the strips serving each level are grouped together and separated from other strips by spacing pieces. Outlets are multipled according to the grading scheme by means of vertical straps of bare tinned wire. Fig. 15 shows a typical T.D.F.



TRUNK DISTRIBUTING FRAME.

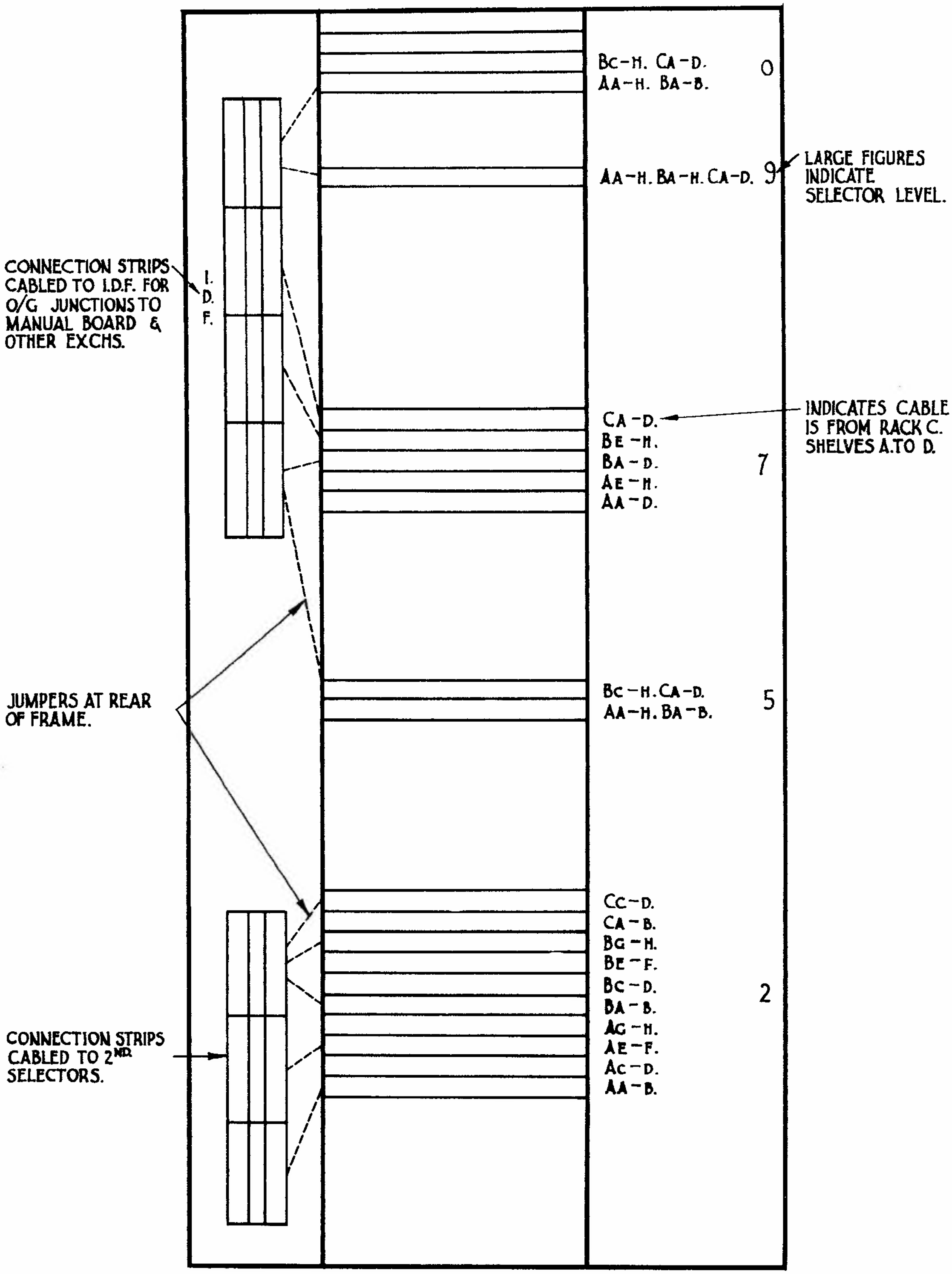
FIG. 15.

Normally, the bank contacts of two shelves of 10 group selectors are multipled together to form a set of 20, but it is not necessary to provide a grading strip on the T.D.F. for each set. According to the grading scheme, any desired number of shelves may be linked together by means of tie cables. The shelves so grouped are then connected to one grading strip by means of an outgoing cable.

A typical arrangement of a T.D.F. is shown in Fig. 16. This T.D.F. is assumed to be serving three 1st selector racks, A, B and C. Racks A and B are fully equipped with eight shelves each, but rack C has only four shelves fitted. The particular grouping of shelves on each grading strip is indicated by the designations on the T.D.F. Considering the outlets from level 9, it is seen that only one grading strip is provided, and the designation indicates that this strip serves all shelves on racks A, B and C. Consequently, level 9 on these racks are linked by means of shelf-to-shelf and rack-to-rack tie cables. On the other hand, level 2 is provided with 10 grading strips, each serving two shelves. It is seen that the number of strips provided is governed mainly by the number of outlets required to the next rank of switches, or, in other words, by the traffic carried over that particular level.

2.6 T.D.F's are also used for grading outlets from subscribers' uniselectors, D.S.R's and junction hunters. D.S.R's have 10 outlets per level and normal group selector grading strips are used. These have 20 sets of tags, so that only 10 will be used, the others being left spare. Subscribers' uniselectors and junction hunters require grading strips with 25 sets of tags and this in turn necessitates a wider frame.

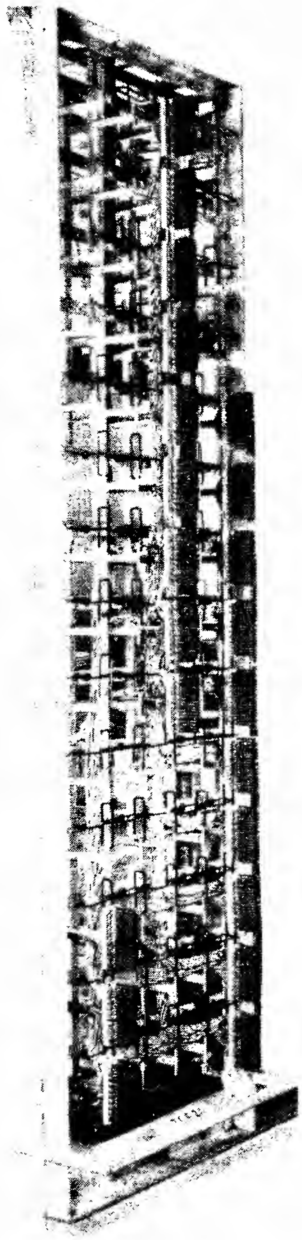
/ Fig. 16.



TYPICAL ARRANGEMENT OF T.D.F.

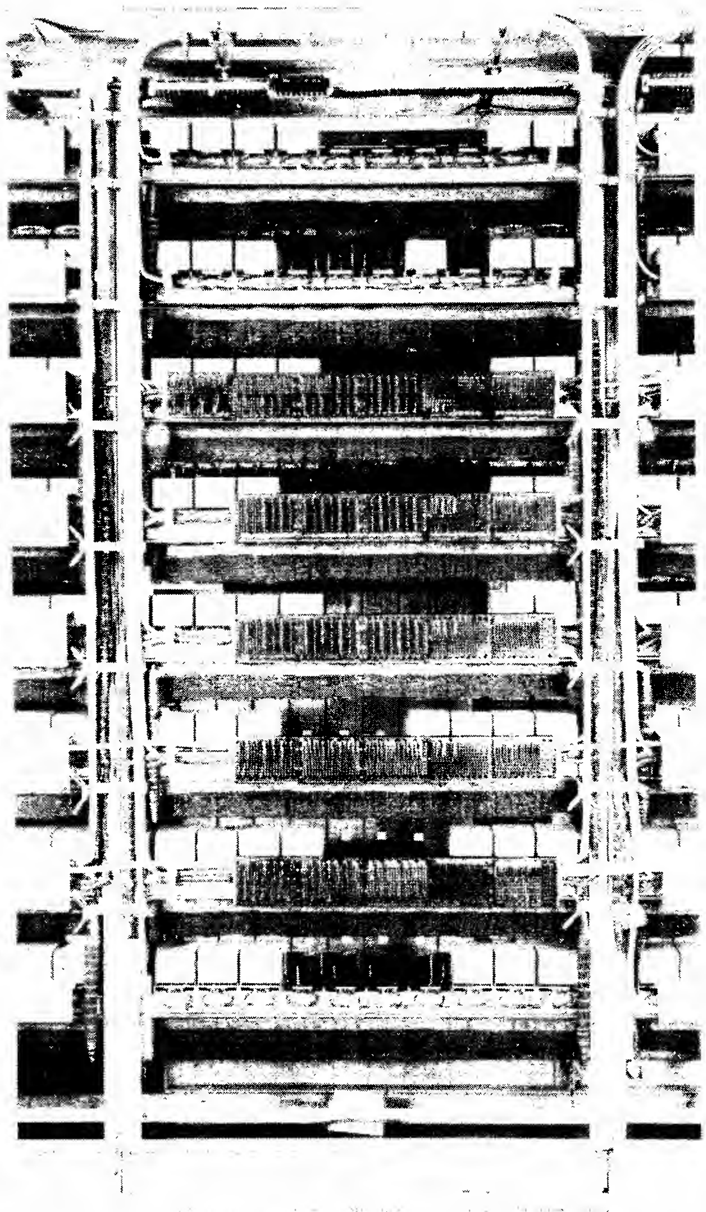
FIG. 16.

2.7 Cabling of Junctions. In earlier exchanges, as shown in Fig.13, both incoming and outgoing junctions are cabled via the I.D.F. in order to give flexibility in allotting the automatic switching apparatus to the various junction groups. Latest practice is to cable outgoing junctions direct from the T.D.F. terminal blocks to the M.D.F. Incoming junctions are cabled from the M.D.F. to a Trunk Connecting Frame (T.C.F.), which takes the place of the I.D.F. A typical T.C.F. is shown in Fig. 17. Being rack-mounted, the T.C.F. takes up less floor space than an I.D.F. and is located to economise in cabling to the apparatus it serves.



TRUNK CONNECTING FRAME (T.C.F.).

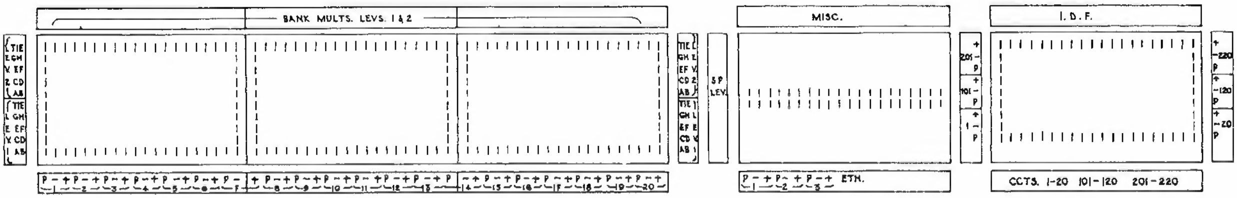
FIG. 17.



GROUP SELECTOR RACK WITH GRADING FACILITIES.

FIG. 18.

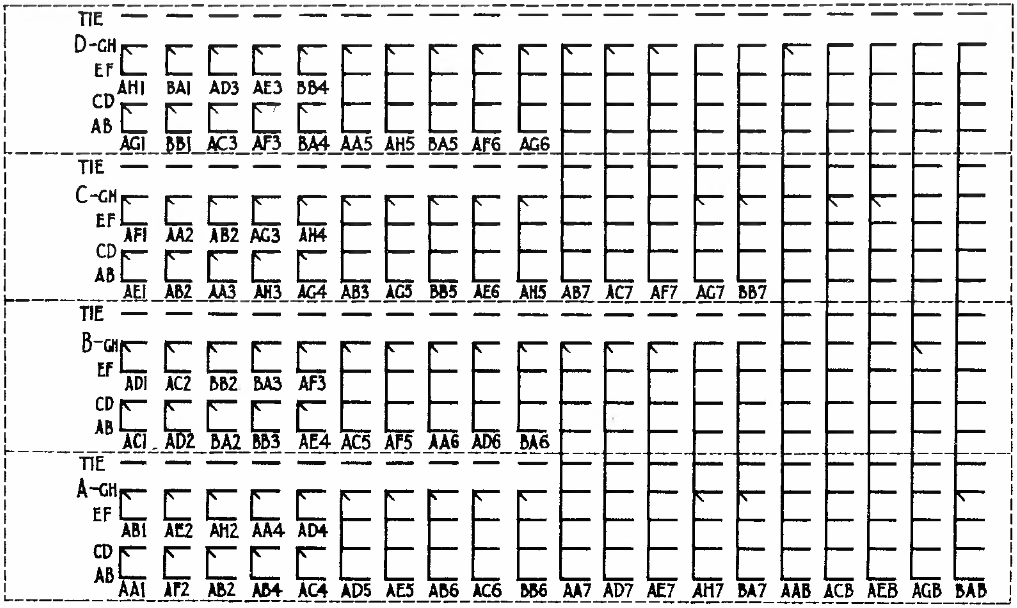
2.8 Group Selector Racks with Grading Facilities. The use of a T.D.F. for grading group selector outlets has limitations as regards flexibility, and it is necessary to allow space on the T.D.F. for the anticipated ultimate development. With this scheme, an unexpected increase in traffic, and consequent modification of gradings, often means interference with permanent cabling. To avoid this condition, and to allow all alterations in trunking to be made by jumpering, a new type of group selector rack has been developed (see Fig. 18). Grading facilities are provided on connection strips at the rear of shelves B to F. For example, the connection strip for levels 1 and 2, mounted at the rear of shelf B, is shown in Fig. 19. Outlets are multipled by means of vertical bare wire straps on the connection strip.



CONNECTION STRIP, SHELF B.

FIG. 19.

The upper set of tags then are connected by a 3-wire jumper to tags on the I.D.F. block. This block is cabled to the I.D.F. (or T.C.F.) where the cross-connection to a selector in the next rank, or to an outgoing junction, is made. Where the multipling extends over two or more racks, tie cables are run directly between the racks and terminated at the outgoing end on the tags shown in Fig. 19. At the incoming end, the level tie cable is terminated on the same set of tags as the bank multiple cable for shelves A and B. A typical grading is shown in Fig. 20.



SHOWS AN 8-GROUP GRADING FROM 4 RACKS OF GROUP SELECTORS. THE PORTIONS OF GRADING CONTAINED WITHIN THE DOTTED LINES ARE AS THEY APPEAR ON THE BACK OF THE RACKS.

TYPICAL GRADING.

FIG. 20.

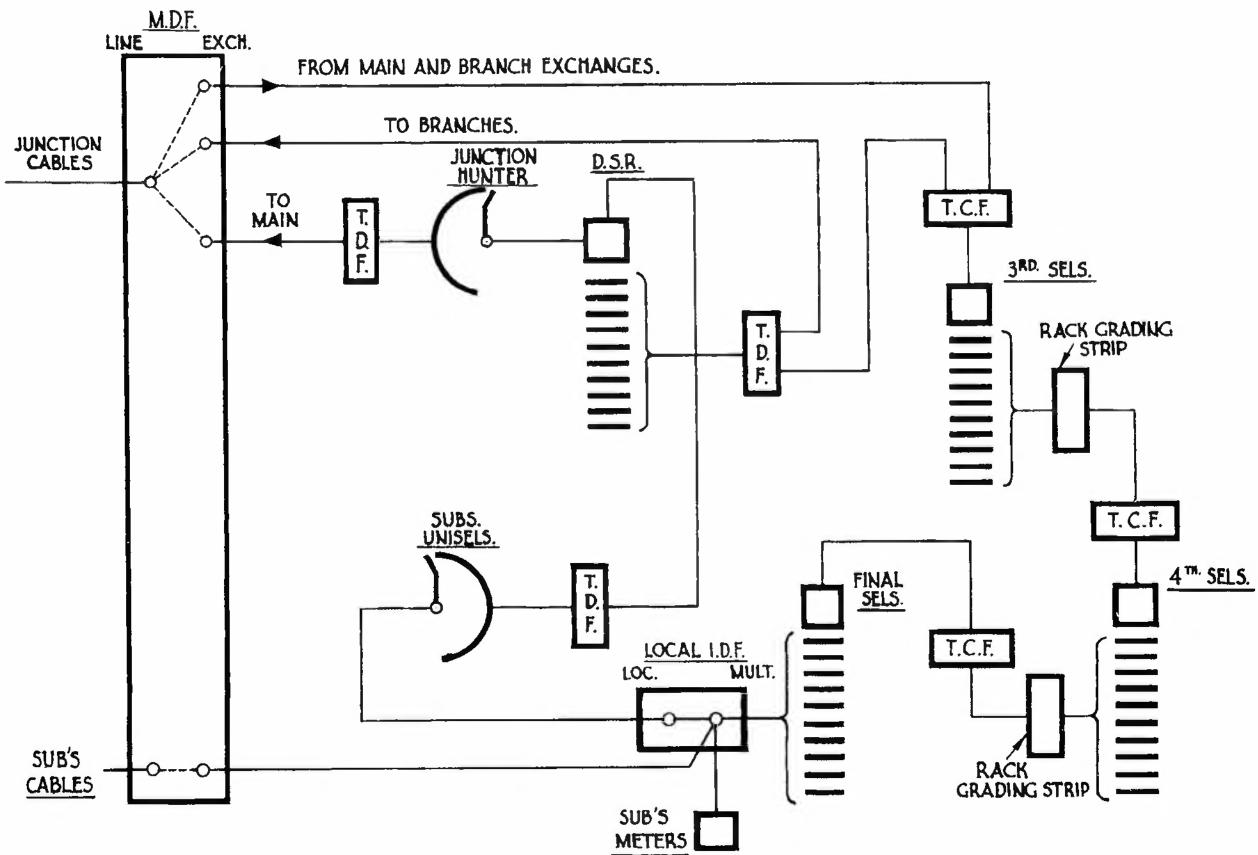
2.9 A typical trunking diagram for a branch exchange equipped with subscribers' uniselectors and using a local I.D.F. and group selector racks with grading facilities, is shown in Fig. 21. This diagram, as compared with Fig. 13, shows the developments which have taken place since 2000 type exchanges were first installed in Australia. The main ones are -

(i) Use of local I.D.F. on final selector racks in lieu of full I.D.F. for cabling of subscribers' line circuits.

(ii) Use of rack type T.C.F. in lieu of I.D.F. for cabling junction and other circuits.

(iii) It is now the practice to provide a common group of selectors of each rank instead of separate groups of local and incoming selectors.

(iv) Rack type grading strips are provided on group selector racks. It is likely in the future that this feature will be extended to subscribers' uniselector and D.S.R. racks.

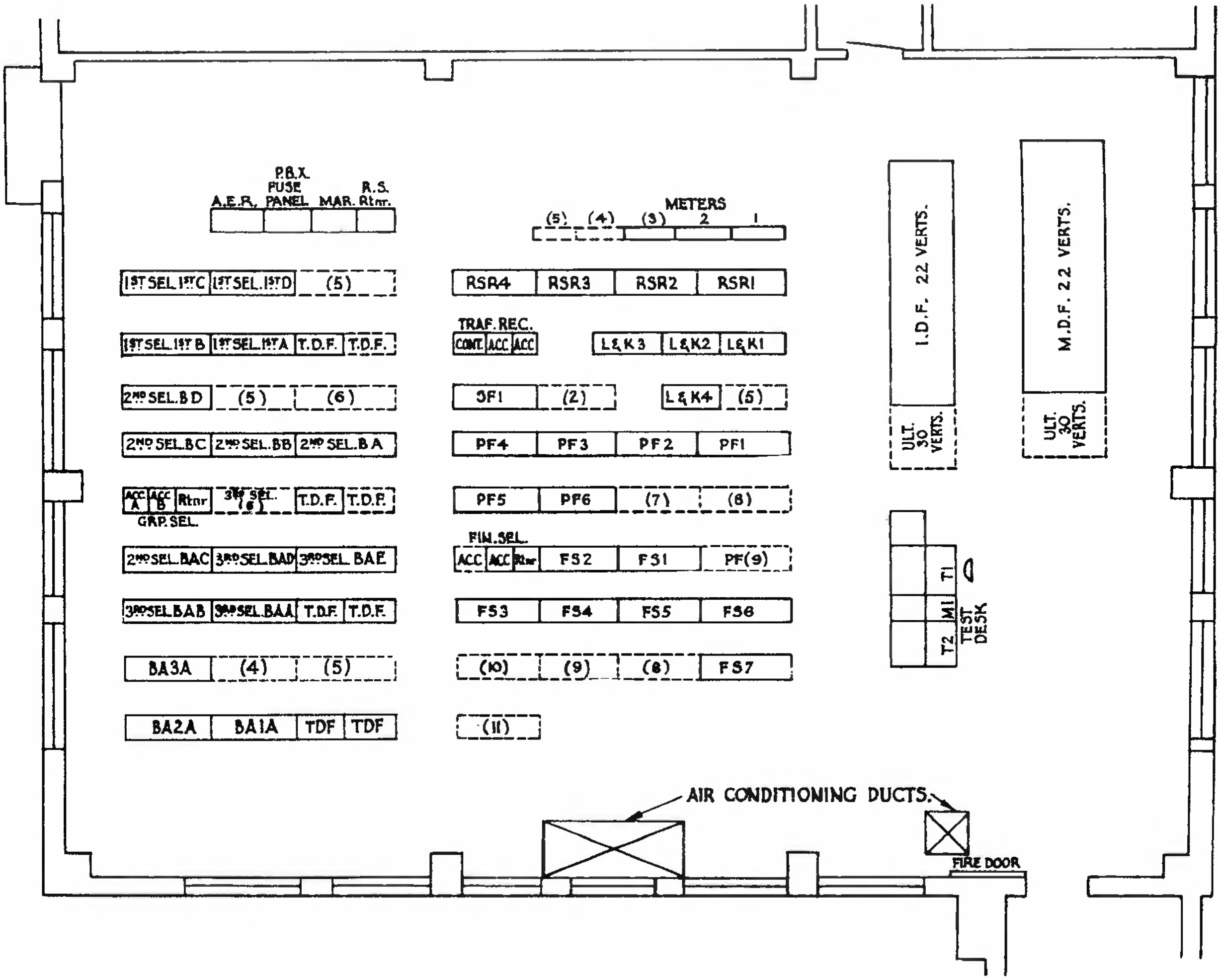


BRANCH EXCHANGE SCHEMATIC CABLING DIAGRAM.

FIG. 21.

3. LAYOUT OF EXCHANGE SWITCHROOM.

3.1 Fig. 22 shows a typical switchroom layout for a main exchange equipped with line finders and using a full I.D.F.



TYPICAL MAIN EXCHANGE SWITCHROOM LAYOUT.

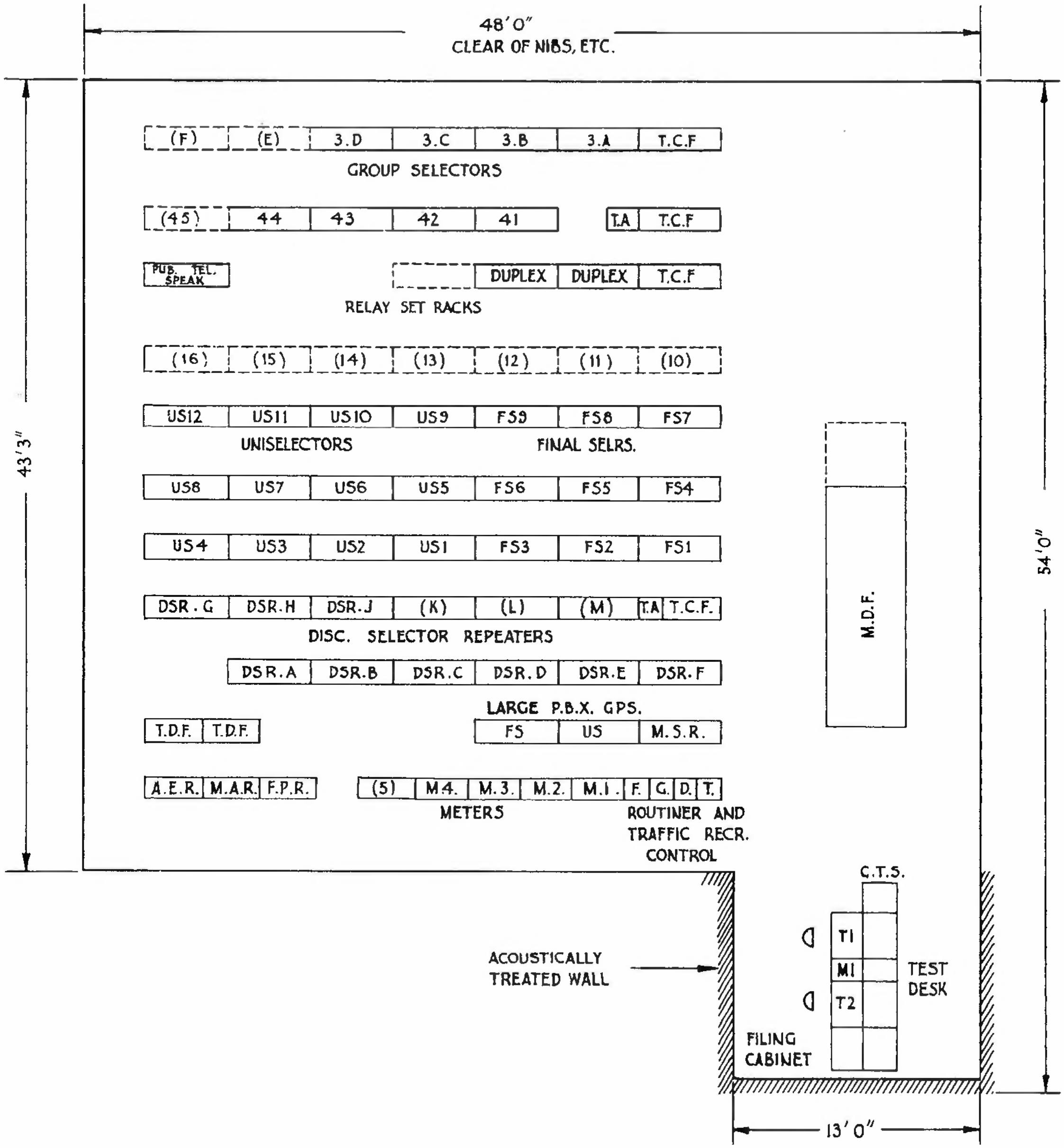
FIG. 22.

This figure should be compared with Fig. 13, which shows the corresponding cabling diagram. The position of the M.D.F. is determined by external cable considerations, and the I.D.F. is placed adjacent to it to save cabling costs. Note that the final selector racks, primary finder racks, L and K relay racks and meter racks are so placed that the cabling to the I.D.F. is as short as possible. Space has been left for installing additional racks in all ranks to cater for development.

Another important point in the layout is the provision of adequate lighting, both natural and artificial.

/ 3.2

3.2 For comparison, Fig. 23 shows a typical layout for a branch exchange, equipped with subscribers' uniselectors and D.S.R's, and using a local I.D.F. in lieu of the full I.D.F. Fig. 23 corresponds with the cabling diagram of Fig. 21.

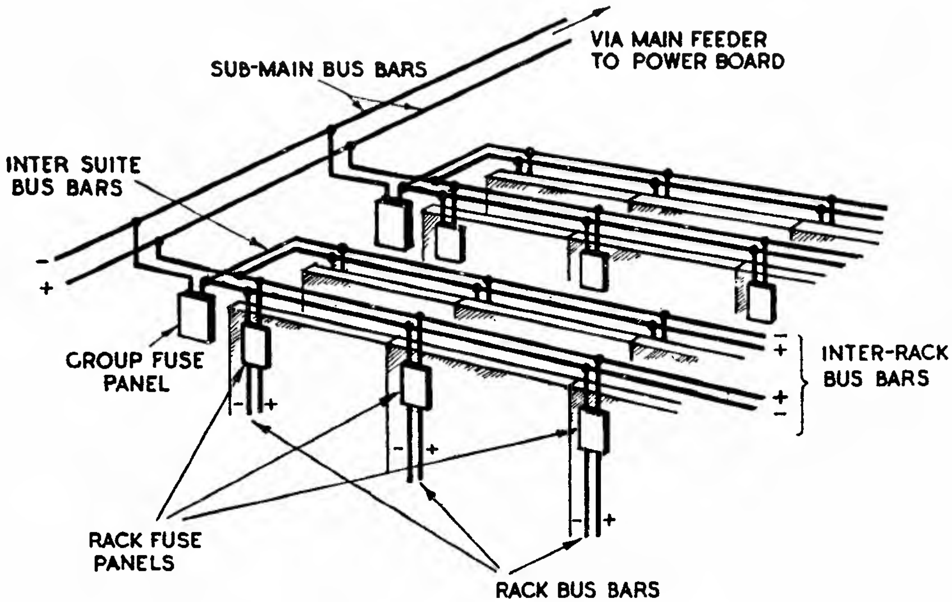


TYPICAL BRANCH EXCHANGE SWITCHROOM LAYOUT.

FIG. 23.

4. POWER DISTRIBUTION.

4.1 In general, the power distribution for 2000 type exchanges consists of a main feed from the Power Board to the Apparatus Room. (The cross-sectional area of this feeder depends upon the load to be carried and varies from exchange to exchange.) In the apparatus room, the main feeder takes the shortest convenient route in order that branch feeders may serve suites of racks (see Fig. 24). From these branches there are further branches which feed the busbars of the rack fuse panels to which the apparatus is wired. As the load decreases, the cross-sectional area of the feed is reduced at convenient points, the reduction being made at a branch.



POWER DISTRIBUTION IN 2000 TYPE EXCHANGE.

FIG. 24.

4.2 Busbars, which are used to distribute power, are classified as follows -

(i) Sub-main Busbars. These busbars are connected by the main feeder to the power board and are situated in main aisles of the apparatus room to enable branches, which feed suites of racks, to be conveniently connected.

(ii) Inter-rack and Inter-suite Busbars. These busbars respectively feed the racks in a suite and connect the inter-rack busbars when more than one suite of racks is served from a single tee off the sub-main busbars.

(iii) Rack Busbars. The rack fuse panels are directly connected to these busbars, which form part of the apparatus racks.

4.3 The connection between the inter-rack busbar and the sub-main busbar may be either direct or via a group fuse. The size of the battery is the factor which influences the provision of this fuse. Group fuses are fitted when the box capacity of the exchange battery exceeds 500 ampere-hours. A fuse is fitted at the source of supply, but this is included in the circuit primarily to protect the battery, and it is considered that it would not provide adequate protection for the busbars on the racks in the larger exchanges. A typical group fuse is shown in the top left corner of Fig. 3.

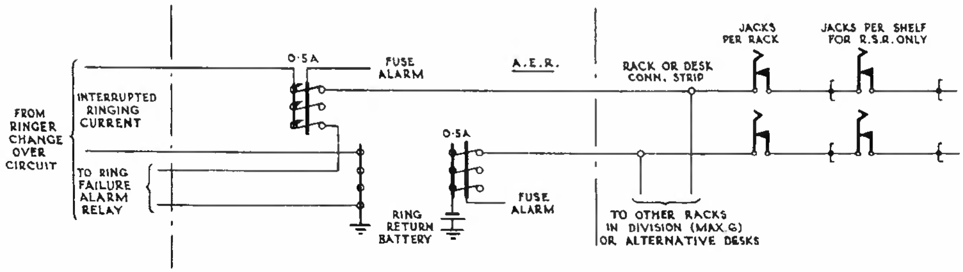
4.4 Busbars have a protective or insulating covering of a distinctive colour. Earth bars, except rack earth bars, are painted red. Covering is not provided on rack earth bars. All negative supply busbars have a blue covering. The covering of the sub-main negative busbar is a tube of manilla paper reinforced with bookbinders' cloth. The inter-rack, inter-suite and rack busbars also have a manilla paper tubing, but reinforcement is not added.

/ 5.

5. RING AND TONE DISTRIBUTION.

5.1 In 2000 type exchanges, equipment associated with the distribution of ringing current and tones is mounted on the Alarm Equipment Rack (A.E.R.). An exception is in the distribution of ringing current to P.B.X's, where the fuses and resistance lamps are mounted on the P.B.X. fuse panel. Details of the various distributions are given below -

5.2 Interrupted Ringing Current. (Fig. 25.) This is fed via 0.5 ampere fuses for each division of not more than six racks, or for alternate manual desks. The three interrupted ringing distributions are distributed over the shelves of the final selector racks as shown in Fig. 25. Jacks mounted on the racks enable each rack to be isolated from the ring supply. Isolating jacks are not fitted on distributions to desks.



RACK NO. IN DIVIS'N	DISTN. Nº 1	DISTN. Nº 2	DISTN. Nº 3
1 & 4	ACE	BDF	—
2 & 5	BDF	—	ACE
3 & 6	—	ACE	BDF
MISC.	MAR	DESKS & TEST RACK	R.S.R.

FIG. 25. INTERRUPTED RING DISTRIBUTION.

5.3 Continuous Ringing Current (Fig. 26) is distributed in a similar manner to interrupted ringing current. The supply to desks uses earth as ring return and a resistance lamp is fitted in each desk. Battery ring return is used in most rack circuits, and a resistance lamp is provided for each division.

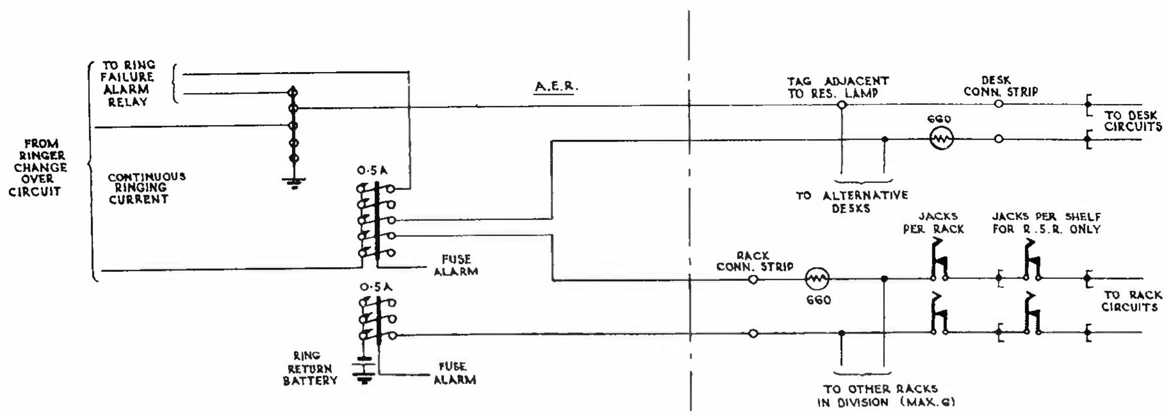


FIG. 26. CONTINUOUS RING DISTRIBUTION.

5.4 P.B.X. Ring Supply. (Fig. 27.) Ringing current for operation of P.B.X's or P.A.B.X's is fed via fuses and resistance lamps on the P.B.X. fuse panel and cabled to the M.D.F. From there it is distributed over external cable pairs to the P.B.X. Continuous ringing current is usually supplied, but interrupted ringing current is supplied to P.A.B.X's. In either case, the ring return is to earth.

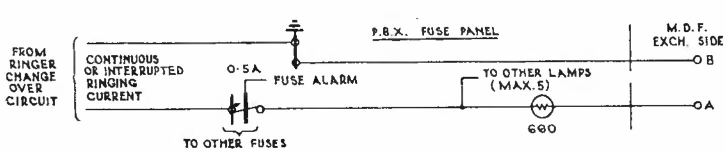
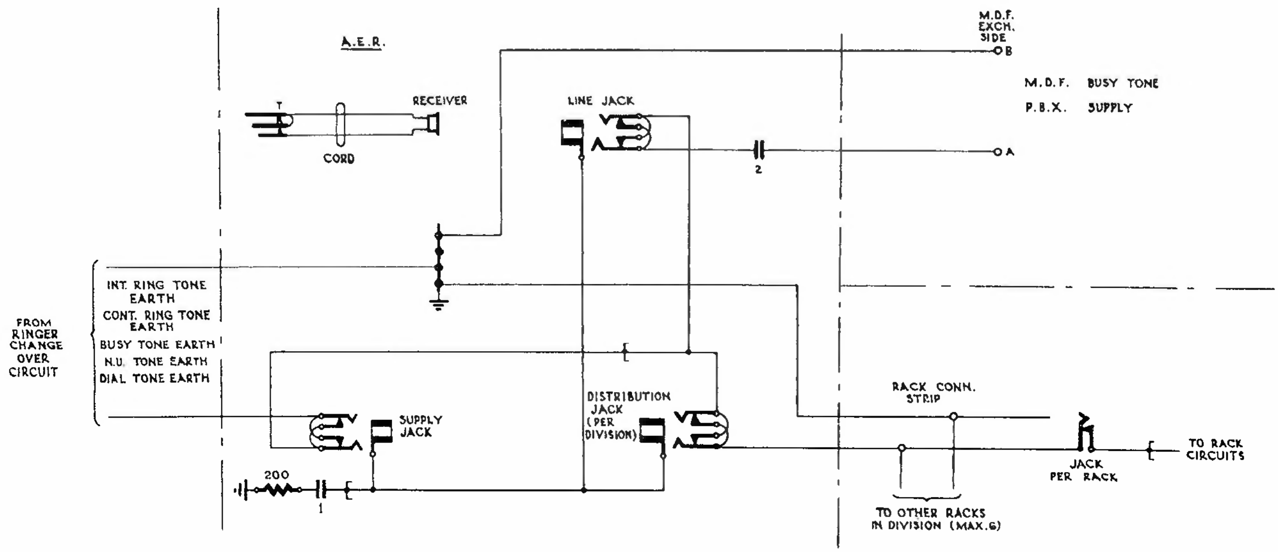


FIG. 27. P.B.X. RING DISTRIBUTION.

5.5 Tone Distribution. All earth-connected tones are distributed as shown in Fig. 28. Isolating jacks enable tests to be carried out in the event of a fault on a tone supply circuit. Each tone is fed through a supply jack, and then through a distribution jack for each division of six racks. Finally, jacks on each rack allow each rack to be isolated in turn from the supply. Dummy plugs are provided to enable these tests to be made, and a receiver connected to a cord and plug is used to make listening tests. The sleeves of all A.E.R. tone jacks are earthed through a 1 μF condenser and 200 ohm resistor to provide a return circuit for the receiver. All tone wiring is carried out in twisted pairs, one wire being earthed to provide electrostatic shielding and prevent induction.

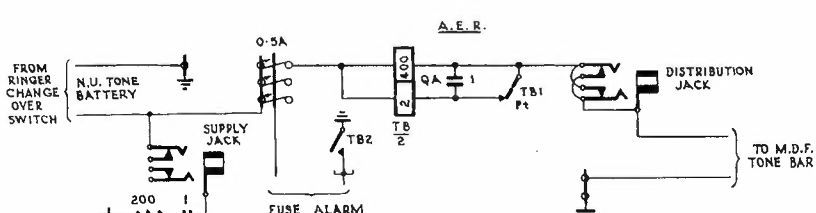


TONE DISTRIBUTION CIRCUIT.

FIG. 28.

5.6 M.D.F. Busy Tone Supply. For distribution to P.B.X's over external cable pairs, busy tone is wired to the M.D.F. as shown in Fig. 28. Each lead is taken through a line jack and a 2 μF condenser.

5.7 N.U. Tone Battery Supply. (Fig. 29.) This is wired to a special tone bar on every eighth M.D.F. protector fanning strip, and is used to give an indication on lines that are faulty and temporarily out of service. Operation of the alarm circuit is described in Paper No. 7.



N.U. TONE BATTERY SUPPLY.

FIG. 29.

6. TEST QUESTIONS.

1. What are the advantages of single-sided racks over the types of mounting rack previously used?

2. List, in the form of a table, the equipment which can be mounted on the following standard racks.

    (i) Group selector rack.
    (ii) Final selector rack.
    (iii) Composite L and K/Primary finder rack.
    (iv) Meter rack.
    (v) L and K rack.
    (vi) Uniselector rack.
    (vii) D.S.R. rack.
    (viii) Relay-set rack.

    In each case indicate the width of the rack.

3. What advantages are obtained by the use of I.D.F. connection strips mounted on the final selector racks?

4. Describe two methods of grading the outlets from group selector banks, and discuss the relative advantages.

5. With the aid of a circuit diagram, explain how dial tone is distributed to 1st group selector shelves.

7. REFERENCES.

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Vol. 2, No. 6 "Automatic Telephone Equipment Racks for Type 2000 Exchanges" - H. Murray.
Vol. 3, No. 5 "The Drummoyne Automatic Exchange, Sydney" - R. W. Turnbull.
Vol. 7, No. 6 "The B.P.O. Type 2000 Selector Rack Equipped with Grading Facilities" - T. E. Dalston.

Telephony.

Vol. 2, Chapter IV - J. Atkinson.

END OF PAPER.

COMMONWEALTH OF AUSTRALIA.

Engineering Branch,
Postmaster-General's Department,
Treasury Gardens,
Melbourne, C.2.

COURSE OF TECHNICAL INSTRUCTION.

SUPERVISORY ALARMS.

[illegible]TENTS:

1. INTRODUCTION.
2. THE ALARM DELAY CIRCUIT.
3. DESCRIPTION OF TYPICAL DELAYED ALARM.
4. RELEASE ALARM.
5. P.G. SUPERVISORY ALARM.
6. C.S.H. SUPERVISORY ALARM.
7. N.U. TONE SUPERVISORY ALARM.
8. LINE FINDER SUPERVISORY ALARM.
9. FUSE ALARM.
10. CONDENSER ALARM.
11. N.U. TONE OVERLOAD ALARM.
12. RING FAIL AND MACHINE FAIL ALARMS.
13. HIGH OR LOW VOLTAGE ALARM.
14. CHARGE FAIL ALARM.
15. POSITIVE BATTERY FAIL ALARM.
16. GENERAL LAYOUT OF ALARM EQUIPMENT.
17. DESCRIPTION OF SECTION AND FLOOR LAMP CIRCUITS.
18. TEST QUESTIONS.
19. REFERENCES.

1. INTRODUCTION.

1.1 In circuits described in previous Papers, various alarm conditions have been mentioned, for example, release alarm, fuse alarm, condenser alarm, C.S.H. alarm, etc. The purpose of these alarm conditions is to call the attention of the maintenance staff to the circuit which is experiencing the abnormal condition. For the purposes of the alarm supervision scheme, the floor or floors of a 2000 type automatic exchange are divided into "sections," each of which is further divided into "subsections." In each subsection, rack lamps and shelf lamps provide for the location of the circuit causing the alarm condition.

1.2 Rack alarm circuits are usually mounted on the right-hand vertical of the rack, as shown in Figs. 2 and 3 of Paper No. 6. The rack alarm lamps are also shown in these figures. Common equipment associated with the alarm circuits is mounted on the Alarm Equipment Rack (A.E.R.), which is also the point from which ringing current, tones and positive battery are distributed. A typical A.E.R. is shown in Fig. 1.

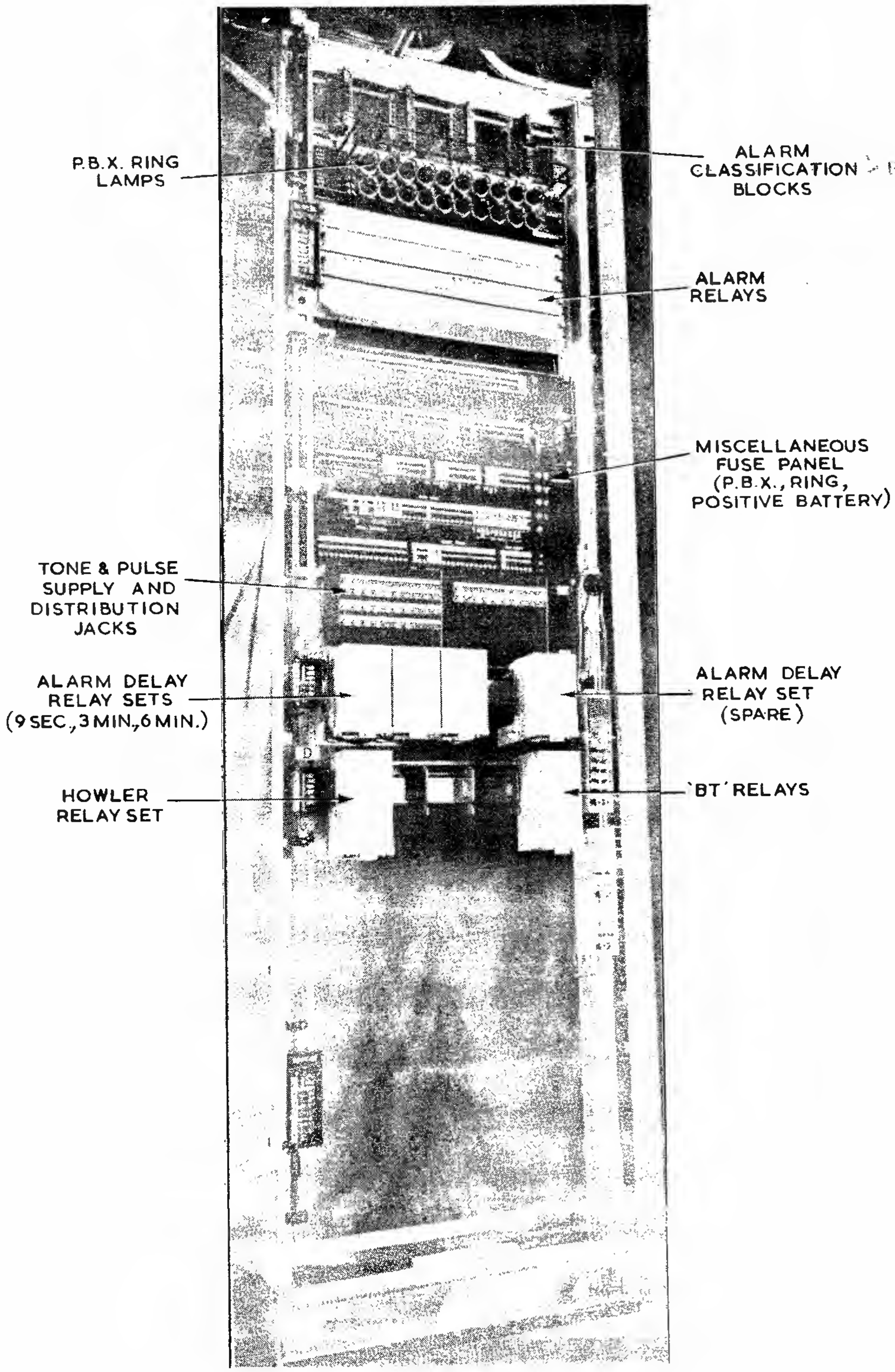


FIG. 1. A TYPICAL ALARM EQUIPMENT RACK (A.E.R.).

1.3 Classification of Alarms. Alarm signals are classified into two groups, Prompt and Deferred. The former indicates that a failure of an urgent nature has occurred and requires immediate attention, whilst the latter is used for faults which may be temporarily neglected without affecting the service of a group of subscribers. In the following table, each type of alarm is briefly described, and details of its classification into Prompt or Deferred and its delay period (if any) are given.

ALARM	CAUSE OF ALARM	PROMPT OR DEFERRED	DELAY PERIOD
Fuse	Operation of an alarm type fuse.	Prompt	Nil
Condenser	Failure of uniselector spark quench condenser.	Prompt	Nil
Release	Selector failing to restore to normal when its release circuit is energised.	Prompt	9 Secs.
Line Finder Supervisory	Line Finder fails to find calling line.	Prompt	6 Secs.
High or Low Voltage	Voltage at main busbars outside prescribed limits.	Prompt	Nil
Ring Fail	Failure of exchange ringing current supply.	Prompt	Nil
Machine Fail	Failure of No. 1 ringing machine. (This does not necessarily indicate a failure of ringing current since the second machine automatically starts.)	Prompt	Nil
Charge Fail	Operation of circuit breaker due to overload or reverse current.	Prompt	Nil
Positive Battery Fail	Failure of positive battery voltage.	Prompt	Nil
P.G. Supervisory	First selector, incoming selector or D.S.R. held for excessive period before receiving impulses.	Deferred	6 Mins.
C.S.H. Supervisory	Calling or called subscriber holding the connection for an excessive period after the other party has cleared.	Deferred	3 Mins.
N.U. Tone Supervisory	A short-circuit or earth negative fault in the exchange equipment associated with an unallotted or ceased line connected to N.U. tone.	Deferred	9 Secs.
N.U. Tone Overload	A low resistance earth fault on a line temporarily connected to N.U. tone.	Deferred	Nil

2. THE ALARM DELAY CIRCUIT.

2.1 During the normal operation of automatic equipment, certain conditions may be set up which would constitute a fault if maintained for an excessive period of time. For example, the rotary magnet is energised during the release of a selector but, if it remains energised for a long period, it will overheat and possibly cause a fire. The object of the alarm delay circuit is to ensure that a certain minimum time elapses between the commencement of an alarm signal and the operation of the exchange alarm system.

2.2 The apparatus consists of a combination of relays and a uniselector which is stepped under the control of pulses occurring at regular intervals. For short delay periods, such as 9 seconds and 30 seconds, the interrupted earth pulses (0.75 sec. earth every 1.5 sec.) from the ringing machine are used. Longer periods up to 6 minutes are controlled by 30-second pulses obtained from the exchange clock (see Fig. 2). The clock also supplies 1-second and 6-second pulses which are used in line finder and traffic recorder circuits.

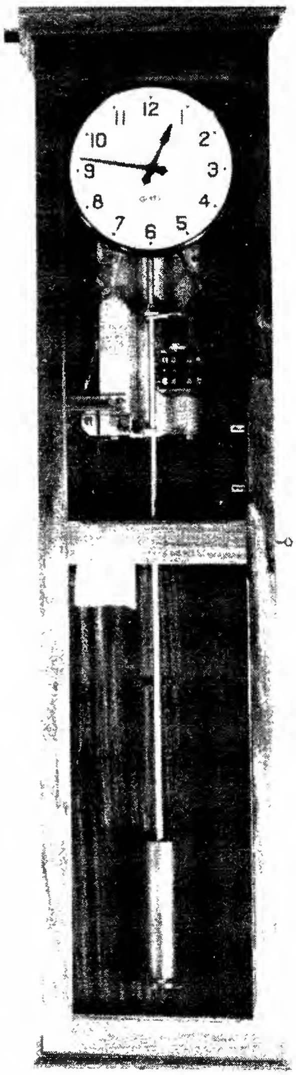


FIG. 2. EXCHANGE CLOCK.

2.3 The alarm delay circuit provides for delay periods of 9, 20 and 30 seconds, 3 and 6 minutes, although 20 and 30 second delay periods are not normally required. One alarm delay relay-set is provided for each delay period and a spare relay-set is usually provided. The spare may be used to replace any of the other delay relay-sets in the event of a fault, as the internal wiring of each set is identical. The circuit connections are shown in Fig. 3. The period of delay is controlled by varying the straps on the shelf jacks, as shown in the figure and listed below -

Delay Period	No. of Steps	Pulses	Shelf Straps
9 sec.	6	Int. eth.	U11-16; U2-4; U1-3
20 sec.	20	1 sec.	U11-18; U13-15; U17-19
30 sec.	20	Int. eth.	U11-18; U13-15; U17-19
3 min.	6	30 sec.	U11-16; U2-4; U1-3
6 min.	12	30 sec.	U11-18; U13-19; U15-17

2.4 Should there be no 30-second clock pulse available to drive the 3 and 6 minute circuits, a 30-second delay circuit which is operated by the interrupted earth from the ringing machine is used for this purpose. It should be noted that, as the 30-second pulses are required for several purposes other than alarms, the start lead is earthed and the circuit operates continuously.

/2.5

2.5 Circuit Operation. (Refer to Fig. 3). Three connections are made from the delay relay-set to the alarm circuits on the selector rack, namely, "S", "Z" and "ST" wires. With the uniselector wipers in the normal position, earth is connected to the "S" wire. When the uniselector steps, this earth is removed and, after the requisite number of steps, earth is connected to the "Z" wire. The operation of the circuit is initiated by an earth on the "ST" wire, and the rack alarm circuits are arranged so that this earth cannot be applied until the circuit is in the normal position. This feature ensures that the minimum delay period is maintained if a fault condition occurs on a rack while the delay circuit is already in operation.

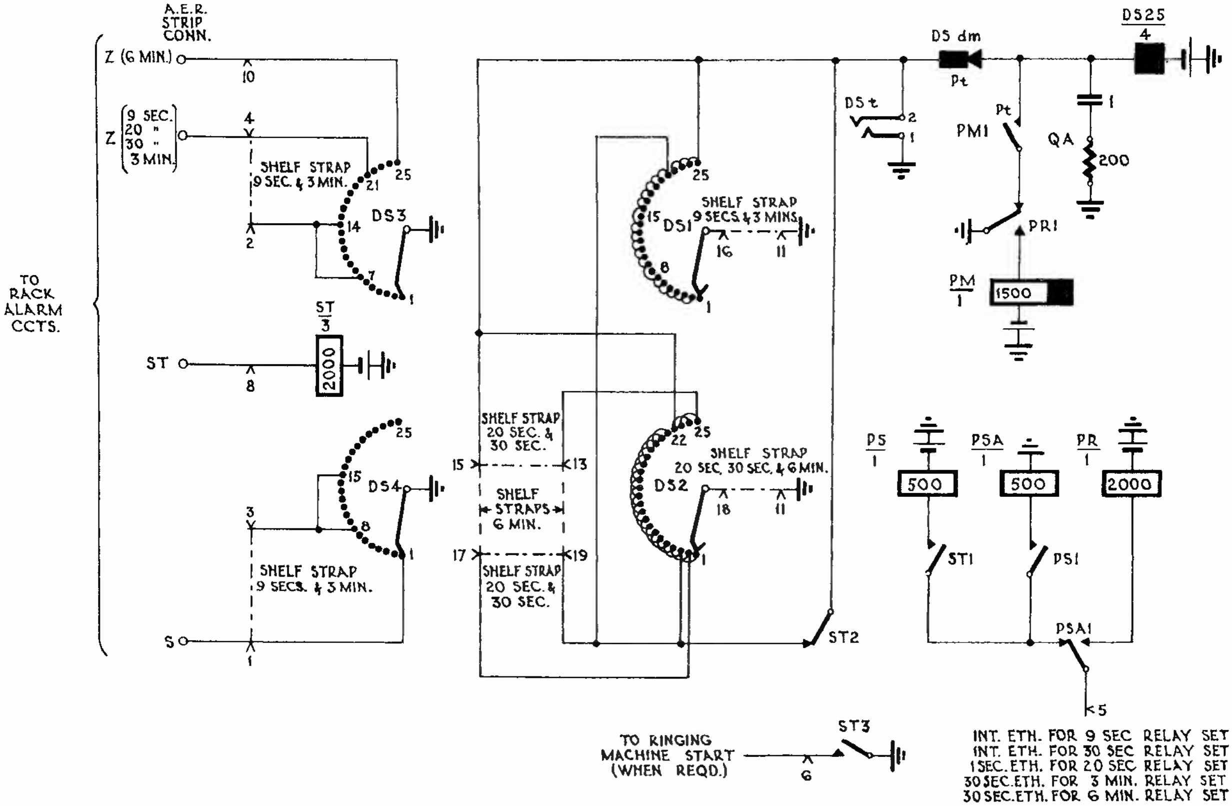


FIG. 3. ALARM DELAY CIRCUIT.

With the switch DS in its normal position, it is possible for the associated rack control relays to operate (via the "S" wire) and apply an earth to the "ST" wire to operate relay ST. ST1 connects relay PS to the pulse lead and PS operates to the next earth pulse. PS1 prepares the circuit of relay PSA, which operates in series with relay PS at the conclusion of the pulse. The next earth pulse operates relay PR via PSA1 and PR1 operates relay PM. Relays PR and PM now respond to each earth pulse in turn and the uniselector drive magnet is energised to earth via PM1 and PR1 during the release time of relay PM. At the completion of the required number of steps, an earth is connected over the "Z" wire via wiper and bank DS3, causing the rack relays to operate and give the desired alarm. The earth on the "ST" wire is removed and relay ST releases. ST1 releases relays PS and PSA. ST2 completes the uniselector homing drive circuit to earth on bank DS1 or DS2, and the switch drives to the next normal position.

Should the circuit be released before a "Z" pulse is given, relay ST releases and the uniselector drives to the next normal position.

It should be noted that in the 6-minute delay circuit the switch actually steps over 24 contacts on 12 pulses. This is arranged by the switch self-driving over every alternate contact (2, 4, 6, etc.).

/Fig. 4.

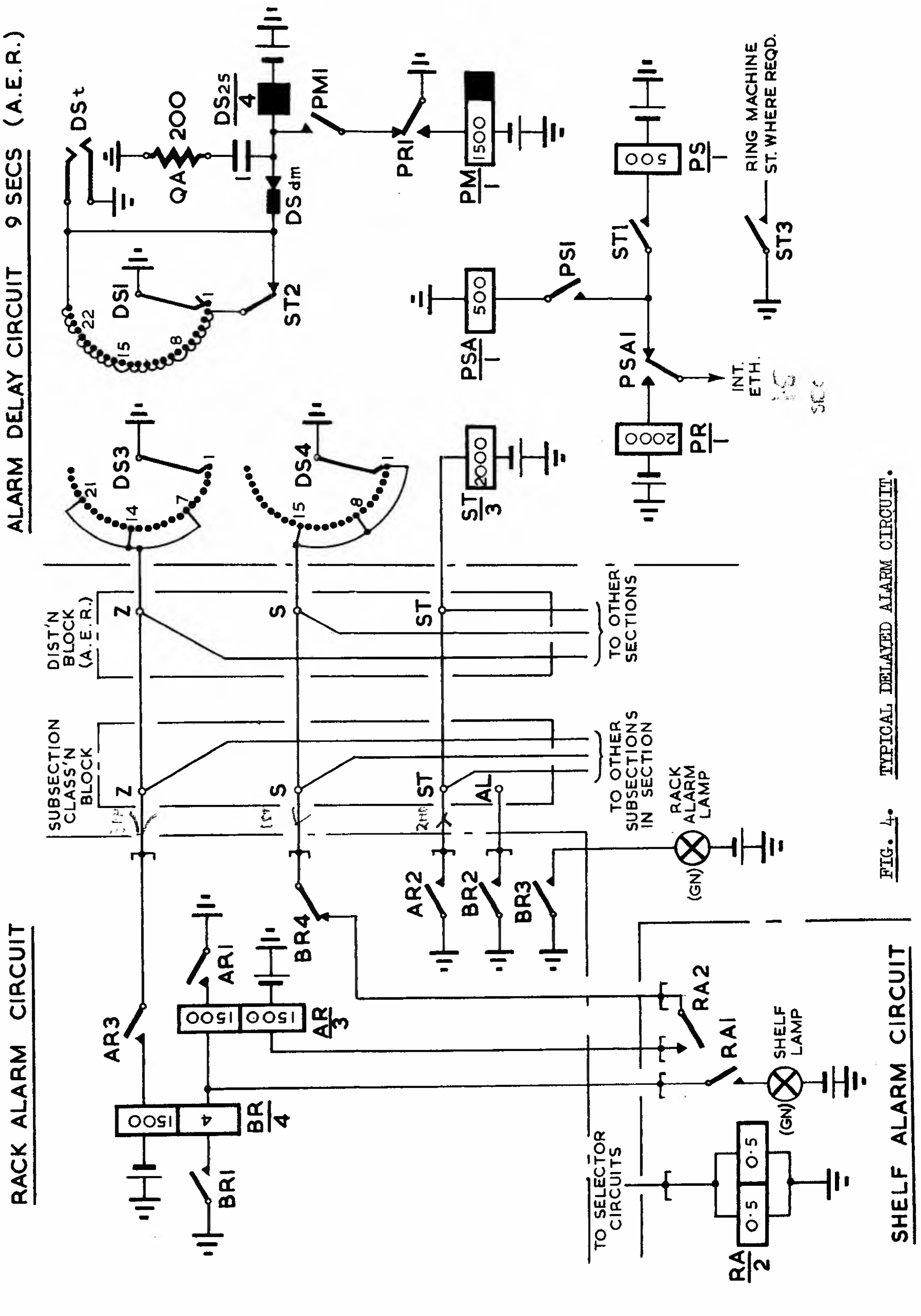


FIG. 4. TYPICAL DELAYED ALARM CIRCUIT.

3. DESCRIPTION OF TYPICAL DELAYED ALARM.

3.1 In order to illustrate the method of connecting the alarm delay circuit with the rack and shelf alarm circuits, the 9-second delay set has been taken as a typical example and is shown in Fig. 4, associated with a rack release alarm.

3.2 Relay RA and the shelf lamp are provided for each two shelves of selectors (20 switches), and relays AR and BR are provided for each rack together with the rack lamp.

3.3 During the release action of the selectors, current is drawn through relay RA, which operates. Assuming that the alarm delay set is not already in operation, relay AR operates via RA2 and BR4 to earth on the "S" wire from wiper DS4 and normal bank contact (1, 8 or 15). AR1 holds relay AR on its second winding in series with RA1 and the shelf lamp. The current through the lamp at this stage is insufficient to produce a glow. AR2 extends an earth over the "ST" wire to operate relay ST in the 9-second delay circuit. AR3 extends relay BR to the "Z" wire.

If the selector fails to release, relays RA and AR remain operated and the uniselector commences to step under the control of the interrupted earth pulses. When it has completed 6 steps, corresponding to a delay period of 9 seconds, wiper DS3 connects an earth to the "Z" wire to operate relay BR in the rack alarm circuit.

BR1 locks relay BR on its 4 ohm winding via RA1 and the shelf lamp. The increased current allows the shelf lamp to glow and the low-resistance shunt causes relay AR to release. BR2 extends an earth to the subsection classification block for operation of the exchange alarm system. BR3 lights the rack lamp. BR4 disconnects relay AR from the "S" wire.

The release of relay AR removes the earth from the "ST" wire, relay ST releases and completes the homing circuit of the uniselector which steps to the next normal position, as previously described.

3.4 Should the delay circuit already be in use when the rack alarm circuit is seized, relay AR cannot operate as there is no earth on the "S" wire until the uniselector returns to the normal position. This feature prevents operation of the alarm with delay periods shorter than normal. In such circumstances, the total delay period may be from 9 to 18 seconds.

3.5 A similar rack alarm circuit is provided for each type of delayed alarm, the only variation being in the period of delay, as shown below.

Alarm	Shelf Relay	Rack Relays	Delay Period
Release	RA	AR, BR	9 seconds
P.G. Supervisory	LA	AS, BS	6 minutes
C.S.H. Supervisory	LA	AS, BS	3 minutes
N.U. Tone Supervisory	LN	AN, BN	9 seconds

3.6 From the foregoing description it is seen that the operation of the rack relays and the alarm delay circuit is initiated by the operation of the shelf relay. The method of operating the shelf relays for each type of alarm is dealt with in the following pages.

4. RELEASE ALARM.

4.1 The release alarm shelf relay RA, which is provided for each two shelves of selectors, is shown in Fig. 5 associated with the release circuit of a 200 outlet group selector.

4.2 During the release action of the switch, the rotary magnet is energised via C4, N1, R1, C2, B7 and T11-12 to release alarm earth via relay RA. RA operates and remains operated until the off-normal contact, N1, opens, indicating that the selector has fully restored.

The release action of a 2000 type selector is normally completed within half a second but, due to a mechanical defect, should the wiper carriage fail to return to its normal position within 9 seconds, the alarm delay circuit completes its operation and an alarm is given.

While the alarm is given, the respective rack and shelf lamps glow. The shelf lamp indicates the shelves in which the faulty selector is located, and it is necessary to examine the 20 switches associated with that lamp. The 6-volt lamp shown in the figure replaces the 50-volt lamps previously used for shelf lamps. The rack lamps are of 50 volts, 8 watts rating.

4.3 Release alarms are provided on the following racks -

(i) Group selector racks.

(ii) Final selector racks.

(iii) D.S.R. racks.

(iv) Primary line finder racks.

(v) Miscellaneous relay-set rack. (Where test selectors are mounted.)

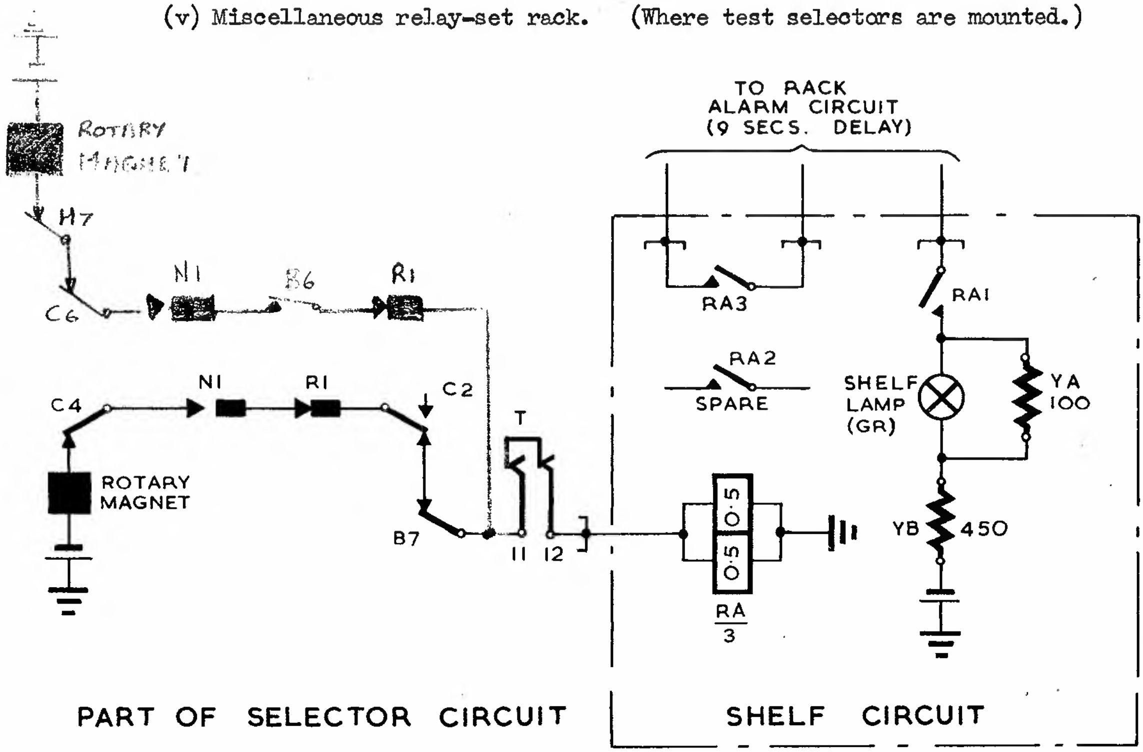


FIG. 5. RELEASE ALARM CIRCUIT.

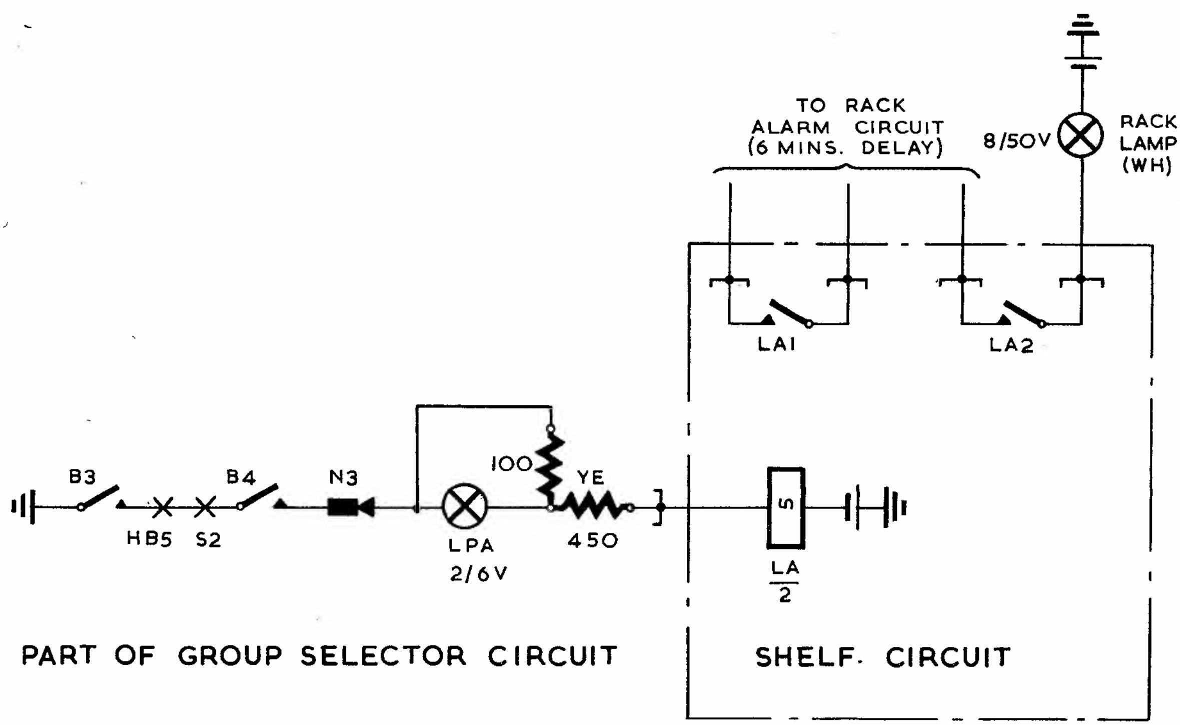
5. P.G. SUPERVISORY ALARM.

5.1 This alarm gets its name from the "permanent glow" condition in a C.B. manual exchange, that is, when a line is looped but no progress is made with the call. The alarm is provided on first and incoming group selector racks and on D.S.R. racks. Fig. 6 shows how the shelf relay LA is associated with the group selector supervisory lamp circuit.

5.2 When the group selector is seized, relay B operates and the circuit of the supervisory lamp LPA is completed in series with the shelf relay LA. The lamp glows and LA operates. When the selector is impulsed, the circuit of the lamp is broken at N3. If the selector is held continuously for a period of 6 minutes without receiving impulses, the alarm delay circuit completes its operation and an alarm is given. The operation of the rack alarm circuit (relays AS and BS in this case) is similar to that of the release alarm circuit previously described.

It will be noted that shelf lamps are not provided but the fault may be quickly located by the glowing of the supervisory lamp on the selector concerned.

During periods of heavy traffic, this alarm may be disconnected from the main alarm scheme by operating a key (see Section 17). Normally, attention to P.G. alarms may be deferred, but a large number of P.G. alarms may indicate a cable fault and, in this case, prompt action is necessary.



P.G. SUPERVISORY ALARM CIRCUIT.

FIG. 6.

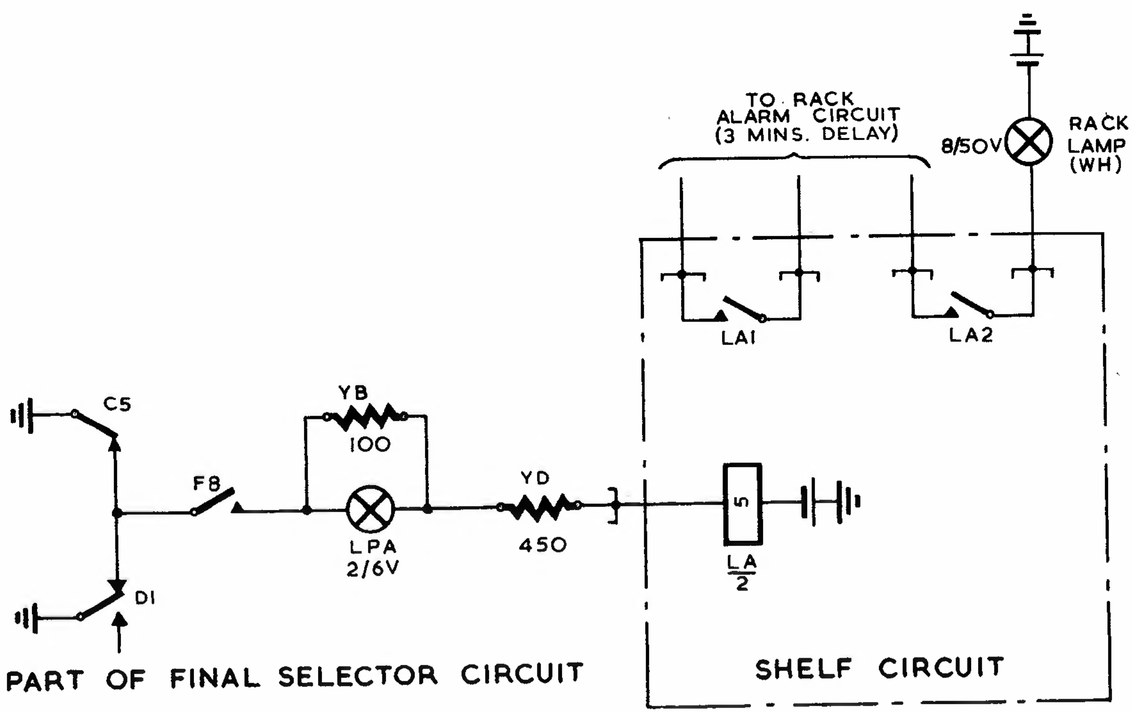
6. C.S.H. SUPERVISORY ALARM.

6.1 The object of the "Called Sub. Held" (C.S.H.) supervisory alarm is to provide an indication in the event of a subscriber's line being held after having received a call. The alarm is provided on all final selector racks.

6.2 Fig. 7 shows the circuit of the shelf relay LA, together with the relevant portion of the final selector circuit. Each shelf relay serves two shelves of final selectors, or 20 switches. Referring to Fig. 7, it is seen that relay LA is operated in series with the supervisory lamp by contacts of relay C or relay D on the final selector, these relays being under the control of the calling and called subscribers, respectively.

If one of the subscribers fails to replace the receiver at the conclusion of a call, relay LA is operated and will cause the exchange alarm system to operate after a delay of 3 minutes. The glowing of the lamp on the final selector will assist the maintenance officer in locating the fault.

As with the P.G. supervisory alarm, this alarm may also be disconnected from the main alarm scheme when not required.



C.S.H. SUPERVISORY ALARM CIRCUIT.

FIG. 7.

7. N.U. TONE SUPERVISORY ALARM.

7.1 Spare lines are connected to N.U. (Number Unobtainable) tone as shown in Fig. 8.

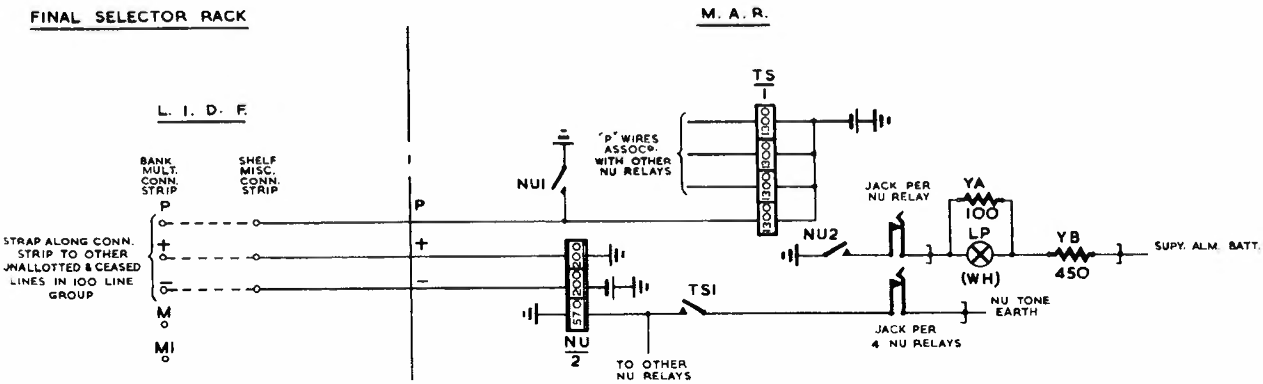


FIG. 8. DISTRIBUTION OF N.U. TONE TO SPARE LINES.

7.2 One "N.U." relay is provided for every 100 subscribers' lines and one "T.S." relay is associated with each four N.U. relays. On a call to a spare line, relay TS is operated by the earth on the P wire from the calling final selector and TS1 connects N.U. tone to the four associated N.U. relays. The ring is tripped by the battery via relay N.U. connected to the negative wire, but the final selector relay D does not operate, being connected in opposition to relay NU. NU tone is induced into the 200 ohm windings of relay NU and so given to the caller.

7.3 In the event of a short-circuit or earth fault on any of the spare lines connected to the circuit, relay NU operates and NU1 earths the P wire to busy all affected lines. NU2 completes the circuit of the NU lamp (one per 4 NU relays) to supervisory alarm battery. The alarm circuit is shown in Fig. 9. Relay LN operates in series with the NU lamp and, if the condition is maintained for 9 seconds, an alarm is given and the rack lamp lights. Jacks are provided to facilitate tracing the faulty line.

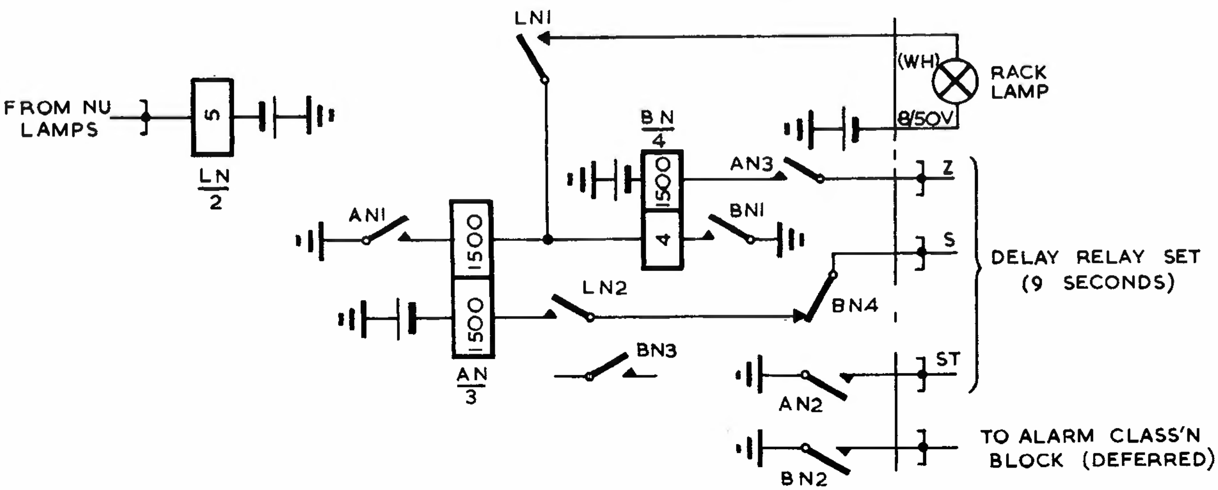


FIG. 9. N.U. TONE SUPERVISORY ALARM CIRCUIT.

8. LINE FINDER SUPERVISORY ALARM.

8.1 This important alarm is designed to operate when a primary line finder fails to locate a calling subscriber within a predetermined time. The alarm circuit is incorporated in the Primary Control Relay sets, and its operation is fully described in Paper No. 3, Section 6. The elements of the alarm circuit are shown in Fig. 17 of that Paper. Briefly, relay ST operates at the initiation of a call and remains operated until the calling line is switched through. ST connects relay TA to the "S" pulse lead, and on the next pulse TA operates and locks. TA prepares the circuit of relay TB to the "Z" pulse lead and, if relay ST is still operated when the "Z" pulse arrives (6 seconds after the S pulse), TB operates and locks. The operation of relay TB operates the exchange alarm system and lights lamps on the control set and on the rack. Other contacts of relay TB divert the start signal to another control relay-set so that the connection may be established over an alternative path.

8.2 "S" and "Z" Pulses. The S and Z pulses are derived, by relays from the 6-second pulses from the exchange clock. The arrangements for their generation and distribution to the primary finder racks is shown in Fig. 10.

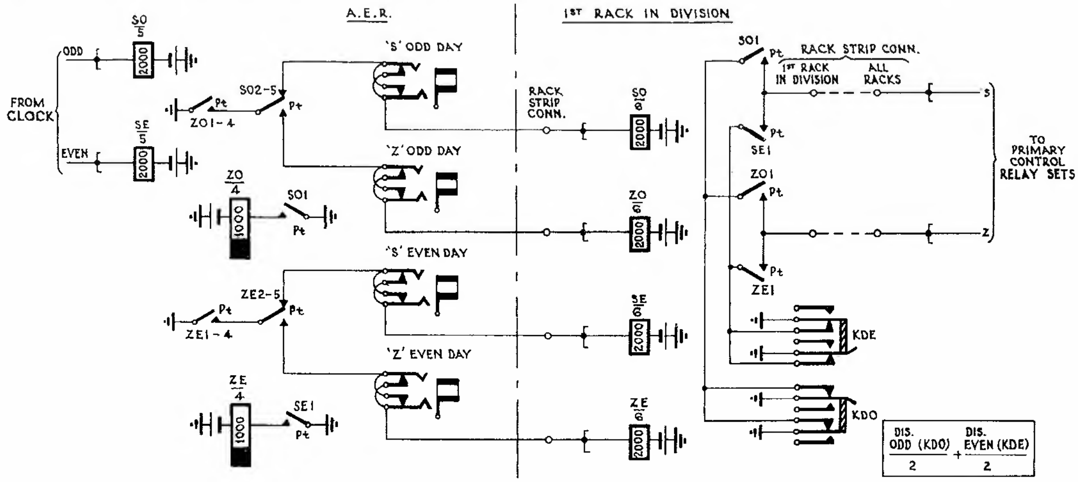


FIG. 10. 6-SECOND S AND Z PULSE CIRCUIT.

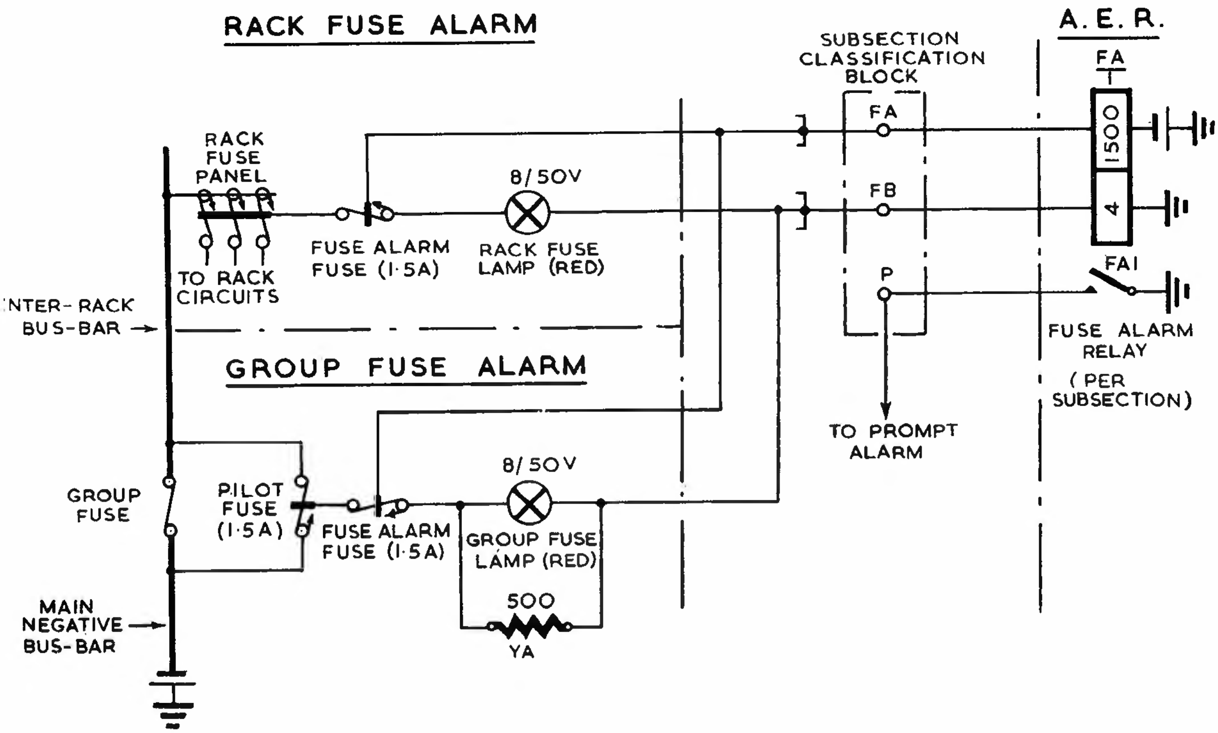
The circuit is duplicated, one set of relays supplying the pulses on "odd" days, the other on "even" days. The operation of the "odd day" circuit will be considered. Relay SO operates to the 6-second pulses from the clock relays and SO1 operates relay ZO. For the duration of the pulse, relays SO and ZO remain operated and a "Z" pulse is delivered to the line finder racks via ZO1-4, SO2-5 and isolating jacks to operate relays ZO which are mounted on the first rack in each line finder suite. The contacts of the rack relays extend the Z pulses to the primary control relay-sets on all racks in the suite.

At the conclusion of the clock pulse, relay SO releases, but relay ZO holds because of its copper slug. During the release time of ZO, an "S" pulse is delivered via the operated contacts ZO1-4 and normal contacts SO2-5 to operate rack relays SO. It will be seen that an S pulse immediately follows the previous Z pulse, therefore the time interval between an S pulse and the next Z pulse is almost 6 seconds. These pulses are supplied continuously to the primary control relay-sets, and it might be noted that, as the circuit may be seized up to 6 seconds before an S pulse is received, the delay period may be anything between 6 and 12 seconds.

The isolating jacks on the A.E.R. allow the alternate use of "odd" and "even" relays, and a key fitted on the first primary finder rack in each suite is used to disconnect the idle circuit.

9. FUSE ALARM.

9.1 A fuse alarm circuit is provided on all racks in an automatic exchange, a typical rack fuse alarm circuit being shown in Fig. 11, which also shows the connections of a group fuse alarm circuit.



FUSE ALARM CIRCUITS.

FIG. 11.

9.2 The operation of an alarm type fuse (see Telephony I) on a rack allows the negative battery busbar and the alarm bar to be bridged. Battery is extended via the fuse alarm fuse, rack fuse lamp and subsection classification block to earth via the 4 ohm winding of relay FA. FA operates and FA1 extends an earth to the subsection classification block to operate the exchange alarm system. The faulty rack is readily seen by the glowing of the rack alarm lamp.

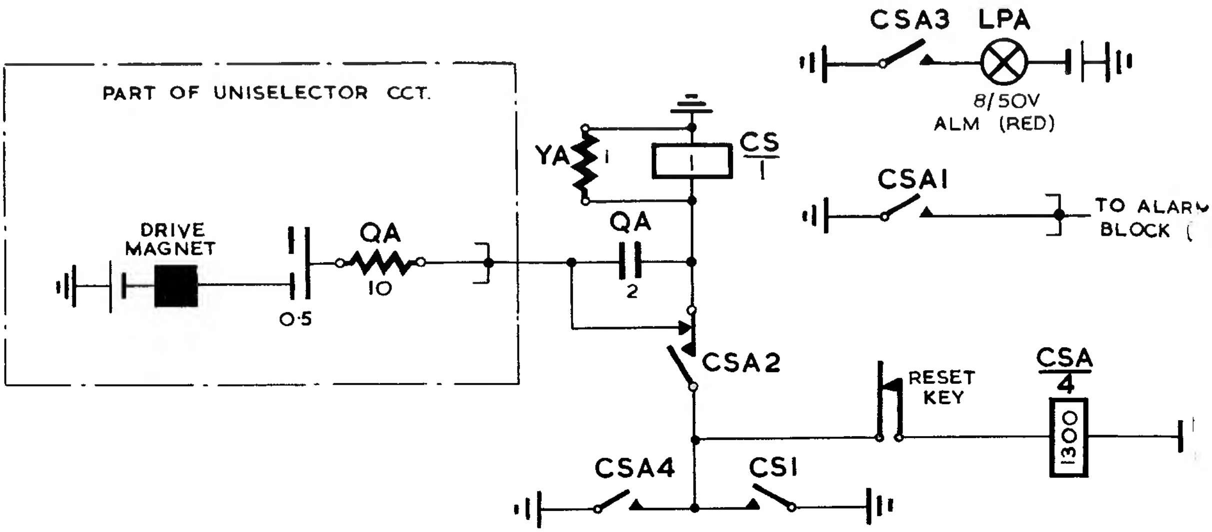
In the event of the fuse alarm fuse operating, relay FA operates with both coils in series. The alarm is brought in as before but, in this case, only the subsection alarm lamp is illuminated. The current through the rack lamp is insufficient to produce a glow.

9.3 Group Fuse. A typical location for a group fuse is shown in Fig. 3 of Paper No. 6. The fuse generally serves one or more suites of racks and is of the cartridge type. A spare fuse is provided in the group fuse panel to allow quick replacement of an operated fuse. In order to provide supervision of the group fuse, an alarm type fuse is connected in parallel so that, in the case of a fault, both fuses operate almost simultaneously. The operation of the alarm circuit is similar to that of a rack fuse alarm and a 500 ohm resistance in parallel with the group fuse lamp ensures that the circuit will still function if the alarm lamp becomes open-circuit.

/10.

10. CONDENSER ALARM.

10.1 Uniselector drive magnet coils are not fully self-protecting and, in the event of breakdown of a uniselector spark quench condenser, the continuous current through the coil will cause overheating and possibly a fire. The subscriber's uniselector line circuit shown in Paper No. 4, Fig. 2, incorporates an alarm circuit to give an immediate indication should a condenser fail. The alarm circuit, together with the relevant portion of the uniselector circuit, is shown in Fig. 12.



CONDENSER ALARM CIRCUIT.

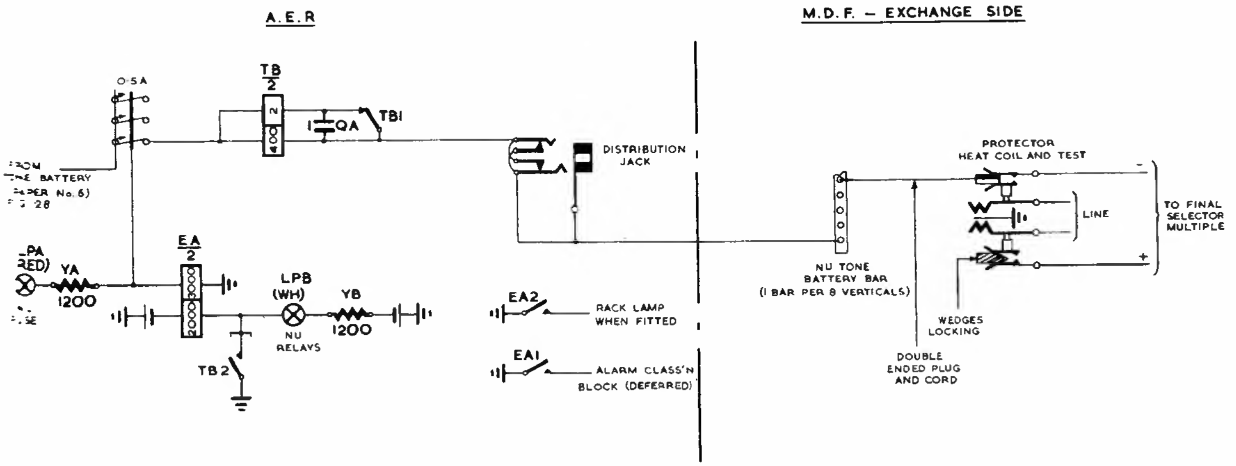
FIG. 12.

10.2 Relays CS, CSA and the alarm lamp are common to a uniselector rack (300 circuits). Normal operation of the uniselectors does not cause the operation of relay CS as it is shunted by 1 ohm YA. Immediately a spark quench condenser in a uniselector circuit breaks down, relay CS operates in series with the drive magnet. CS1 extends an earth via the Reset key to relay CSA, which operates and locks to earth at CSA4. CSA1 extends an earth to the subsection classification block to give a prompt alarm, and CSA3 lights the rack lamp. CSA2 removes the short-circuit from 2µF condenser QA in the alarm circuit, and the continuous current through the drive magnet ceases. Relay CS releases, but CSA remains operated until the reset key is operated.

10.3 The faulty condenser on the rack may be located simply by operating and releasing the reset key. The uniselector associated with the faulty condenser will be seen to operate as the key is operated.

11. N.U. TONE OVERLOAD ALARM.

11.1 For connection to subscribers' lines which are faulty or temporarily out of service (T.O.S.), N.U. tone battery is wired to tone bars fitted at every eighth vertical on the exchange side of the M.D.F. An alarm arrangement is incorporated in the circuit to give an immediate indication in the event of an overload on the N.U. tone supply. The N.U. tone distribution and alarm circuit is shown in Fig. 13.



DISTRIBUTION OF N.U. TONE TO FAULTY AND T.O.S. LINES.

FIG. 13.

11.2 N.U. tone is temporarily connected to the required lines by means of double-ended cords. One end plugs into the N.U. tone bar and the other end into the negative side of the subscriber's protector unit. The L relay of the line must be disconnected by insulating the K relay springs. When a call is made to the line, the ring is tripped by the N.U. tone battery on the negative wire and N.U. tone is heard by the caller.

11.3 Fault Conditions. It will be seen from Fig. 13 that N.U. tone is fed via the 2 ohm winding of relay TB. In the event of a low resistance earth fault on the negative wire of a subscriber's line circuit which is connected to the circuit, relay TB operates. TB1 introduces the 400 ohm winding of TB into the circuit to reduce the current flow. TB2 lights the "N.U. Relays" lamp and operates relay EA on its 2000 ohm winding. EA1 extends an earth to operate the exchange alarm system and EA2 lights the rack lamp, when fitted.

The faulty circuit may be quickly located by removing each of the plugs in turn from the N.U. tone bar. When the faulty circuit is disconnected, relay TB releases, releasing relay EA and the alarm is cleared.

Relay EA also acts as a fuse alarm relay, but a clear indication as to whether an overload or a fuse is the cause of an alarm is given by the glowing of the "N.U. relay" lamp in the first case and the "N.U. Fuse" lamp in the second case.

12. RING FAIL AND MACHINE FAIL ALARMS.

12.1 Two machines are installed to supply ringing current and tones to the exchange equipment. Usually, one is driven from the supply mains, the other operates from the 50 volt exchange battery. In some smaller exchanges, both machines are battery-driven.

Normally, the first ringing machine carries the exchange load but, in the event of failure of ringing current, an automatic change-over arrangement comes into operation, starting-up the second ringer and transferring the load thereto. In order to test for failure of ringing current, tappings are taken from each ringing busbar on the A.E.R. to testing relays RFK, RFL, RFM and RFN as shown in Fig. 14. These relays are mounted at the rear of the power board ringing panel.

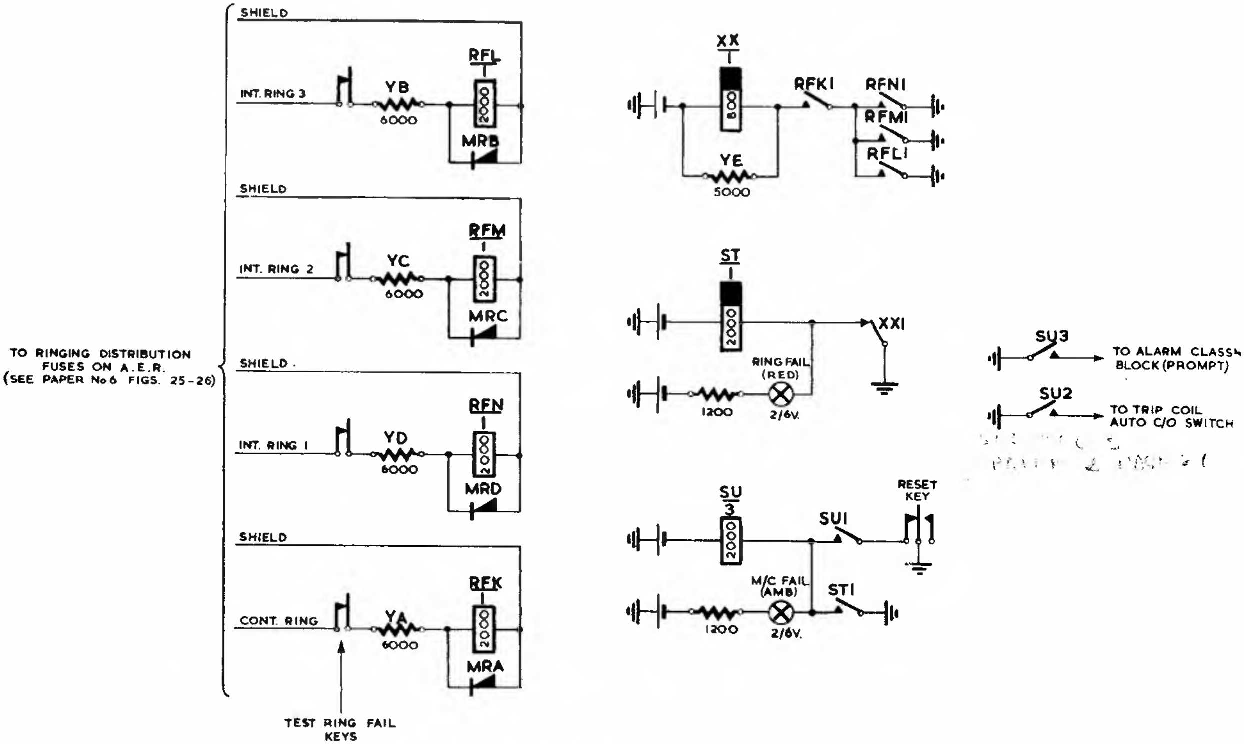


FIG. 14. RING FAIL ALARM CIRCUIT.

12.2 Relay RFK is operated by the continuous ring, while relays RFN, RFM and RFL are operated in turn by the three interrupted ring supplies. Relay XX is normally held operated by the contacts of these relays and, if a failure of ringing current occurs, the appropriate testing relay releases, thus releasing relay XX. XX1 operates relay ST and lights the "Ring Fail" lamp on the power board. ST1 operates relay SU and lights the "Machine Fail" lamp. SU locks via SU1 to earth at the Reset key. SU3 extends an earth to operate the exchange alarm system and SU2 extends an earth to the trip coil of the change-over switch, which starts up the second ringer and connects it to the load. If the ringing current is restored on all busbars, relay XX reoperates and releases relay ST. The alarm is maintained until the reset key is operated, thus ensuring a personal attendance at the power board.

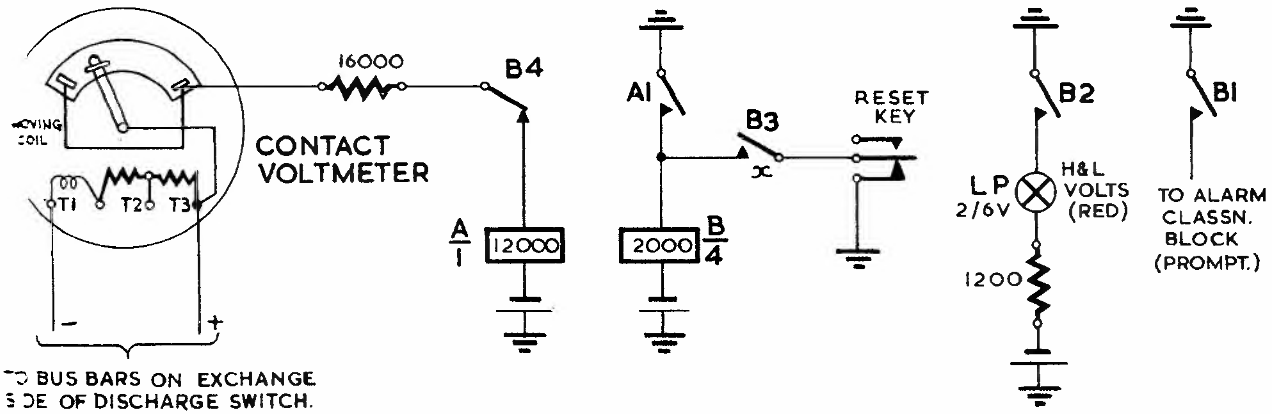
Test keys are provided for disconnecting each testing relay so that the operation of these important alarms can be checked.

/13.

13. HIGH OR LOW VOLTAGE ALARM.

13.1 Automatic exchange equipment is designed to operate satisfactorily between the limits of 46-52 volts, and this alarm gives an immediate indication in the event of the voltage at the main busbars being outside of these limits.

13.2 To supervise the voltage on the main busbars, a contact voltmeter is permanently connected across them as shown in Fig. 15.



HIGH OR LOW VOLTAGE ALARM CIRCUIT.

FIG. 15.

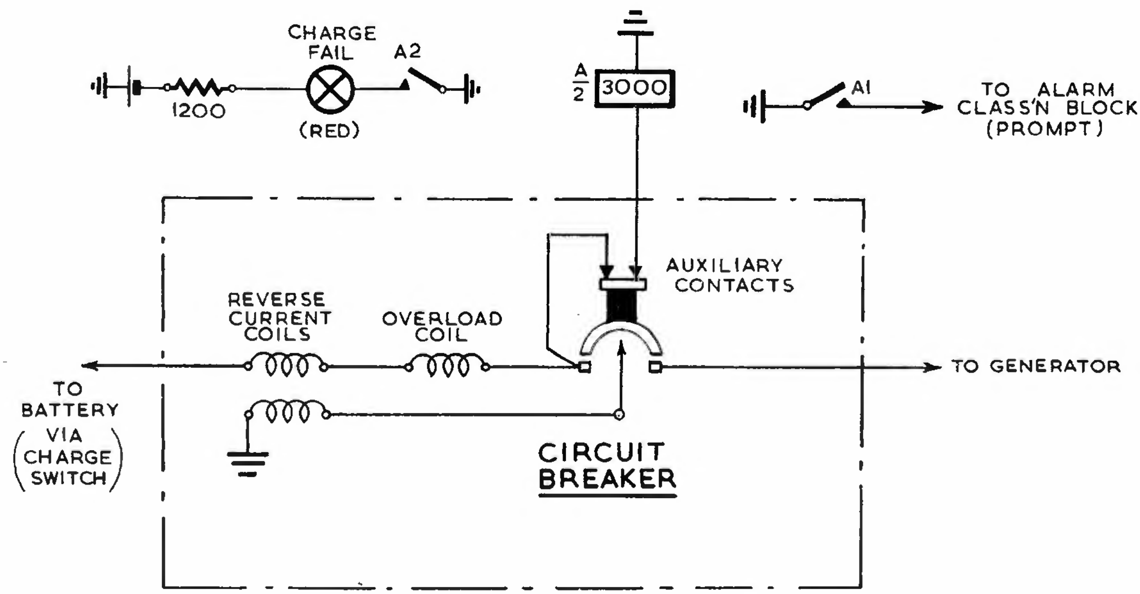
The contact voltmeter is of the suppressed-zero type and is mounted on the power board ringing panel. The pointer carries a contact which is connected to the positive exchange busbar (earth). Adjustable high and low voltage contacts are provided and, should the exchange voltage rise or fall beyond the set limits, the contacts close to operate relay A. A1 operates relay B, which locks via B3 to earth at the reset key.

B2 lights the "H and L Volts" lamp on the ringing panel and B1 extends an earth to operate the exchange alarm system.

The voltmeter contacts are very light and the high resistance of relay A, together with the 16,000 ohm resistance, ensures that the current carried by these contacts is kept to a minimum. On the operation of relay B, B4 disconnects the voltmeter contacts and relay A releases. Relay B remains operated until the reset key is operated, ensuring a personal attendance at the power board even if the fault is only of a transitory nature.

14. CHARGE FAIL ALARM.

14.1 When the power room is remote from the automatic apparatus and is not permanently under supervision, it is desirable that premature tripping of the charge circuit breaker should operate the exchange alarm system. This may be achieved by fitting on the circuit breaker auxiliary contacts connected to an alarm relay as shown in Fig. 16.



CHARGE FAIL ALARM CIRCUIT.

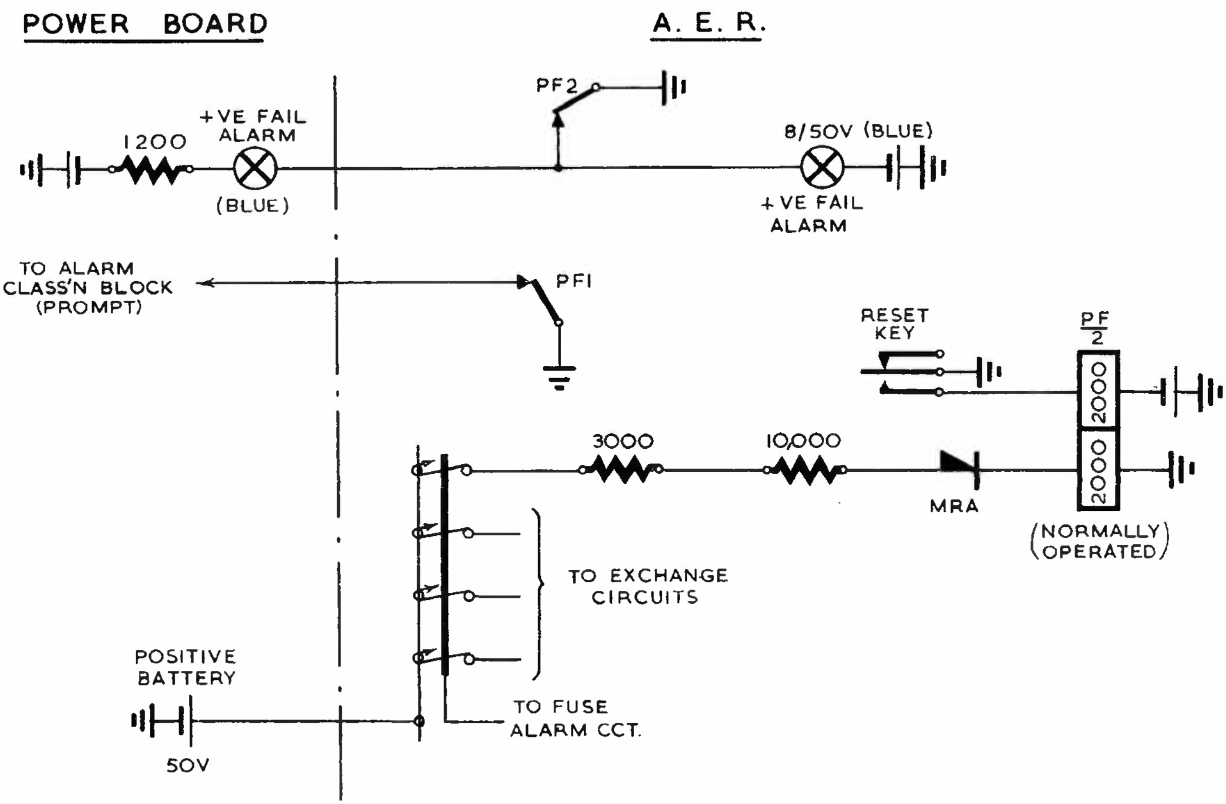
FIG. 16.

When the circuit breaker is closed, the auxiliary contacts are broken and the generator is connected to the battery. Should, however, the circuit breaker operate due to an overload or reverse current, the auxiliary contacts close the circuit of relay A to the exchange battery. A1 extends an earth to operate the exchange alarm system. A2 lights the Charge Fail lamp on the panel.

14.2 In some exchanges, instead of a circuit breaker a contact ammeter is fitted (see Applied Electricity II). In the event of an overload or reverse current, the ammeter contacts cause the operation of a relay whose contacts operate a contactor to disconnect the generator from the battery. Other contacts of the relay operate the charge fail alarm as described above.

15. POSITIVE BATTERY FAIL ALARM.

15.1 The positive battery supplies current for the operation of subscribers' meters and for other miscellaneous purposes. An alarm circuit is arranged to give an immediate indication in the event of failure of the positive battery voltage. The connections are shown in Fig. 17.



POSITIVE BATTERY DISTRIBUTION AND ALARM CIRCUIT.

FIG. 17.

15.2 Relay PF is normally held via MRA and resistances of 10,000 and 3,000 ohms by the positive battery. Should the positive battery voltage drop below approximately 25 volts, relay PF releases. PF1 extends an earth to the power board alarm classification block to operate the exchange alarm system. PF2 completes the circuit of the "+ve Fail" lamps on the A.E.R. and on the power board.

Restoration of the normal positive battery voltage will not reoperate relay PF, which must be reoperated by operating the reset key.

16. GENERAL LAYOUT OF ALARM EQUIPMENT.

16.1 The preceding pages have described the various alarms which are provided to indicate abnormal conditions on the automatic switching plant and power plant. In some circuits, a lamp is provided to indicate the alarm condition on any individual selector or relay-set. The tracing of the faulty circuit is facilitated by the provision of rack (and sometimes shelf) alarm lamps. In addition to these local alarms, a comprehensive system of floor alarms is provided in order to direct the maintenance staff to the appropriate part of the exchange.

16.2 Each floor in an automatic exchange is divided into areas, known as "sections." Each section covers an area of some 3000 square feet and is further subdivided into "subsections." The subsections are, as far as possible, arranged so that they include similar classes of equipment, and each subsection usually covers an area of up to 700 square feet. As an example, Fig. 18 shows the division for alarm purposes of the typical main exchange switchroom shown in Fig. 21 of Paper No. 6.

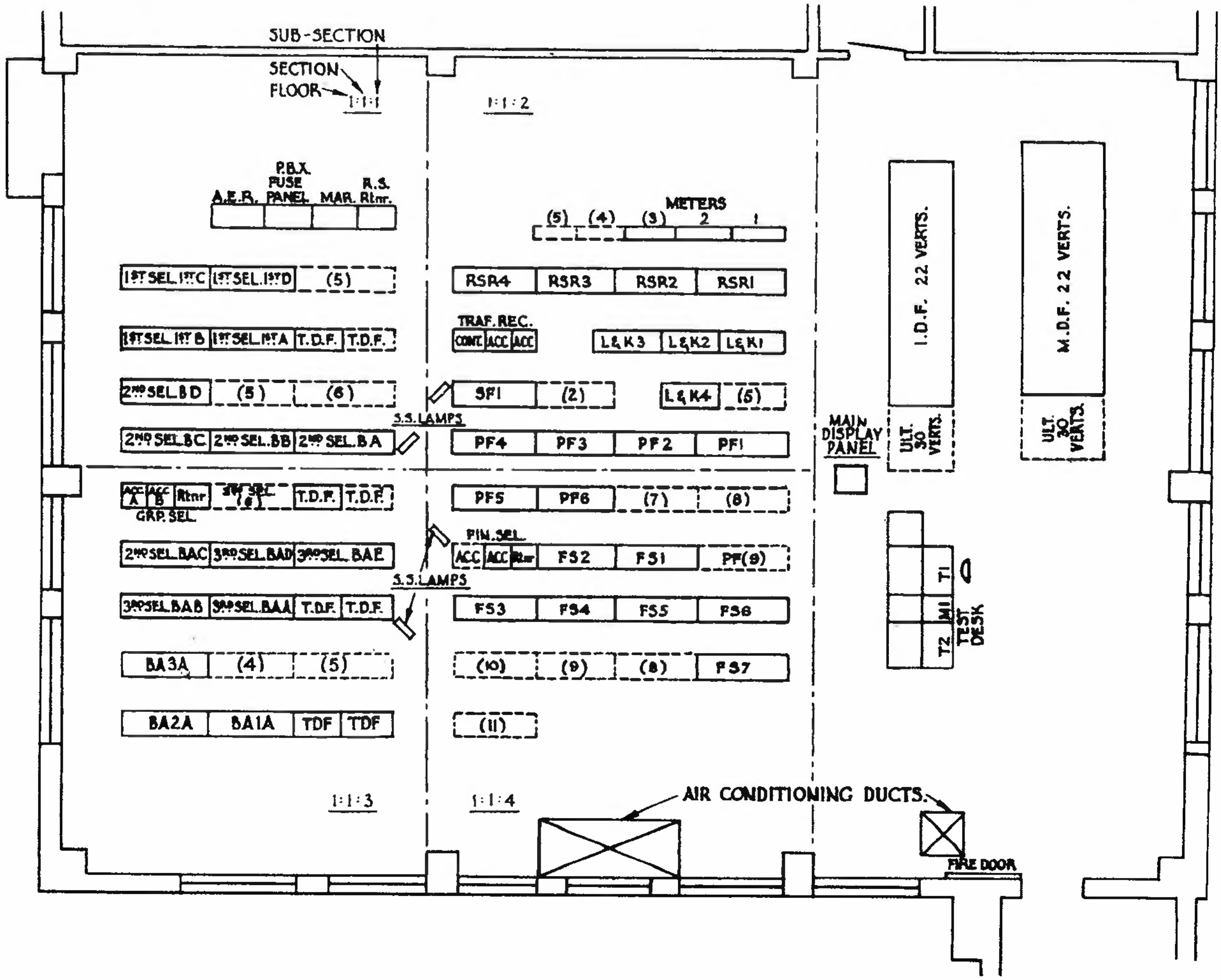
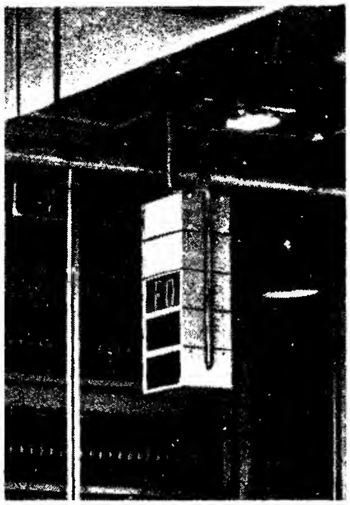


FIG. 18. LAYOUT OF ALARM EQUIPMENT.

16.3 Subsection Lamps. Two alarm lamps are provided per subsection - a white lamp for the deferred condition and a red lamp for a prompt alarm. The lamps are placed in a conspicuous position in an aisle. It is usual to locate all the subsection lamps of one section in the same aisle.

/16.4

16.4 Main Display Panel. A main display panel is provided on each floor with lamps for each section on that floor. Any fault in a section is indicated on this panel by the red illuminated number of the section. Lamps are also provided in this panel for each other floor of the exchange, so that, if an alarm condition exists on any floor, an indication is given on all other floors of the exchange by the white illuminated number of the floor.



MAIN DISPLAY PANEL.

FIG. 19.

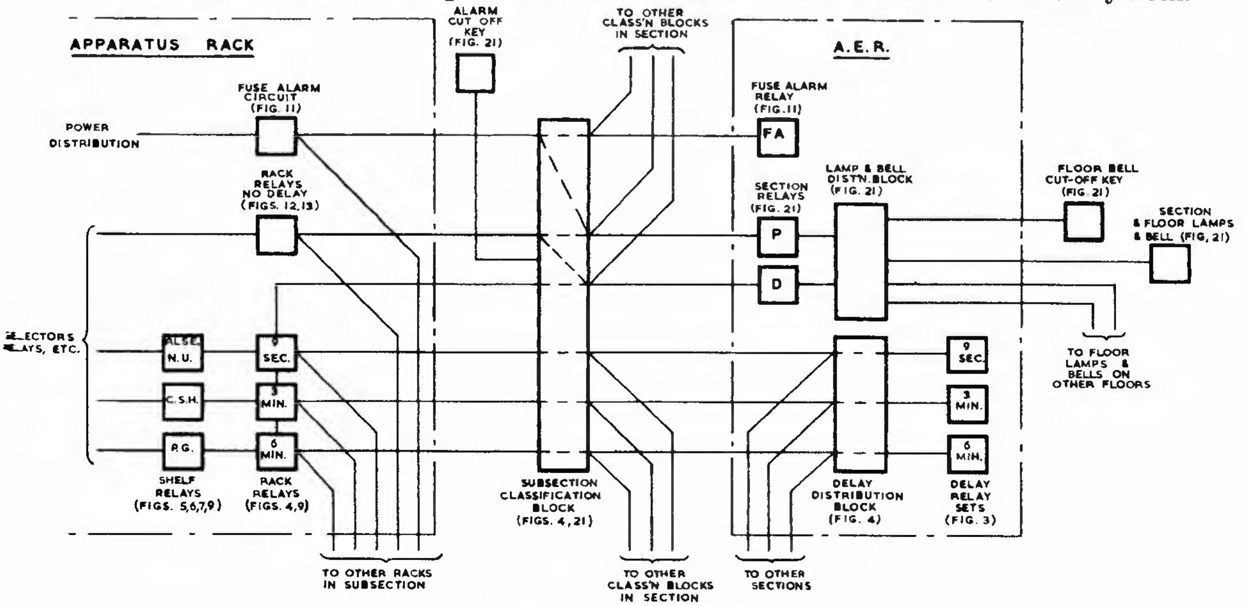
The power plant of an exchange is treated as one section and is distinguished throughout the floor alarm panels by the adoption of a blue number panel.

If necessary, more than one appearance of the main display panel is made on any floor in order that the panel shall be visible to the maintenance staff from the normal working positions.

Fig. 19 shows the main display panel for an exchange having two sections on that particular floor and two other floors, plus the power section.

16.5 Floor Bells. In addition to the system of lamps, a floor bell is fitted near the main display panel to draw attention to the fact that an alarm lamp is glowing. If necessary, these bells are duplicated at a number of points on the floor so that the alarm can be heard above the noise of the apparatus. Section bells are also provided if the floor contains a large number of sections.

16.6 Subsection Classification Block. Associated with the subsection lamps in each subsection is a terminal block to which all alarm connections in the subsection are made. Fig. 20 shows the connections made on the subsection classification block. The figure numbers against each item refer to diagrams contained in this Paper, thus allowing the relationship of each circuit element to the whole to be readily seen.



CONNECTIONS TO SUBSECTION CLASSIFICATION BLOCK.

FIG. 20.

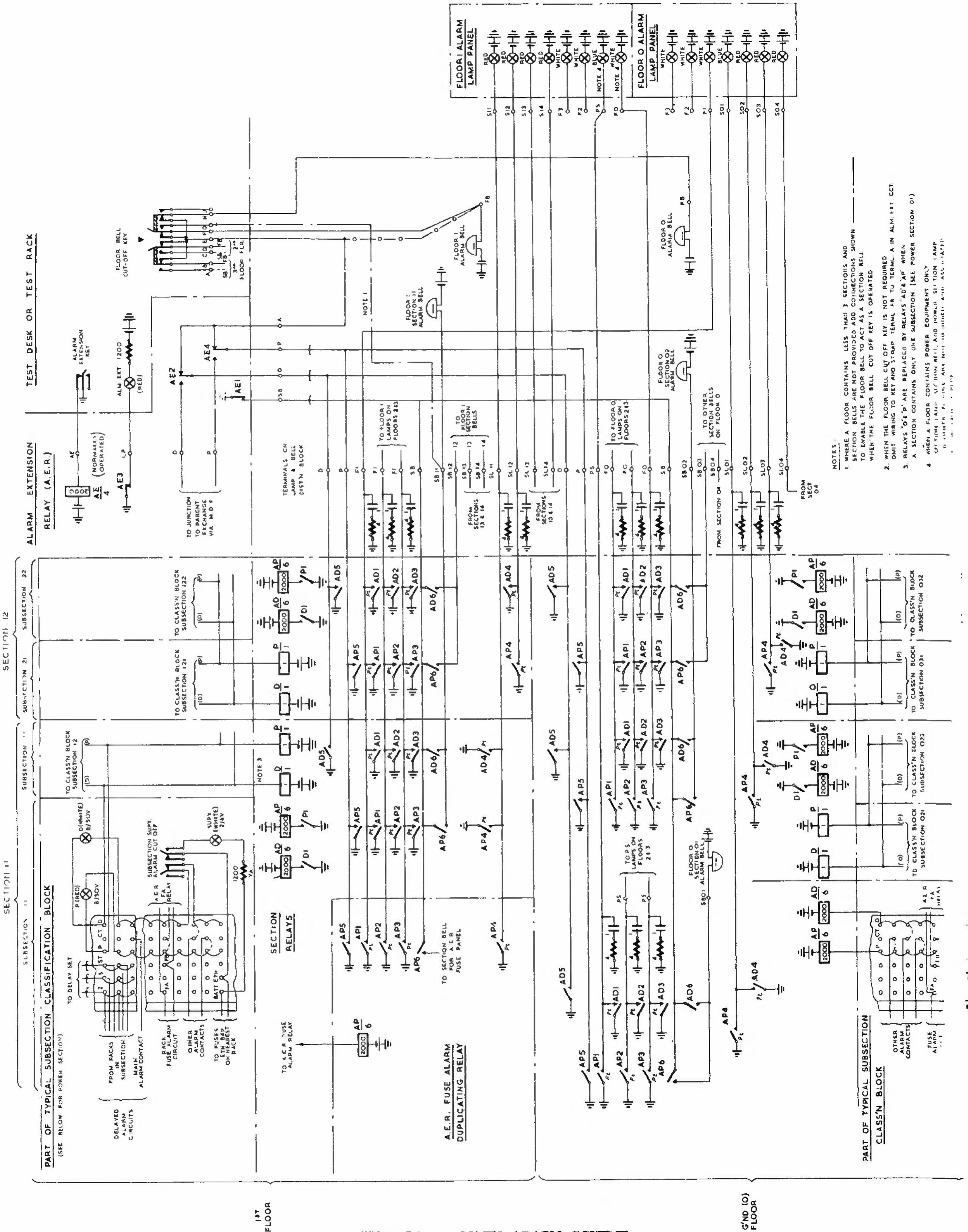


FIG. 21. MAIN ALARM SCHEME.

17. DESCRIPTION OF SECTION AND FLOOR LAMP CIRCUITS.

17.1 In each of the alarm circuits previously described, an earth is extended to the subsection classification block to operate the exchange alarms, that is, to light the appropriate floor, section and subsection lamps and operate the alarm bells. Discrimination is made on the classification block as to whether a particular alarm shall illuminate the Prompt or Deferred subsection lamp, also, in the case of the latter, whether it shall be connected via the alarm cut-off key.

17.2 Fig. 21 shows the circuit connections of an alarm scheme serving an exchange of two floors and having two sections on each floor in addition to the power section on the ground floor. The scheme may be extended to serve up to four floors each having four sections. Details of the classification block are shown for subsection 111, and the alternative strapping for prompt, deferred, and deferred via cut-off key is shown dotted. Alarms are only connected via the cut-off key when they are of such a nature that they can be temporarily ignored, for example, P.G. alarms on first selectors. As a reminder to the maintenance officer, a warning light glows when the key is operated.

17.3 Section Relays. The earth from the rack alarm circuits passes via the respective subsection lamp to operate either relay P or D, which are of very low resistance to permit the lamp to be fully illuminated. These relays carry a single make contact to operate the slave relays AP or AD which carry sufficient contact units to control the section lamps, floor lamps and bells. When a section contains only one subsection, the subsection lamps are not provided, relays P and D are omitted and relays AP and AD are operated directly by the earth from the alarm circuit. The relays are provided for each section and are mounted on the A.E.R. together with the necessary terminal blocks for cross-connections. The terminal blocks on the A.E.R. provide a convenient point for cross-connecting from the section relays to the lamps and bells and also allow extensions to be made without causing any interference to the working equipment.

17.4 Lamps. Operation of relay AP or AD in a section causes the section lamp to be illuminated on that floor, and the floor lamp on all other floors. For example, a fault in section 11 causes the illumination of S11 lamp (red) on the 1st floor lamp panel and F1 lamp (white) on the ground floor. An exception is made in the case of the power section for which a section lamp (blue) is provided on all floors. When a floor contains power equipment only, the power section lamp on other floors is not required, and the associated floor lamp (F0) is blue.

17.5 Bells. Operation of relay AP or AD also causes operation of the floor bells on all floors and the section bell (when fitted) in the particular section.

17.6 Floor Bell Cut-off Key. This key is mounted on the Test Desk and its function is to isolate the floor bells during hours of continuous attendance on each floor. Where section bells are not provided, the key connects the floor bells to act as section bells when operated.

17.7 Alarm Extension Circuit. When an exchange is not continually attended, arrangements are made to extend the alarms over a junction to the parent exchange. Operation of the Alarm Extension key on the Test Desk releases relay AE, which is normally operated. AE3 extinguishes the associated indicating lamp. AE1 disconnects the operating earth for all section bells. AE2 and AE4 extend the Deferred and Prompt leads, respectively, to the junction, at the same time disconnecting the operating circuit for the floor bells.

17.8 A.E.R. Fuse Alarm Duplicating Relay. This relay is provided in the section containing the A.E.R. Its purpose is to give an alarm in the event of the regular alarm circuit being put out of action due to the operation of a fuse. Relay AP is operated by an additional contact on the A.E.R. fuse alarm relay, and duplicates the functions of the normal section relay.

18. TEST QUESTIONS.

1. List the alarms in an automatic exchange which require -

   (i) Urgent attention.
   (ii) Non-urgent attention.

2. What delay periods are necessary in connection with alarms in a 2000 type automatic exchange? State the method used to obtain the required delay period in each case.

3. A subscriber connected to a main automatic exchange leaves the receiver off the hook. Describe the operation of the exchange equipment culminating in the operation of the alarm system. What attention should be given to the alarm?

4. During a period of light traffic it is noticed that a large number of 1st selectors are held under P.G. conditions. What is the probable significance of this, and what attention should be given?

5. What is the purpose of the High or Low Voltage Alarm in an automatic exchange? List three possible causes of the alarm condition.

6. Describe the sequence of events following the failure of ringing current supplied by the mains-driven ringing machine at an automatic exchange.

19. REFERENCES.

Telecommunication Journal of Australia.

Vol. 1, No. 5, "Supervisory Alarm System for Automatic Exchanges" - B. Draper.

Vol. 6, No. 6, "Power Plant in Telephone Exchanges" - E. J. Bulte.

END OF PAPER.

COMMONWEALTH OF AUSTRALIA.

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COURSE OF TECHNICAL INSTRUCTION.

THE TEST DESK.

CONTENTS.

1. INTRODUCTION.
2. TEST SELECTOR TRUNK, TEST SELECTOR AND TEST FINAL SELECTOR.
3. TEST TRUNKS TO M.D.F.
4. TEST AND PLUGGING-UP LINES.
5. INCOMING TRUNKS.
6. IN AND OUT TRUNKS.
7. ORDER-WIRE CIRCUIT.
8. PILOT AND NIGHT ALARM CIRCUIT.
9. SPECIAL SERVICE ON FAULTY LINES.
10. TEST CIRCUIT.
11. DIAL TEST CIRCUIT.
12. TESTING OF SUBSCRIBERS' SERVICES.
13. TEST QUESTIONS.
14. REFERENCES.

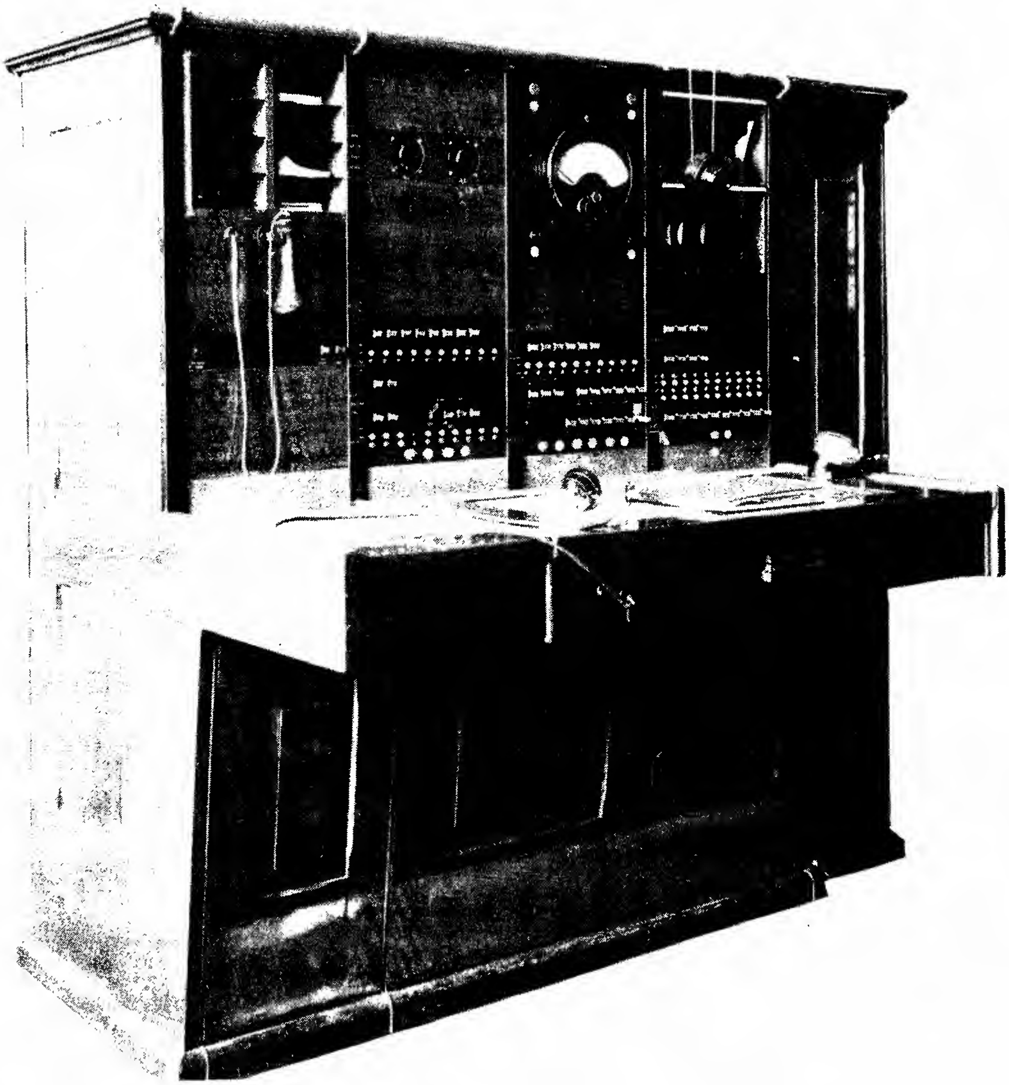
1. INTRODUCTION.

1.1 Foremost amongst the testing equipment provided at automatic exchanges is the Test Desk, for there all subscribers' complaint reports are received and their probable causes diagnosed from the results of tests performed on the reported circuit. The test desk generally consists of a cordless floor pattern switchboard as shown in Fig. 1, and is provided with a voltmeter and keys for testing and connecting purposes. Pigeon-holes are provided for fault dockets and subscribers' master cards. A number of positions may be installed, according to the testing requirements. In smaller exchanges the testing apparatus may be rack-mounted, in which case it is known as a Test Rack.

1.2 The test desk or rack provides circuits enabling the testing officer to test or speak to any subscriber, junction or other line connected to the exchange. These circuits are listed below -

(i) Test Selector Trunks.
(ii) Trunks to M.D.F., Exchange side.
(iii) Trunks to M.D.F., Line side.
(iv) Test and Plugging-up Lines.

1.3 Incoming trunks to the test desk or rack allow technicians and linemen to call the testing officer, and tests may be performed on these lines. In and Out trunks provide telephone facilities for the testing officer, and are arranged so that calls can be made to the test desk without the necessity for inserting coins in a public telephone or without causing operation of a subscriber's meter. Order-wire circuits provide intercommunication facilities between adjacent exchanges.

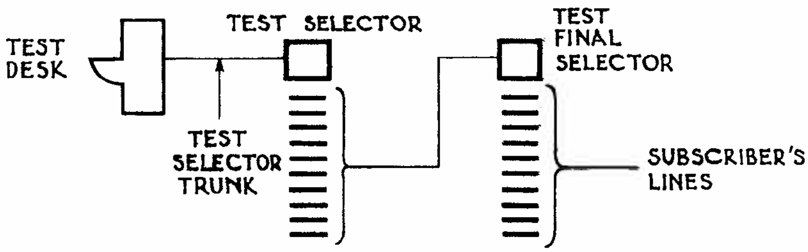


TEST DESK, 2,000 TYPE EXCHANGE.

FIG. 1.

2. TEST SELECTOR TRUNK, TEST SELECTOR AND TEST FINAL SELECTOR.

2.1 As indicated in previous Papers, each 200-line group of subscribers is provided with a Test Final Selector, which is mounted on the end position of the final selector bank multiple for that group. These test final selectors are wired from the bank contacts of a Test Selector (or Test Distributor) as shown in Fig. 2.



TEST SELECTOR TRUNK.

FIG. 2.

More than one test selector is generally required, and the number provided in an exchange is generally one per 1,000 subscribers' lines. The banks of the test selectors are multipled and connected to the test final selectors in numerical order. For example, the test final selector serving the $\frac{11}{10}$ group of subscribers' lines (1000-1199) is wired from the first and tenth contacts of the first level. Thus, 50 test final selectors, each giving access to 200 lines (or 100 test final selectors, each serving 100 lines) can be connected to the test selector bank multiple.

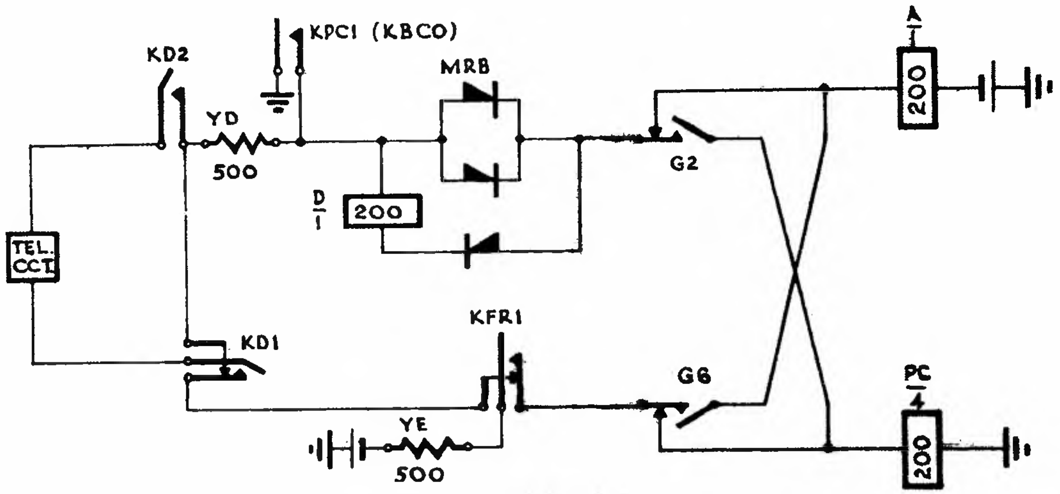
Connection to the test selector is made via Test Selector Trunks. These trunks are multipled over the test desk positions, and terminate on keys. Operation of Test and Dial keys at the test desk connects the dial to a test selector, and, by dialling the last four digits of the required number, the testing officer may connect the test circuit to any subscriber's line. The first two digits dialled step the test selector vertically to the level corresponding to the first digit, and rotarily to a contact on that level corresponding to the second digit. The last two digits operate the selected test final selector and step it to the bank contacts of the required number. The test wires from the test desk are extended to the subscriber's line and the K relay is operated from earth at the test selector. Thus, testing of the line may be carried out without interference from battery or earth in the subscriber's line circuit.

2.2 The general functions of the test selector are -

(i) Steps vertically under the control of the first train of impulses received.
(ii) Rotates under the control of the second train of impulses.
(iii) Repeats the third and fourth trains of impulses to the test final selector, if free.
(iv) If the test final selector is busy, returns busy tone and gives a lamp signal at the test desk.
(v) If the subscriber's line is found to be busy, gives a lamp signal only and extinguishes the lamp when the line becomes free.
(vi) Extends the test wires from the test desk to the test final selector, allowing the testing of both line and exchange conditions over a clear loop.
(vii) Provides for rotary stepping of the test final selector over a level by dialling single digits.
(viii) Allows the test final selector to be released without releasing the test selector.
(ix) Provides for releasing 1st selectors held by faulty lines, and after the 1st selector has released, the test selector immediately seizes the subscriber's line circuit.

2.3 The circuits of the Test Selector Trunk, Test Selector and Test Final Selector are shown in Fig. 3, attached. The operation of this circuit is described below.

Test Selector Seized. Assuming that the test selector is free, as indicated by the "busy" lamp, the circuit is seized by momentarily operating the test key (KT). Relay A in the test selector trunk operates to earth at KT5 and locks via A3 to earth at KR1. A4 earths the test selector P wire and lights the busy lamps on other test desk positions. KT2 and KT4 complete the circuit for relays A and PC in the test selector, the simplified holding circuit being shown in Fig. 4. Relay D does not operate as the current is in the non-operate direction. In the test selector, the operation of relay A completes the operating circuit for relay B at A1, and B4 and PC3 operate relay BP. B1 and B3 prepare the circuit for impulsing.



TEST SELECTOR HOLDING CIRCUIT.

FIG. 4.

Test Selector Vertical Stepping. (Relays operated: A, PC, B, BP.) Operation of the dial key (KD) connects the telephone circuit dial into the test selector holding circuit, and relays A and PC respond to the dialled impulses. On the first impulse, relay C and the vertical magnet are operated in series via H1, E1, G7, RC3, B3 and A1 to earth at B1. The shaft and wipers are stepped to the dialled level and, during the first step, the N springs operate. Relays C, B and BP hold during impulsing and, at the end of the impulse train, C releases slowly and completes the circuit of relay E via EA2, C4 and BP3 to earth at N3. E operates slowly and E1 changes the impulsing circuit over to the rotary magnet.

Test Selector Rotary Stepping. (Relays operated: A, PC, B, BP, E.) When the second digit is dialled, the rotary magnet and relay C are operated by impulses via H2, E1, G7, RC3, B3 and A1 to earth at B1. C holds during impulsing and relay E holds via E3 when C4 operates. The reoperation of relay C operates relay EA via C2, E4 and BP3 to earth at N3. At the end of the impulse train, C again releases and C4 opens the circuit of relay E. During the slow release period of E the selected test final selector is tested by relay G.

Test Final Selector Busy. If the test final selector is busy, relay G operates over the Z lead from battery via resistance YA, N1, Z wiper, H3, E2, C3 and H5 to earth at BP4. G1 holds relay G should the test final selector subsequently become free. G8 prevents the operation of relay H when E4 releases, and G7 disconnects the impulsing circuit. G2 and G6 reverse the direction of current in the test selector holding circuit (see Fig. 4) and rectifier-polarised relay D operates. D1 energises the busy lamp, indicating to the testing officer that the test final selector is busy. A further indication is given by busy tone connected to the 280 ohm windings of relays A and PC by G5, and induced into the holding loop circuit.

/ Test

Test Final Selector Free. If the selected test final selector is free, there is no battery on the Z lead as the N springs of the test final selector will not be operated. In this case relay G cannot operate and, on the release of relay E, relay H operates via G8, EA1, E4 and BP3 to earth at N3. H6 completes the circuit of relay FS which operates, and H1 extends the impulsing circuit of the test selector to the vertical magnet of the test final selector. H3 connects battery via resistance YA to the Z wiper to guard the selected test final selector until it steps off normal.

Test Final Selector Vertical Stepping. (Relays operated: A, PC, B, BP, EA, H, FS.) When the third digit is dialled, the vertical magnet of the test final selector is impulsed over the V wiper and bank via H1, E1, G7, RC3, B3 and A1 to earth at B1. Relay C reoperates and, at C4, opens the holding circuit of relay EA, which releases. At the end of the impulse train C releases slowly and relay E reoperates via EA2, C4 and BP3 to earth at N3.

Test Final Selector Rotary Stepping. (Relays operated: A, PC, B, BP, H, FS, E.) The fourth and last impulse train operates the rotary magnet of the test final selector over the R wiper and bank via H2, E1, G7, RC3, B3 and A1 to earth at B1. C reoperates and C2 completes the circuit of relay EA, which again operates. At the end of the impulse train C releases, and at C4 breaks the circuit of relay E. During the slow release of E, relay RC is operated via B2, FS1, EA3, C2, E4 and BP3 to earth at N3, and locks via RC5.

Testing Subscriber's Line. If the line is free, battery via the line circuit relay K extended over the P wiper operates relay PT via PT2, H7 and C1 to earth at B5. PT2 locks relay PT with both windings in series, and PT1 extends an earth over the P wiper to operate the K relay. Operation of relay K disconnects battery and earth from the subscriber's line and gives a clear loop for testing from the test desk.

Testing Exchange Equipment. If it is desired to test the exchange equipment of the line under test, the testing officer operates the Private Control key (KPC) (previously known as the B.C.O. key). This connects a full earth on the positive lead to the test selector, short-circuiting relay PC, which releases. PC1 removes the earth from the P wiper, releasing relay K and reconnecting the subscriber's L relay. The testing officer may connect the test desk telephone circuit across the testing leads and test the exchange apparatus by making a test call via the subscriber's line finder or uniselector equipment. (The Listening key in the test circuit is operated so that the dialled impulses go out via the negative and positive test wires.)

Subscriber's Line Busy. If the line is busy, there will be an earth on the P contact and relay PT cannot operate. When relay E releases, relay G operates from battery via resistance YA, RC6, E2, C3, H5 and PT1 to earth at B5. G2 and G6 reverse the current in the test selector holding circuit (see Fig. 4) and relay D operates to give an indication to the testing officer that the subscriber's line is busy. As relay FS is operated, busy tone is not given under this condition.

G3 and G4 disconnect the testing loop, but condensers QB and QC allow monitoring of the called line. When the line becomes free, relay PT operates and releases relay G.

Release of Connection. To release the connection the testing officer momentarily operates the Release key (KR), opening the holding circuit of relay A in the test selector trunk, which releases. A1 opens the test selector holding circuit and relays A and PC release, followed by the release of relay B. The release circuit of the test final selector is completed over the Z wiper via FS3 and B6 to release alarm earth, and this switch restores to normal when its off-normal contact N1 opens the release circuit. Relay FS is held on its 5 ohm winding during this release from battery via resistance YA in the test final selector. The release of relay B releases relays BP, RC and PT, and BP releases relays H and EA. When the test final selector restores to normal the N springs break the holding circuit of relay FS, which releases and completes the test selector release circuit at FS3. The test selector restores to normal, and N1 opens the release circuit.

Test Final Selector Release Facility. The test final selector may be released without releasing the test selector by operating the Final Release key (KFR) in the test circuit. This arrangement obviates releasing both selectors when tests are required consecutively on subscribers in the same final selector group.

Operation of the final release key holds relay PC with battery via resistance YE and releases relay A, followed by the release of relays B, RC and PT. Relays PC, BP, EA, H and FS remain operated, and the test final selector release circuit is completed via FS3 and B6 to release alarm earth. The switch restores to normal when N1 opens the release circuit.

After allowing sufficient time for the test final selector to release, the final release key is restored and relays A and B reoperate. The test selector is now in the condition to impulse the vertical magnet of the test final selector and, by dialling the last two digits of the number, connection is made to the required subscriber's line.

Testing a Complete Level. When a test is completed on a subscriber's line and a single digit is dialled without releasing the connection, the test final selector will step to the next contact and a test may be made on that particular line. This facility allows a complete level of lines to be tested without releasing the test final selector.

The single impulse energises the rotary magnet of the test final selector over the R wiper via H2, RC3, B3 and A1 to earth at B1. Relays C and E reoperate, and C releases after the impulse. During the release time of relay E the subscriber's line is tested as previously described. Relay PT operates if the line is free, and relay G if it is busy.

This process may be repeated by dialling single digits until all subscribers' lines on the level have been tested.

Testing Other Lines. A line may be held whilst the test circuit is used to make other tests. This is effected by restoring the Test key without operating the Release key. Relay A remains operated and relay B is connected to the test wires so that, should the subscriber originate a call, B operates and B1 lights the supervisory lamp. Restoration of the test key connects relay R across the test selector holding loop via A1. Operation of relay R disconnects the test circuit from the test selector, and the testing officer may proceed to test other lines. Reoperation of the test key disconnects relay R, and the test selector is again placed under the control of the test circuit.

Revertive Ring Facility. In later test desks, provision is made for supplying ringing current for adjustment of bells at subscribers' premises. After dialling the last four digits of the subscriber's number, the Ring key (KRR) is operated and interrupted ringing current is applied to the line via the 300 ohm winding of relay C. The test key may then be released, the holding circuit to the test selector being maintained by relay R via A1, KT2 and KT4. This disconnects the test circuit from the test selector, and the testing officer may proceed to test other lines.

When the line is looped, relay C operates and locks on its 400 ohm winding to earth at KRR3. C4 and C2 disconnect the ringing current and ring return, respectively. C1 lights the Answer lamp from battery via the pilot relay. The testing officer answers by operating the test key and releasing the ring key.

/ 2.4

2.4 Releasing Switches Held by Faulty Lines. The facility is provided of releasing first selectors held by faulty lines. After the first selector has released and removed the busying earth from the subscriber's line circuit, the test selector immediately seizes the line and allows a test to be made. Fig. 5 shows the circuit conditions.

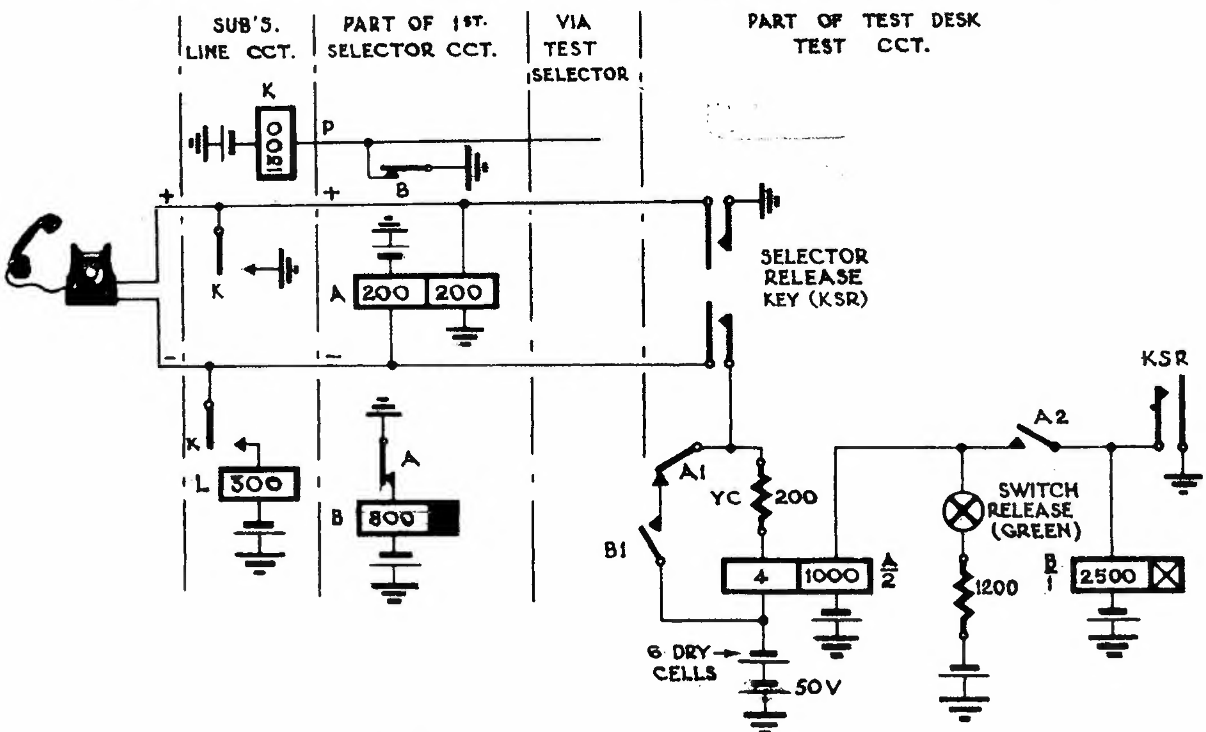


FIG. 5. SELECTOR RELEASE FACILITY.

In this case the subscriber has left the receiver off the hook and a first selector is held by the loop. When the testing officer dials this number, relay G in the test selector operates and the busy lamp glows. The Private Control key (KPC) is now operated, releasing relay PC. PC in releasing shunts condensers QB and QC, and allows the selector release circuit to be brought into use.

Operation of the Selector Release key (KSR) connects earth to the positive line wire, short-circuiting one winding of the 1st selector A relay. A 58 volt negative potential (6 dry cells plus exchange battery) is connected to the negative line wire and causes the current in the second winding of the first selector A relay to fall to zero and then rise slightly in the reverse direction. This overcomes the effect of residual magnetism and the A relay releases, followed by the release of relay B. The selector releases and the earth is removed from the P wire of the subscriber's line circuit. Relay PT in the test selector immediately operates, releasing relay G and the busy lamp is extinguished.

The testing officer now restores the private control key, operating relay PC, and PC1 earths the P wire, operating relay K in the subscriber's line circuit to give a clear line for testing. Finally, the selector release key is restored.

The four ohm winding of relay A provides a guard against excessive current, because, when the key is operated, relay B, being slow to operate, allows the four ohm winding of relay A to test the line. If excessive current flows relay A operates and A1 opens the low resistance path through which the booster battery is normally applied. A2 locks relay A on its 1000 ohm winding and lights the Switch Release pilot lamp. Thus the circuit cannot release switches held by very low resistance loop or earth faults, and in these cases the switches must be released manually.

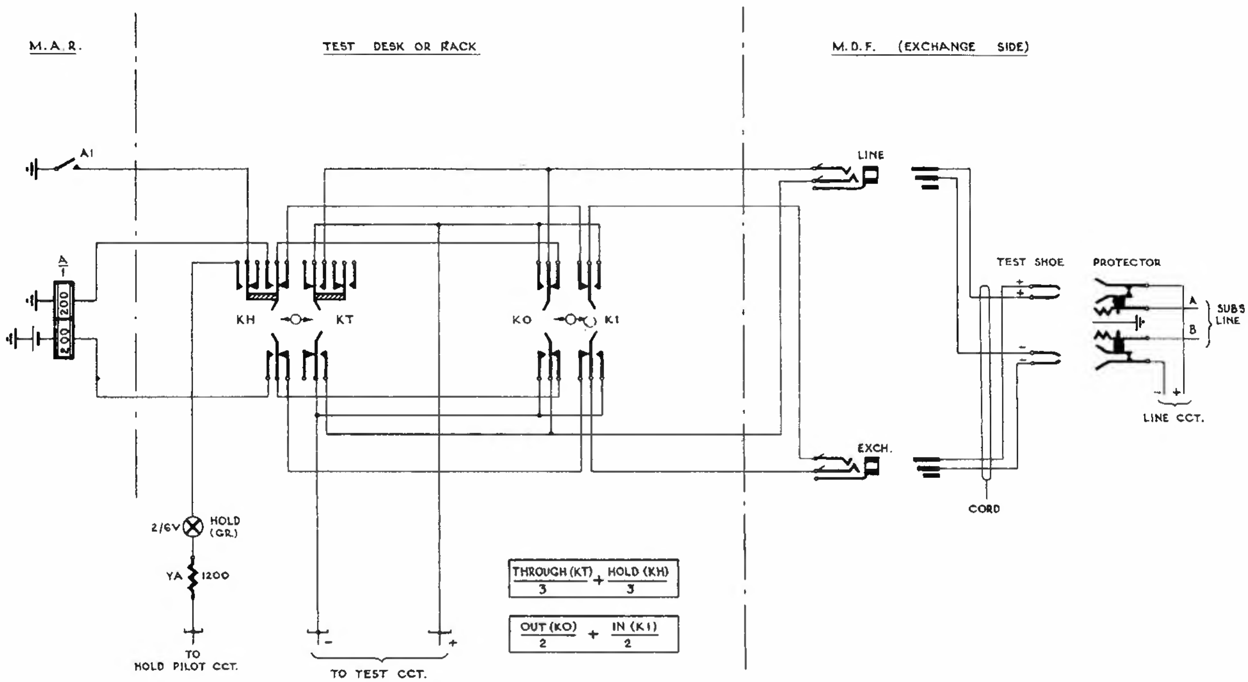
At branch exchanges, where D.S.R's or relay-set repeaters with 50/50 ohm A relays are installed, it is sometimes found that the circuit will not operate satisfactorily using six dry cells, and it is necessary to reduce the number of cells. This is because the reverse current may be sufficient to cause reoperation of the A relay.

/ 3.

3. TEST TRUNKS TO M.D.F.

3.1 Direct lines are wired from the test desk to jack strips fitted on either side of the M.D.F. These test trunks enable the test circuit to be connected to any line or cable pair (subscriber's, junction, extension, power lead, telegraph, broadcasting, private line, etc.) terminated on the M.D.F. A cord and plug with an appropriate test clip is used to complete the connection to the line to be tested.

3.2 Test Trunks to M.D.F. (Exchange Side). This circuit gives access to both the inside portion and the outside portion of a line without changing the connection at the M.D.F. A special test "shoe" or test plugs inserted into the protector makes the necessary connections. The circuit connections are shown in Fig. 6.



TEST TRUNKS TO M.D.F. (EXCHANGE SIDE).

FIG. 6.

With all keys normal, the "in" and "out" sides of the circuit are connected together, and service on the line is unaffected.

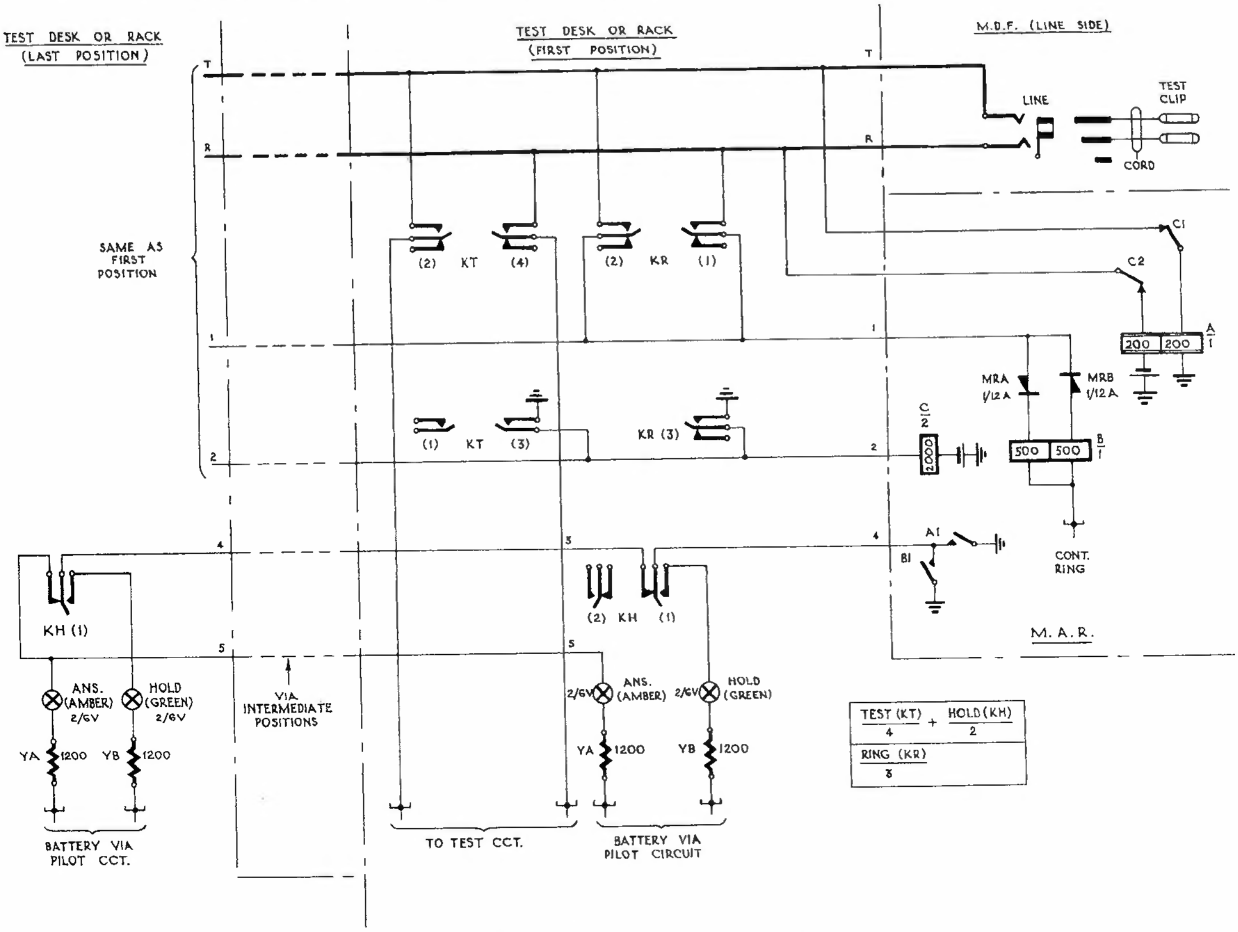
Operation of the Through key (KT) connects the test circuit in parallel with the through connection for listening and testing purposes.

Should the testing officer desire to test the subscriber's exchange apparatus, the In key (KI) is operated, connecting the test circuit to the "in" side of the circuit.

Operation of the Out key (KO) connects the test circuit to the "out" side of the circuit, enabling the subscriber's line to be tested. Should a fault need to be corrected at the subscriber's premises, the maintenance man can hang the receiver up and the testing officer restores the out key to normal and operates the Hold key (KH). This connects relay A to the subscriber's line. When the maintenance man wishes to recall the testing officer, he lifts the receiver and relay A operates. A1 lights the Hold lamp from battery via the hold pilot circuit. The testing officer restores the hold key and reoperates the out key, which connects the test circuit through again to the subscriber's line.

/ 3.3

3.3 Test Trunks to M.D.F. (Line Side). These circuits may be used to test any cable pair by means of a test clip inserted into the M.D.F. fuse strip. The circuits are multipled over the test desk positions, as shown in Fig. 7.



TEST TRUNKS TO M.D.F. (LINE SIDE).

FIG. 7.

When the connected cable pair is looped, relay A operates and A1 lights the Answer lamps on all positions via normal KH1 contacts in series.

Operation of a Test key (KT) connects the test circuit to the trunk at KT2 and KT4, and KT3 operates relay C. C1 and C2 remove relay A from the line and the answer lamps are extinguished.

The testing officer may hold the trunk by operating the Hold key (KH), in which case the answer lamps are extinguished and the Hold lamp on one position only glows when the line is looped.

On later test desks, facilities are provided for supplying ringing current to the cable pair for identification purposes. Operation of the Ring key (KR) operates relay C to remove relay A from the line, and connects continuous ringing current to both wires of the line. When the line is earthed, relay B operates on the ringing current and B1 lights the answer lamps (or hold lamp if a hold key is operated).

/ 4.

4. TEST AND PLUGGING-UP LINES.

4.1 The Test and Plugging-Up line circuit (see Fig. 8) enables a line which is out of service due to one of a number of faults to be plugged out of service, but available for periodic testing. Subscribers calling the faulty line receive Number Unobtainable tone. In addition, when the fault is cleared, the circuit reverts to normal working and gives an indication that this has occurred.

The various faults that can be catered for are described below -

4.2 Earth on "B" Line or Battery on "A" Line. After inserting the test shoe into the protector of the faulty line, the line is tested by operating the Test key (KT). Under one or both of these fault conditions, the A key (KA) is operated before the test key is restored. Relay CO operates to earth from KT and locks via CO4 and M2 to earth at KA. CO2 and CO3 connect the "In" lines to relay MS in readiness for incoming calls to the line. When the test key is restored, relay L is connected to the faulty line via CO6 and CO7, and operates to the fault on either or both line wires.

Relay M operates via M3, L2 and L1 to earth at KA and locks via M3 to this earth. The holding circuit of relay CO is changed over to earth at KA via L1 and KC contacts.

When the fault is cleared, relay L releases, releasing relay CO. CO2 and CO3 connect the "In" and "Out" lines together, giving normal service on the line. The Supervisory lamp is energised via M1 and L1 to earth at KA, indicating that the fault has cleared.

4.3 Earth on "A", Battery on "B", or Short-Circuited Lines. For any one of these cases (or combination of the first two) the B key (KB) is operated before the test key is restored. Relay CO operates and locks as before, and when the test key is restored, relay L operates to the fault (connections reversed at KB). Relay M also operates as before, and when the fault clears relay L releases to give the supervisory lamp and relay CO releases to restore the line to normal working.

4.4 Open Circuit. In the case of this fault it is necessary to operate the B and C keys before the test key is restored. Relay CO operates and locks as before, but on the release of the test key, relay L does not operate.

When the fault is cleared and the line wires looped, relay L operates, operating relay M, which locks via M3 to earth at KB. Relays CO and L release. The supervisory lamp glows, and the circuit is restored to normal working conditions. Relay M releases when the B key is restored.

4.5 Incoming Calls from Final Selector. With relay CO operated, when the final selector rings on the faulty line, relay MS is operated on one winding via the ring return battery, and the other 200 ohm winding of MS applies a tripping condition to the final selector. After the ring has been tripped, N.U. tone is given to the caller. MS1 closes the ringer start circuit, if required. CO5 applies earth to the sleeve of the "Exch." jack, which is used for busying P.B.X. lines when necessary.

5. INCOMING TRUNKS.

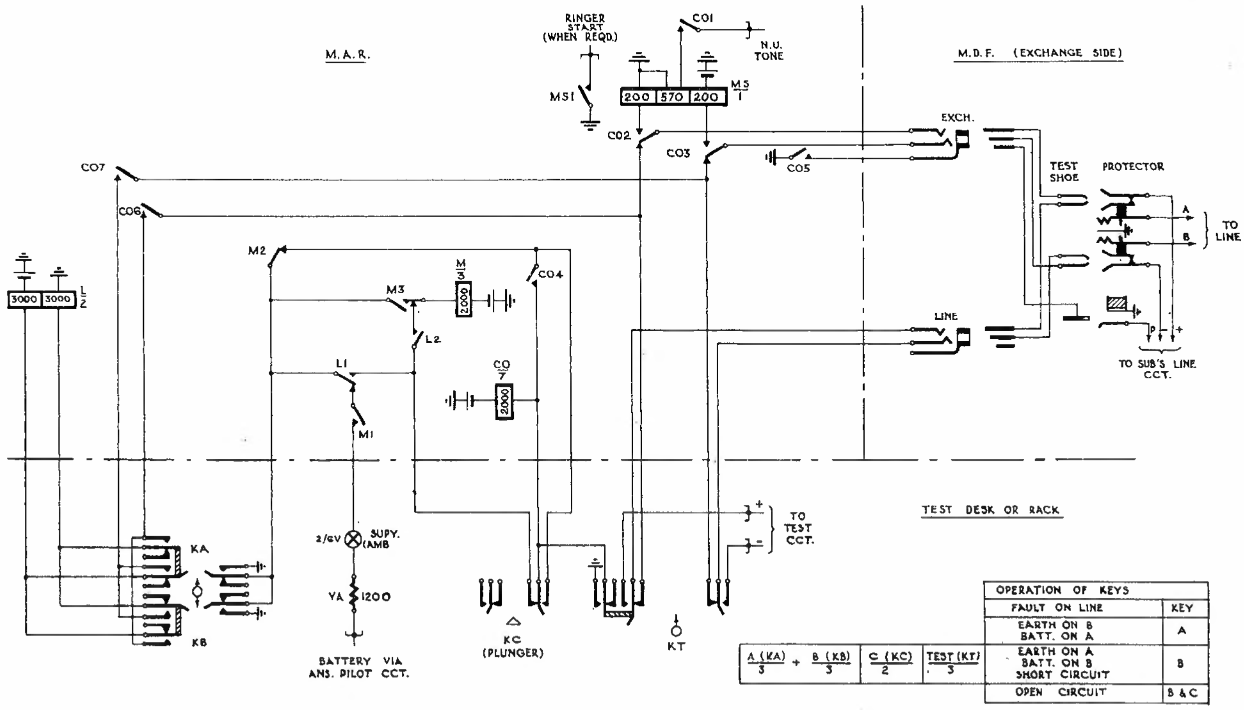
5.1 These circuits allow access from selector levels to the test desk, and, due to the absence of a transmission bridge, tests can be carried out on the incoming lines. The circuits are usually wired from special 3rd or 4th selectors and the test desk may be called by dialling the exchange prefix followed by the digits "09" (for example, WA09). The circuit connections are shown in Fig. 9.

5.2 Relay A operates in series with the calling loop and A1 returns ring tone to the caller. A2 operates relay B and B1 earths the P wire to hold and guard the connection. A3 lights the Answer lamps on all positions via KH2 contacts in series.

To answer the call, a Test key (KT) is operated, operating relay C from earth at KT1. C1 and C2 remove relay A from the lines to give a clear loop for testing. KT3 holds relay B when A2 releases, and the answer lamps are extinguished.

Operation of the Hold key (KH) transfers the answer lamp circuit to the Hold lamp (on one position only) and holds relay B operated to earth at KH1.

/ Fig. 8.



OPERATION OF KEYS	
FAULT ON LINE	KEY
EARTH ON B BATT. ON A	A
EARTH ON A BATT. ON B SHORT CIRCUIT	B
OPEN CIRCUIT	B & C

FIG. 8. TEST AND PLUGGING-UP LINES CIRCUIT.

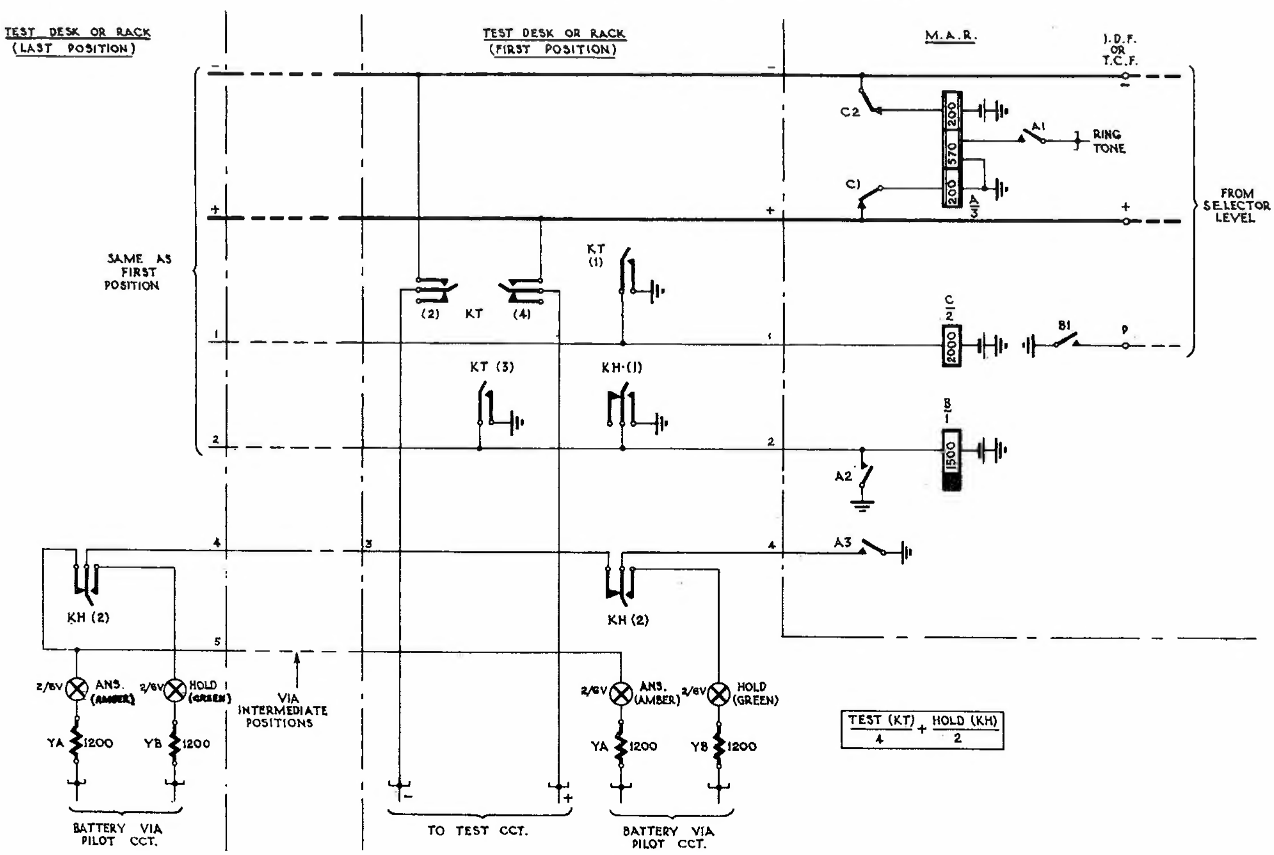
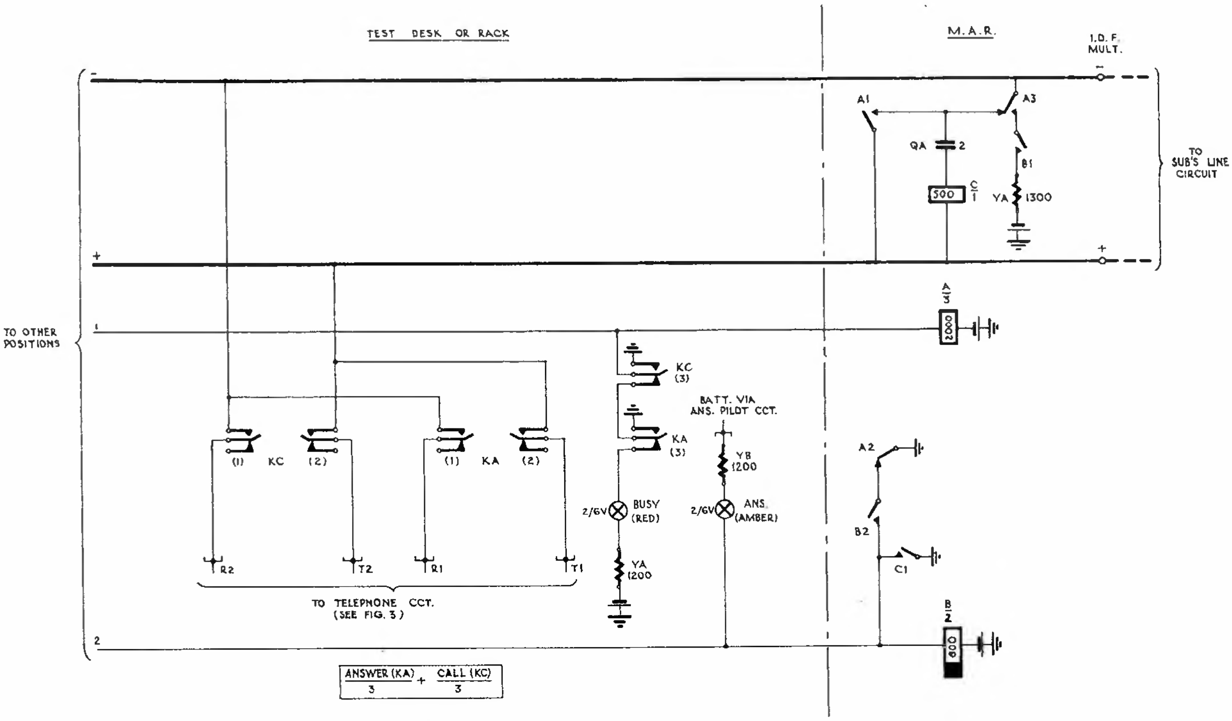


FIG. 9. INCOMING TRUNK CIRCUIT.

6. IN AND OUT TRUNKS.

6.1 These circuits are connected to ordinary subscriber's line circuits, and enable the test desk operator to make outgoing calls through the automatic exchange. Incoming calls are answered in such a way that no coins are required on a call from a public telephone, and operation of a calling subscriber's meter is prevented. It is not possible to connect the testing circuit to these trunks. The circuit connections are shown in Fig. 10.



IN AND OUT TRUNKS CIRCUIT.

FIG. 10.

6.2 Incoming Call. Relay C operates on the ringing current from the calling final selector, and C1 operates relay B. B2 locks relay B to earth at A2, and the Answer lamps on all positions are energised in parallel with relay B.

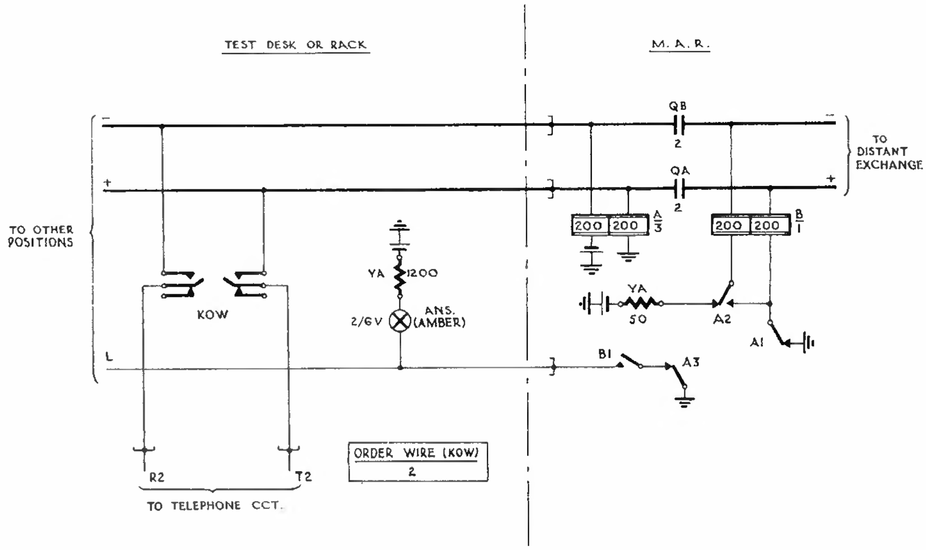
Operation of an Answer key (KA) lights the Busy lamps on all other positions, and operates relay A. A1 short-circuits condenser QA and relay C, and A2 extinguishes the answer lamps and disconnects relay B. During the release time of relay B, battery via resistance YA, B1 and A3 is connected to the negative wire to operate the final selector ring trip relay. Thus, the ring is tripped and the lines are connected to the test desk telephone circuit at KA1 and KA2. As shown in Fig. 3, attached, lead R1 has a 2μF condenser in series which prevents operation of the final selector battery feed relay, and no metering of the call takes place.

6.3 Outgoing Call. Operation of the Call key (KC) connects the telephone circuit to the line at KC1 and KC2. KC3 lights the busy lamps on associated test desk positions, and operates relay A. Condenser QA and relay C are disconnected and short-circuited. In this case connection is made to terminals R2 and T2 in the operator's circuit, therefore the dial is connected in circuit and the call proceeds in the normal manner.

/ 7.

7. ORDER-WIRE CIRCUIT.

7.1 When required, direct order wires are provided between exchanges. For example, a main exchange may have order wires to each of its branches. These lines terminate at each exchange on the Order-Wire Cabinet, and also appear on the test desk. The elements of the order-wire circuit are shown in Fig. 11.



ORDER-WIRE CIRCUIT.

FIG. 11.

7.2 Outgoing Call. Operation of the Order-Wire key (KOW) connects the telephone circuit to the lines and relay A operates. A1 and A2 connect the two windings of relay B in series across the order-wire line to the distant exchange. A3 opens the circuit of the Answer lamp.

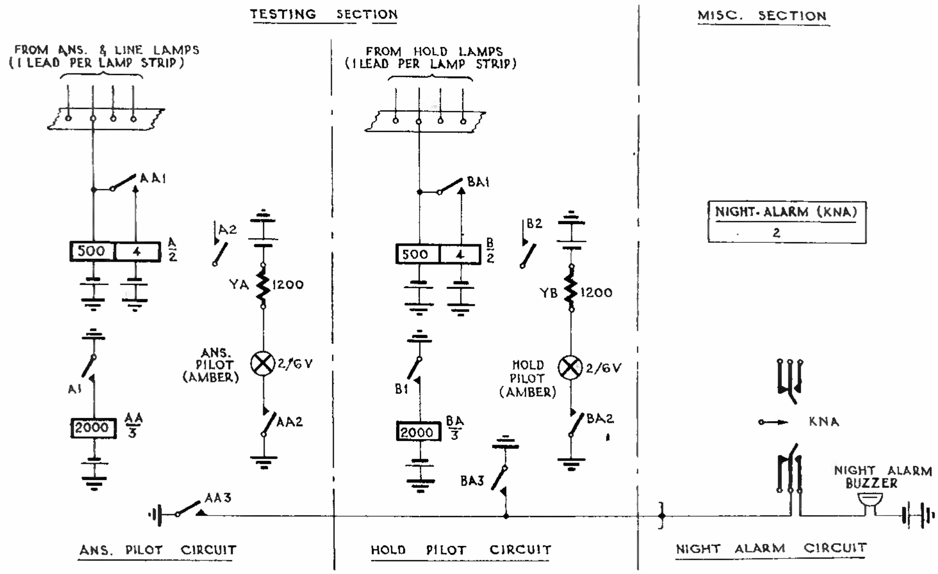
7.3 Incoming Call. When the order wire is looped at the distant exchange (as described in paragraph 7.2) relay B operates and B1 lights the answer lamps on the test desk positions and order-wire cabinet. Other contacts of relay B (not shown in Fig. 11) give an indication on the exchange alarm system. When the call is answered, either from the test desk or order-wire cabinet, relay A operates and A3 extinguishes the lamps. A1 and A2 change the connections of relay B, which releases.

Note. When the order-wire circuit is not in use, the battery from relay B at each exchange is in opposition and neither relay operates.

8. PILOT AND NIGHT ALARM CIRCUIT.

8.1 Battery for answer and line lamps is fed via relay A in each testing section (see Fig. 12). When a lamp is energised, relay A operates and A1 operates relay AA. AA1 connects the four ohm winding of relay A in circuit to reduce the voltage drop across the pilot relay. AA2 lights the Answer Pilot lamp and AA3 closes the night alarm buzzer circuit if the Night Alarm key (KNA) is operated. Similarly, relays B and BA operate when a hold lamp in the section lights.

/ Fig. 12.



PILOT AND NIGHT ALARM CIRCUIT.

FIG. 12.

9. SPECIAL SERVICE ON FAULTY LINES.

9.1 This circuit provides a temporary service for subscribers whose telephone would otherwise be out of order owing to one of the following fault conditions -

(i) Line earthed on one side.
(ii) Line open on one side.
(iii) Line looped or short-circuited.

The equipment is connected between the subscriber's line and the normal line circuit, the necessary connections being made by plugging into the M.D.F. protector unit. The faulty line is thus diverted to this apparatus and isolated by means of a transformer from the exchange apparatus.

9.2 On earthed lines, the line is so plugged up that the battery side of the auxiliary apparatus is connected to the sound wire, and dialled impulses are received over this wire.

On a line which is open one side, service is given by connecting the terminal of the open wire to earth at the subscriber's premises and plugging the auxiliary equipment into the faulty line, which thus becomes a single wire earthed circuit.

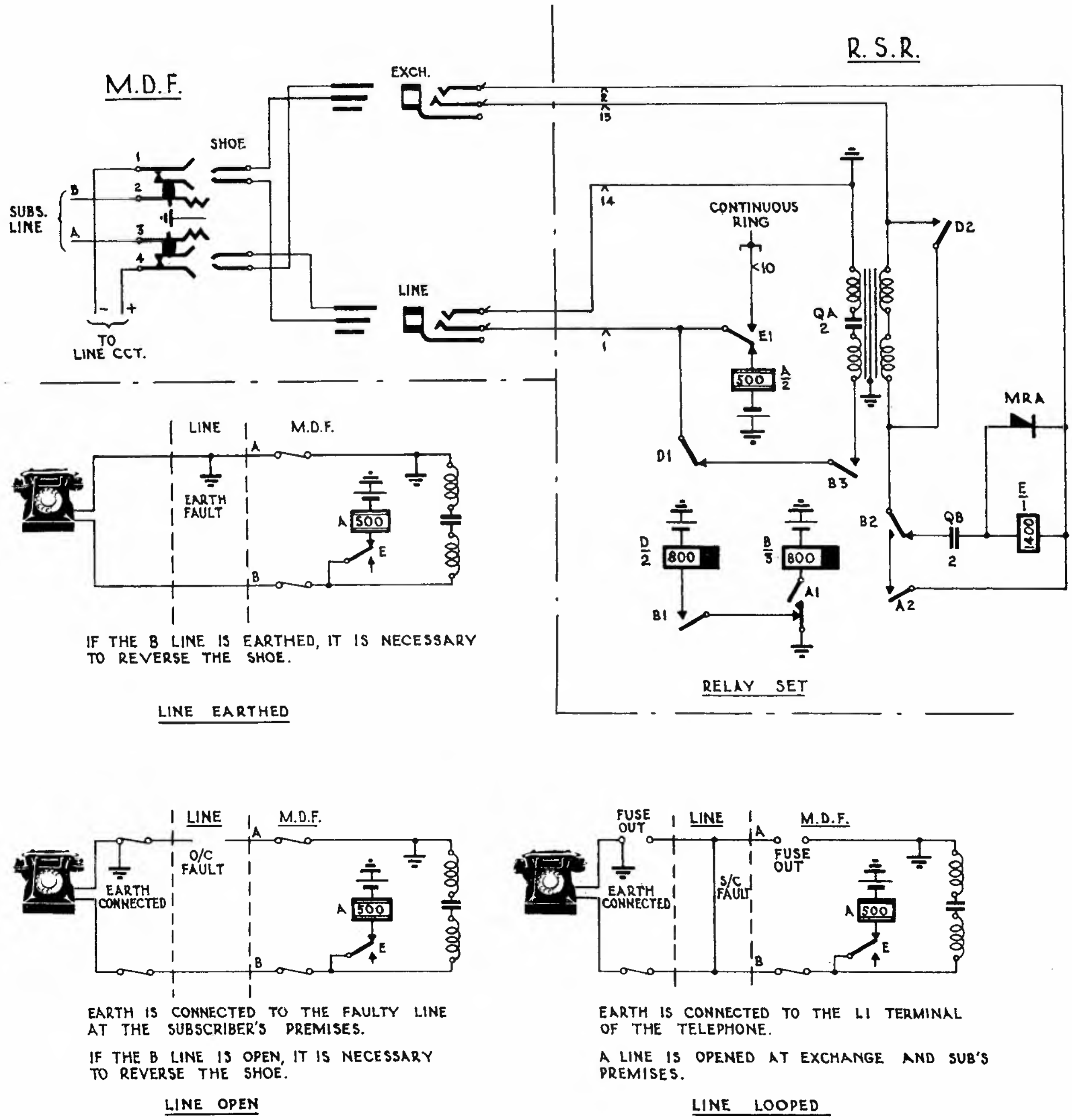
On a looped line, service is given by opening one wire at the exchange and at the subscriber's premises, and the telephone terminal is earthed to give an earthed single wire circuit to the exchange.

9.3 The apparatus is contained in relay sets mounted on the R.S.R., and is wired to jack strips placed on the M.D.F. The circuit connections are shown in Fig. 13.

9.4 Circuit Operation. When the subscriber connected via this equipment originates a call, relay A operates as the line is so plugged up that relay A is connected to the good wire. Relay B operates to earth at A1. B2 prepares an impulsing circuit to the exchange equipment via A2, and B3 completes the transformer circuit. B1 prepares the circuit of relay D which operates during each impulse train and opens the line side of the transformer circuit at D1 and short-circuits the exchange windings of the transformer at D2. Relays B and D are slow releasing so that they hold during impulsing, and at the end of each train D releases, reconnecting the transformer in circuit for transmission.

/ 9.5

9.5 Incoming Call. On receipt of an incoming call, relay E is operated by ringing current from the calling final selector. E operates and releases in synchronism with the interrupted ring periodicity, and E1 repeats the ring to the subscriber's telephone over the non-faulty wire. When the subscriber answers, relay A operates in the next silent period, operating relay B, which in turn completes the circuits to the transformer windings and disconnects relay E. The loop given via the exchange windings of the transformer trips the ringing from the final selector and conversation can proceed.

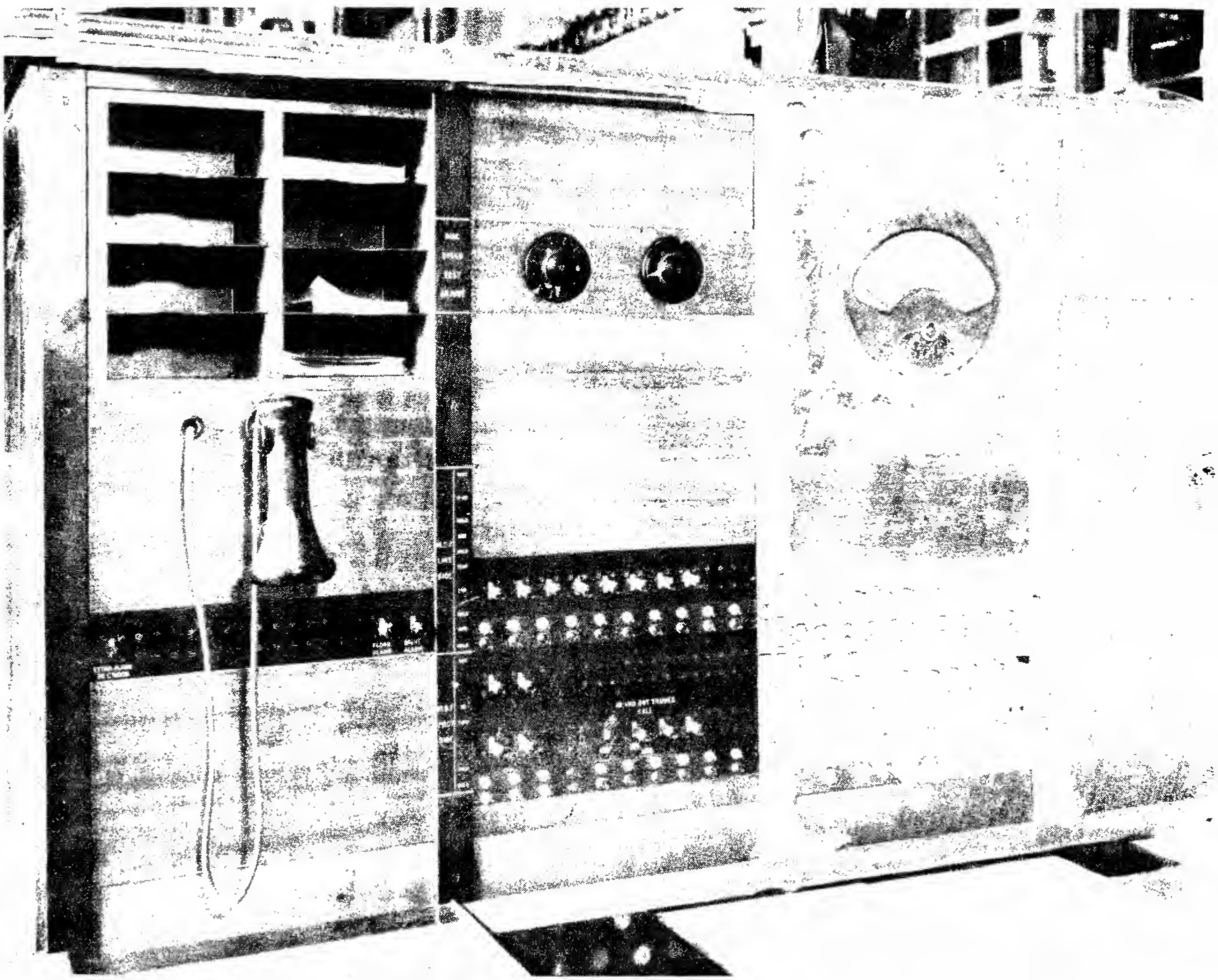


SPECIAL SERVICE ON FAULTY LINES.

FIG. 13.

10. TEST CIRCUIT.

10.1 The foregoing sections describe the various means provided to connect subscribers' lines, junctions, etc., to the test desk and then via keys to the test circuit. Fig. 14 shows the keyboard of a test desk, including the keys and voltmeter of the test circuit.



TEST DESK KEYBOARD.

FIG. 14.

Details of the functions and testing circuits of the test desk are given on the following pages. Fig. 15 shows the complete test circuit, and simplified diagrams of the various test conditions are given in Fig. 16.

10.2 The voltmeter used on the standard test desk has two scales, one giving a range of 80 volts and having a resistance of 200,000 ohms, the other a range of 8 volts with a resistance of 20,000 ohms. Three terminals (common positive, -8 volts and -80 volts) are provided on the voltmeter.

/ 10.3

10.3 The functions performed by the keys of the test circuit are listed below -

Transmitter Cut-Off Key (KTCO). If it is required to monitor on a line with a minimum of interference, this key is operated. The transmitter is short-circuited, and an 0.25µF condenser QB is inserted in series with the negative test wire to reduce the shunting effect on the line.

Line Reverse Key (KLR). This reverses the connections to the line under test.

Selector Release Key (KSR). Used for releasing first selectors held by a fault.

Earth Key (KE). For foreign battery tests connects earth to the test circuit. On earth tests disconnects the test circuit earth from the line under test.

Ring Key (KR). Operation of this key sends ringing current out on the line under test.

Listening Key (KL). This key connects the test desk telephone circuit to the line.

Howler Key (KH). Enables the howler tone to be fed out on a subscriber's line when the receiver has been left off.

Battery and Buzzer Key (KB). Supplies transmission battery via relay C to the line under test. When the line is looped, the relay operates and its contacts complete the circuit for a buzzer to operate and for supervisory lamps mounted on the M.D.F. to glow.

Loop Key (KLP). Short-circuits the test wires. Used for checking resistance tests.

Foreign Battery Key (KFB). Connects voltmeter across negative and positive test wires.

Voltmeter Reverse Key (KVR). Reverses the connections of the voltmeter across the test wires.

Resistance Test Key (KRT). This key connects the voltmeter in series with an 80 volt battery to the line under test.

Low Scale Key (KLS). This key disconnects the high voltage scale of the voltmeter and connects a voltage divider circuit across the exchange battery, so that tests are carried out using the 8 volt scale of the voltmeter.

Insulation Resistance Key (KIR). When this key is operated, the circuit of relay BS is completed and the contacts of BS connect a 400 volt potential to the voltmeter when KRT is thrown. Used for insulation tests.

25 Decibel and 40 Decibel Keys (K25 db and K40 db). The operation of these keys introduces an artificial cable with a 25 db or 40 db loss between the line and the test desk telephone.

Artificial Cable Key (KA). Transfers the artificial cables to the adjacent test desk position.

Private Control Key (KPC). (Formerly known as the B.C.O. Key.) This key enables the subscriber's exchange equipment to be tested. Its contact short-circuits relay PC in the test selector, thus releasing relay K in the subscriber's line circuit.

Final Release Key (KFR). The operation of this key allows the release of the test final selector, but holds the test selector.

Dial Key (KD). Connects the test desk telephone circuit dial to the test selector trunk.

Impulse Weight Key (KIW). Connects the line through to the impulse weight test circuit.

Weight Reset Key (KWR). This key is operated before each weight test is made, and sets the voltmeter reading to a value corresponding with the normal weight reading.

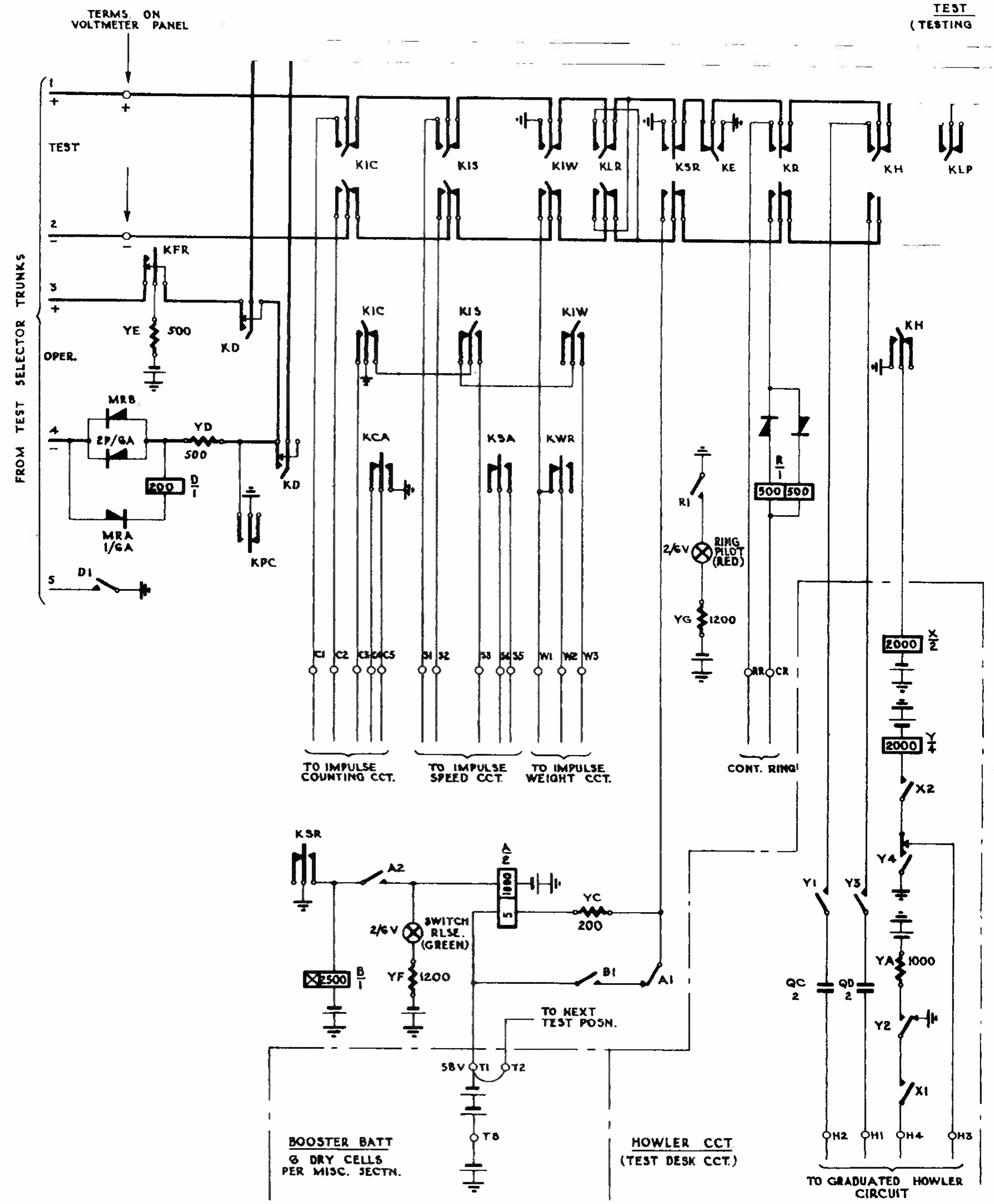
Impulse Speed Key (KIS). Connects the line through to the impulse speed test circuit.

Speed Adjust Key (KSA). Allows the voltmeter to be adjusted for impulse speed tests.

Impulse Count Key (KIC). Connects the line to the impulse count test circuit.

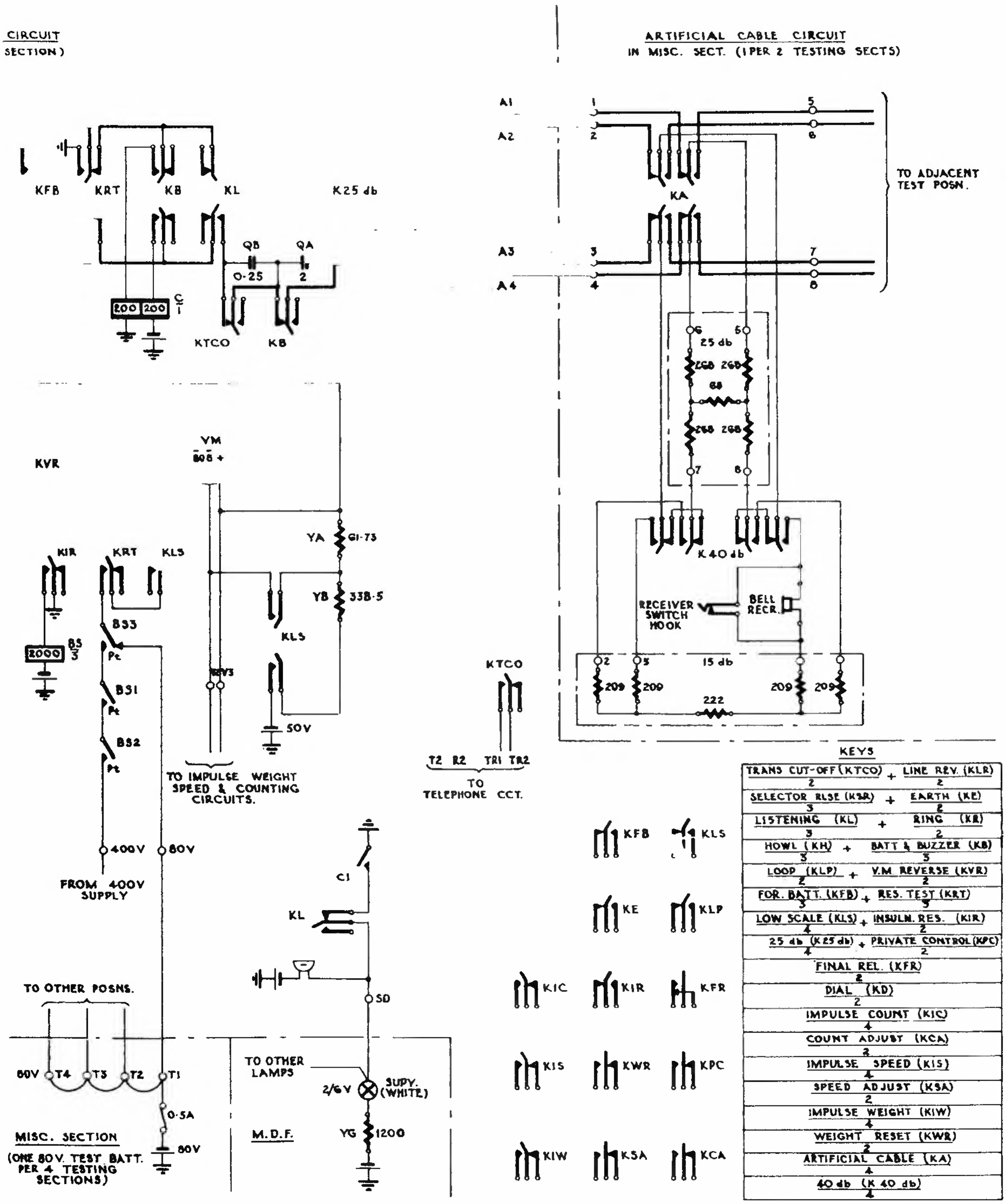
Count Adjust Key (KCA). Allows the voltmeter to be adjusted for impulse count tests.

/ Fig. 15.



TEST DESK OR RACK

FIG.

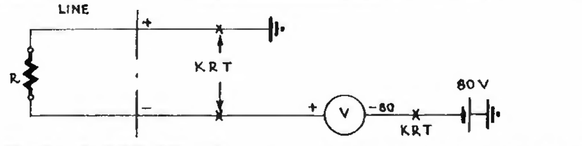
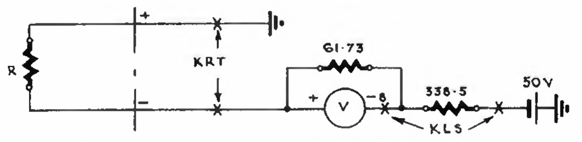
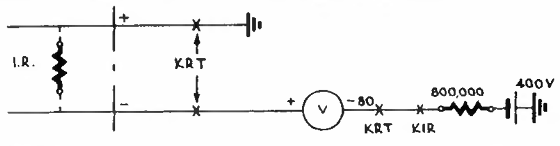
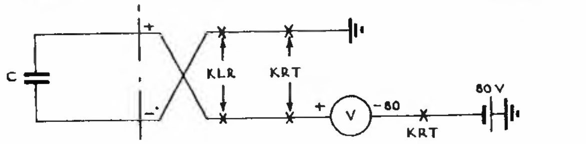
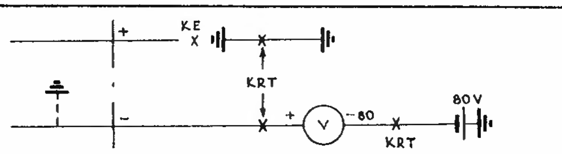
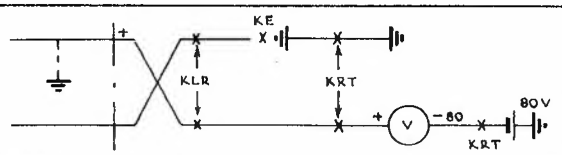
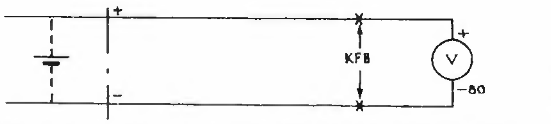
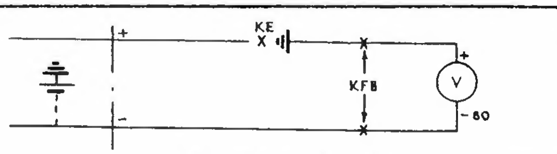
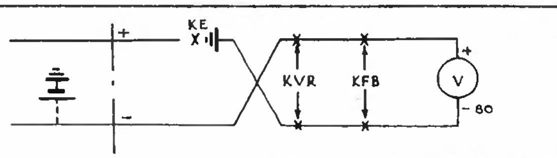


KEYS

TRANS CUT-OFF (KTCO) 2	+	LINE REV. (KLR) 2
SELECTOR RLSE (KSR) 3	+	EARTH (KE) 2
LISTENING (KL) 3	+	RING (KR) 2
HOWL (KH) 3	+	BATT & BUZZER (KB) 3
LOOP (KLP) 2	+	V.M. REVERSE (KVR) 2
FOR. BATT. (KFB) 3	+	RES. TEST (KRT) 3
LOW SCALE (KLS) 4	+	INSULN. RES. (KIR) 2
25 db (K 25 db) 4	+	PRIVATE CONTROL (KPC) 2
FINAL REL. (KFR) 2		
DIAL (KD) 2		
IMPULSE COUNT (KIC) 4		
COUNT ADJUST (KCA) 2		
IMPULSE SPEED (KIS) 4		
SPEED ADJUST (KSA) 2		
IMPULSE WEIGHT (KIW) 4		
WEIGHT RESET (KWR) 2		
ARTIFICIAL CABLE (KA) 4		
40 db (K 40 db) 4		

TEST CIRCUIT.

15.

TEST FOR -	CIRCUIT CONDITIONS	KEYS OPERATED
(a) Resistance		Resistance Test (KRT)
(b) Low Resistance		Resistance Test (KRT) Low Scale (KLS)
(c) Insulation Resistance		Resistance Test (KRT) Insulation Resistance (KIR)
(d) Capacity		Resistance Test (KRT) Line Reverse (KLR)
(e) Earth - Line		Resistance Test (KRT) Earth (KE)
(f) Earth + Line		Resistance Test (KRT) Earth (KE) Line Reverse (KLR)
(g) Foreign Battery		Foreign Battery (KFB) If battery potential is reversed, operate Voltmeter Reverse key (KVR)
(h) Earthed Foreign Battery (Positive Plate Earthed)		Foreign Battery (KFB) Earth (KE) If fault is on positive line, operate Line Reverse key (KLR)
(i) Earthed Foreign Battery (Negative Plate Earthed)		Foreign Battery (KFB) Earth (KE). Voltmeter Reverse (KVR) If fault is on positive line, operate Line Reverse key (KLR)

VOLTMETER TESTS.

FIG. 16.

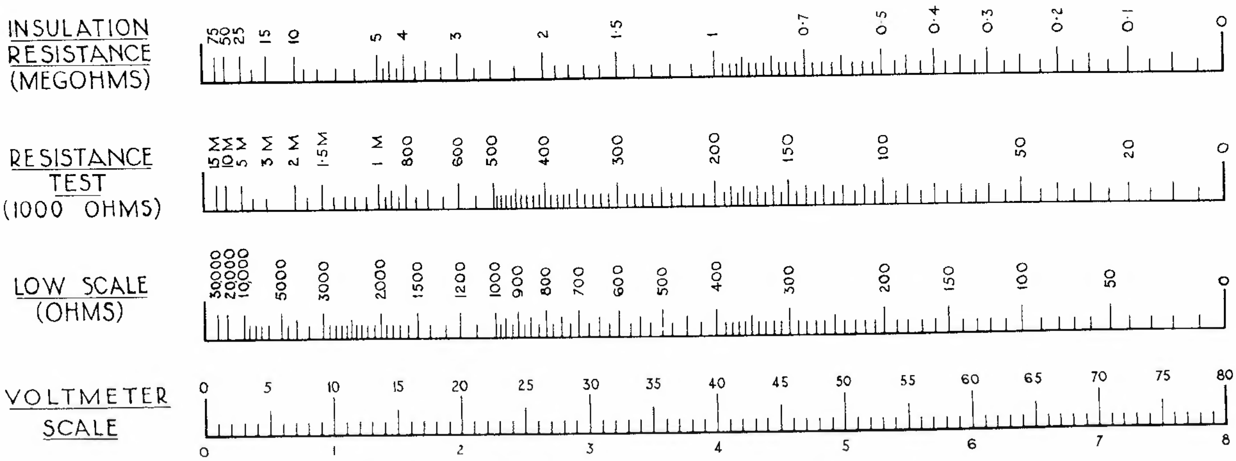
10.4 Resistance Tests. Three separate tests are provided for the measurement of loop and insulation resistances, as described below.

(i) Resistance Test. Operation of the Resistance Test key (KRT) connects the voltmeter in series with an 80 volt battery to the negative line and earth to the positive line. The circuit conditions are shown in Fig. 16a. Any circuit from the negative line to the positive line or to earth allows a current to flow through the meter, giving a corresponding deflection. The resistance of the circuit may be calculated from the formula -

$$R = \frac{V_1 - V_2}{V_2} \times R_M$$

where R = resistance under test,
V_1 = deflection of voltmeter with zero resistance in circuit (in this case, 80 volts),
V_2 = deflection of voltmeter with unknown resistance in series, and
R_M = resistance of the voltmeter system (in this case, 200,000 ohms).

In practice, the formula is worked out for each division of the voltmeter scale and the results tabulated and placed near the voltmeter. Consequently, only the V_1 and V_2 values are necessary to enable the testing officer to read the value of an unknown resistance. In some cases, adjustable resistances are fitted to allow the reading V_1 to be adjusted to exactly 80 volts, and, in such cases, the scale shown in Fig. 17 may be used for measuring resistances. It may be seen from this scale that the test is suitable for measuring resistances from 5,000 ohms to 15 megohms.



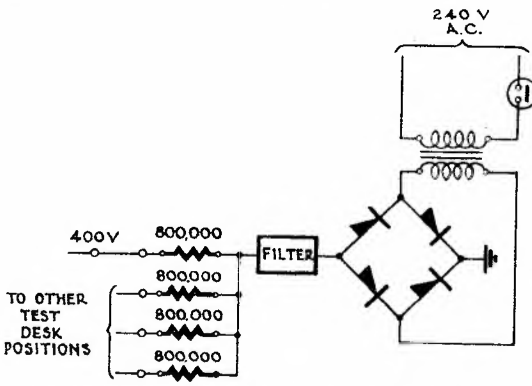
VOLTMETER SCALE CALIBRATED FOR RESISTANCE TESTS.
FIG. 17.

(ii) Low Scale Test. This test (see Fig. 16b) is necessary in order to obtain a greater degree of accuracy in measuring resistances below 5,000 ohms. Operation of the Low Scale key (KLS) in conjunction with the Resistance Test key (KRT) changes over to the 8 volt terminal of the voltmeter. As the 50 volt exchange battery is used for this test, the voltmeter must have a suitable shunt and series resistance in order to reduce the maximum deflection to 8 volts. The shunt of 61.73 ohms across the resistance of the voltmeter (20,000 ohms) gives a joint resistance of 61.5 ohms for this combination. The series resistance is 338.5 ohms, and thus the total resistance of the voltmeter system is 400 ohms. With a short-circuit on the testing leads, and assuming the maximum exchange voltage to be 52 volts, then the potential drop across the voltmeter is -

$$P.D. = \frac{r}{R} \times E$$
$$= \frac{61.5}{400} \times 52$$
$$= 8 \text{ volts.}$$

/ (iii)

(iii) Insulation Resistance Test. In this test the insulation of lines, etc., is subjected to a potential of 400 volts in order that "insulation breakdown", caused by high ringing and dialling voltages may be more readily detected. Voltages greater than ~~400~~ 250 volts cannot be used for this purpose because of the limitations of condensers which may be connected across the lines. The D.C. voltage is supplied from a rectifier unit (see Fig. 18) which is generally mounted on the M.A.R. or test rack. Resistances of 425 ~~800~~,000 ohms in the unit prevent any danger of shocks from the 400 volt leads and, in addition, limit the current through the meter so that on a short-circuit the potential drop across the meter is 80 volts.



RECTIFIER CIRCUIT FOR 400 VOLT SUPPLY.

FIG. 18.

Operation of the Insulation Resistance key (KIR) operates relay BS (see Fig. 15), and the contacts of this relay connect the ~~400~~ 250 volt lead to the 80 volt terminal of the voltmeter. The resistance of the voltmeter system in this condition is 1 megohm (200,000 ohms + ~~800~~ 425,000 ohms), and this scale is suitable for the measurement of insulation resistance values up to 25 megohms.

10.5 Capacity Test. Operation of the Line Reverse key (KLR) in conjunction with the Resistance Test key (KRT) provides this test, as shown in Fig. 16d. The line reverse key is slowly operated and released, and the consequent charging and discharging of the condenser and line capacity via the voltmeter indicates by the swing of the needle the capacity of the circuit. The voltmeter functions as a ballistic galvanometer, the deflection being proportional to the capacity under test.

10.6 Tests for Earth. As previously mentioned, a voltmeter deflection when the resistance test key is operated indicates either a circuit between the negative and positive lines or a circuit from the negative line to earth. Operation of the Earth key (KE) disconnects earth from the positive line, and any reading on the voltmeter then indicates a circuit to earth. The resistance of the circuit may be measured by application of the appropriate resistance test, as described in paragraph 10.4.

This test does not disclose the presence of an earth condition on the positive line, and a further test is made by operating the Line Reverse key (KLR), as shown in Fig. 16f.

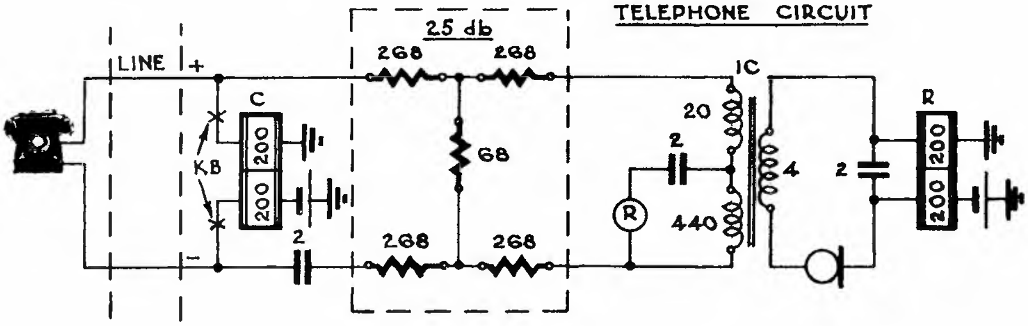
10.7 Tests for Foreign Battery. The presence of a foreign battery potential on a line causes irregular readings in the previous tests by aiding or opposing the testing battery. Operation of the Foreign Battery key (KFB) connects the voltmeter directly to the lines as shown in Fig. 16g, and the foreign battery potential may be measured (on the 80 volt scale). Should the polarity of the foreign battery be reversed, the voltmeter will be deflected in the reverse direction, and it is necessary in such cases to operate the Voltmeter Reverse key (KVR).

To test for contact with a foreign battery which is earthed on the positive plate (for example, contact with the negative wire of another line), it is necessary to operate the Earth key (KE) in conjunction with the Foreign Battery key (KFB). As this test is applied only to the negative line, it must be repeated on the positive line by operating the Line Reverse key (KLR).

If the foreign battery is earthed on the negative plate, the voltmeter will be deflected in the reverse direction, and it is necessary to operate the Voltmeter Reverse key (KVR).

/ 10.8

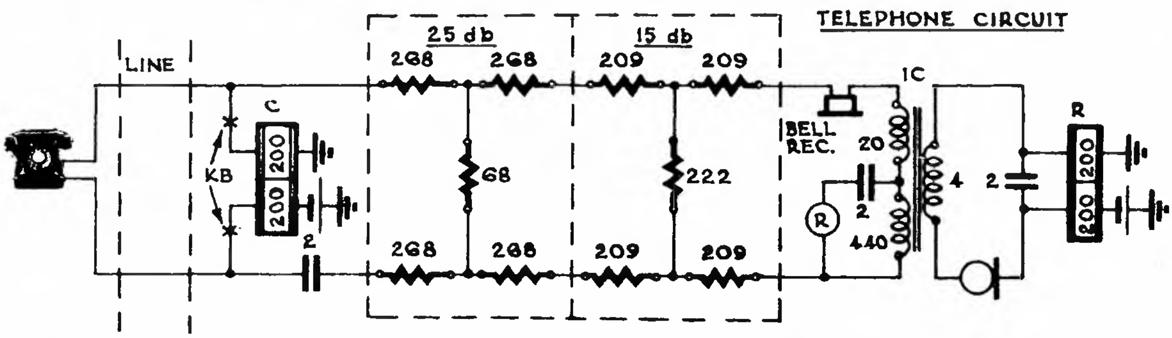
10.8 Transmission Tests. To speak to the telephone under test, the testing officer operates the Listening key (KL). It is also necessary to operate the Battery and Buzzer key (KB) in order to feed transmitter current to the line. Two tests are provided to check the transmission performance of a subscriber's service, the first by inserting a 25 decibel network between the line under test and the test desk telephone circuit, as shown in Fig. 19.



25 db TEST.

FIG. 19.

Operation of the 40 db key (K40 db) in addition to the 25 db key (K25 db), connects an additional 15 decibel network in the circuit, giving a total attenuation of 40 decibels. A bell type receiver is included in the circuit to give the testing officer standard listening facilities, using both ears. The circuit conditions during this test are shown in Fig. 20.



40 db TEST.

FIG. 20.

10.9 Level Meter. In some test desks a level meter is included in lieu of the attenuation networks described above. This is a moving coil instrument which is calibrated to read power level directly in decibels. The range is from -10 to +6 db, referred to a zero of 1 milliwatt in 600 ohms. The level meter is used in conjunction with a noise generator used for testing subscribers' services. The output from the noise generator is applied to the transmitter of the telephone under test, and the level received on the level meter should be -5 db or better for standard volume of transmission.

Alternatively, the normal test desk voltmeter may be utilised for this purpose after being suitably calibrated in decibels. A Transmission Test key (KTT) makes the necessary circuit connections.

Note. For an explanation of the unit "decibel," reference should be made to Long Line Equipment I, Paper No. 1.

/ 10.10

10.10 Graduated Howler Circuit. This circuit (see Fig. 21) is provided to signal a subscriber by means of a high pitched note in the receiver should the receiver be left off the telephone. The note provided is a graduated howl, soft when first applied but increasing to its full intensity. The object of this graduated howl is to avoid acoustical shock should anyone be listening when the howler is applied to a line, by giving time for the removal of the receiver from the ear before the howl reaches its maximum amplitude.

Circuit Operation. When the Howler key is operated, relay X operates. Assuming the howler circuit is not already in use, the uniselector wipers will be standing on the home contacts (1 or 13), and relay Y operates via X2 to earth from wiper and bank H3, and locks to earth at Y4. Battery via 1,000 ohm YA, Y2 and X1 operates relay Z in the howler relay set. Z2 completes the circuit of the polarised howler relay HR which vibrates and induces a howler tone via the induction coil. This tone is prevented from reaching the line initially because of the short-circuit via wiper and bank H1.

The uniselector is stepped from interrupted earth via wiper and bank H2 and contact Z3, the first step being taken via Z1. As the switch is stepped, the shunt resistance is gradually increased from a short-circuit on the 1st and 2nd contacts, 5 ohms on the 3rd contact, 15 ohms on the 4th, 35 ohms on the 5th, and so on until the 10th contact is reached, when the shunt is entirely removed. The gradually increasing tone is applied to line via Y1, Y3 and condensers QA and QB, and remains at its maximum until the howler key is restored or another circuit is set up.

The howler relay set is common to all test desk positions, and should the howler key on a second position be operated while the howler tone is being applied to a line, that is, while the uniselector is off-normal, the switch is caused to restore to normal and the graduated howler is applied to the two lines in parallel.

Relay X in the second test desk operates, but relay Y cannot operate due to absence of earth on the H3 lead. Earth via Y2 and X1 is extended over the H4 lead to shunt relay Z in the howler relay set, which releases and Z2 and Z3 complete the homing drive circuit over wiper and bank H2. On reaching the home contact, relay Y operates, followed by the reoperation of relay Z and the howler circuit again operates as described above.

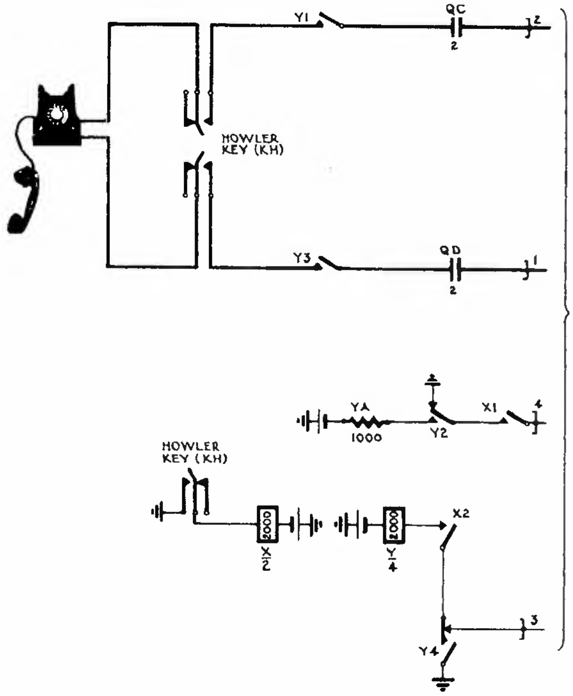
The scheme of short-circuiting relay Z should the switch be off-normal, that is, already providing a howler tone to other lines, ensures that the tone is applied at its minimum value to each line as it is introduced.

Restoring the howler key releases relays X and Y, but relay Z remains operated until the last circuit is disconnected. Then Z2 and Z3 complete the homing drive circuit, the wipers coming to rest on contacts 1 or 13.

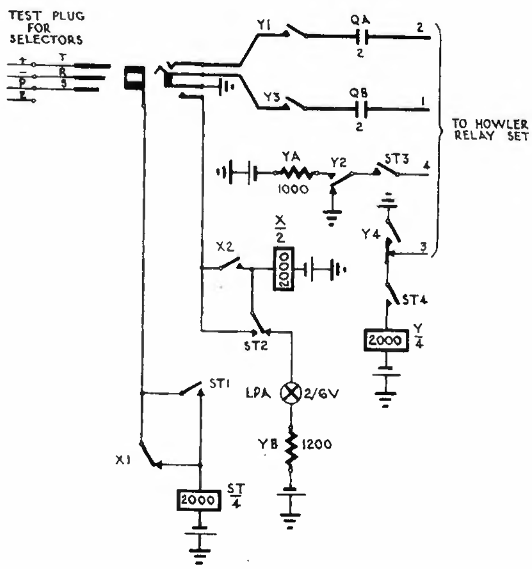
Selector Rack Howler Equipment. The howler tone may also be applied to a subscriber's line by inserting the howler plug and cord into the 1st group selector (or D.S.R.) held by the faulty line. The equipment is similar to that provided in the test desk, and it functions in the same way, but an additional facility ensures that the howler tone is removed from the line when the subscriber replaces the receiver, and is not reapplied when the selector is again taken into use. This is arranged by an additional relay ST which is held by earth from the private wire of the selector, and when the subscriber hangs up the selector releases and ST restores. A supervisory lamp gives an indication that the circuit is cleared, and the howler plug may be withdrawn.

In exchanges where the ultimate capacity exceeds 4,000 subscribers, two howler relay sets are usually provided, one for selector racks and the other for test desk positions.

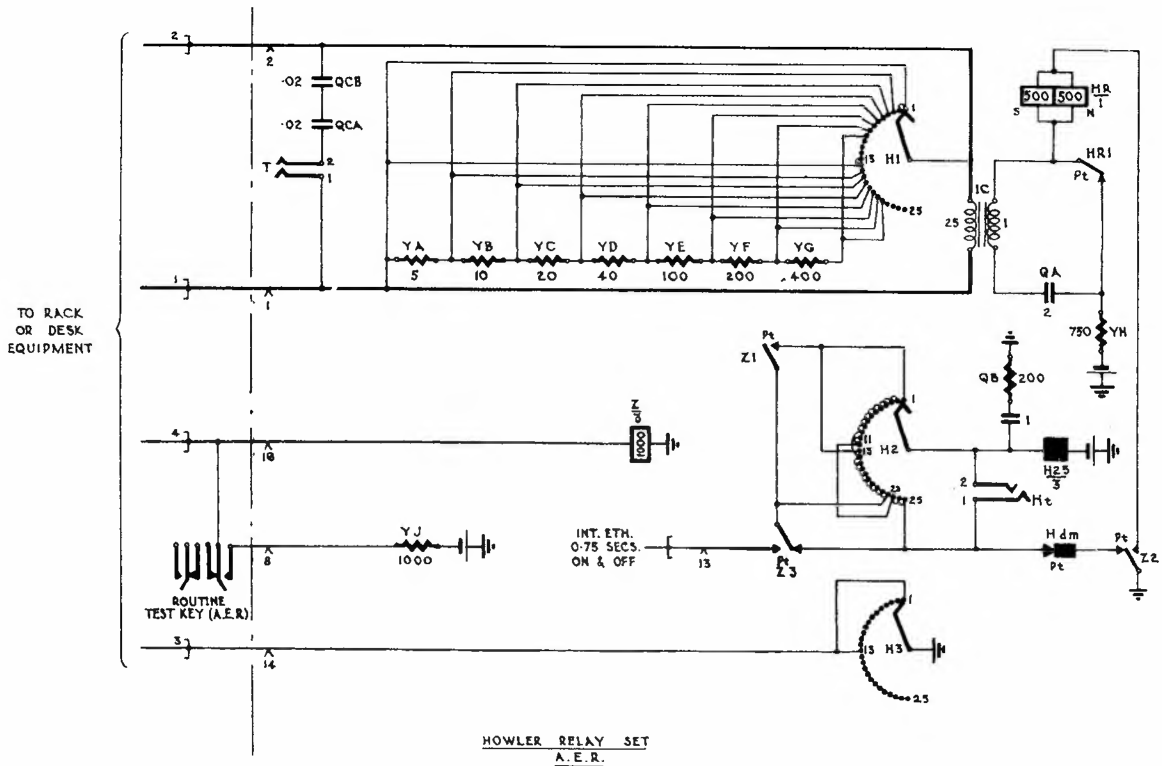
/ Fig. 21.



HOWLER EQUIPMENT
TEST DESK



HOWLER EQUIPMENT
SELECTOR RACK



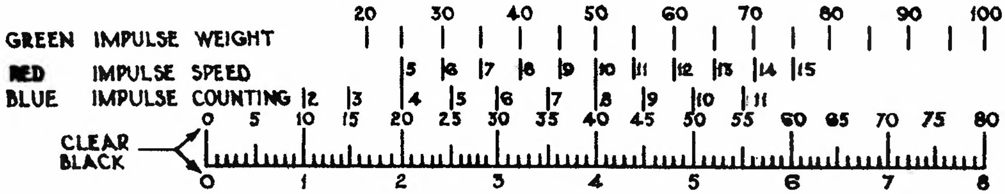
HOWLER RELAY SET
A.E.R.

GRADUATED HOWLER CIRCUIT.

FIG. 21.

11. DIAL TEST CIRCUIT.

11.1 This circuit enables the impulses from a subscriber's dial to be tested for weight, speed and count, using the test desk voltmeter to give direct readings. For this purpose the voltmeter scale is suitably calibrated, as shown in Fig. 22.

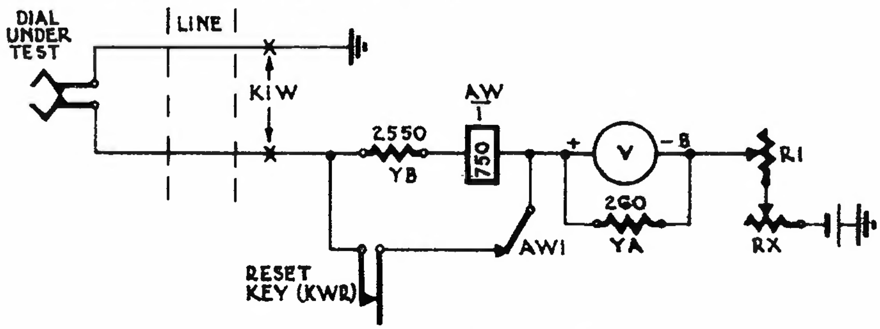


VOLTMETER SCALE.

FIG. 22.

Associated with each circuit is an adjustment key which, in conjunction with a potentiometer (RX) and variable resistance (RI), is used to obtain a suitable zero reading on the voltmeter scale before the observation is taken. The circuit connections are shown in Fig. 25, and for the following circuit descriptions simplified diagrams are given.

11.2 Impulse Weight. This circuit is used to measure the percentage make ratio of impulses received from telephone dials or from other sources of impulses. Operation of the Impulse Weight key (KIW) operates relay BW (see Fig. 25), and the circuit connections are set up as shown in Fig. 23.



IMPULSE WEIGHT TEST CIRCUIT.

FIG. 23.

With the line connected to the test circuit, RI and RX are adjusted to give a voltmeter reading corresponding to 100 per cent. make ratio. It is important that the dial of a subscriber's telephone is held off-normal while the voltmeter is being set, as otherwise an incorrect reading will be obtained.

The Reset key (KWR) is next operated momentarily, and this removes the short-circuit from relay AW and resistance YB. Relay AW operates, and the additional resistance introduced moves the voltmeter needle to a position corresponding to approximately 30 per cent. make, thereby reducing the movement of the needle during impulsing and enabling a steady reading to be obtained sooner than would be the case if the pointer had to move from the 100 per cent. make position.

With the receipt of the first impulse, AW releases and AW1 short-circuits YB and AW. The make portion of an impulse is represented by a potential of 8 volts across the voltmeter and the break portion represents no voltage. As the voltmeter movement is heavily damped, the pointer will indicate the average voltage over a number of impulses, if a large digit, such as 9 or 0, is dialled. Thus, a 33-1/3 per cent. make ratio will be indicated by 2.66 volts on the voltmeter scale, which is calibrated to read impulse weight directly.

When the impulse train is ended, the pointer indicates a 100 per cent. make ratio and may be returned to the preset position by again throwing the reset key momentarily.

/ 11.3

11.3 Impulse Speed. Operation of the Impulse Speed key (KIS) connects the line to relay AS and operates relay BS (see Fig. 25). The contacts of BS complete a potential dividing circuit in conjunction with variable resistances RI and RX for charging condensers QA and QB. A simplified circuit for this test is shown in Fig. 24.

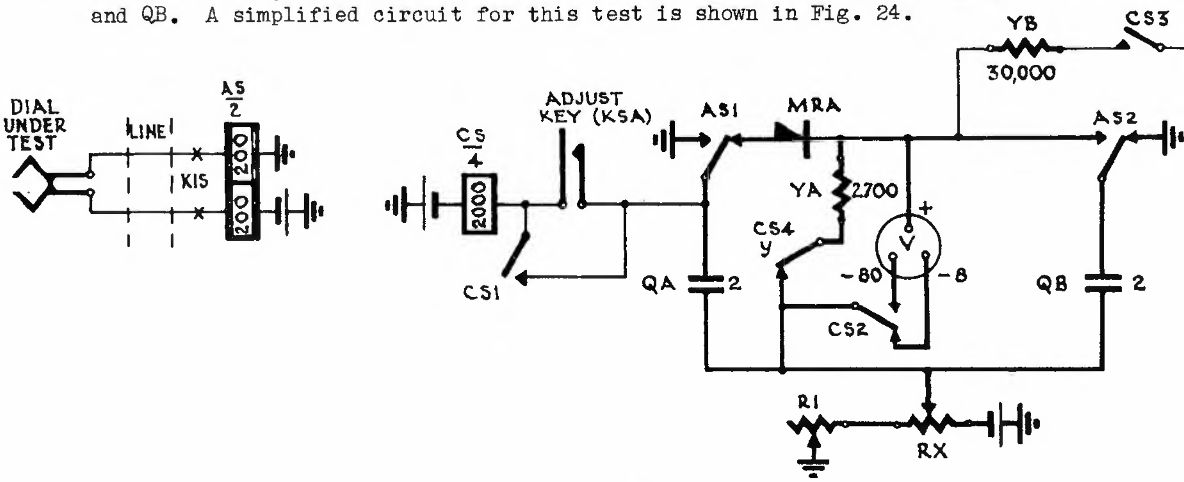


FIG. 24. IMPULSE SPEED TEST CIRCUIT.

The circuit is adjusted by momentarily operating the Speed Adjust key (KSA), completing a circuit for relay CS to earth at AS1. CS1 locks the relay independent of KSA; CS2 changes the negative connection to the voltmeter from the 8 volt terminal to the 80 volt terminal; and CS3 connects earth through 30,000 ohms YB to the positive terminal. Resistances RI and RX are now adjusted to give a reading of 40 volts on the voltmeter, giving a potential of 46 volts for charging the condensers (40 volts across 200,000 ohm voltmeter, plus 6 volts across 30,000 ohms YB). This adjustment, in addition to ensuring that the correct voltage will be applied, also reduces movement of the pointer during the impulse train and enables a steady position to be reached sooner than would be the case if the pointer had to drop from a full scale deflection position. The initial position in this case (40 volts) corresponds to the normal speed of a dial (10 i.p.s.).

When the impulse train is received, relay AS responds and, during the first break of AS1, relay CS releases. The contacts of CS connect the 8 volt section of the voltmeter, shunted by 2,700 ohms YA, in the discharge circuit of condensers QA and QB. When relay AS is in the operated condition, QA is charged and QB is discharged via the voltmeter. While AS is released, QA is discharged and QB charged. The discharges of both condensers thus pass alternately through the shunted voltmeter. The charging of the condensers, although not instantaneous, is accomplished quickly enough to be independent of the time of break and make of the impulses. The same may be said of the discharge, as the voltmeter system is arranged to allow the discharge to take place in a few milliseconds. The quantity of electricity is the same for each discharge and, therefore, the value of the current will be the same for each pulse passing through the voltmeter. The meter, being heavily damped, records the average value of the voltage drop due to this current, and the average will depend on the proportion that each pulse of current bears to the time of no current, that is, the time elapsing before the next pulse is received. In other words, the average voltage indicated on the meter depends on the speed of impulsing.

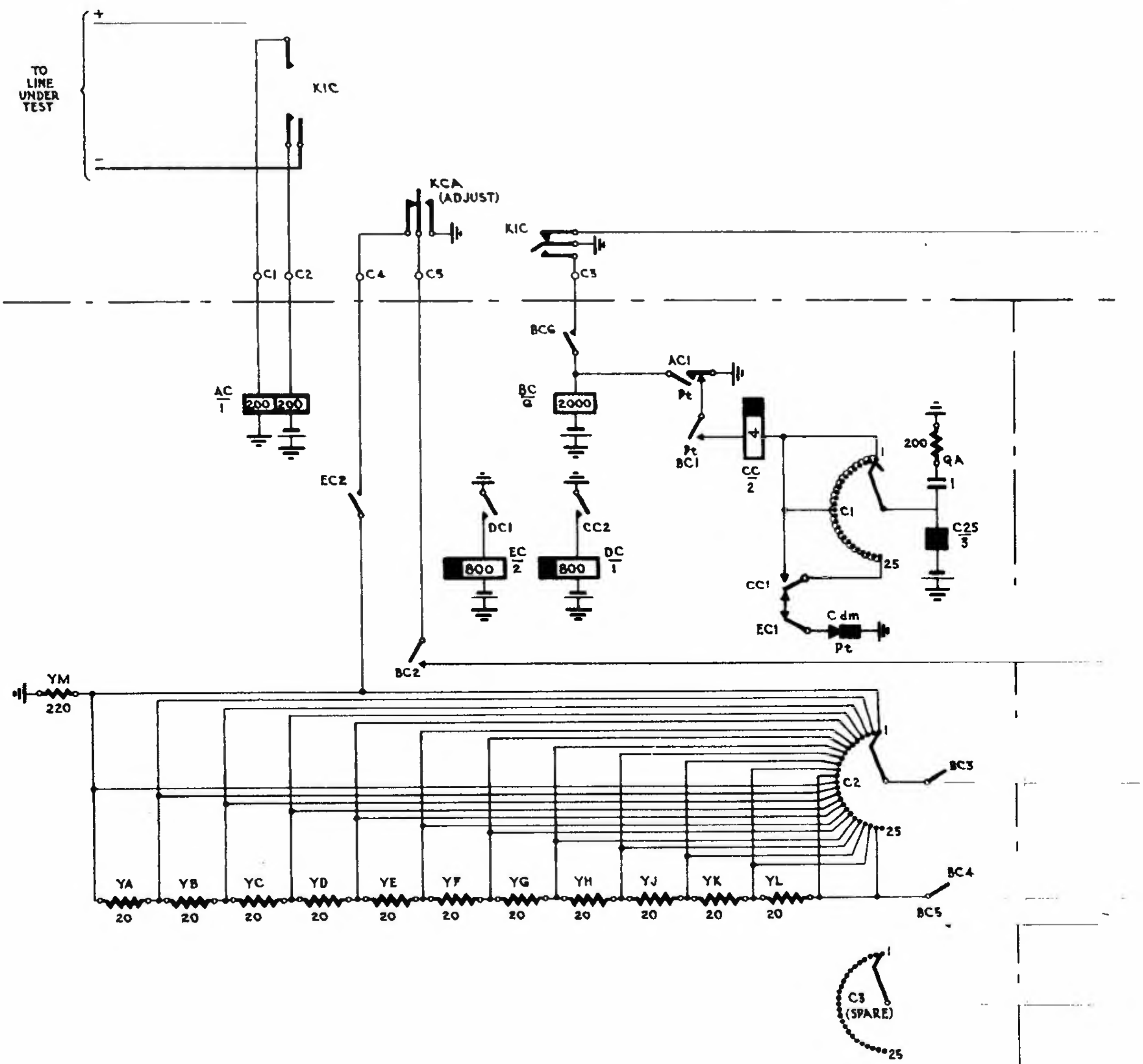
If, for example, the speed of impulses is slow, the discharges consist of pulses of current separated by comparatively long intervals, consequently the voltmeter needle will tend to restore to zero after each discharge. The resultant voltmeter reading will not be as large as the reading obtained if the discharges followed each other at short intervals, which would be the case if the speed of impulsing were increased.

The value of resistance YA and the capacity of the condensers QA and QB are determined in conjunction with the voltmeter to give deflections in accordance with the Impulse Speed calibrations on the voltmeter scale (see Fig. 22) when RI and RX are adjusted to give 46 volts.

Rectifier MRA is included to prevent locking relay CS to earth at CS3 when relay AS releases for the first impulse in the train.

/ Fig. 25.

PART OF

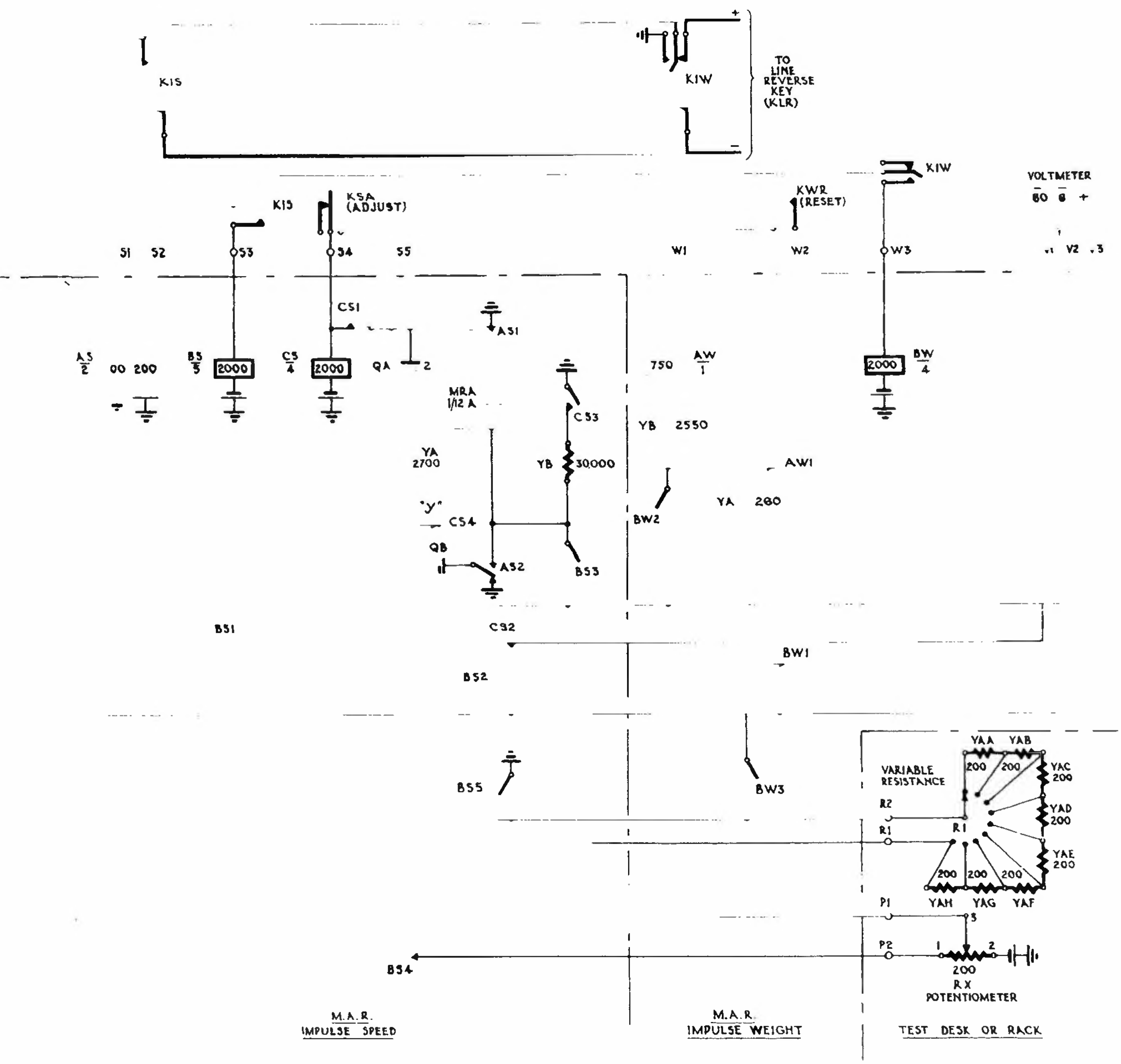


M.A.R.
IMPULSE COUNTING

TEST DESK OR RACK

FIG.

TEST CIRCUIT

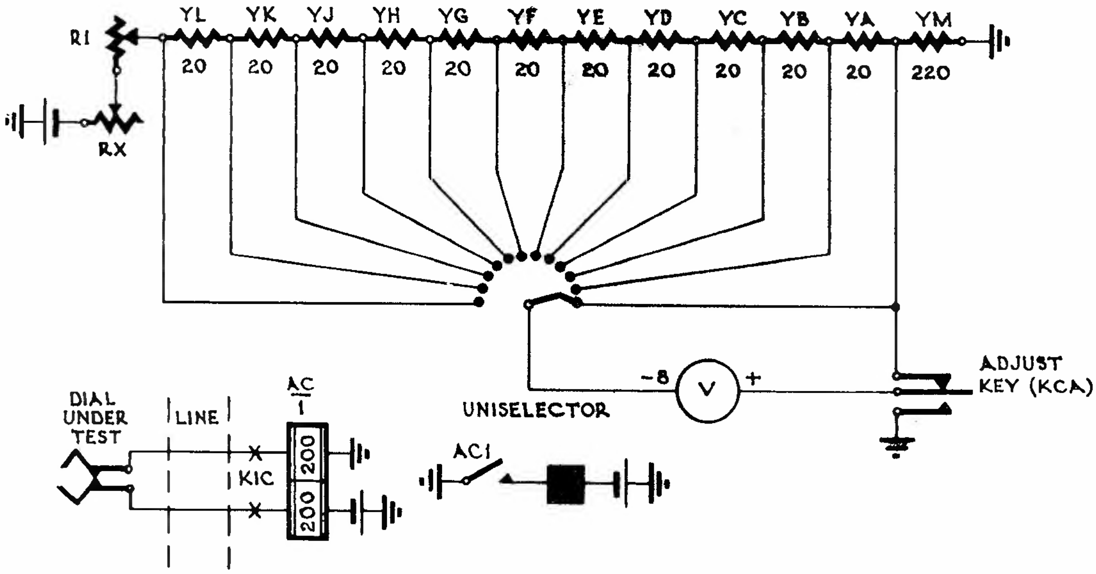


DIAL TEST CIRCUIT.

25.

11.4 Impulse Counting. This test employs a 25-point homing type uniselector which is stepped a number of times according to the digit dialled. The voltmeter is connected to the uniselector wiper and the circuit is arranged to give a voltmeter reading equal to 0.5 volt for each step taken. Thus, the digit dialled is indicated on the voltmeter and the scale is calibrated accordingly.

Operation of the Impulse Count key (KIC) connects the line under test to relay AC and operates relay BC. The contacts of BC prepare a stepping circuit for the uniselector drive magnet; connect the 8 volt terminal of the voltmeter to the uniselector wiper and connect battery via the variable resistances RI and RX to the uniselector bank contacts. Full circuit details are shown in Fig. 25, but the simplified circuit of Fig. 26 is used for explanatory purposes.



IMPULSE COUNT TEST CIRCUIT.

FIG. 26.

The Count Adjust key (KCA) is next thrown and resistances RI and RX adjusted until the voltmeter registers 5.5 volts, that is, 11 impulses. This is the potential across 220 ohm resistance YM, and as YM has the same value as the sum of resistances YA-YL and is in series with them, it follows that the potential across YA-YL must also be 5.5 volts, that is, 0.5 volt across each 20 ohm resistance. The adjust key is restored, and the voltmeter needle restores to normal, being short-circuited via the uniselector wiper and No. 1 bank contact.

When the subscriber dials, relay AC responds to the impulses, stepping the uniselector a number of steps according to the digit dialled. At each step of the wipers the potential across the voltmeter is raised by 0.5 volt. Thus, if 7 impulses are received by relay AC, the potential across the voltmeter is 3.5 volts and the pointer indicates 7 impulses.

During each impulse train, three slow releasing relays, CC, DC and EC (shown in Fig. 25, but not in Fig. 26) are operated, and at the end of the train these relays release in sequence. The uniselector pauses on the dialled contact for a period equal to the combined release lags of the three relays before the homing circuit is completed. This allows sufficient time for the testing officer to note the number of impulses received before the voltmeter needle returns to zero on the release of relay EC.

/ 12.

12. TESTING OF SUBSCRIBERS' SERVICES.

12.1 The following is a summary of the tests necessary to ensure the correct operation of a subscriber's external and exchange equipment -

Access is gained to the line via the test selector trunk as described in Section 2.

(i) The Resistance test is applied and, if any doubt exists, the Insulation Resistance test should be used (see paragraph 10.4).

(ii) The capacity of the line is tested by operating the Line Reverse key in conjunction with the Resistance Test key (paragraph 10.5).

The minimum allowable insulation resistance for a subscriber's line is 0.5 megohm, and the normal condenser kick is about 70 scale divisions. If these tests are satisfactory, no tests for earth or foreign battery are necessary, but, otherwise, tests (iii) to (vi) must be performed.

(iii) Earth test on B wire.

(iv) Earth test on A wire.

(v) Test for earthed foreign battery on B wire.

(vi) Test for earthed foreign battery on A wire.

(vii) The subscriber's telephone is rung and the Low Resistance test is applied to measure the loop resistance.

(viii) The testing officer checks the transmission performance of the subscriber's service by listening with the 25 db and 40 db pads in circuit.

(ix) Dial Impulse Weight test. The dial must be held off-normal while adjusting the variable resistances for this test and, while the dial is off-normal, the line resistance may be measured. The limits of impulse weight allowable are from 34 per cent. to 39 per cent. make ratio, and, if the dial under test is outside these limits, it should be changed and not adjusted. Adjustment of the weight of a dial requires the use of special gauges, and is most satisfactorily performed at the dial repair centre in each State. Incorrect dial weight readings may also be caused by abnormal line conditions (see Telephony III, Paper No. 4).

(x) Dial Impulse Speed test. The normal dial speed is 10 impulses per second, and the limits are from 9 to 11 i.p.s. Adjustment of the dial speed is permissible.

(xi) As a final check on the telephone dial, all the digits should be dialled and checked by using the Impulse Counting circuit.

This completes the test on the external equipment and, to test the exchange apparatus, the Private Control key (previously known as the B.C.O. key) is operated.

(xii) Operate the Foreign Battery key, and a 50 volt reading should be seen on the voltmeter indicating correct line relay connections and polarity.

(xiii) Operate the Listening key, and dial tone should be heard. A test call may be made through the exchange apparatus, using the test desk telephone circuit.

12.2 In addition to the above tests, new services are also tested for -

(i) Satisfactory earth on substation protector (if fitted).

(ii) Correct operation of subscriber's meter.

/ 13.

13. TEST QUESTIONS.

1. Enumerate the facilities provided on a test desk to allow subscribers to be connected to the desk.

2. Give simple diagrams illustrating the methods of measuring resistances from a test desk.

3. How would you test a condenser on a test desk?

4. Could you determine the approximate capacity of a cable pair from the test desk?

5. What tests are necessary in order to ascertain that a dial is impulsing correctly?

6. In what order should the tests on a dial be made?

7. Describe the transmission tests made from test desk.

8. Enumerate the tests you would make on a new subscriber's line from the test desk.

9. Describe the Impulse Speed test circuit.

10. Sketch the circuit conditions for the Impulse Ratio test.

11. A battery giving a constant terminal P.D. of 80 volts and a voltmeter of 200,000 ohms resistance are used in making an insulation resistance test to earth on one wire of a telephone line 5 miles in length. If a reading of 20 volts is obtained, what is the insulation resistance of the wire in megohms per mile?

    (Answer: 3.0 megohms/mile.)

14. REFERENCES.

Telecommunication Journal of Australia:

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Vol. 4, No. 2, "A Noise Generator for Testing Subscribers' Services" - A. H. Little.

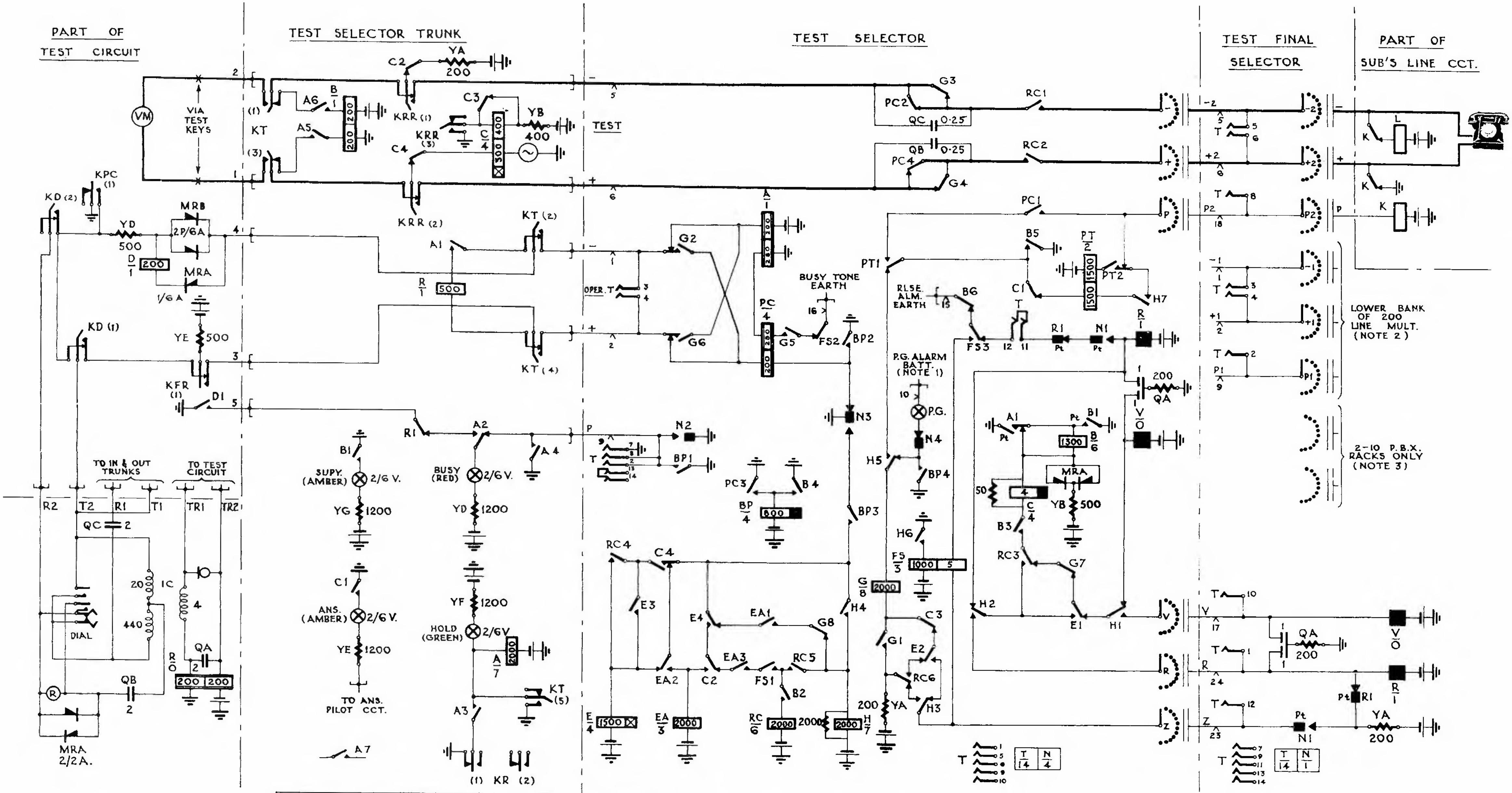
Vol. 4, No. 2, "Automatic Exchange Howler Circuit" - K. B. Smith.

Vol. 4, No. 4, "Light Reflector for Test Desks" - S. J. Davie.

Vol. 6, No. 4, "Centralised Testing Services and Maintenance Control in the Adelaide Metropolitan Network" - J. L. Harwood.

Vol. 7, No. 4, "Transmission Testing in Automatic Exchange Areas" - J. L. Harwood.

END OF PAPER.



NOTES.

1. P.G. ALARM BATTERY IS ONLY REQUIRED WHEN THE TEST SELECTOR TERMINATES A JUNCTION.
2. CONNECTIONS ARE SHOWN FOR UPPER BANK OF 200 LINE MULTIPLE, i.e. ODD HUNDRED GROUP. TEST SELECTOR CONTACTS CORRESPONDING TO EVEN HUNDRED GROUPS ARE WIRED TO LOWER WIPERS OF TEST FINAL SELECTOR.
3. ON 2-10 P.B.X. GROUPS, MECHANISM MUST FIT 4 BANK MULTIPLE.

TEST SELECTOR TRUNK, TEST SELECTOR AND TEST FINAL SELECTOR.

COMMONWEALTH OF AUSTRALIA.

Engineering Branch,
Postmaster-General's Department,
Treasury Gardens,
Melbourne, C.2.

COURSE OF TECHNICAL INSTRUCTION.

MISCELLANEOUS APPARATUS.

CONTENTS:

1. INTRODUCTION.
2. INTERCEPTION CIRCUIT.
3. CHANGED NUMBER CIRCUIT.
4. CENTRALISED SERVICE OBSERVATION CIRCUIT.
5. SPECIAL JUNCTION CIRCUIT, CENTRALISED OBSERVATION.
6. FINAL SELECTOR OBSERVATION CIRCUIT.
7. COMPLAINTS CIRCUIT.
8. REVERSE BATTERY AND TONE SIGNAL CIRCUIT.
9. RING BACK CIRCUIT.
10. SPARE LEVEL N.U. TONE CIRCUIT.
11. THE IMPULSE MACHINE.
12. THE AUTOMATIC TRAFFIC RECORDER.
13. TEST QUESTIONS.
14. REFERENCES.

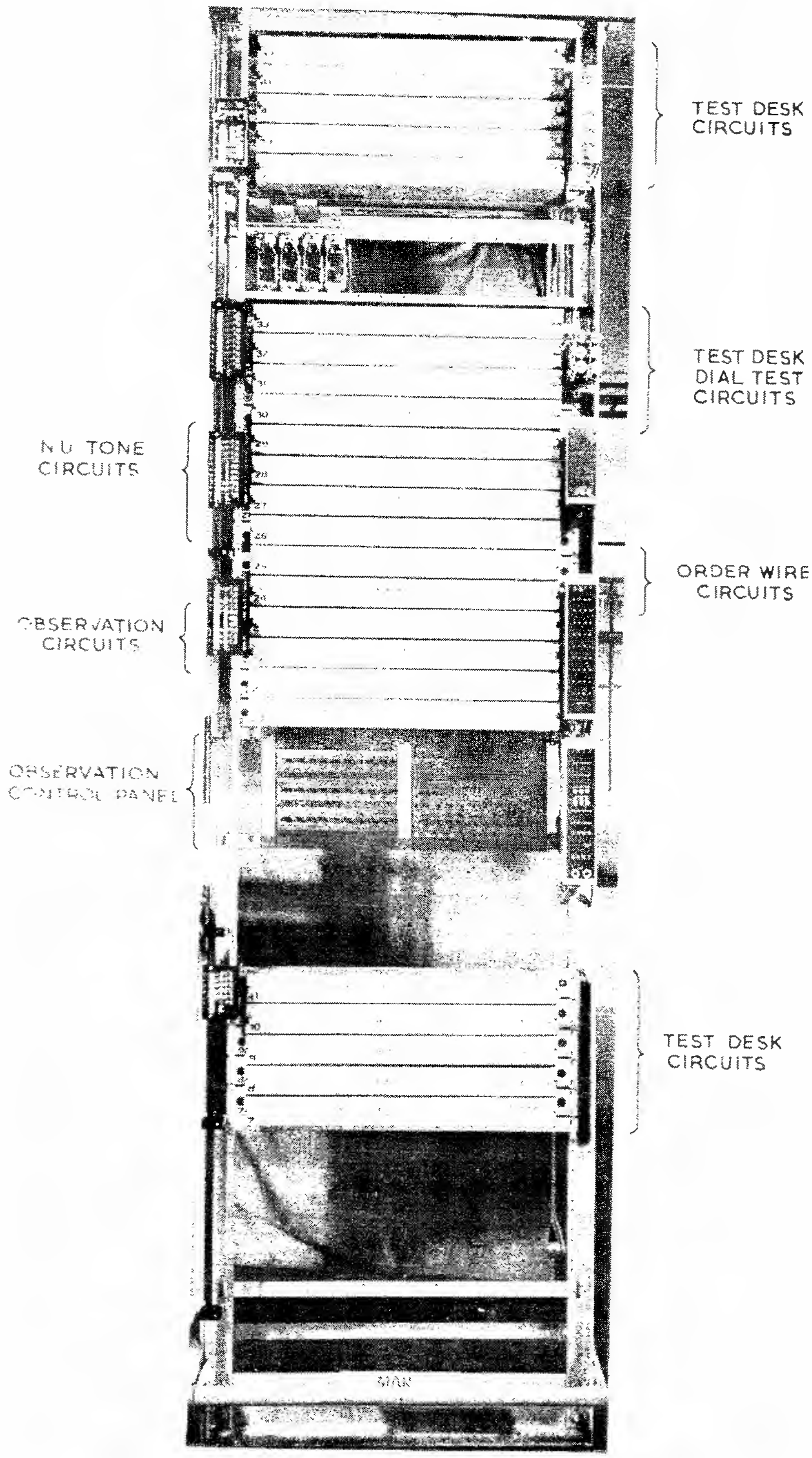
1. INTRODUCTION.

1.1 In addition to the switching apparatus, many miscellaneous circuits are to be found in automatic exchanges. The previous Papers describe miscellaneous apparatus associated with the exchange alarm system and with the test desk. Other circuits are described in this Paper.

Some, such as Interception and Complaints circuits, provide special services to subscribers. Observation circuits and the Automatic Traffic Recorder are for checking the grade of service given by the switching equipment. Other circuits, such as the Reverse Battery and Signal Tone circuit and the Ring Back circuit, assist in the testing of substation equipment and junctions.

1.2 Manual test sets and automatic routiners are described later in the Course. The impulse machine, which generates impulses for use by the routiners and test sets, is described in this Paper.

1.3 Some of the miscellaneous circuits are mounted in relay-sets on the miscellaneous R.S.R. Other circuits, including observation and test desk circuits, are strip-mounted on the Miscellaneous Apparatus Rack (M.A.R.). A typical M.A.R. is shown in Fig. 1.



A TYPICAL MISCELLANEOUS APPARATUS RACK (M.A.R.).

FIG. 1.

2. INTERCEPTION CIRCUIT.

2.1 Under certain conditions, calls normally completed over the automatic equipment require to be diverted to a manual position to be given personal attention. Some of the circumstances in which it is necessary to intercept calls incoming to a subscriber's line are -

(i) Directory Errors. Misprints, duplicate entries, transposition of numbers, etc., in Telephone Directories make it necessary that calls incoming to certain lines shall be intercepted, so that the subscribers affected are saved the trouble of answering calls intended for other subscribers, and enabling the callers to be advised of the correct number for future use. Such interception is only necessary until the issue of a new directory.

(ii) Service Complaints by Subscribers. In the case of a subscriber complaining of the receipt of calls for another number, the interception equipment provides the means of investigating the subscriber's complaint, incoming calls to the subscriber being checked by the operator before being put through.

2.2 Special equipment is installed in automatic exchanges to provide this facility of intercepting incoming calls to subscribers and diverting the calls to an operator at a manual board. The intercepted calls are generally diverted to a centralised position via a junction circuit. Interception line tapping relay-sets are wired to multipled jacks on the M.D.F. and, by means of a cord and test plugs, any subscriber's line can be associated with the interception equipment. Fig. 2 shows how the line to be intercepted is diverted from the exchange side of the M.D.F. to the interception equipment.

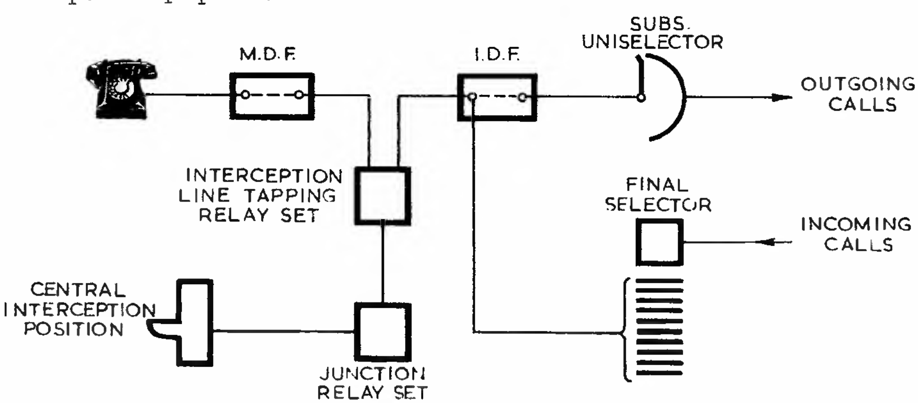


FIG. 2. INTERCEPTED LINE.

2.3 The main facilities provided by the interception circuit are -

(i) An incoming call for the intercepted line is diverted to a manual position where the call is indicated by the operation of a signal lamp.

(ii) The operator answers the incoming call and, if necessary, switches it through to the intercepted line. A flashing lamp signal is given until the called subscriber answers. The interception junction is then cleared in readiness for another call.

(iii) If the call is not to be switched through to the intercepted subscriber, the operator advises the caller of the correct number. The junction may be cleared by operation of the "Lock-off" key.

(iv) Calls outgoing from the intercepted line are not affected, impulses being repeated in the same way as in an auto-auto repeater. The subscriber need not be aware that the line is intercepted.

/2.4

2.4 A number of interception circuits may be common to the junction and, if another call is in progress, busy tone is given to the second call. No interference can take place with a call already in progress. On incoming calls, ring tone is transmitted to the call from the central position. Metering only takes place after the call has been switched through and the intercepted subscriber has answered. Fig. 3 shows the connections of the interception circuit, and a description of the circuit operation follows.

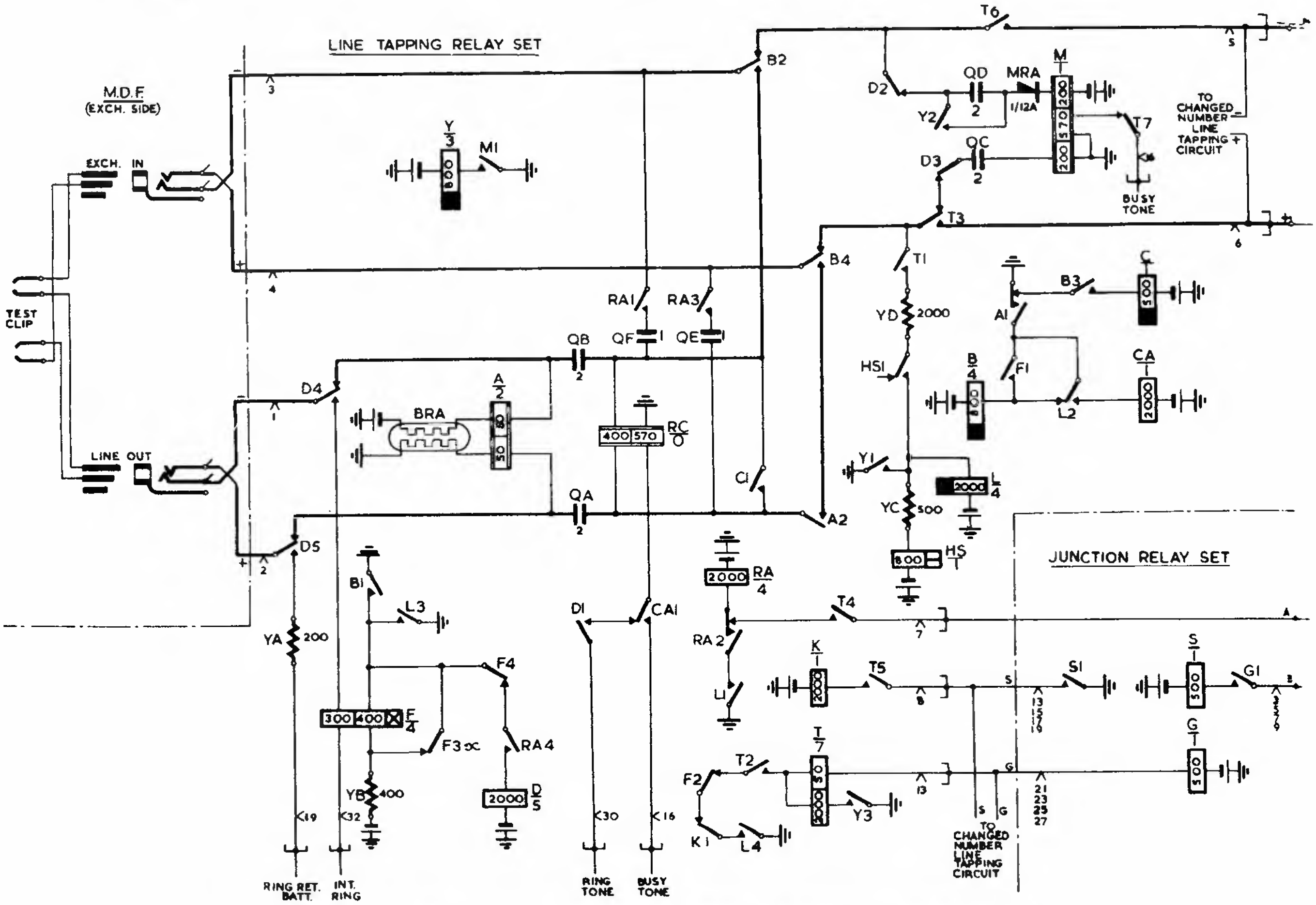


FIG. 3. CENTRALISED INTERCEPTION CIRCUIT (CE.385).

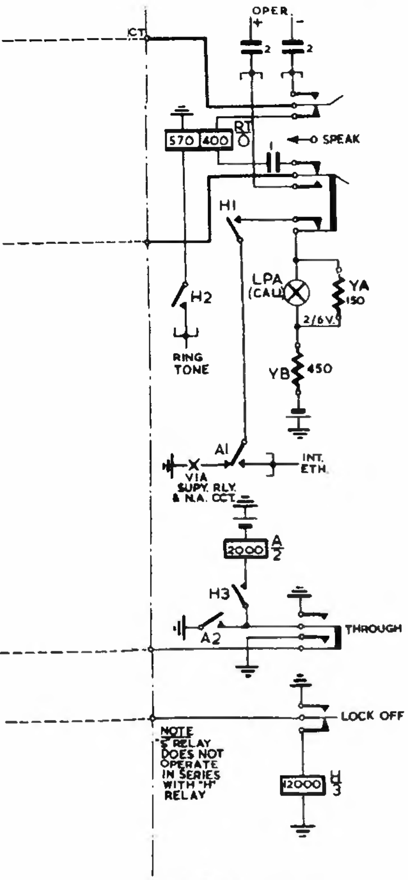
2.5 Call Originated by Intercepted Subscriber. Relay A operates in series with the subscriber's loop and A1 operates relay B. The exchange equipment is looped via A2, B2, B4 and the 400 ohm winding of RC. The subscriber is connected to the exchange equipment via condensers QA and QB and, on receipt of dial tone, commences to dial the required number. Relay A respønds to the impulses and A2 repeats them to the exchange equipment. Relay C operates during each impulse train and C1 short-circuits RC to give a low impedance impulsing loop.

Relays A and B remain operated throughout the call and, when the calling subscriber clears, A releases, followed by the release of B, and the circuit restores to normal.

2.6 Incoming Call to Intercepted Subscriber. Relay M operates via rectifier MRA and condenser QD to the ringing current applied to the negative line by the calling final selector. M1 operates relay Y.

/Assuming

Assuming that the junction is free, relay T operates with both windings in series from earth at Y3 to battery via relay G in the junction relay-set. Y1 operates relays L and HS. Y2 short-circuits condenser QD in series with the battery winding of relay M, whereupon the ring trip relay in the final selector operates and battery and earth are connected to the negative and positive lines, respectively. Relay M releases and M1 disconnects relay Y, which releases slowly. Relays L and HS hold via HS1, 2000 ohm YD and T1 to the earthed winding of the final selector relay D, which does not operate because of the high resistance of the circuit.



CENTRAL POSITION

The operation of relay T switches the caller through to the central position at T3 and T6. Earth via L4, K1, F2 and T2 holds relay T on its 50 ohm winding and busies the junction.

In the event of the junction being busy, relay T cannot operate due to a 50 ohm earth being applied to the junction common via relay T in another line tapping circuit. In this case busy tone is connected via T7 to the 570 ohm winding of relay M and is transmitted to the caller.

Relay G in operating connects relay S in series with relay H at the central position. H operates but relay S does not operate due to the high resistance of H. H1 lights the Call Lamp and H2 connects ring tone to the caller via retard RT.

When the operator answers, the operation of the Speak key disconnects the ring tone and enables her to speak to the caller. The operator may deal with the call in either of the following ways -

(i) If the call is to be connected through to the intercepted subscriber, the operator momentarily operates the "Through" key. Relay A operates via H3 to earth at the key and holds to earth at A2. A1 connects interrupted earth to the call lamp to give a flickering signal. Earth from the key is also extended over the junction to operate relay RA, which locks via RA2 to earth at L1. RA4 completes the circuit of relay D to earth at L3. D operates and connects ringing current and ring return battery to the intercepted line at D4 and D5, respectively. D1 connects ring tone to the 570 ohm winding of retard RC and RA1 and RA3 allow the tone to be heard by the caller. D2 and D3 disconnect relay M from the transmission circuit.

When the intercepted subscriber answers, relay F operates on its 300 ohm winding and locks by removing the short circuit across its winding at F3. F4 opens the circuit of relay D which releases and extends the intercepted subscriber's loop to operate relay A. A1 operates relay B via F1, and the calling and called parties are connected together for conversation at B2 and B4. Relays L, T and G release and the junction is freed. At the central position, relays H and A release and the Call lamp is extinguished.

Should the calling party clear before the intercepted subscriber answers, relay HS (Siemens high speed type) releases during the brief interval between the removal of earth from the positive line by the calling final selector and its replacement by the release of the subscriber's line circuit. HS1 releases relay L, L4 releases relay T and the junction is freed as before.

(ii) If the call is not to be extended to the intercepted subscriber, the operator momentarily operates the "Lock-off" key after giving the necessary information to the caller. Relay S operates over the junction and S1 operates relay K. K1 releases relay T and the junction is freed and is available for another call. Relays S and H release. When the caller clears, the exchange equipment restores to normal and the line tapping circuit releases.

Should the intercepted subscriber originate a call while an incoming call is being dealt with by the operator, relay CA operates via L2 to earth at A1 and applies busy tone to the line as an indication that the call should be made later.

/3.

3. CHANGED NUMBER CIRCUIT.

3.1 When a subscriber's number is altered due to a change of address, etc., it is necessary to intercept all calls to the old number and advise callers of the change in the telephone number. The circuit shown in Fig. 4 is a simplified version of the interception circuit and, in fact, may share the same junction to the central position. The final selector multiple of each changed number is jumpered on the I.D.F. to a changed number circuit.

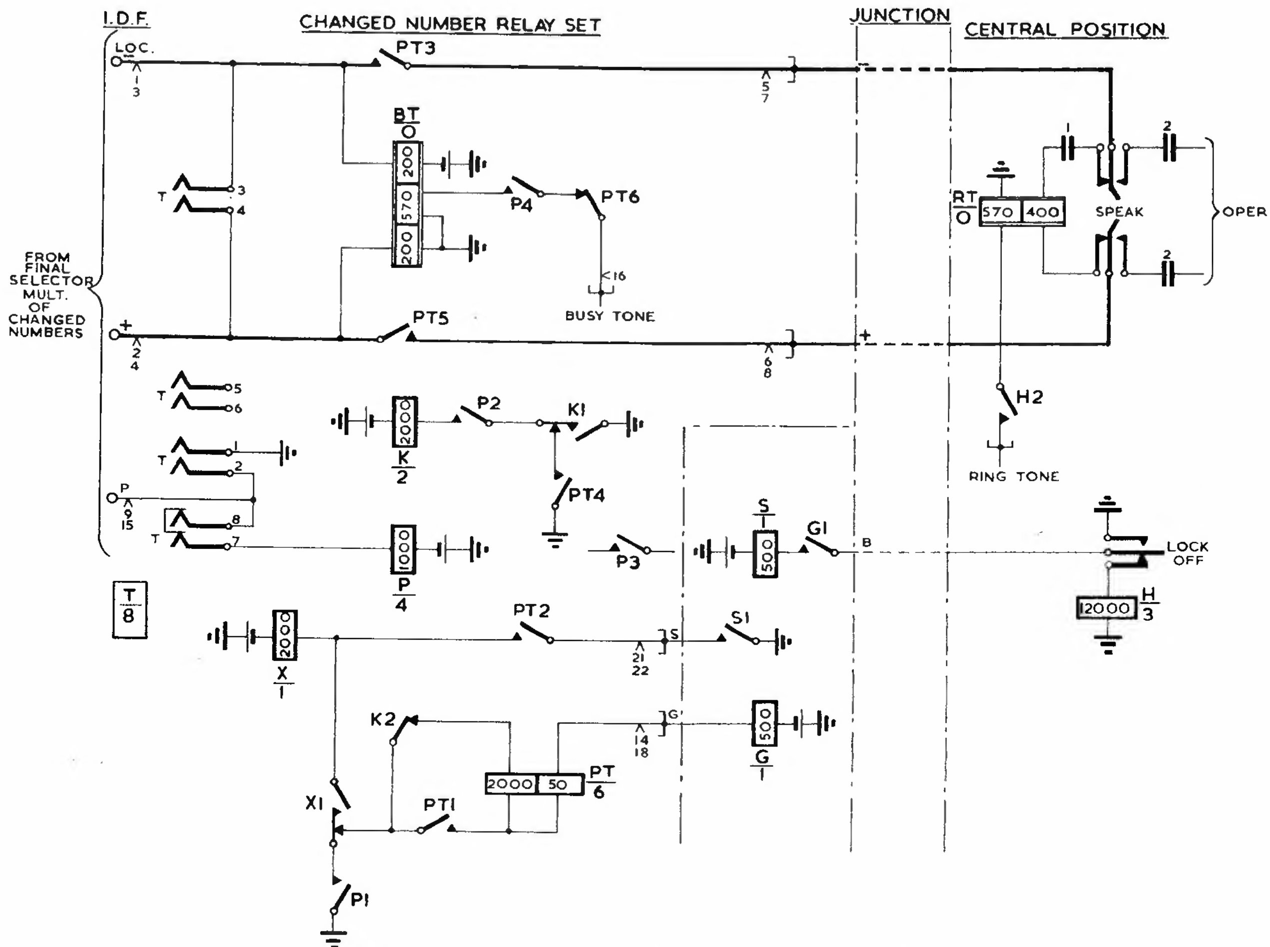


FIG. 4. CHANGED NUMBER CIRCUIT (CE.384).

3.2 Circuit Operation. On a call to a changed number, relay P operates to the earth on the P wire from the calling final selector. The ring is tripped by the battery via retard BT on the negative line. If the junction is free, relay PT operates from earth at P1 to battery via relay G. PT1 holds relay PT on its 50 ohm winding and the junction is busied by the low resistance earth. Relay K operates to earth at PT4 and locks via K1. PT3 and PT5 connect the caller to the junction. The operation of relay G connects relays S and H in series over the junction and H operates. H2 connects ring tone to the calling party and H1 lights the call lamp (see Fig. 3).

By operating the Speak key, the ring tone is disconnected and the operator may give the required information to the caller. The Lock-off key is then momentarily operated, relay S operates and S1 operates relay X, which locks to earth at P1. X1 rele ses relay PT and the junction is freed. When the caller clears, relays P, K and X release and the circuit restores to normal.

/4.

4. CENTRALISED SERVICE OBSERVATION CIRCUIT.

4.1 The object of undertaking service observations is to obtain data regarding the quality of service given to subscribers. It is generally not practicable to provide separate observation equipment in each exchange and, in practice, a centralised observation centre provides observation facilities for a number of exchanges in the district. From this centre, routine observations are carried out on a group of subscribers' lines in each exchange. The layout of the observation equipment is shown in Fig. 5.

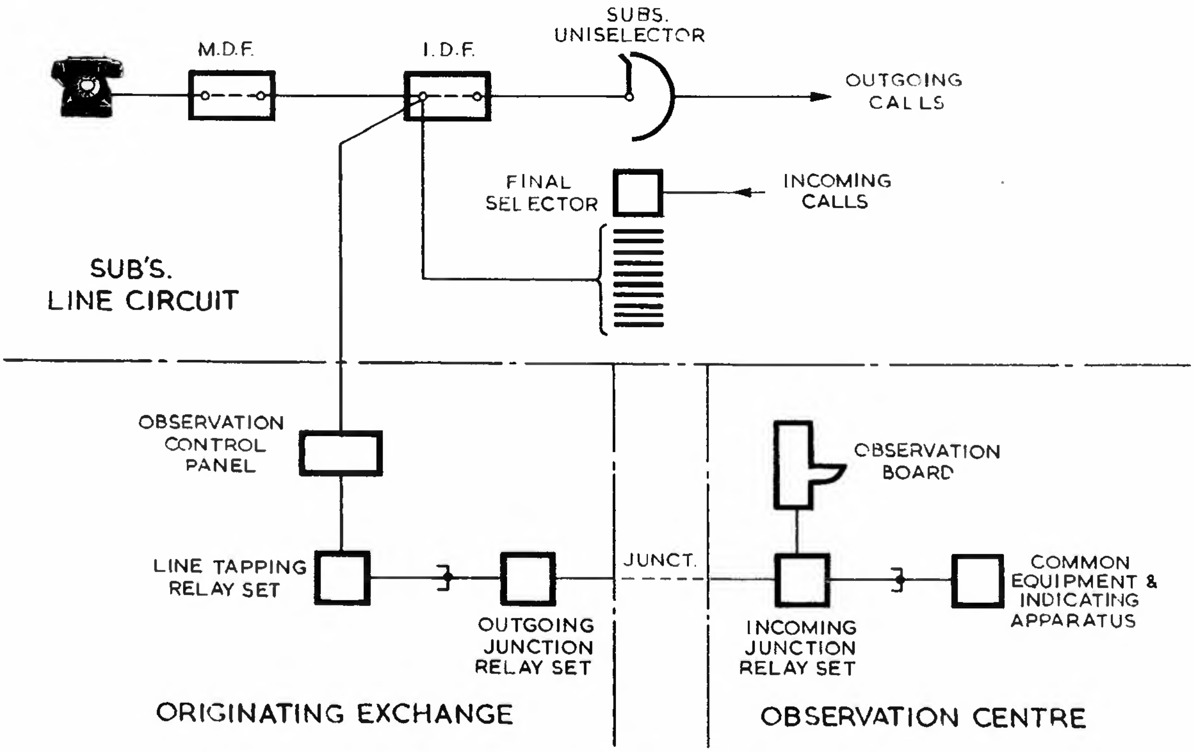


FIG. 5. LAYOUT OF CENTRALISED SERVICE OBSERVATION EQUIPMENT.

4.2 The subscribers' lines selected for observation are connected to the observation circuit by 4-way cords on the I.D.F. multiple side. The observation jacks on the I.D.F. are connected to the line tapping relay-sets via a control panel on the M.A.R. (see Fig. 1). Up to 24 line tapping relay-sets may be associated with each junction, each being numbered in series. Only one line in each group may be observed at a time. All other lines are disconnected from the observation equipment and, if another call is made during this time, it is not observed. When a subscriber originates a call, the line is extended over the junction to the observation board. The outgoing junction relay-set transmits a series of impulses to the observation board, indicating the number of the line tapping circuit that is being used. The observing officer is provided with the list of subscriber's lines corresponding to each of the line tapping circuits.

The digits dialled by the observed subscriber, as well as actuating the automatic selectors, are received over the junction by the indicating apparatus and displayed on lamps to the observing officer. An indication is also given of the meter pulse when the called party answers. The observing officer may release the call from the observation equipment at any time and, in most cases, it is only necessary to ensure that the calling subscriber has successfully reached the called number. When the release key is operated, the display equipment is cleared down and the observation equipment is ready to take the next call initiated in the group under observation.

/4.3

4.3 The circuit connections of the observation equipment at the originating exchange and observation centre are shown in Fig. 6, and a description of the circuit operation follows.

4.4 Line Tapping Circuit. When a subscriber whose line is under observation originates a call, relay L in the associated line tapping circuit operates in parallel with the subscriber's line relay over the subscriber's loop. L2 operates relay LR. LR2, LR1 and LR3 extend the -, + and P wires, respectively, over the junction to the observation centre. LR5 extends an earth via the isolating key to operate relay RG in the outgoing junction relay-set and relay B in all other line tapping circuits associated with this junction. The B1 contacts in these circuits disconnect the L relays from the subscribers' lines, giving the call the exclusive use of the common junction equipment without possibility of interference from any other subscriber's line.

Earth from the P wire of the calling line circuit operates relay B. Relay L holds via B1, L1, 2000 YB, wiper JF3 and bank contact to earth at TY2 in the outgoing junction circuit.

If, when a subscriber originates a call, the junction is already in use on a previous call, then, since relay B is operated, the looping of the line by the subscriber will not have any effect on the circuit as relay L is disconnected. Should the junction become free while the second call is in progress, the holding of relay B from the P wire ensures that the junction will not be seized except at the initiation of a call. Only one L (and LR) relay in the group, therefore, can be operated at the one time, and relay TX in the outgoing junction circuit will be connected only to the particular subscriber's line being observed.

4.5 Control Panel. The purposes of this panel are -

(i) By the operation of the appropriate Isolating key, to disconnect the observation equipment from the subscriber's line to allow testing from the test desk, etc., to be carried out under normal conditions. Earth from the isolating key operates relay B in the associated line tapping circuit, and calls from this tapping circuit are thus prevented from seizing the junction.

(ii) By the operation of the appropriate Hold key, to disconnect the line under observation and hold it while fault conditions are being investigated. Also to provide a tone to the subscriber indicating that the line is temporarily out of action. An indication is given to the observation officer that the originating exchange has taken control of the call.

Operation of a Hold or Isolate key on the control panel causes a pilot lamp to glow while the key is operated.

4.6 Outgoing Junction Circuit. When a call is originated, earth from the appropriate line tapping circuit operates relay RG. RG1 completes the circuit of relay X, which operates. X2 completes the circuit of relay TY which locks via TY3, at the same time disconnecting relay X. By this means, the common from the line tapping circuits and 2000 ohm YB is earthed during the slow release period of relay X. The earth may be maintained by CC3 but, if relay CC has not operated before relay X releases, the holding circuit of relay L will be opened and the line tapping circuit thereby released. Relay CC operates only if the observation board is free to receive the call. Earth from the P wire of the subscriber's line is extended over the junction "C" wire to operate relays at the observation centre and, if the equipment is free, a circuit from earth is completed back over the "PU" wire to operate relay CC. If, however, the central equipment is not free, relay CC will not be operated and the call will not be observed.

Assuming that the call is to be observed, relay CC operates and relay IT operates via RG3, JFdm, RG5, wiper JF1 and bank contact to earth at CC1. IT2 operates the JF drive magnet and an interaction is set up between the magnet and relay IT which steps the switch, dependent on the earths on level 1 of the uniselector bank. When the

/contact

contact corresponding to the line tapping circuit in use is reached, relay IT cannot reoperate (operating earth opened at L1) and the wipers come to rest. In this manner, a number of impulses, corresponding to the number of the line tapping circuit in use, are transmitted over the junction "PU" wire.

When relay TX operates to the metering pulse, TX1 operates relay TR and TR1 applies positive battery over the junction "C" wire. Relay TY releases.

When the call is released from the observation board, earth is removed from the PU wire and relay CC releases. CC2 opens the holding circuit of relay L which releases, followed by relay LR, and the line is disconnected from the junction. Relay RG releases and the homing circuit of the JF uniselector is completed via RG3, JFdm and RG5 to earth on the homing arc JF2.

4.6 Observation Board and Incoming Junction Circuits. Assuming that the observation equipment is ready to receive the call, relay JL operates to the earth extended over the C wire from the observed subscriber's line circuit. The current is insufficient to operate relay JR. JL1 operates relay JS and JS3 connects earth via the isolating key to the common over which the PB relay of all other incoming junctions associated with this observation position are operated. JS4 lights the Call lamp and JS5 connects the earthed relay PP to the junction PU wire (to operate relay CC in the outgoing junction circuit). JS1 and JS2 extend the A and B wires of the junction to the indicating apparatus.

When the party being called by the subscriber under observation answers, the meter pulse operates relays TX and TR in the outgoing junction circuit, as previously described. Positive battery is applied to the junction C wire and relay JR operates to the increased current. JR1 lights the Registration lamp, indicating to the observer that the call has been metered. The observer may listen to the conversation by operating the Observation key.

If it is desired to hold the call and investigate a fault condition, the Hold key at the observation board is momentarily operated and relay H operates. H1 operates relay HA and HA1 holds relay H across the - and + wires of the observed line. HA3 lights the hold lamp. The originating exchange is notified and the operation of the appropriate Hold key on the control panel holds the call and allows relay H at the observation board to release. The hold lamp is extinguished.

To clear a call from the observation board, the Common Release key is operated. Relay M operates and M1 operates relay PB. Relays JL, JR, JS and PP release and earth is removed from the PU wire to release the outgoing junction circuit at the originating exchange.

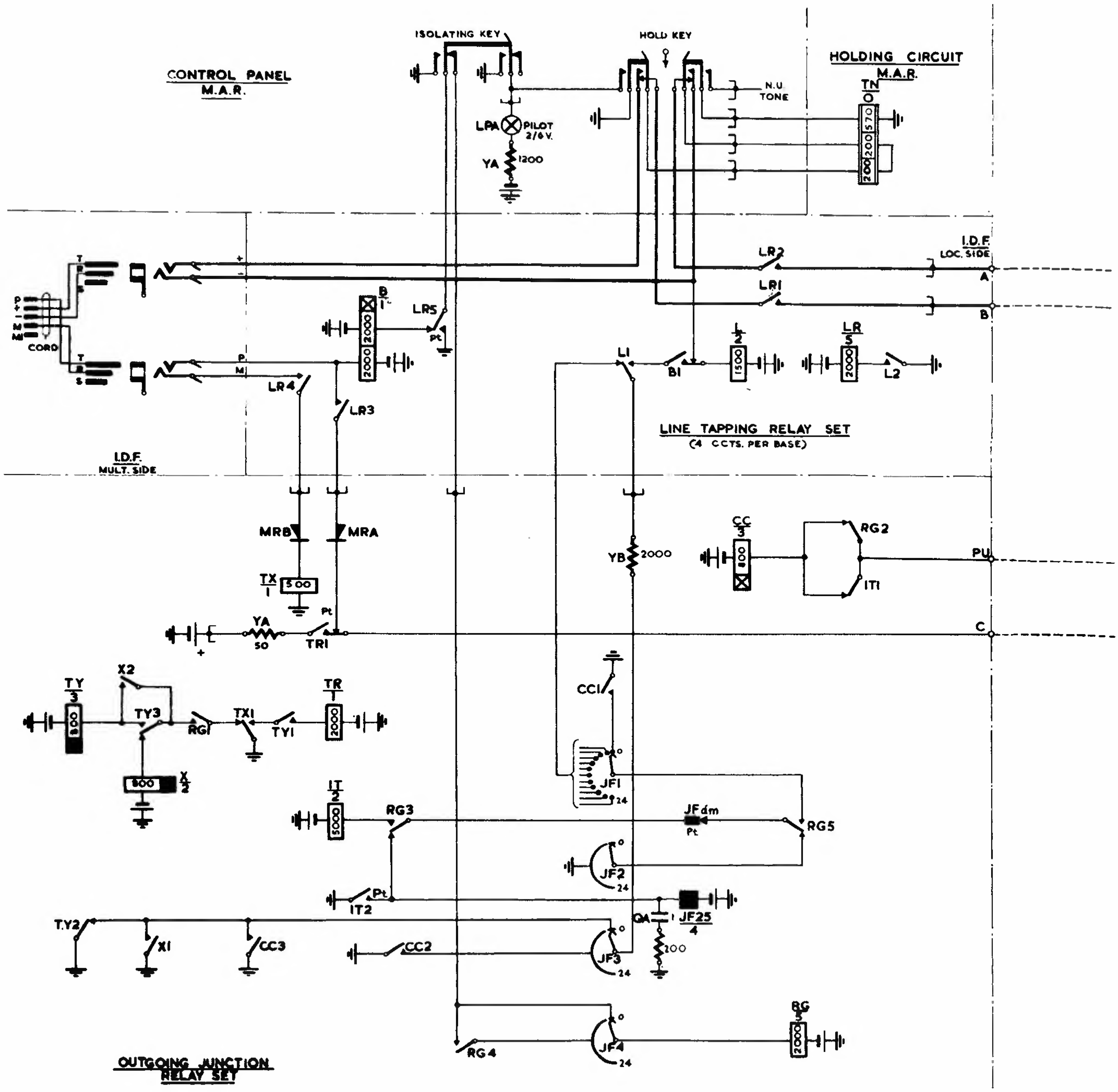
When the observation key is operated, the extra springs connect the C and PU wires together, leaving relay CC under the control of the calling subscriber. By this means, a circuit under observation is retained while the operation of the common release key releases the indicating equipment for the reception of other calls.

If the indicating apparatus on an observation position is in use and a call is received on a second junction associated with the position, relay PB will be operated and relay CR operates to the earth extended over the junction C wire. CR1 flashes the call lamp but such calls cannot be observed.

The operation of an Isolating key operates relay PB in the associated incoming junction and prevents calls being observed on the junction although the call lamp may flash.

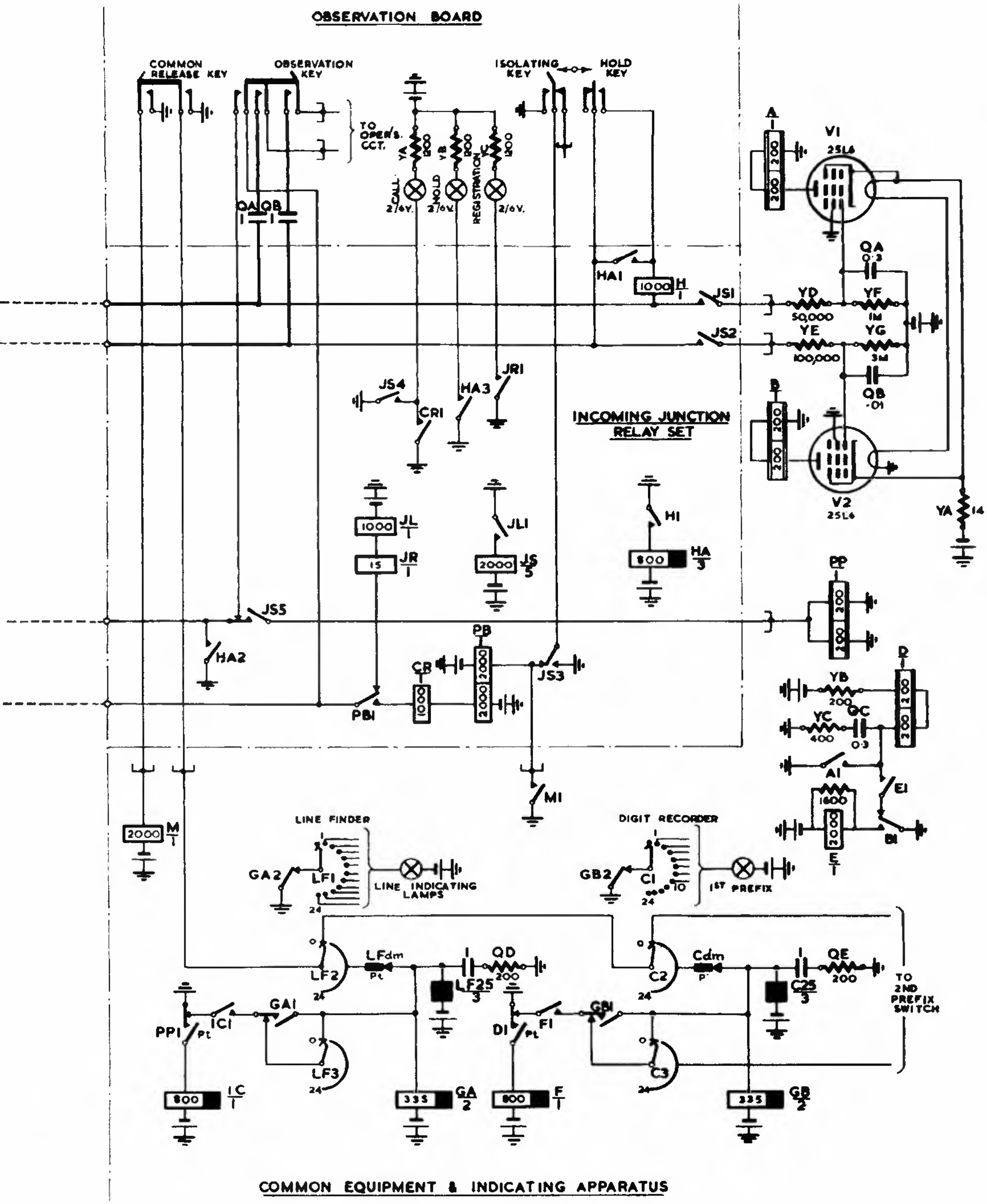
4.7 Common Equipment and Indicating Apparatus. The impulses sent over the PU wire cause relay PP to release a number of times corresponding to the number of the line tapping circuit in the junction group. PP1 operates relay IC and IC1 prepares the circuit of the LF drive magnet. At each release of PP the drive magnet is operated. Relay GA operates on the first impulse and releases slowly at the end of the impulse train. GA2 lights the particular line indicating lamp on which the LF1 wiper is standing.

/Fig. 6.



CENTRALISED SERVICE OBSERVATION

FIG.



CIRCUIT (CE.256, SH. 1).

4.8 Valve Impulse Repetition Circuit. The object of this circuit is to repeat impulses from the subscribers' lines under observation to the indicating apparatus without introducing additional dialling or transmission losses in the subscriber's line. In earlier circuits a sensitive telegraph relay was used to repeat the impulses to the indicating equipment but this has the disadvantage of imposing an additional shunt loss on the subscriber's line under observation. As a valve operates to potential only and draws no current from its grid circuit, no such loss is caused by this circuit. However, special precautions must be taken in the valve impulse repetition circuit to guard against false impulses due to surges, etc., on the line. The circuit connections are shown in Fig. 7.

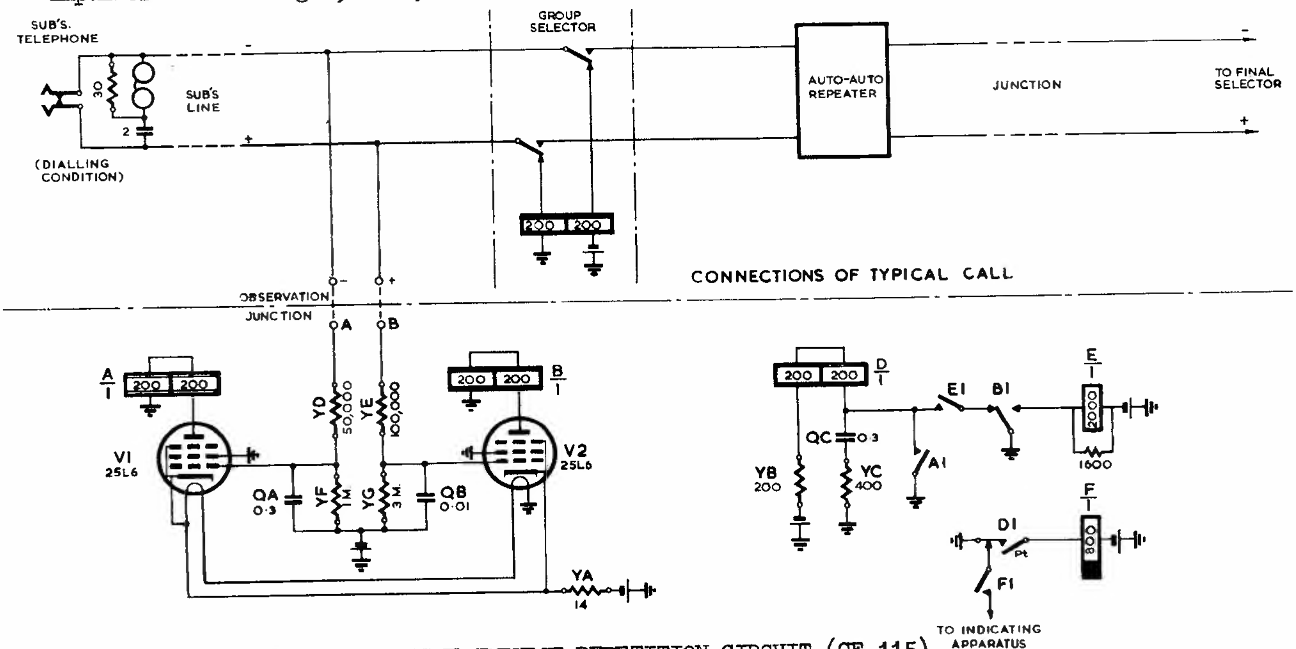


FIG. 7. VALVE IMPULSE REPETITION CIRCUIT (CE.115).

The circuit uses two 25L6 valves operating from the exchange battery. The control grid of the first valve is connected via 50,000 ohms YD to the negative wire of the line under observation and, by means of relay A in the anode circuit, repeats the impulses dialled by the subscriber to the indicating apparatus. An 0.3μF condenser is connected from the control grid to negative battery to damp out positive voltage peaks caused by oscillations set up in the subscriber's line due to the action of the dial condenser. The valve operates with a negative grid bias of 4 volts derived from the drop across 14 ohm YA. The 1 megohm grid leak prevents the grid attaining positive bias when it is disconnected.

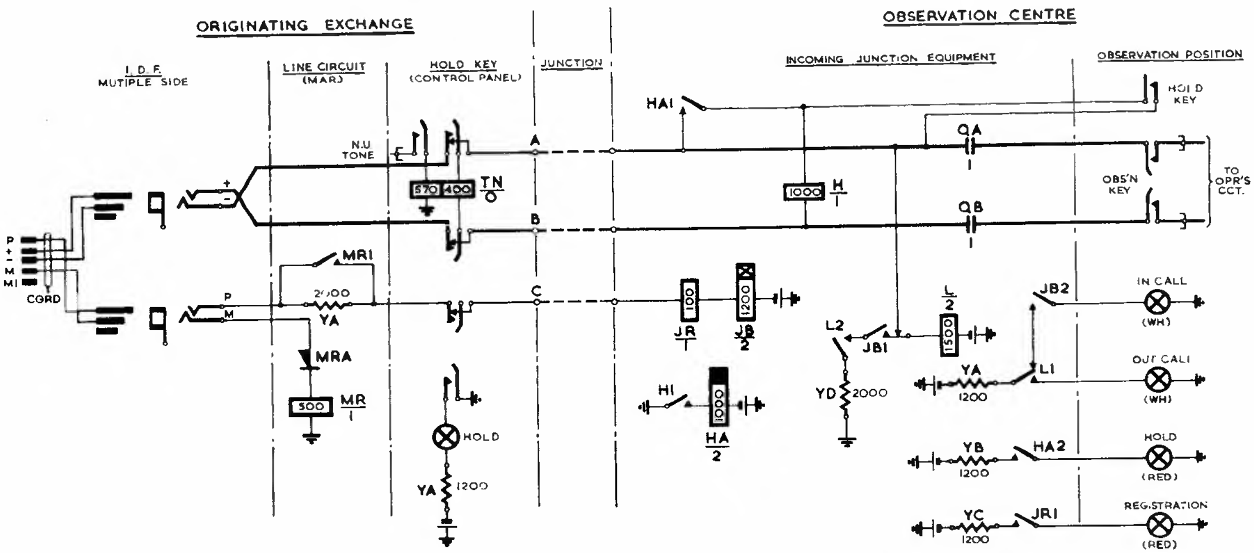
The control grid of the second valve is connected via 100,000 ohm YE to the positive wire of the line. Its function is to suppress false impulses which are otherwise likely to occur when the group selector switching relays operate and momentarily open the line. Under steady loop conditions and during dialling, the control grid of this valve is always at a high positive potential relative to the cathode so that relay B remains operated. B1 holds relay E operated. If, during the operation of the group selector switching relay, the potential on the control grid of V1 becomes negative, so tending to release relay A, the potential on the grid of V2 also becomes negative and relay B releases. B1 holds relay D via E1 and prevents a false impulse being recorded on the indicating apparatus. Relay E is made slow to release by virtue of the 1,600 ohm non-inductive shunt.

The impulses from relay A are repeated by relay D to the Digit Recorder uniselectors. D1 operates relay F and, when D releases, earth via D1, F1, GB1 (see Fig. 6) and wiper C3 and bank contact operates the drive magnet and relay GB in parallel. The uniselector wipers are stepped a number of times according to the first digit dialled and, at the end of the impulse train, relay GB releases and GB2 lights the appropriate 1st Prefix lamp. The next impulse train is directed to the 2nd Prefix switch, and so on.

5. SPECIAL JUNCTION CIRCUIT, CENTRALISED OBSERVATION.

5.1 This circuit is used when it is desired to observe every call to or from a particular subscriber. It is particularly useful to investigate subscribers' complaints of unsatisfactory service when the cause of the complaint is not apparent. A separate 3-wire junction is required for each individual line to be connected to this circuit.

At the Centralised Observation Centre the incoming junction circuit gives lamp indications of out and in calls, registration and hold conditions. Operation of the Observation key allows the observer to monitor the conversation and, in the event of a fault, operation of the Hold key holds the connection to allow the fault to be traced. The circuit connections are shown in Fig. 8.



CENTRALISED OBSERVATION - SPECIAL JUNCTION CIRCUIT.

FIG. 8.

5.2 Circuit Operation. The subscriber's line is connected to the special observation circuit by means of a cord and plugs on the multiple side of the I.D.F. The observation jacks are wired to line tapping circuits mounted on the M.A.R.

Out-going Call. When the observed subscriber originates a call, relay L operates in parallel with the line relay and L1 lights the "Out Call" lamp. Earth on the P wire of the subscriber's line circuit is extended via 2,000 ohm YA to the junction C wire to operate relay JB. JB is slow operating to allow relay L to operate first and, when JB operates, L holds to earth via JB1, L2 and 2,000 ohm YD. The current on the C wire is insufficient to operate relay JR.

When the called party answers and the meter pulse is received, relay MR operates and MR1 short-circuits 2,000 ohm YA. The increased current allows relay JR to operate and JR1 lights the Registration lamp. No provision is made to observe the impulses dialled by the subscriber.

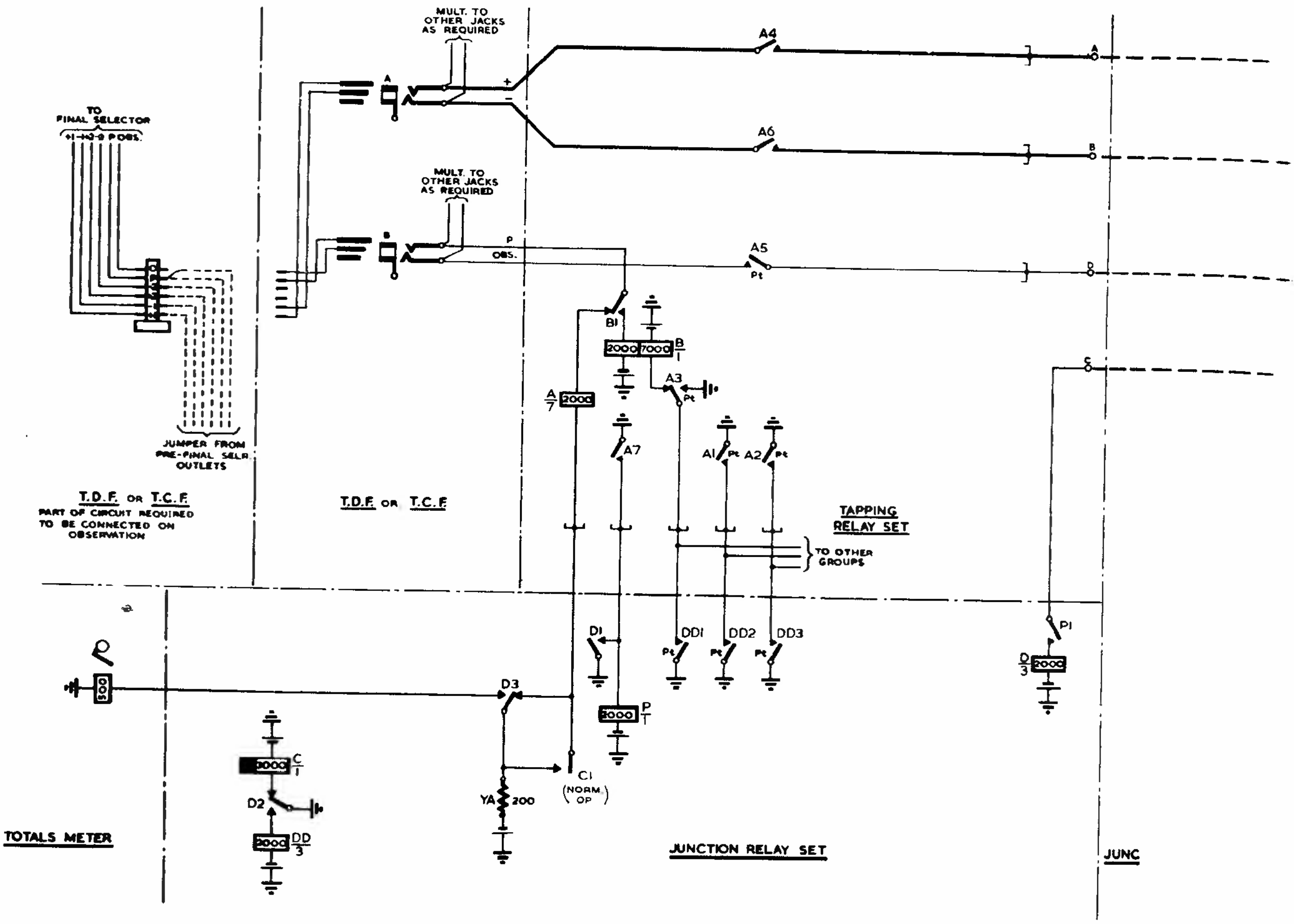
Incoming Call. When the subscriber's line is seized by a calling final selector, relay JB operates from the earth applied to the P wire. JB1 disconnects relay L from the line and JB2 lights the "In Call" lamp.

6. FINAL SELECTOR OBSERVATION CIRCUIT.

6.1 It is self-evident to a subscriber if the number of exchange lines is sufficient for outgoing calls. It is difficult, however, for a subscriber to determine if the number of lines is sufficient to handle incoming calls. The final selector observation circuit was developed primarily as a means of determining the number of calls made to a particular subscriber's line, or group of lines, during the time the line is engaged on another call. When this information is made available to the subscriber, appropriate action may be taken to increase the number of lines.

A tapping circuit is connected to the trunk incoming to each final selector in the appropriate 200-line group. A number of these tapping circuits share a common junction to the observation centre. When a final selector in the group is seized, the digits dialled on the final selector are observed. The observer may listen by operating the Observation key and then operating the Release key to clear the junction. The short time of observation of each call ensures that practically every incoming call to the group is recorded, and a record is obtained of all calls to each subscriber in the group.

The circuit connections of the final selector observation equipment, both at the originating exchange and at the observation centre, are shown in Fig. 9. Connections to the tapping circuits are made by means of special cords and plugs inserted into the T.D.F. or T.C.F. terminal blocks.



FINAL SELECTOR OBSERVATION

FIG.

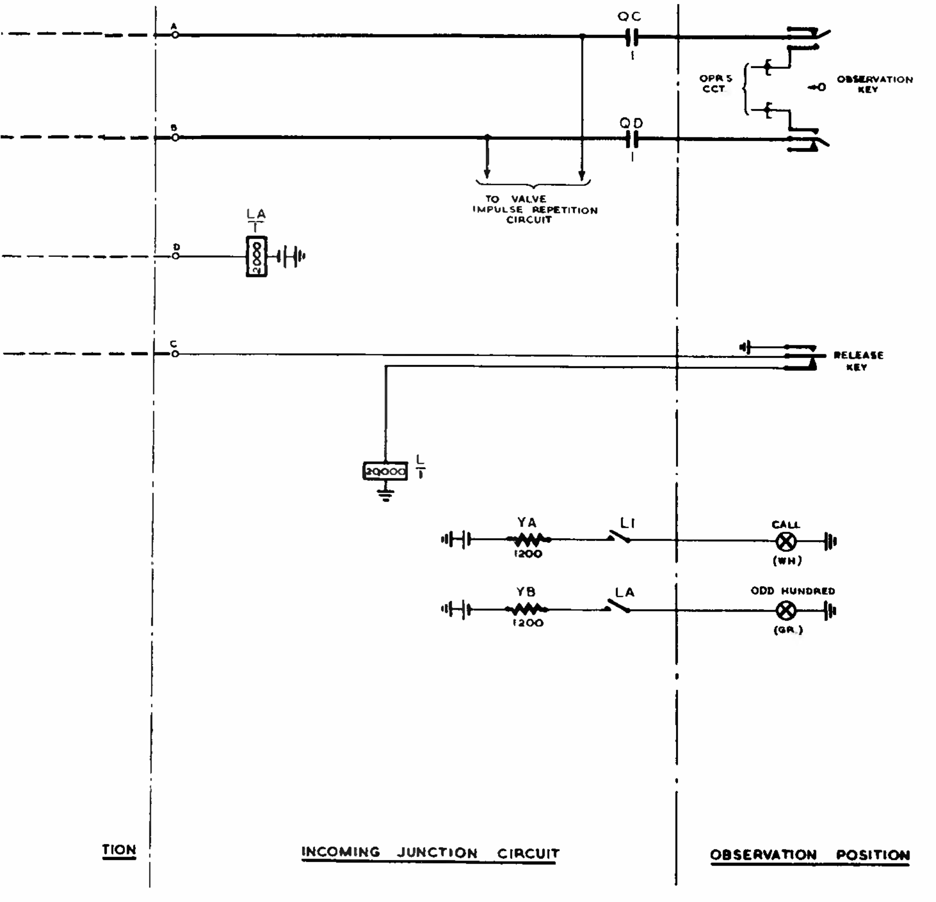
6.2 Circuit Operation. When a final selector in the group under observation is seized, relay A in the particular tapping circuit operates from earth on the P wire to battery via 200 ohm YA in the junction relay-set. A1, A2 and A3 operate relays B in all other tapping circuits associated with the junction, thus disconnecting, at B1 contacts, all other A relays. A4, A5 and A6 connect the final selector to the observation junction. A7 operates relay P and P1 connects relay D over the junction C wire to operate relay L in the incoming junction circuit. Relay D does not operate in series with relay L.

L1 lights the Call lamp on the observation position. The digits dialled into the final selector are received by the valve impulse repetition circuit and are indicated on the display panel (see Fig. 6). The observer records these digits and, by operating the observation key, notes whether the called line is free or busy.

If the call is for the odd hundred of a 200-line group, relay WS in the final selector operates (see Paper No. 2) and earth from a contact of this relay is extended via A5 over the junction D wire to operate relay LA. LA1 lights the Odd Hundred lamp, indicating to the observer in which hundred group the called party is situated.

When the details of the call are recorded, the observer frees the junction by operating the Release key. Relay D operates and D1 holds relay P. As relay C is operated, D3 releases relay A and operates the Totals meter. D2 releases relay C and operates relay DD. DD1, DD2 and DD3 operate relays B in all tapping circuits, including the call which has been released from the observation position. The holding of relay B to the earth on the P wire locks out this final selector from the observation circuit until the call is completed.

Restoration of the release key releases relays D, DD and P, and the junction is ready to observe the next call. Note that any calls received in the group while the observer has been attending to the first call will be locked out due to their B relays being held to the P wire earth, and thus the only calls to reach the observation position will be newly received calls.

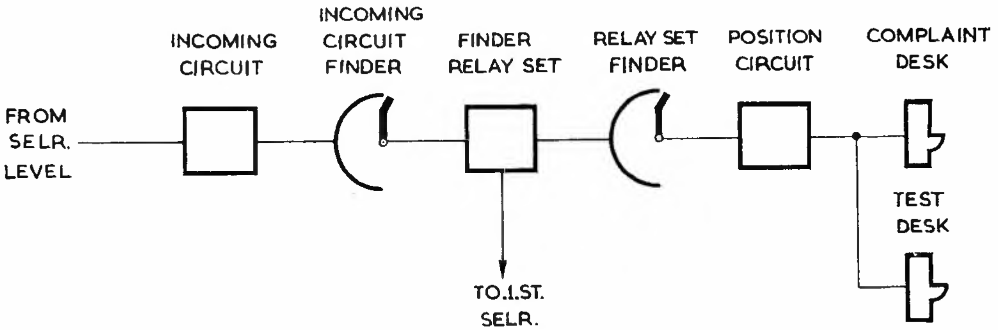


CIRCUIT (CE.256, SH. 2).

7. COMPLAINTS CIRCUIT.

7.1 Subscribers experiencing difficulties in the operation of their telephone services are advised to dial "00" prefixed by the call letter of the exchange to which they are connected. All traffic over the 00 levels is designated "Complaints Traffic" and is normally handled at a special "Complaints Desk."

The circuits from the special 3rd or 4th selector levels terminate on the banks of a group of finder switches as shown in Fig. 10. The Incoming Circuit finders are 25 point or 50 point switches, depending on the number of incoming circuits.



LAYOUT OF COMPLAINTS CIRCUIT.

FIG. 10.

7.2 A "Waiting Call" pilot lamp is provided on each complaints desk position. These lamps commence to glow as soon as a complaint call is received and are extinguished when the call is answered. Callers waiting to be answered receive ring tone as an indication that the call has been correctly routed. The tone is disconnected when the call is answered.

A number of Position circuits are provided for each complaints desk position and, when the operator answers a call, the associated Relay-set Finder searches for a free Finder Relay-set. The incoming circuit finder in turn searches for the calling incoming circuit and switches the calling party through to the complaints operator. After ascertaining details of the complaint, provision is made for connecting the caller to the required number, which is dialled by the complaints operator. When the switching operation is completed, the call is placed under the control of the calling party and the position circuit is freed in readiness to answer the next call. The incoming circuit, incoming circuit finder and finder relay set are released when the calling party clears.

7.3 The complaints desk is staffed only during the busier periods and, outside these periods, for example, at night-time and week-ends, complaints calls are handled at the test desk. Operation of the night alarm key transfers the waiting call pilot lamp circuit from the complaints desk to the test desk. The answering circuits on the first complaints desk position are duplicated on the test desk, and the calls are dealt with as described in the previous paragraph.

In smaller exchanges, a complaints desk is not provided and all complaints calls are handled at the test desk. In some cases, the relay-set finders are not fitted and an answering circuit is associated with each finder relay-set. This arrangement has the disadvantage that the answering circuits are held up for the duration of a call via the complaints equipment.

/7.4

7.4 The panel equipment of each answering circuit consists of -

(i) Answering key. This key is operated when it is desired to answer a complaint call.

(ii) Dial key. This key is operated when it is desired to extend the call. On operation of the key, an out line is seized and dial tone is heard by the complaints operator, who dials the required number. Restoration of the dial key connects the out call under the control of the calling party. The complaints operator may monitor the conversation.

(iii) Release key. This key is operated to release an out call if, for any reason, this is necessary, for example, a mistake in dialling by the operator.

(iv) Meter Control key. This key is operated if a through call is to be metered against the caller or coins collected if a public telephone is connected. With the key in its normal position, through calls are free. Thus the operator may determine whether the call is to be metered or not.

(v) Disconnect key. This key is operated after details of the complaint have been noted and the caller switched through, if necessary. The position circuit is then free to answer the next call.

(vi) Supervisory lamp. This lamp commences to glow as soon as the complaints operator is connected to a caller. If only one call is waiting, the waiting call pilot lamp will cease to glow as soon as the call is answered. In the event of two or more complaints operators attempting to take over the same call, assuming that only one call is waiting, the supervisory lamp lights on the answering circuit which secures the call. The extinction of the waiting call pilot lamp together with no glow on the supervisory lamp indicates to the other operator that the call has been taken over elsewhere. The supervisory lamp glows until the position circuit is released as an indication that the associated answering circuit is in use.

Should the calling party clear while the complaints operator is dialling a number, a flashing signal is given on the supervisory lamp as an indication that the call should be abandoned.

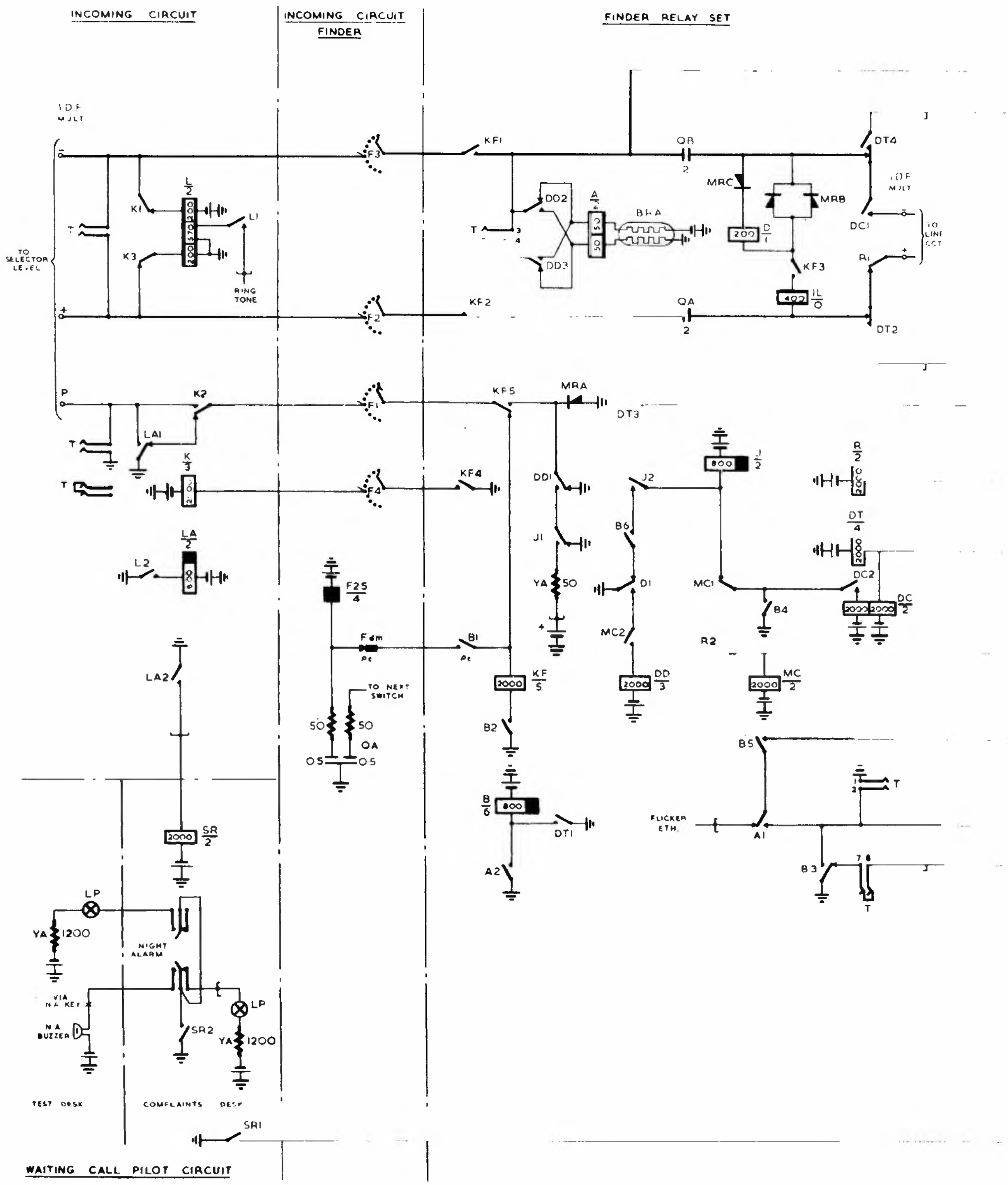
(vii) Congestion lamp. Should an operator attempt to answer a complaint call when all finder relay-sets are busy, the relay-set finder stops on the 25th contacts and lights the congestion lamp, indicating that a further attempt to answer the call should be made later. This feature prevents continuous rotation of the relay-set finders.

7.5 The connections of the complaints circuit are shown in Fig. 11, and a description of the circuit operation is given below.

Subscriber calls "Complaints." When the incoming circuit is seized by the previous selector, relay L operates via the calling loop. L1 connects ring tone to the 570 ohm winding of relay L and L2 operates relay LA. LA1 connects an earth to the P wire to hold and guard the connection, at the same time removing the earth from the incoming circuit finder bank F1 to mark the circuit. LA2 extends an earth to operate relay SR in the complaints desk waiting call pilot circuit. SR1 extends an earth for the operation of relay ST in the position circuit when the call is answered (see next paragraph). SR2 lights the waiting call pilot lamps on the complaints desk via the normal contacts of the night alarm key.

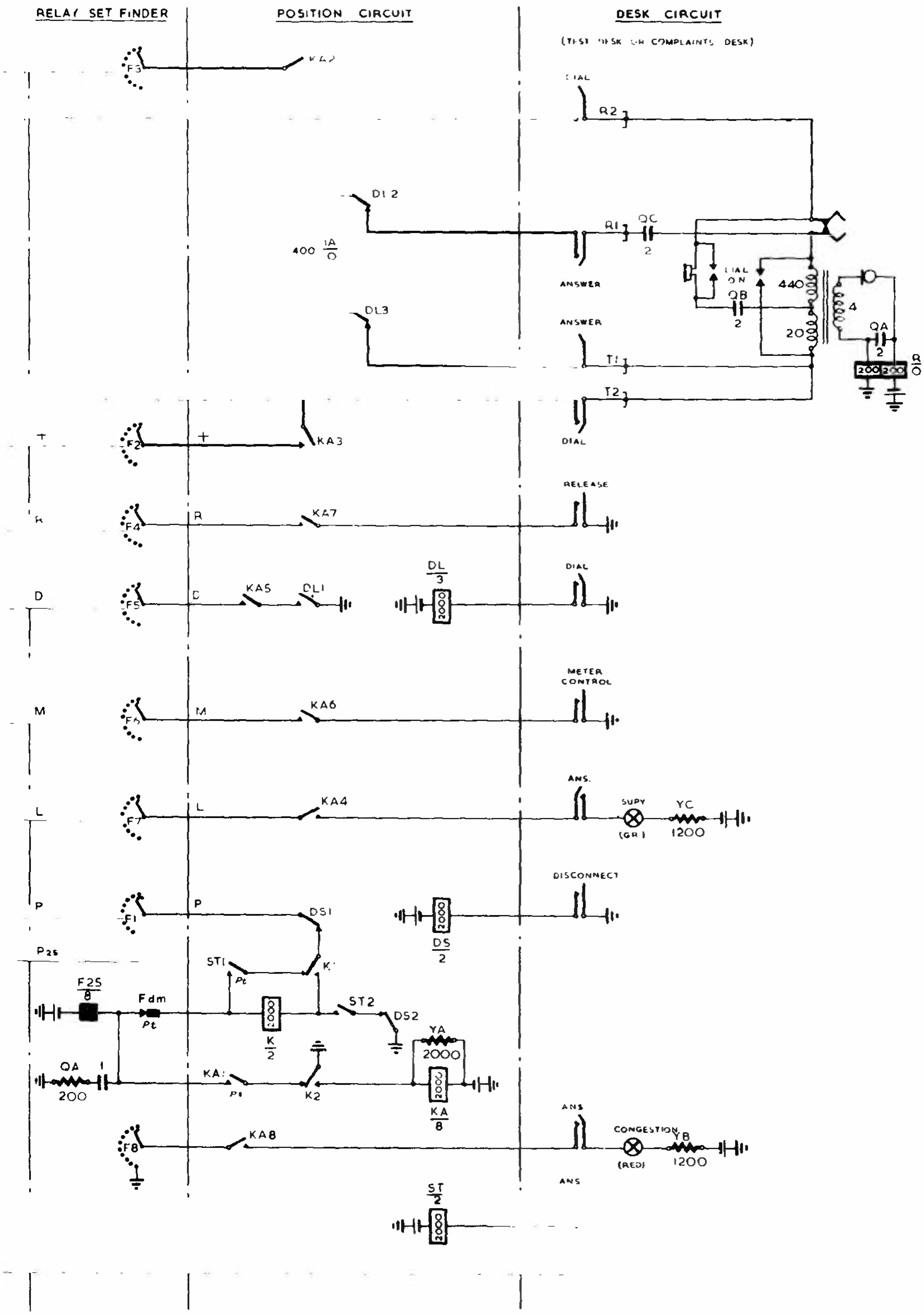
When the complaints desk is unattended, operation of the night alarm key transfers the operating circuit for the waiting call pilot lamps from the complaints desk to the test desk.

/Fig. 11.



COMPLAINTS

FIG.



CIRCUIT (CE.176).

Operator Answers the Call. To take over the call, the complaints (or test desk) operator operates the Answer key. Relay ST operates to the earth from SR1. ST1 connects the relay-set finder drive magnet via its interrupter contacts and DS1 to the F1 wiper. The F1 contacts associated with busy finder relay-sets are marked by earth, and the finder steps over busy contacts. Relay K is short-circuited by the earth on busy contacts and, when a free circuit is reached, K operates in series with the drive magnet to earth via ST2 and DS2. K1 applies an earth to the F1 wiper to busy the bank contact and, at the same time, prevents reoperation of the drive magnet. K2 operates relay KA.

KA2 and KA3 extend the operator's telephone circuit through to the finder relay-set transmission bridge and relay A operates to the loop via retard LA. A2 operates relay B. B3 connects a further earth to the F1 bank contact and this same earth is extended via A1, B5, F7 bank contact and wiper, KA4 and the answer key to light the supervisory lamp. B4 operates relay J which locks via J2 and B6 to earth at D1.

The incoming circuit finder drive magnet is connected via its interrupter contacts, B1 and KF5 to the F1 wiper. The F1 bank contact corresponding to the calling circuit is marked by the absence of earth, and the finder searches until the marked contact is reached. During the finding action, relay KF is short-circuited and, when the calling circuit is reached, KF operates in series with the drive magnet to earth at B2. KF5 applies an earth via DD1 to hold and guard the connection when LA1 subsequently restores, at the same time preventing the reoperation of the drive magnet. KF4 extends an earth over the F4 wiper and bank contact to operate relay K in the incoming circuit. K1 and K3 disconnect relay L from the line, which is connected through to the complaints operator's circuit at KF1 and KF2. Relay L releases, followed by the slow release of relay LA. The connection is now held by the finder relay-set with earth via DD1, KF5, F1 wiper and bank contact, and K2 to the P wire. LA2 opens the waiting call pilot circuit for that particular call and, if no other calls are waiting, relay SR releases and the pilot lamps cease to glow.

It will be noticed that relay ST operates via SR1. This ensures that rotation of the finders does not occur if an answer key is operated when no calls are waiting.

All Finder Relay-sets Busy. The 25th outlet of the relay-set finders is not wired to a finder relay-set but is busied, as long as a free finder relay-set is available, by earth via normal contacts B3 and T7-8 on to the F1 bank contact. When the last finder relay-set is taken into use, this earth is removed, allowing a searching finder to seize this outlet and relays K and KA in the associated position circuit operate. Earth on the 25th F8 bank contact is extended via KA8 and the answer key to light the congestion lamp, indicating to the complaints officer that no free circuit is available.

To artificially busy a finder relay-set for any reason, the test plug is transferred from T7-8 to T1-2.

Call not Extended. After noting particulars of the complaint, the operator restores the answer key and momentarily operates the disconnect key. Relay ST releases and relay DS operates. DS1 and DS2 release relay K, and K2 releases relay KA. During the slow release time of relay KA, earth is extended via K2 and KA1 to operate the finder drive magnet and, when KA releases, the wipers are stepped to the next outlet. This step-on feature ensures that different finder relay-sets are used on successive calls. The release of relay KA extinguishes the supervisory lamp and the answering circuit is free to handle the next call.

The finder relay-set is held until the calling party clears, when relay A releases, followed by the release of relays B, KF and J and the circuit restores to normal.

/Extending

Extending a Call. In some circumstances, the operator may desire to extend the caller to the required number. Operation of the dial key operates relay DL in the position circuit. DL2 and DL3 disconnect the operator's telephone circuit and DL1 extends an earth via KA5 and wiper and bank contact F5 to operate relays DT and DC in the finder relay set. DC locks via DC2 to earth at B4.

The operator's dialling circuit is connected to the associated line circuit via DT2, DT4, DC1 and R1, and dial tone is heard by the operator. DT3 disconnects retard IA, leaving relay A dependent on the calling party. DT1 holds relay B, independent of A2.

Should the calling party clear while the operator is dialling the required number, relay A releases but B holds. A flashing signal is given on the supervisory lamp in this case by flicker earth via A1, B5, F7 bank contact and wiper, KA4 and the answer key.

After dialling the required number, the operator restores the dial key and relays DL and DT release, but DC holds on its second winding. The release of relay DT connects the out call to the finder relay-set transmission bridge and the call is held by the loop via retard IL, KF3 and rectifier MRB. At the same time, the operator's dialling circuit is disconnected but, with the answer key operated, the operator may monitor the call.

When the called party answers, the direction of current in the outgoing line is reversed and relay D operates in series with rectifier MRC.

Metering. If the calling party complains of having received a wrong number, or in other special circumstances, the operator may extend the call without operating the meter control key. In this case, the call is not metered against the calling party or, if the call is from a public telephone, it is not necessary to insert further coins.

On the other hand, if the call is to be metered or coins collected, the meter control key is momentarily operated. Relay MC is operated over the F6 bank contact and wiper and locks via R2 and MC1 to earth at B4. MC1 places relay J under the control of D1, and MC2 prepares the circuit of relay DD. When the called party answers, relay D operates and D1 operates relay DD and opens the circuit of relay J, which releases slowly. During the release time of relay J, positive battery is applied via 50 ohm YA, J1, DD1, KF5 and wiper and bank contact F1 to the P wire to operate the caller's meter. When J releases, earth is applied to the P wire at J1. Rectifier MRA maintains an earth on the P wire during the transit time of DD1 and J1, but does not shunt the metering pulse. DD2 and DD3 reverse the direction of current on the incoming line wires.

If, for any reason, such as a mistake in dialling or incorrect operation of the meter control key, the operator wishes to release the outgoing call, the release key is operated, operating relay R in the position circuit. R1 releases the outgoing call, and R2 releases relay MC, if previously operated. The release key is then restored and the call repeated.

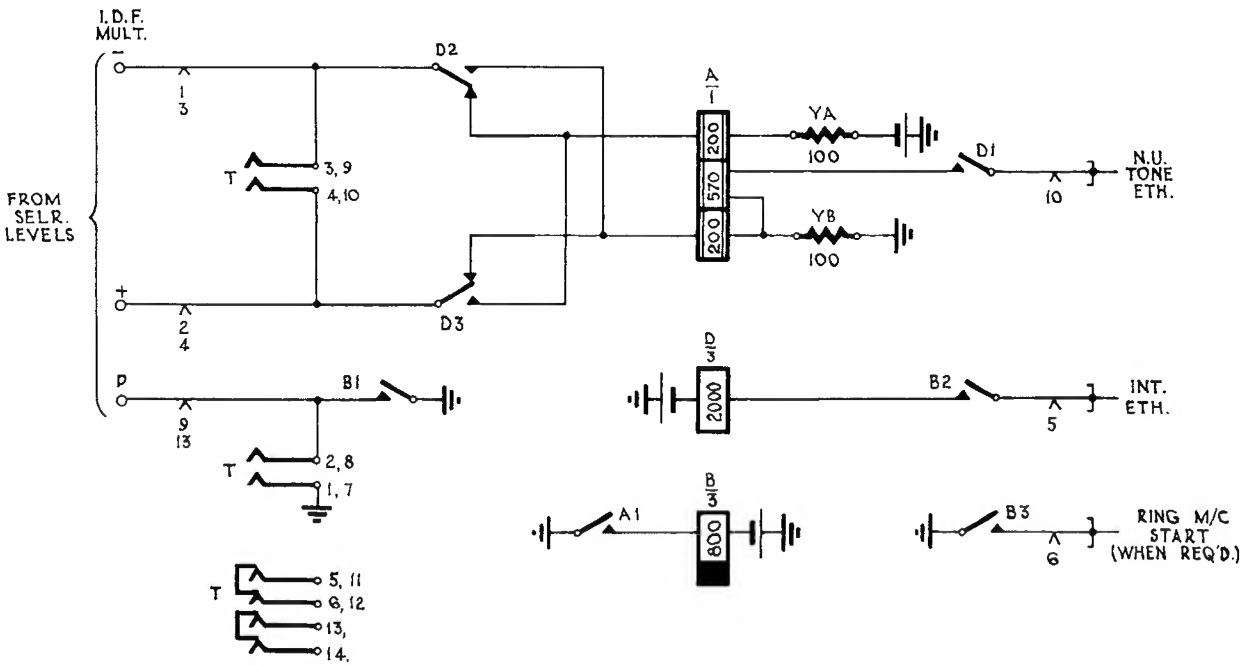
After ensuring that the call is proceeding satisfactorily, the operator momentarily operates the disconnect key and the call is released from the position circuit, as described on the previous page. Relays K and KA release and the relay-set finder steps on to the next set of bank contacts in readiness for the next call.

The finder relay-set is held until the calling party clears, with relays KF, A, B, DC, D and J operated in the case of a free call, or relays KF, A, B, DC, D, DD and MC in the case of a call which has been metered against the caller.

8. REVERSE BATTERY AND TONE SIGNAL CIRCUIT.

8.1 This circuit is provided for testing junctions or public telephones, or for any other test requiring a reversal of battery and a transmission test tone signal. A number of circuits wired as shown in Fig. 12 (two circuits per relay-set base) are wired from the eighth level of special 3rd or 4th group selectors. Connection to these circuits is obtained by dialling the prefix of the exchange concerned, followed by the digits "08", for example, WA08.

When the circuit is seized, the battery on the incoming line wires is periodically reversed and, on each reversal, a signal tone (400 c/s N.U. tone) is connected to the line.



REVERSE BATTERY AND TONE SIGNAL CIRCUIT (CE.404, SH. 1).

FIG. 12.

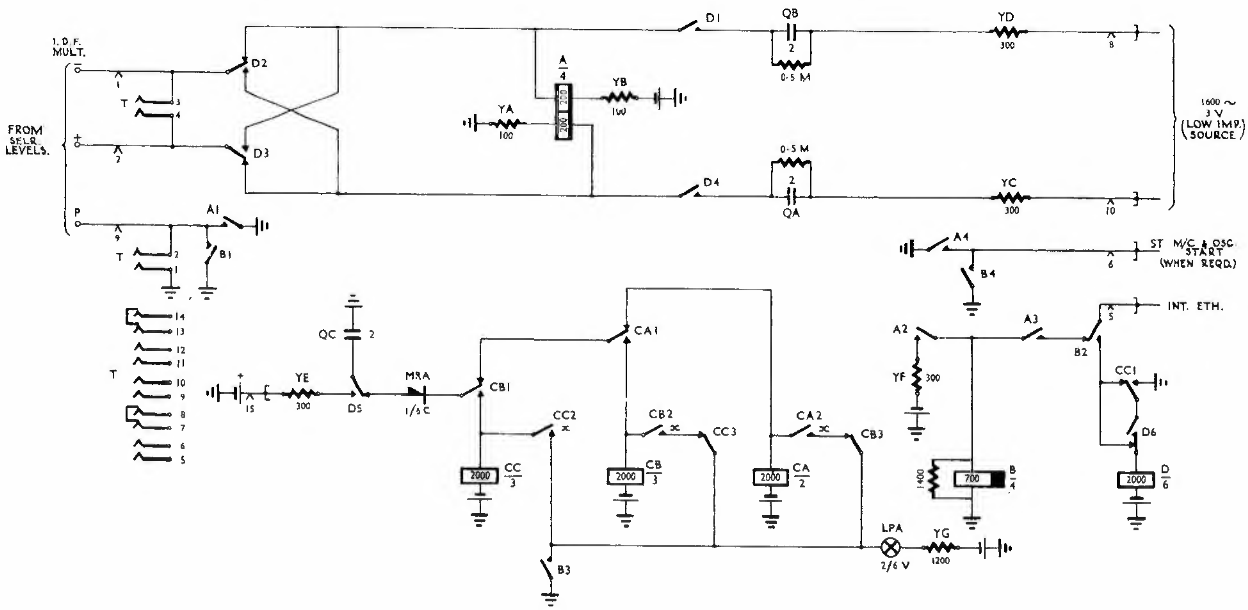
8.2 Circuit Operation. When the circuit is seized, relay A operates to the calling loop. The 100 ohm resistors YA and YB limit the current for testing purposes. A1 operates relay B and B1 earths the P wire to hold and guard the connection. B2 connects relay D to the interrupted earth lead (0.75 second earth every 1.5 seconds) and B3 earths the ringing machine start lead when required.

In some exchanges, instead of using the interrupted earth pulses, an interrupter circuit consisting of three relays, TA, TB and TC is provided on the A.E.R. These relays commence to operate when the start lead is earthed by B3 and are timed to give approximately 25 pulses every 20 seconds to relay D.

Each time relay D operates, N.U. tone is connected to the tone winding of relay A at D1 and so is transmitted to the line. D2 and D3 reverse the direction of current on the incoming line wires.

/8.3

8.3 Alternative Circuit. A modified circuit for testing junctions is shown in Fig. 13. This circuit provides three complete reversals after the incoming trunk is seized, then connects a permanent reversal to the line. During each reversal, a 1,600 c/s tone is connected to the line. The level of the tone is such that a power of +5 dbm. will be dissipated in a 600 ohm N.I. resistance across the incoming line. It is possible, therefore, to measure the transmission loss of a junction and its associated repeater by the use of this circuit.



REVERSE BATTERY AND TONE SIGNAL CIRCUIT (CE.404, SH. 2).

FIG. 13.

8.4 Circuit Operation. When the circuit is seized via the special selector level, relay A operates and A1 earths the P wire. A2 completes the operating circuit of relay B but, should the interrupted earth be applied at the time of seizure, relay B is prevented from operating. A4 earths the machine and oscillator start lead. Relay B operates when the interrupted earth is removed and B1 and B4 connect earths to the P wire and start lead, respectively, in case relay A momentarily releases during reversals. B3 lights the supervisory lamp LPA.

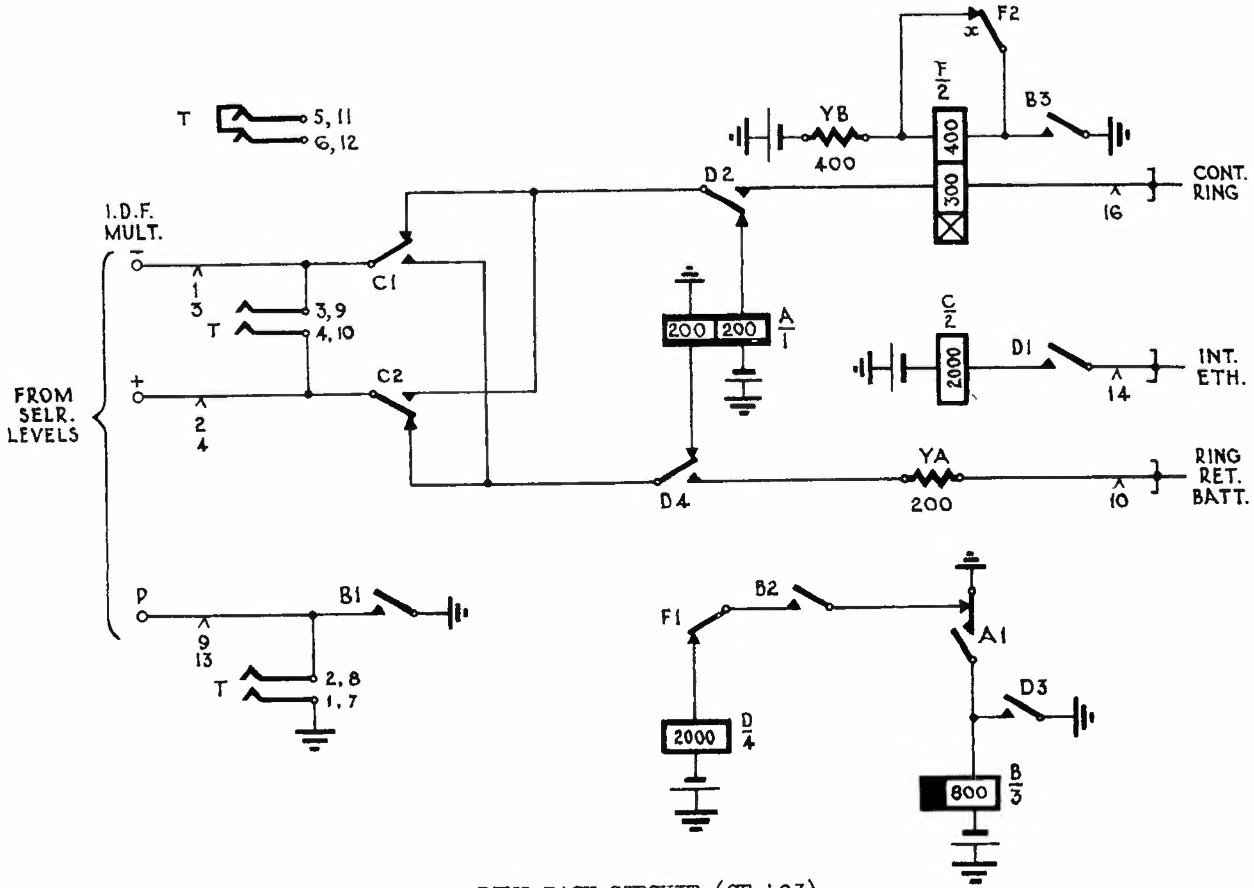
On the next interrupted earth pulse, relay D operates and reverses the incoming lines at D2 and D3. D1 and D4 connect the 1,600 c/s tone to the line and D5 charges condenser QC to 50 volts positive potential. D6 has no function at this stage. At the conclusion of the interrupted earth pulse, relay D releases and restores the normal polarity of the incoming lines. Condenser QC discharges via rectifier MRA and relay CA and recharges negatively. CA operates and locks via CA2 and CB3 to earth at B3. MRA prevents the negative charge on the condenser being dissipated via the fleeting earth applied by CA2 "x". CA1 prepares the operating circuit for relay CB, which operates after the second reversal and releases relay CA.

Two more reversals are given in this manner and, at the end of the 3rd reversal, relay CC operates and releases relay CB. CC1 prepares a locking circuit for relay D. On the next interrupted earth pulse, relay D operates and locks via D6 to earth at CC1. A permanent reversal and tone are then connected to the incoming trunk until the circuit is released.

9. RING BACK CIRCUIT.

9.1 This circuit is intended for use on revertive calls on party lines. Subscriber X dials subscriber Y and then replaces the receiver. The bells of both subscribers are then rung alternatively. When the called subscriber answers, the ringing current is disconnected from both lines. The calling party is therefore aware that the called party has answered and again removes the receiver. Both parties may then converse.

Note that this facility cannot be used with the duplex service as secrecy is provided in that case. The ring back circuit may be used by substation technicians to check the operation of telephone bells. Access to the circuit is obtained by dialling "07" prefixed by the local exchange prefix. The circuit connections are shown in Fig. 14.



RING BACK CIRCUIT (CE.403).

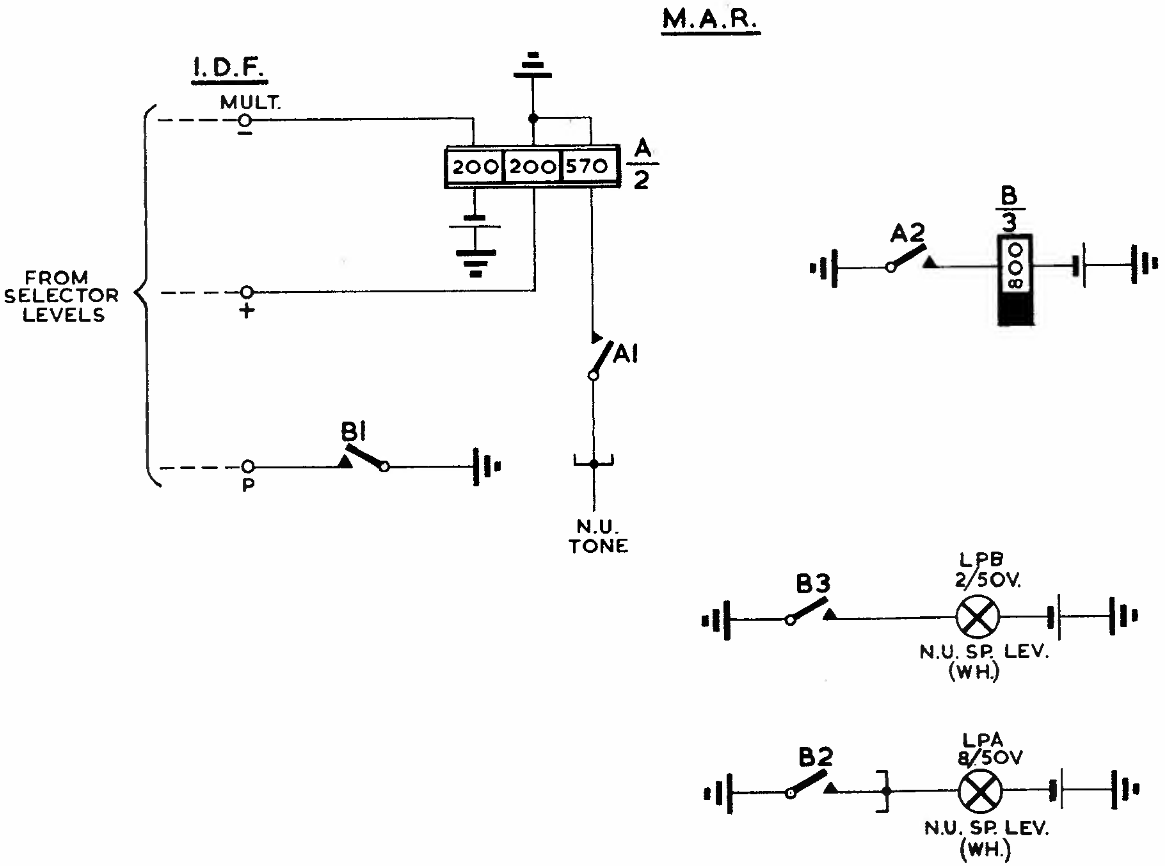
FIG. 14.

9.2 Circuit Operation. Relay A operates when the circuit is seized and A1 operates relay B. B1 earths the P wire and B2 prepares the circuit of relay D. When the calling party hangs up, relay A releases and relay D operates. D3 holds relay B. D2 and D4 connect ringing current and ring return battery to the line. D1 connects relay C to the interrupted earth lead. Each time relay C operates, the ringing connections to the line are reversed. When the called party answers, relay F operates and locks. F1 releases relay D and relay A is re-connected to the line to provide the transmission current for conversation between the parties.

/10.

10. SPARE LEVEL N.U. TONE CIRCUIT.

10.1 The object of this circuit is to provide an indication to the calling subscriber when a spare level is dialled. A number of circuits, as shown in Fig. 15, are provided on the M.A.R. and wired to the multiple side of the I.D.F. (or T.C.F.). The first three outlets of all spare group selector levels are cross-connected to these circuits, the remaining outlets in the levels being busied.



SPARE LEVEL N.U. TONE CIRCUIT.

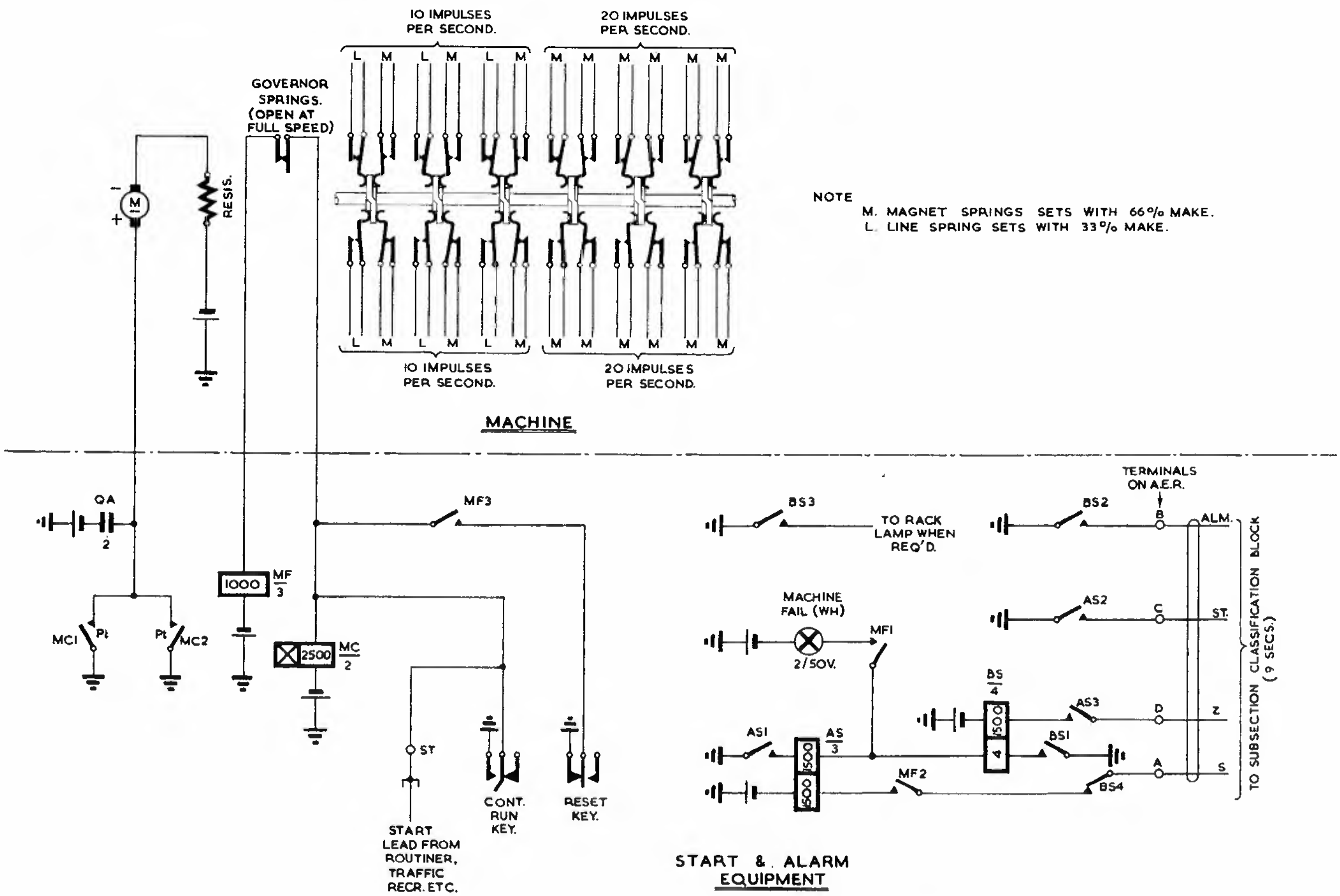
FIG. 15.

10.2 Circuit Operation. When the circuit is seized by the group selector, relay A operates to the calling loop. A1 connects N.U. tone to the 570 ohms winding of relay A, whence it is induced into the line windings and heard by the caller. A2 operates relay B and B1 earths the P wire to hold and guard the connection. B3 lights the supervisory lamp which is provided for each circuit on the M.A.R. and B2 lights a common rack lamp. The lamps glow until the circuit is released, but no indication is given on the exchange alarm system.

In the event of a fault on the circuit, relay A operates and the circuit is automatically busied out of service.

11. THE IMPULSE MACHINE.

11.1 Fig. 16 shows the start and alarm circuit for the G.E.C. type impulse machine used for supplying 10 and 20 impulses per second for the use of routiners, traffic recorders, etc.



START AND ALARM CIRCUIT FOR IMPULSE MACHINE.

FIG. 16.

11.2 Circuit Operation. When the start lead is earthed or the Continuous Run key operated, relay MC operates and closes the circuit of the motor. Relay MF also operates via the governor springs and locks to earth at the Reset key. As the motor speeds up, the governor springs open and MF releases.

Should, however, the machine not attain its normal speed, relay MF remains operated and an alarm is given after a delay period of 9 seconds. The operation of the alarm circuit is similar to that described for other delayed alarms in Paper No. 7. To clear the alarm, the Reset key is operated.

In later exchanges, the impulse machine is replaced by separate relay type impulsing circuits in routiners and traffic recorder, as shown in Fig. 17 (Relay IG).

/12.

12. THE AUTOMATIC TRAFFIC RECORDER.

12.1 General. In an automatic telephone exchange, the amount of apparatus provided is determined by the traffic to be carried and the Grade of Service required. Telephone traffic and grade of service are explained in Paper No. 8 of Telephony III. If, on any group of switches, the average number in use during a period is determined, then this number will be the traffic in traffic units (T.U.) carried by the group over that period. This number may be obtained by counting the number of switches in use at regular intervals and calculating the average of the observations. These observations may be made manually by examining the switches visually at intervals of three minutes and recording the number in use. The limitations of this method are that the number of circuits on which one observer can make observations is limited, as is the number of observers who can be accommodated at once in an exchange. Moreover, three minutes is the minimum practicable interval between counts and the degree of accuracy is consequently low. The many objections to the manual method of traffic recording has led to the development of an Automatic Traffic Recorder which not only measures the traffic carried by the apparatus in an automatic exchange but also serves the purpose of analysing the traffic carried by individual groups in a grading.

12.2 For the purpose of recording the traffic automatically, a lead is brought out from each piece of apparatus and connected to the bank contact of an access uniselector. This lead is earthed when the associated apparatus is busy. The traffic recorder provides the facilities for testing these outlets at regular intervals, a meter being operated each time a busy lead is encountered. In the case of this recorder, which tests apparatus held in conversation (that is, group selectors, final selectors, repeaters, line finders, etc.), testing of the leads takes place every 30 seconds. The arrangements in this case are that four leads, connected consecutively on the access uniselector bank, operate one meter. The traffic carried by a group of switches can be determined by dividing the number of busy leads encountered, as shown by the meters associated with the group, by the number of tests made, as shown by the test cycle meter. For example, if the total number of busy tests in a period were 480 and the number of test cycles made during the period were 120, then the traffic carried by the group would be 4 T.U.

12.3 To measure the traffic offered to each group in a grading, the individual outlets of each group are connected to separate meters and the common outlets to a further meter. The total of the readings of the meters indicate the traffic carried by the grading as a whole and, by dividing this traffic in the ratios given by the individual meters, the traffic carried by each group of the grading can be determined, as the individual outlets carry by far the greatest proportion of traffic of the group. The traffic carried by the first two or three outlets may therefore be taken as an indication of the total traffic carried by, or offered to, the group. The circuit of the recorder is so arranged that it is possible to divide the banks of the access uniselectors into small groups for metering purposes so as to record the traffic on each of these groups on a separate meter. Arrangements are made, however, so that during a normal traffic record one meter only need be used on gradings of average size. The leads from the apparatus are connected to the access switch banks via a jumpering field. The cross connections in this field are of a semi-permanent nature and only require changing when regrading is carried out.

12.4 The recording apparatus consists of access uniselectors which are connected by means of Access Uniselector Connecting keys to the banks of a control switch. Each control switch controls six testing uniselectors in three pairs. All the access and control switches are controlled from one common equipment. Each access uniselector has eight banks arranged as three 50-point testing arcs and one 50-point control arc. As previously mentioned, six such uniselectors are provided and are connected to a bank of the control switch via an access uniselector connecting key. The connections of this key are such that only one testing uniselector can be connected at a time, although the circuit is arranged to change over to the partner uniselector when the first testing uniselector has made a complete revolution.

/12.5

12.5 Circuit Operation. (Refer to Fig. 17.) The testing switches are stepped round the bank at a speed of 5 impulses per second, these impulses being generated by relays or obtained by converting 10 i.p.s. pulses from the impulse machine. In the former case, relay R, which operates after the start key is operated, causes relay IG to operate. In operating, IG breaks its own circuit and extends the earth from R5 to operate relay A. Relay IG, in conjunction with the associated condensers, is designed to deliver impulses at the rate of 10 per second to relay A. If an impulse machine is available, relay IG is omitted and impulses are delivered from the machine directly to relay A.

In either case, on the first pulse relay A operates and holds in series with one winding of relay B to earth via A1 and C1. At the end of the impulse make period, relay B operates and B2 operates relay D. B1 connects the pulse lead to the second winding of relay B and relay C in series. On the next impulse relay C operates. C1 releases relay A and A2 provides an alternative holding circuit for relay D. At the end of this impulse, relays B and C release but relay D remains operated. At the commencement of the next impulse make period, relay A operates and disconnects relay D. The cycle of operations is repeated, thereby causing relay D to impulse at the rate of 5 i.p.s.

To take a traffic record, the access uniselector connecting keys are operated to the positions which connect the access switches leading to the group to be tested to the appropriate control switches. The control keys of the control switches which it is desired to use are then operated. The operation of the start key will cause the apparatus to function in the following manner -

An earth via the 30 second pulse lead causes relay ST to operate via R3 and SF3 and ST holds via ST3 for the duration of the pulse. ST2 operates the test cycle meter and ST1 operates relay R via FA4, wiper and normal bank contact CN1, KC, ST1 and the 500 ohm winding of relay ST to earth. The operation of relay R causes relay D to impulse at 5 impulses per second, as previously described. D2 and D3 cause the relief relays DA, DB, etc. to impulse. Relay DA is used for meter testing as described later, and relays DB, etc., which are provided one per control switch, cause the extension of the meter leads to the access equipment.

The first pulse is extended via the home contacts of the CN2 arcs to the control switch (CN) magnets. At the end of the pulse, the control switch steps to the first contact. When the earth is disconnected from the 30 second pulse lead, relay ST releases but relay R remains operated to earth on the CN1 bank contacts.

The second pulse is connected to the magnets of the access uniselectors which are connected and, at the end of the pulse, the wipers step on to the first contacts. The next operation of the relief relays DB, etc., connects the earth from the busy leads on the access bank contacts to the meters connected to the CN bank contacts and completes the circuit for the access uniselector magnets. The release of relays DB, etc., causes the access switches to step to the next outlet and also causes the operated meters to release.

The access uniselectors continue to step round the bank under the control of impulses from relays DB, etc., the earthed leads from the apparatus being tested causing the operation of the meters as described above. The first four leads connected to the access uniselector bank operate the same meter. This is brought about by the commoning arrangement on banks T7-8. Every fourth step the control uniselector is energised via KC, tag "CN", bank contact and wiper T7 or T8 to earth at DB2. Thus, the control uniselector connects the busy leads to a different meter every fourth step of the access uniselector. The meters are connected to the control switch by means of double-ended single-way cords. If, however, several groups are required to operate one meter, the appropriate contacts of the CN arcs are commoned by inserting U links into the appropriate jack points.

It will be seen from the circuit that three recording leads are tested simultaneously by each access switch in use. The access uniselector takes 10 seconds (stepping at 5 impulses per second) to step to the 50th contact. As the testing cycle is only commenced every 30 seconds, there is still time left to record on another uniselector so the pulses are transferred to the partner access uniselector. This is done by connecting the 50th contact of arc T8 of the first uniselector of a pair to tag "S".

/The

The next operation of relays DB, etc., as well as testing the leads connected to the last contacts, operates relay SA. SA2 operates relay CS and the contacts of CS energise the control uniselector magnets. SA1 locks relay SA in series with relay SB to earth at R6. At the conclusion of the pulse relay SB operates and SB1 disconnects relay CS and operates relay SC. The release of CS allows the control uniselectors to step to the 13th contacts. The contacts of relay SC transfer the operating circuit via bank CN2 from the first to the second access uniselector of the pair. The next pulse via DB, etc., contacts starts the cycle of operations again and the leads connected to the bank contacts of the partner access switches are tested in the same manner as previously described.

After the partner access uniselectors have made a complete revolution, it is necessary for all apparatus to be restored to normal before the commencement of the next testing cycle. The control switch, therefore, has to take 24 steps during the rotation of the pair of access uniselectors. To accomplish this, it will be seen that a total of 24 contacts on arcs T7-8 of both switches are connected to the CN tag or, if the change-over facility is required, 23 to the CN tag and one to the S tag. When the testing cycle is completed, the access and control uniselectors return to the normal positions and the circuit of relay R is opened at CN1.

Release. The release of relay R causes relays SA and SB to release and disconnects the impulsing circuit. SB1 releases relay SC and SC contacts prepare the circuits to the first uniselectors of each pair. The circuit is now ready to commence the next cycle of operations when the next 30 second earth pulse is received.

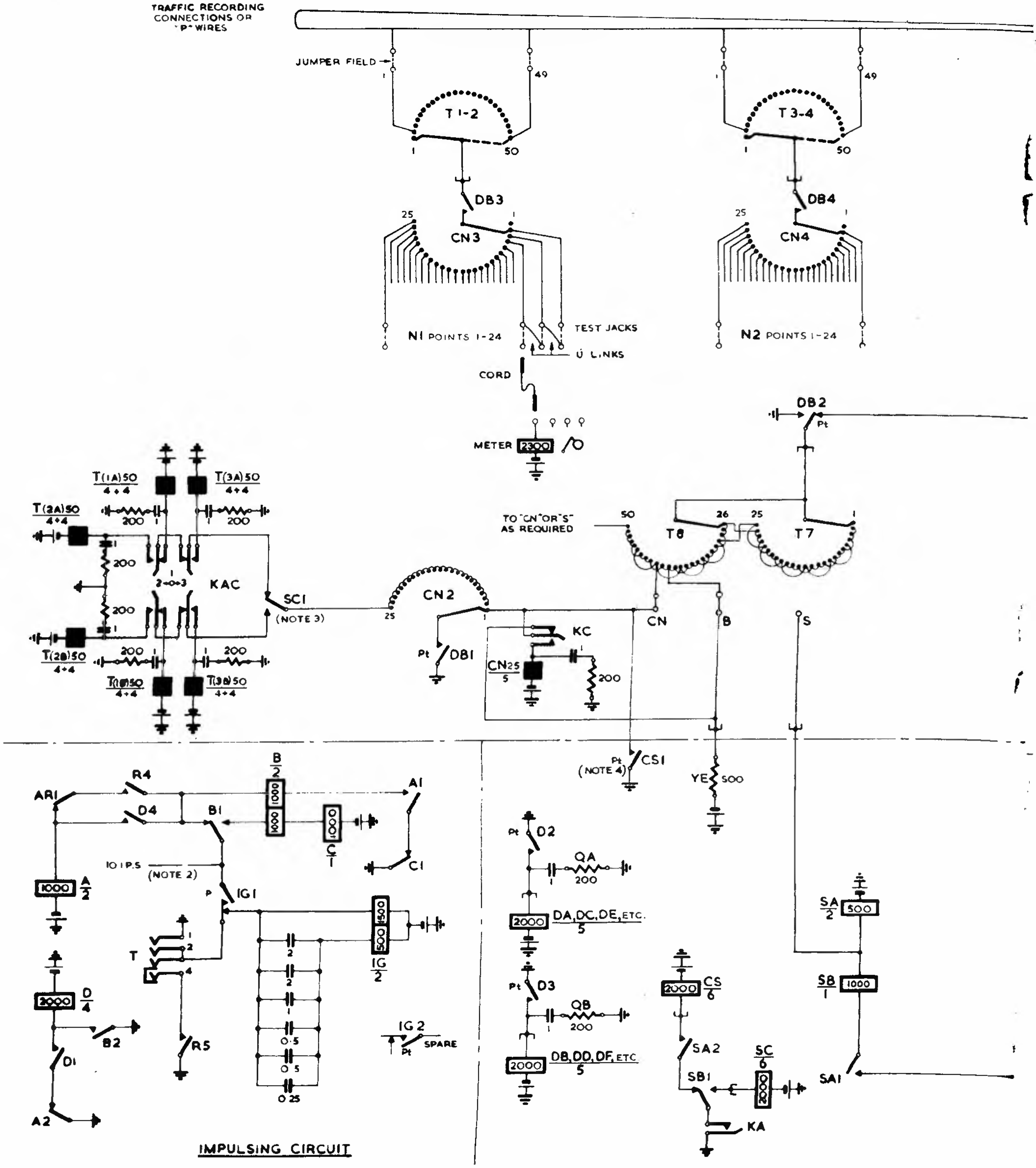
Fault Conditions. As incorrect functioning of the traffic recorder will not be shown up except by providing incorrect traffic records, the following facilities are provided to guard against various faults which may occur. All contacts on the T7 and T8 arcs are connected to battery. The contacts connected to the CN tag derive battery via the control magnet, those connected to the S tag via relay SA and the intermediate contacts are connected to battery via the B tag and resistance YE. Should a testing uniselector move off normal when the recorder is not in use, relay SF operates from earth at R6 to battery from one of the above sources. SF1 lights the busy lamp, SF2 operates the exchange deferred alarm and SF3 prepares the circuit of relay FA. Should the recorder be taken into use, relay FA operates from the 30 second earth pulse via KS, ST3, R3 and SF3. FA1 locks relay FA to earth at the reset key and lights the fault lamp and FA4 disconnects relay R to prevent operation of the recorder.

If a control uniselector is moved off normal when the recorder is not in use, relay R operates to earth on the CN1 bank. R1 lights the busy lamp, R2 operates the exchange deferred alarm and R3 transfers the time pulse to relay FA. Should a control uniselector fail to restore to normal during recording, relay R remains operated at the end of the cycle. In either case, the next 30 second earth pulse causes relay FA to operate, which disconnects relay R. The recorders stop and the alarm is given. If the recorder, for any reason at all, fails to complete a cycle within the allotted time (30 seconds), recording will be stopped due to the operation of relay FA on the next pulse and the alarm is given as previously described.

If the control uniselectors should get out of step, relay AR operates via ST1 to earth via arc CN1 and the wipers which are out of step. AR1 disconnects the circuit of relay A in the impulsing circuit, thus stopping the traffic recorder. This ensures that only the faulty uniselector is off normal and the localisation of the fault is simplified.

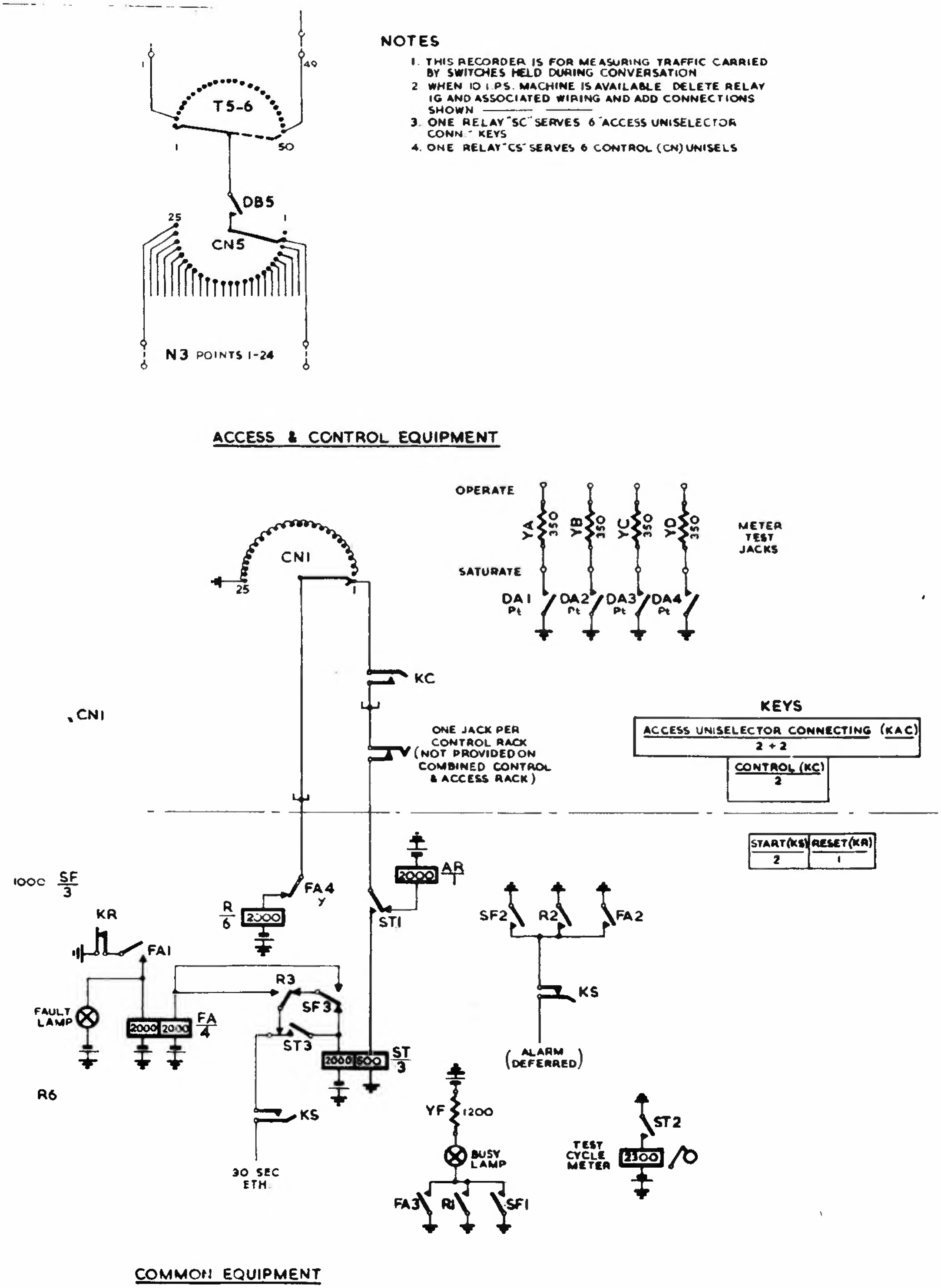
Meter Testing. Facilities are provided for testing four meters simultaneously under operate conditions or saturate conditions. The meters are connected to the appropriate "Saturate" or "Operate" jacks by means of double-ended cords. Any control key is operated and then the start key. Each meter under test should then operate 101 times for each cycle of the recorder (100 pulses are required to step the pair of testing uniselectors through a complete revolution and one pulse to step the control switch off normal).

/Fig. 17.



TRAFFIC REC

FIG.



ORDER CIRCUIT.

13. TEST QUESTIONS.

1. In earlier interception circuits, the high-speed relay HS is not provided. What disadvantage will be associated with its omission?

2. Describe the operation of the interception circuit when an intercepted subscriber originates a call while an incoming call is being dealt with by the operator at the control position.

3. How do the facilities offered by the Changed Number circuit differ from those of the Interception circuit?

4. Explain with the aid of a diagram the general layout of the Centralised Service Observation equipment.

5. What is the advantage of the Valve Impulse Repetition circuit used in conjunction with Centralised Service Observation equipment?

6. What is the purpose of the Special Observation Junction circuit and how does it differ from the normal observation circuit?

7. Explain briefly the operation of the Final Selector Observation circuit.

8. Describe the operation of a circuit that could be used to test the polarised relay in a public telephone. For what other purpose is this circuit used?

9. Describe the method of applying N.U. tone to spare group selector levels in a 2000 type automatic exchange.

10. Give a brief description of an Automatic Traffic Recorder.

14. REFERENCES.

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END OF PAPER.