COURSE OF TECHNICAL INSTRUCTION

TELEPHONY 5

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

THE AUSTRALIAN POST OFFICE

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ISSUED 1960

Contents:-

POWER PLANT COMPONENTS.

1. INTRODUCTION.

1.1 The components used in supplying electric energy to the many and varied types of telecommunication equipment are classed under the board heading of Power Plant.

In the past decade or so, new production techniques and materials have brought so many changes to many power plant components that they are hardly recognisable at a glance as performing the same functions; the future will doubtless bring many further developments. However, the useful life of most of the older components installed is far from ended and items of earlier and recent designs will be working together for years to come.

The changes have been quite far reaching and the savings in building space, electric energy, and installation and maintenance effort are already considerable.

What is common practice this year may soon be superseded and it is important to keep an open mind and observe closely the power supply methods at each installation.

1.2 This paper deals mainly with the construction and operation of power components, the details of their application are covered in the paper "Power Plant Telephone and Long Line Stations". It is not possible or desirable to study the components entirely separate from their application so a small amount of overlapping is necessary.

2. BATTERIES.

2.1 For the basic details of lead-acid secondary cells refer to Course of Technical Instruction paper "Primary and Secondary Cells".

2.2 Open type cells are in use having capacities from 72 to 4500 ampere hours, and before 1953 all batteries of greater capacity than 200 Ah used cells of this type.

The containers are of glass for the smaller capacities and are lead-lined wooden boxes for the larger cells. The active material on the lead plates is formed on the positive plates by the Plante process, and applied as a paste to the negative plates. Separators are glass rods and tubes or porous woodboard. In a fully charged open cell the S.G. of the dilute sulphuric acid electrolyte is about 1.210 or a little higher, but this depends to some extent on the maker and the condition of the battery.

Open type cells are fully described in E.I. POWER PLANT Batteries A 2010.

2.3 Enclosed cells have been designed in recent years especially to suit the operating conditions met in telecommunications, namely, continuous "floating". The first of these was a 500 Ah cell with a moulded hard-rubber container and is known as the PPS 33 cell. These cells have pasted plates (33 per cell) and, in later supplies, separators of a porous P.V.C. plastic material called "Porvic", or micro porous rubber. The positive plates are wrapped in glass wool to retain the active material. Pure lead or an alloy substantially free from antimony is used for the positive plate grids, since with floating operation its use as a strengthening agent can seriously reduce cell life.

A further development is the use of clear polystyrene containers for the 500 Ah cells and smaller sizes also designed for telecom service. Fig. 1 shows a 500 Ah cell (PPS 33), a 200 Ah cell and a 6V, 90 Ah battery in clear polystyrene containers. Note the diffuser type vent plugs which prevent accidental ignition of the explosive hydrogen air mixture in the cell. Also visible are the three coloured balls set into the case and which indicate the state of charge of the cell.

This series which is described in E.I. POWER PLANT Batteries A 2020 also includes a 45 Ah 6V battery.

Larger enclosed cells have also been designed and in 1958 a 50V, 4500 Ah battery was replaced by a 6,000 Ah battery comprised of 3 parallel sets of 2,000 Ah enclosed cells, having bonded fibre glass containers with clear inspection ports in the sides. The space occupied is about two thirds of that taken by the 4500 Ah battery.

2.4 For many years enclosed cells of the radio, home lighting and car types have been widely used. The containers are mostly of hard rubber but a few of the more recent home lighting batteries are in clear cases. All these types are superseded by the 'telecom' type.

2.5 The advantages of enclosed cells are -

Smaller space required.

Less maintenance.

May be housed in cabinets or cubicles in the same room as other equipment.

Negligible loss of electrolyte by evaporation and spraying.

Virtually no fumes.

Much easier to install.

Lower Cost.

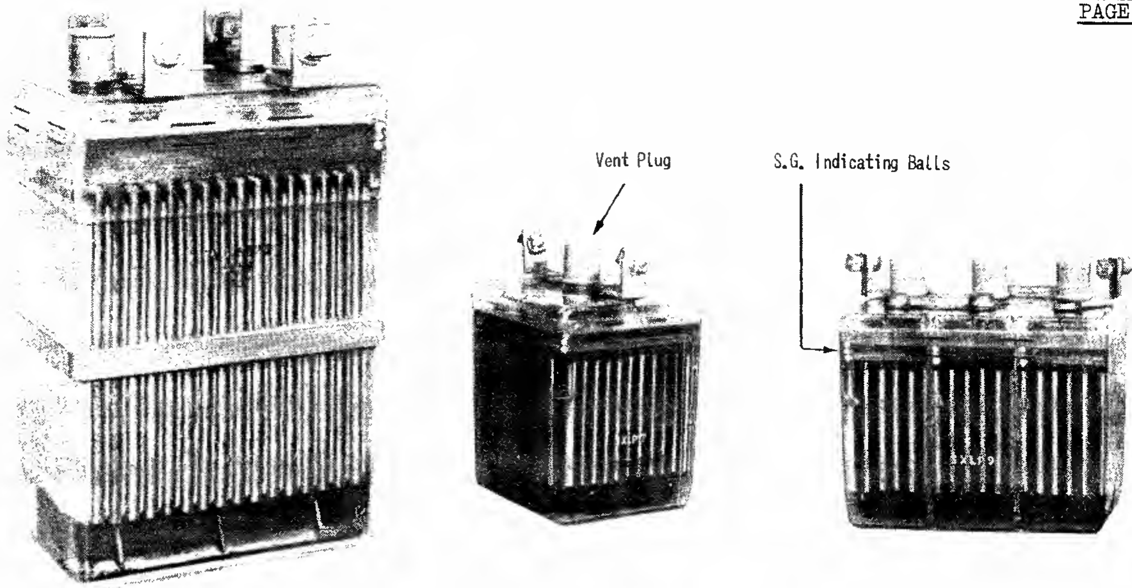


FIG. 1. ENCLOSED CELLS IN CLEAR CONTAINERS.

3. RECTIFIERS.

3.1 For the conversion of A.C. to D.C., static rectifiers in one form or another have been used ever since commercial power authorities have supplied A.C. It is only since the fairly recent development of semiconductor 'metal' rectifiers for the purpose that the very large D.C. outputs often required in telecom have been converted by completely static devices.

3.2 The essential parts of a rectifier are -

Transformer.
Rectifying device (metal rectifier elements or a rectifying valve).

Additional items often included with a rectifier unit are -

Filtering equipment for smoothing the D.C. output.
Means of controlling the output; manual, automatic or both.
Ammeter, or voltmeter and ammeter.
Output switchgear (knife switches or contactors).
Cooling fan.

The transformer used for any particular rectifier depends on -

The input voltage and number of supply phases.
The D.C. output voltage and current required.
The type of rectifying device.
The form of rectifier circuit used.
The character of the load.

For large output rectifiers the transformers are usually designed on a reasonably liberal basis to avoid overheating and to give good regulation, that is, only a small voltage drop from minimum to maximum load.

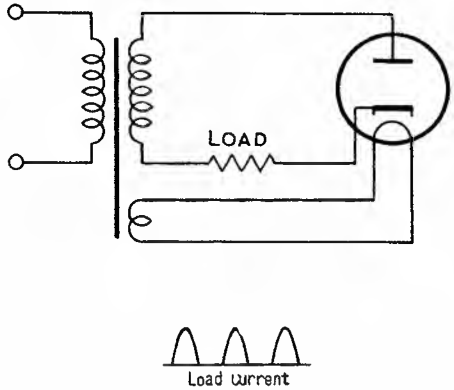
The rectifying device used depends on the application, and the output voltage and current required.

Thermionic valves of the high vacuum, mercury vapour, and tungar types will cover the range up to about 20 amps.

Selenium rectifiers with outputs ranging from a few milliamps up to 18,000A are now widely used for telecom purposes, having superseded tungar tubes, motor generator sets and copper oxide rectifiers. One of the largest single units purchased by the A.P.O. has an output of 800A, 50V.

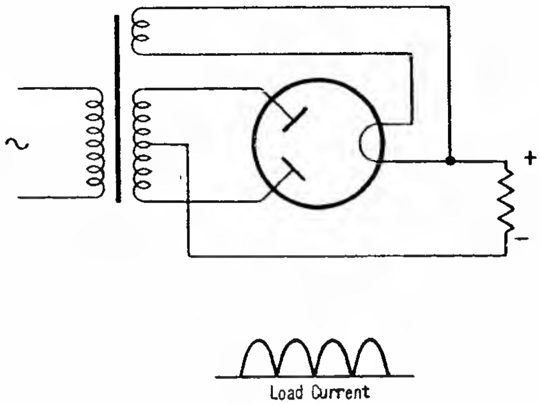
Mercury arc rectifiers are used only where high voltages and high currents are involved, such as for traction systems.

3.3 Thermionic Valve Rectifiers are used in self-contained equipment for long line, radio and testing. The simple diode valve (Fig. 2) is not used in power supplies as only half wave rectification is obtained. Usually a dual anode tube is used together with a centre tapped transformer (Fig. 3).



1/2 WAVE VALVE RECTIFIER.

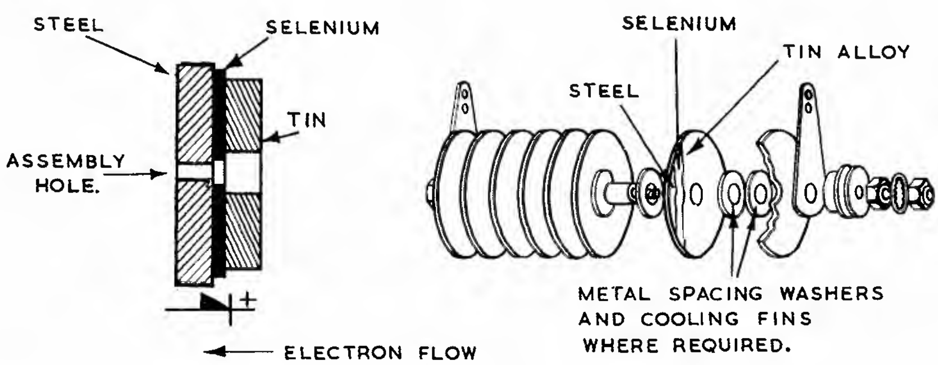
FIG. 2.



FULL WAVE VALVE RECTIFIER.

FIG. 3.

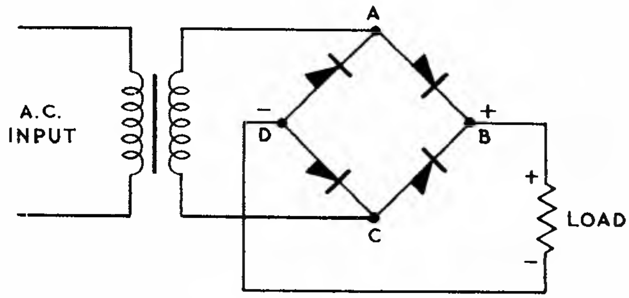
3.4 Selenium Rectifier elements are preferred to copper oxide discs because less than half as much space is required for units of the same current and voltage rating. Modern selenium elements will withstand inverse voltages of more than 30V (many times that for copper oxide) and may be safely operated at a higher temperature - up to about 75° C. The basic construction of a typical selenium rectifier element is shown in Fig. 4.



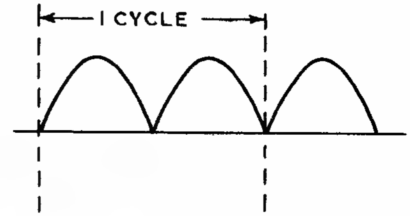
CONSTRUCTION OF SELENIUM RECTIFIER.

FIG. 4.

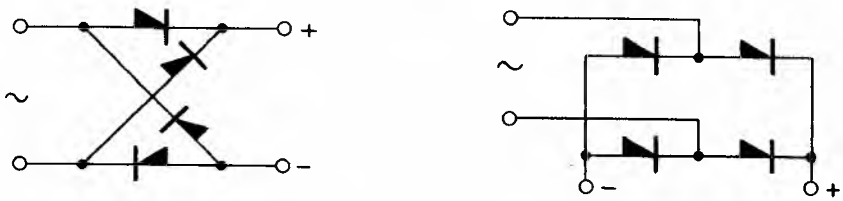
Full wave rectification is obtained by connecting sets of elements in 'bridge' formation - 4 for single phase input, and 6 for 3-phase input (Figs. 5 and 6).



(a) Usual Basic Circuit.



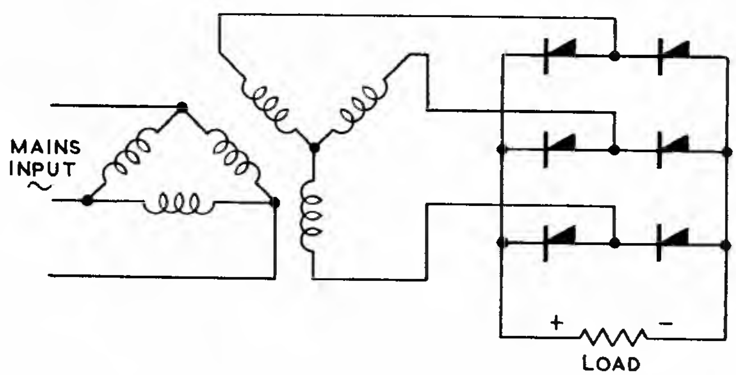
(b) Output.



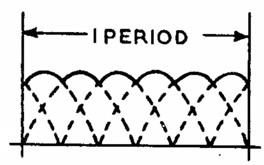
(c) Alternative Schematic Arrangements.

SINGLE PHASE BRIDGE RECTIFIER.

FIG. 5.



(a) Basic Circuit.



(b) Output.

THREE PHASE BRIDGE RECTIFIER.

FIG. 6.

Each set of elements consists of sufficient discs in series to give the required inverse voltage rating, and a number of such sets are paralleled to give the required current rating. For power rectifiers, fins are included with the elements to dissipate the heat.

Air cooling is used in all power rectifiers used by the Department but oil cooling is also used overseas. With large output units a fan may be used to give a forced draught.

3.5 Filtering. As can be seen from Figs. 2, 3, 5 and 6, the output D.C. from rectifiers is pulsating. This may be used direct in a few applications but in most cases a steady D.C. is required, especially where speech circuits are concerned as an objectionable hum would be heard if the output were left unsmoothed.

A smoothing filter consists of a suitable network of inductance and capacitance. There are two main types of smoothing filter - choke input and capacitor input. (See Fig. 7.)

(a) Capacitor input. (b) Choke input.

FIG. 7. BASIC SMOOTHING FILTERS.

Both types operate in a similar way. The rectifier output may be regarded as D.C. having an A.C. superimposed on it (A.C. ripple), and this is removed by the filter to produce steady D.C. The ripple frequency depends on the type of rectifier - half wave or full wave. For 50 c/s mains supply the ripple frequencies are: single phase, half wave - 50 c/s; single phase, full wave - 100 c/s; 3 phase full wave - 300 c/s.

The inductor-capacitor combination forms a simple low pass filter with a cut-off frequency which is less than the ripple frequency.

Capacitor Input Filters. The capacitor C1 in Fig. 7a charges to the peaks of the pulses so that when other factors are equal the capacitor input filter gives a higher output voltage than the choke input type. For rectifiers designed to supply relatively small currents of a fairly constant value, the capacitor input filter is generally used since a high degree of filtering is obtainable with few components. Typical values for capacitor input filters are 8 to 16 μF for the electrolytic capacitors and 10 to 30 henries for the choke.

The capacitor input filter is unsuitable for use with a varying load because the voltage variation would be excessive (poor regulation). This is because an increase of load prevents the capacitor C1 from maintaining the same degree of charge or terminal voltage, as it is discharged further between successive pulses than with lighter loads. Another disadvantage is that owing to its very low reactance, capacitor C1 (Fig. 7a) will allow large values of current on peaks of pulses which may exceed the maximum safe value of some types of rectifier element. For these reasons the use of capacitor input filters is limited mainly to high vacuum valve rectifiers in such equipment as test gear, valve amplifiers, etc., where the output rarely exceeds 250 mA and is fairly constant.

Choke input filters are used for larger output rectifiers and wherever good regulation is required (stable output voltage with varying loads). Where large currents are involved the chokes must have low resistance to reduce losses. This keeps inductance down to a fraction of a henry. However capacitances may be high, for example, 40,000 μF, using parallel banks of 4,000 μF electrolytic capacitors.

A smoothing filter may have more than one stage depending on the degree of smoothing required, as except with very light loads a single stage of filtering will leave a small amount of A.C. ripple voltage superimposed on the D.C. output (Fig. 8).

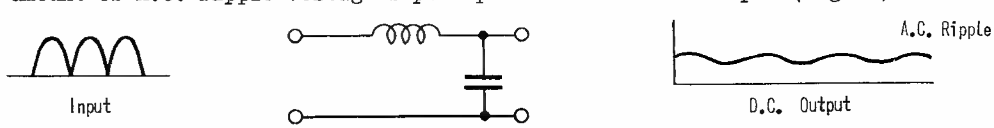


FIG. 8.

For many applications a ripple voltage of 1 or 2% of the D.C. voltage is acceptable. With high quality audio equipment it must be a very much smaller figure.

The number of stages of filtering required depends also on the load characteristics and the ripple frequency. Fig. 9 shows two stage filter circuits.

In cases where a secondary battery is a permanent part of the power supply the problem of smoothing is not so difficult since the greater part of the A.C. hum component is shunted out by the low impedance of the battery; also the final filter capacitor is not used, since it would serve no useful purpose.

(a) Choke input.   (b) Capacitor input.

FIG. 9. TWO STAGE FILTERS.

3.6 Output control is provided on all large rectifiers and also on many of the smaller types. It may be either manual or automatic, or auto/manual which means the rectifier may be switched from one form of control to the other.

Manual control can be arranged by altering the transformer output voltage by means of adjustable tappings on the secondary, as shown in Fig. 10. The tapping switch is operated by a knob on the front of the rectifier to vary the A.C. input to the rectifier elements.

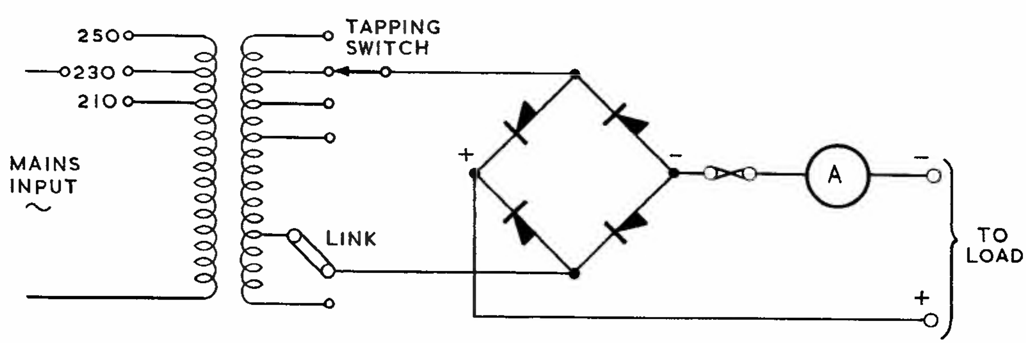


FIG. 10. RECTIFIER WITH MANUAL OUTPUT CONTROL.

Manual control of auto/manual rectifiers is not generally by means of a tapped transformer, but by rheostat control of the saturable reactors normally excited by the auto control equipment. (See Page 11.)

Two other sets of tappings are generally provided on the transformer - one set on the primary to adjust for different mains supply voltages and another on the secondary to compensate for ageing of the rectifier elements. These are not variable from outside the unit.

Automatic control. The use of rectifiers to supply a load directly without batteries, and the practice of 'floating' the battery across the rectifier on load, have led to the development of several forms of automatic control. Rectifiers are in use which maintain the output voltage to within ± 1% (or less) of the desired value.

3.7 The Transrecter was the earliest of the rectifiers with automatic output control used by the Department. Fig. 11 shows the early Transrecter circuit and Fig. 12 the improved circuit.

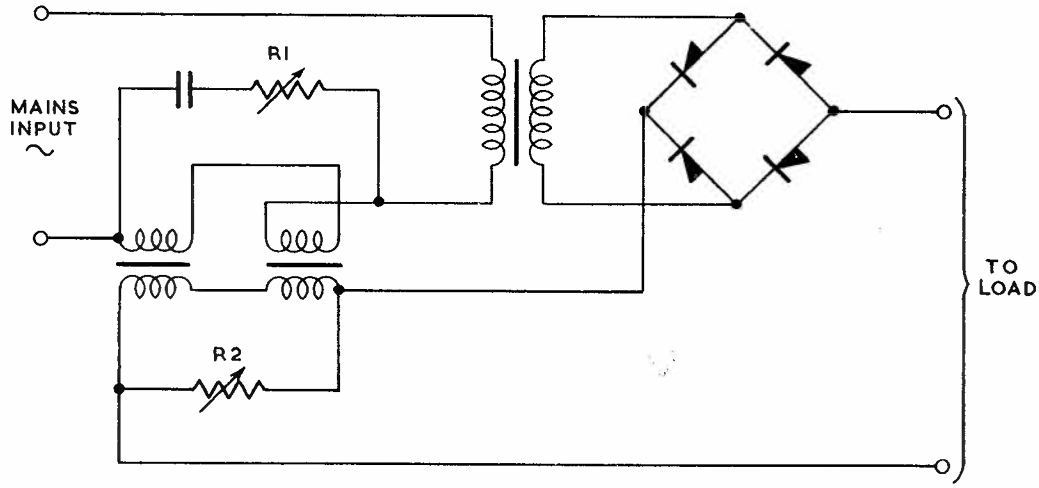


FIG. 11. "TRANSRECTER" - EARLY TYPE.

The control is by means of two saturable reactors or coupled chokes with windings in both the A.C. input and D.C. output circuits. A saturable reactor will give a large variation in impedance of the A.C. winding with variations of magnetic core flux in the region of saturation, and this in turn is controlled by the value of current in the D.C. windings.

Referring to Fig. 11, the A.C. windings have maximum reactance (and therefore maximum voltage drop) when the magnetisation of the core is least (minimum D.C. load). When the load increases the extra current in the D.C. windings of the reactor raises the degree of core magnetisation which lowers the reactance of, and the voltage drop across, the A.C. windings. The increased voltage applied to the main transformer primary results in an increased input to the rectifier elements. This enables the greater load demand to be met and also compensates for the increased losses in the transformer and rectifier elements so that no large drop in output voltage occurs.

Further increases in the D.C. load cause the degree of magnetisation of the reactors to rise until saturation of the core is reached and the maximum output of the Transrecter is obtained.

Two identical chokes are provided and connected in such a way that the induced effects from the A.C. to the D.C. circuit are cancelled out.

When used with a battery floating across the load the Transrecter maintains a high output after the load drops off until the battery is fully charged, and then drops back and maintains a trickle charge during no load periods to compensate for standing losses.

The change from high output to trickle charge and vice versa is quite sudden and the voltages at which this occurs and the rate of trickle charge is adjusted by rheostats R_1 and R_2 shown in Fig. 11.

The later circuit shown in Fig. 12 operates in a similar manner. Each of the reactors has a third winding (C) and these two windings in series are connected to a voltage sensitive network shunted across the output.

This network is a barretter bridge balanced at or about the desired output voltage. The tendency for the output voltage to depart from this value is counteracted by a current in the windings C in such a direction as to either assist or oppose the effect of the D.C. in windings B; this results in more sensitive control of the reactance of windings A. This extra control has the further action of reducing the effect of A.C. supply variations.

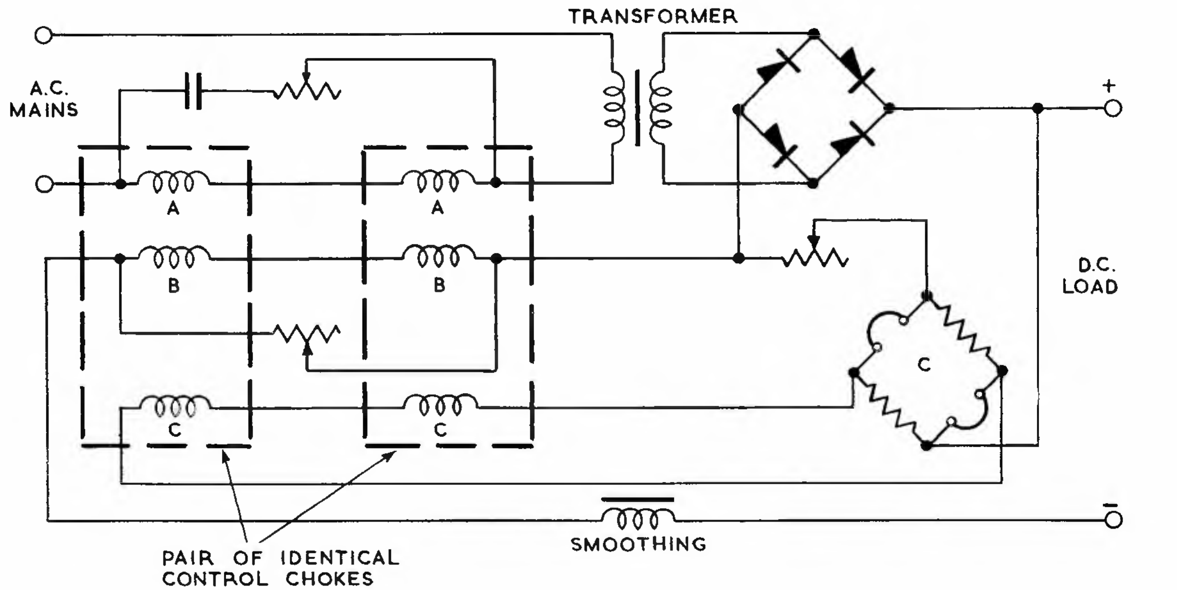


FIG. 12. TRANSRECTER - LATER CIRCUIT.

As before, the reactors are so connected to neutralise the A.C. induced into windings B and C although this is not represented in the schematic circuit of Fig. 12 as is done for explanatory purposes in Fig. 11

NOTE: The arrangement of Fig. 12 is used without batteries as the self contained supply for the units of 2 V.F. trunk line equipment at some country magneto exchanges. See paper "Trunk Line Switching" Section 4.

3.8 The Westat is another type of rectifier with automatic output control. The basic circuit is shown in Fig. 13.

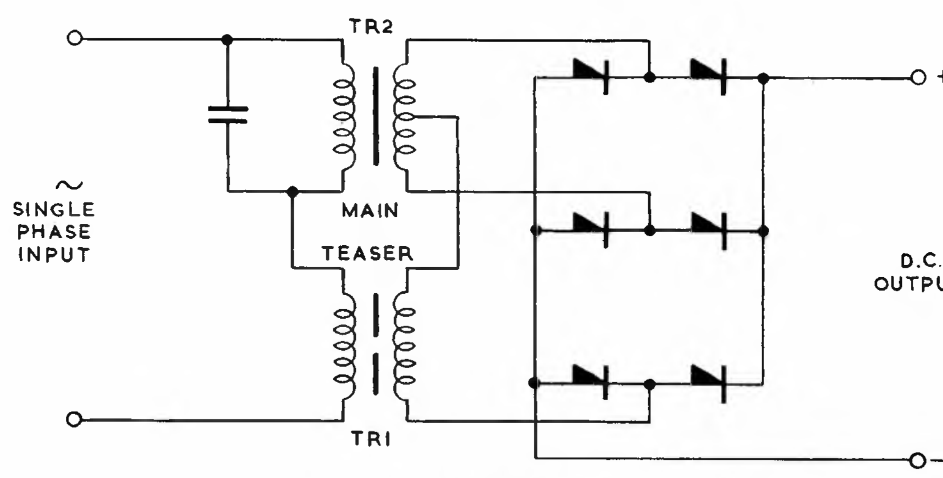
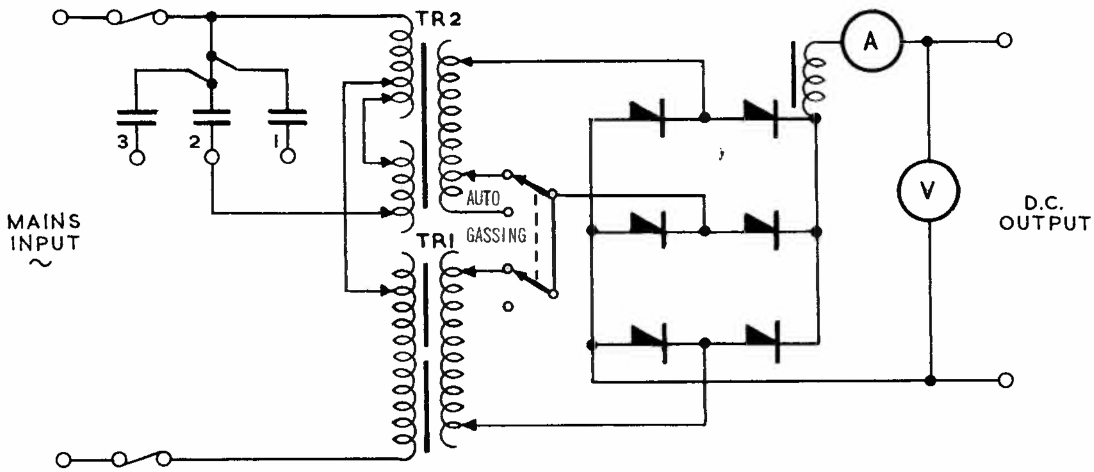


FIG. 13. WESTAT RECTIFIER BASIC CIRCUIT.

There are two input transformers, the 'main' and the 'teaser'. The primary circuit contains a phase splitting arrangement in the form of capacitance shunted across TR2 primary; the main transformer TR2 is designed to work within a definite section of its permeability curve (approaching saturation) so that changes in flux density are reflected in the reactance of the primary winding; the core of teaser transformer TR1 includes an air gap to prevent any tendency toward saturation.



WESTAT RECTIFIER.

FIG. 14.

These three design features plus the turns ratios of the various windings, result in the input to the rectifier bank varying from single phase on no load (or trickle charge) to three phase on full load, at a fairly constant output potential.

This method of obtaining 3 phase A.C. from two out of phase voltages is an adaption (in reverse) of the Scott transformer principle.

Fig. 14 gives a more complete circuit of the Westat. With some units a switch "Auto-Gassing" is provided which in the gassing position disconnects the teaser transformer secondary while stepping up on the TR2 secondary. This gives a single-phase input to the rectifier bank largely independent of the battery voltage and allows for overcharges of the battery as necessary. In later units the "gassing" position is replaced by a "boost" charge. This is arranged to raise the floating voltage to a point where the battery is fully charged but gassing does not occur.

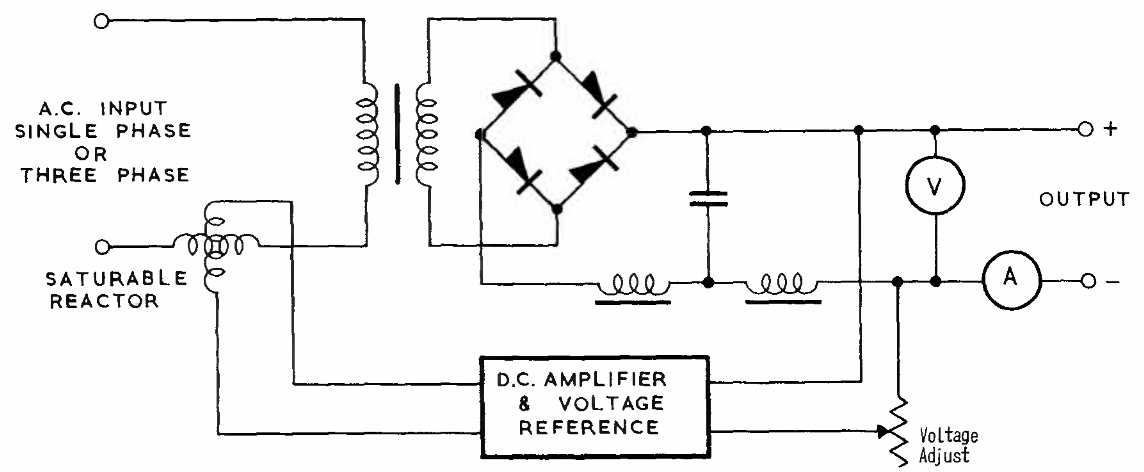
On all Westats a wide range of adjustment is provided by means of tappings to allow the floating voltage to be altered, or the voltages varied at which the maximum three phase "boost" cuts in and cuts out.

3.9 Rectifiers with Amplified Control. When batteries are floated, the voltage is critical. If floated continuously outside the specified voltage limits the useful life of the cells may be seriously reduced.

The early forms of auto control were not entirely satisfactory in this respect, particularly when the mains voltage or frequency varied to any extent. For these reasons a number of more sensitive forms of automatic voltage control have been developed. Modern 50V rectifiers are controlled to maintain the output voltage constant within a 1V range from 5% to 100% full load even though the mains supply may vary +5%, -10% in voltage and ±3% in frequency. The requirements for 24V and 130V units are a little less stringent since the load currents are more constant.

On battery floating rectifiers, automatic overload protection is also included in the control circuit to limit the output to the maximum rating of the rectifier should the load rise above this value.

Some form of D.C. amplifier is used in the control circuit and the output from this is fed to saturable reactors in the input circuit. Fig. 15 shows the basic principle of the arrangement. Larger units operate on 3 phase supply with one reactor in each phase. Quite often the reactors (or transductors as they are also called) are connected in the secondary side of the input circuit.



SIMPLIFIED CIRCUIT OF AUTO CONTROL RECTIFIER
WITH D.C. AMPLIFIER.

FIG. 15.

The D.C. amplifier may be wholly electronic using thermionic valves, or consist of magnetic amplifiers or some combination of valve and magnetic amplifiers. A constant voltage reference circuit is included in the amplifier, to which the output voltage is automatically compared in order that the smallest changes may be detected. The D.C. amplifier derives its supply from the A.C. mains via separate rectifiers; this is omitted in Fig. 15 for simplicity.

A fall in output voltage results in the amplifier increasing the D.C. to the control windings of the saturable reactor (or reactors in the case of 3 phase units). This lowers the reactance of the A.C. windings to increase the input to the rectifier, enabling it to meet the extra load demand with minimum drop in voltage. A rise in output voltage as the load drops has the reverse effect.

Nearly all auto control rectifiers are equipped so that if required, they may be changed to manual control by means of a switch on the front panel. The manual control is now usually a rheostat which controls the value of D.C. into the transductors. Transformer tapping was used in earlier auto/manual units.

Rectifiers for telephone exchanges and long line stations where duplicate batteries are provided, have input and output switching as an integral part of the unit. The knife switches and contactors used for this are described in Section 7.

The auto control amplifiers are now arranged to give the rectifiers load sharing facilities so that where two or more rectifiers are connected in parallel they supply an equal share of the load.

3.10 A gradual increase in efficiency and sensitivity together with a reduction in overall size has been achieved by suppliers of large rectifiers so that many different models are in service which differ from each other in several details, particularly in the layout and the D.C. amplifier circuits (or controllers as they are often called).

It is not necessary to describe each model which may be encountered, as the basic principle has changed little. A list of the significant developments by two companies since 1950 may however be of value -

S.T.C.

(i) D.C. amplifier having thermionic valves in two or more stages of amplification; parallel operation of output valves to supply transductors.

(ii) A 2 stage valve amplifier followed by a magnetic amplifier.

(iii) Two stages of magnetic amplifiers - no valves.

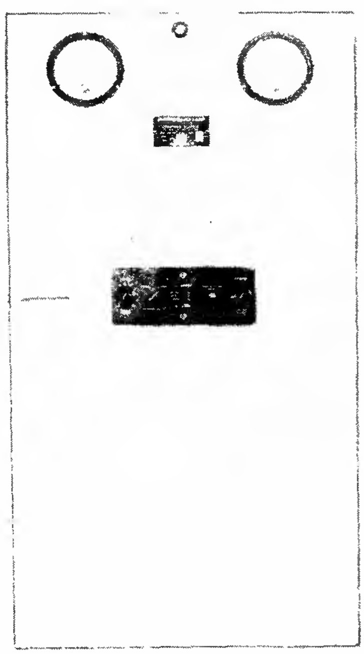
McKenzie & Holland. (making Westinghouse rectifiers under licence).

(i) "Transbooster" rectifier. D.C. amplifier using thermionic valves and known as "Westronic controller"; parallel operation of output valves.

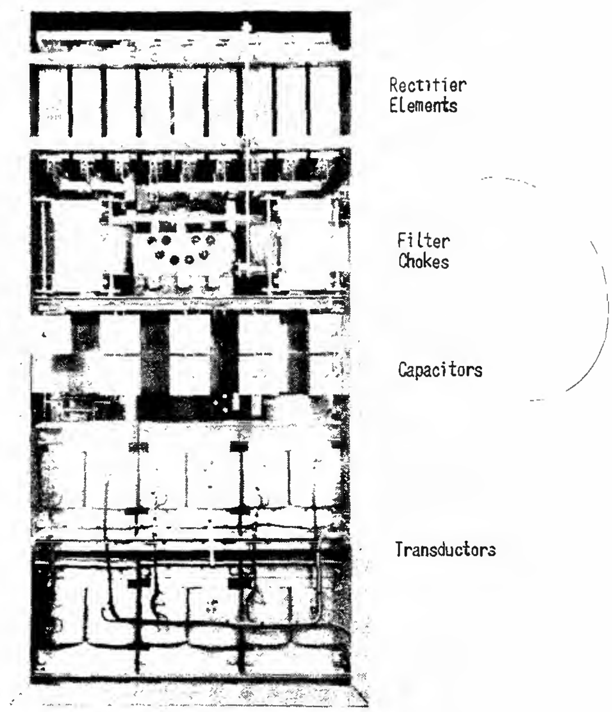
(ii) Ordinary transductor control rectifier (as in Fig. 15) using controller as in (i) above.

(iii) Transistorised controller developed and tested (may eventually replace valve controller).

Fig. 16 shows the front and rear of a typical modern rectifier designed for floating service. The input and output switchgear and the D.C. amplifier are accessible from the front by opening a door or removing a panel.



(a) Front.

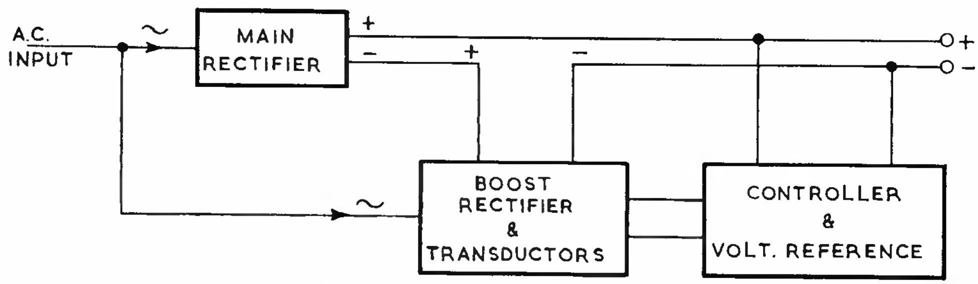


(b) Rear.

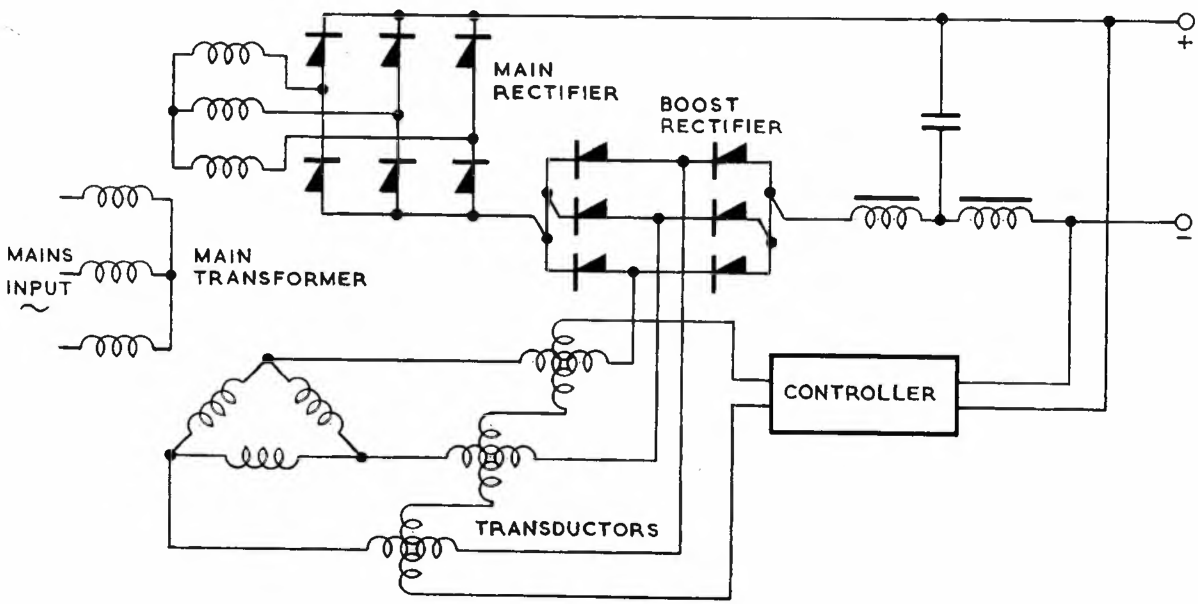
TYPICAL MODERN RECTIFIER.

FIG. 16.

3.11 Transbooster rectifiers differ from the arrangement of Fig. 15 only in that the output is fed by two separate rectifiers in series; the main rectifier supplying most of the output is not controlled while the boost rectifier having a smaller output includes the transductors fed from the controller. Fig. 17a shows the principle and Fig. 17b the basic circuit of a 3 phase Transbooster rectifier.



(a) Principle.



(b) Basic Circuit.

FIG. 17. 3 PHASE TRANSBOOSTER RECTIFIER.

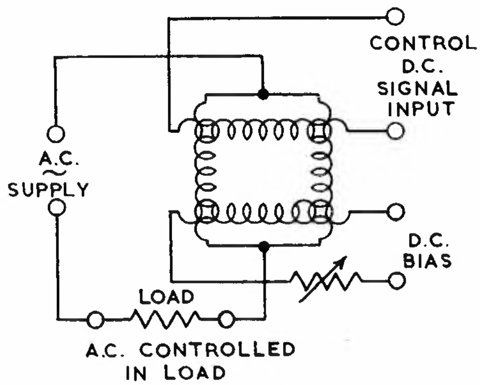
3.12 Magnetic Amplifiers. Although the principle of the magnetic amplifier has been known for over 50 years its development has been overshadowed by the electronic amplifier.

Magnetic amplifiers are current operated devices with comparatively low input and output impedances, and cannot in general take the place of thermionic valve amplifiers. They are however used in applications to which valves are not so well suited. They have no moving parts, are robust, are not subject to the same variations due to ageing, require no warm-up period and have long life. They are used in the pilot control of some carrier systems, in automatic machine tools and the remote control of aircraft servo mechanisms as well as in rectifier controllers.

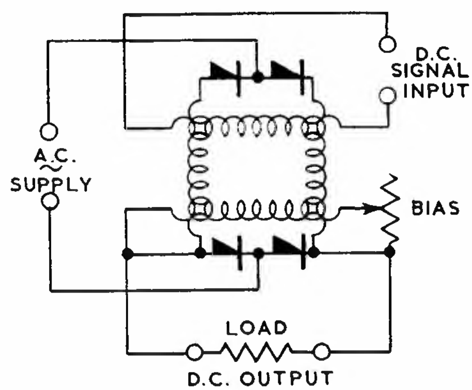
This does not infer that they give superior performance to the valve controllers when used in rectifiers, for valve controllers have long life and are able to maintain the output voltage within very fine limits.

The saturable reactors already described are a form of magnetic amplifier, but the name is generally reserved for refinements of the principle although it is fundamentally the same. The term transductor is applied to both saturable reactors and magnetic amplifiers so it is difficult to draw a definite line between them. Both operate with the core flux at such a value, that a small change of flux caused by a small change of current in the control or signal winding, results in a comparatively large change of inductance (and therefore reactance and impedance) of the A.C. or controlled windings.

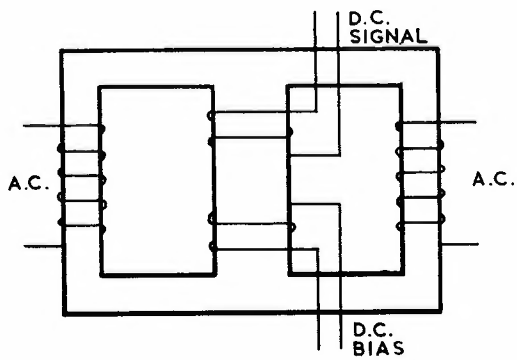
In order to adjust the flux to the correct operating value it is usually necessary to have a D.C. bias winding as well as signal and output windings. With magnetic amplifiers a full-wave rectifier is generally a part of the unit so that the output is D.C. also, and the unit self biasing. Fig. 18a is a typical arrangement for a saturable reactor and 18b a typical arrangement for a magnetic amplifier. Fig. 18c shows a typical arrangement of the windings on the core; the result is no mutual inductance between the D.C. input (control) coils and the output coils. This achieves the same purpose as the two chokes in the Transrecter (no A.C. induced in the D.C. coils) although the two chokes are still used in some cases for reactors.



(a) Saturable Reactor.



(b) Magnetic Amplifier.



(c) Typical Arrangement of windings on core.

FIG. 18.

Saturable reactors may or may not have a separate bias winding. The amplifier in Fig. 18b has unidirectional pulses of D.C. (half cycles) in each of the two output windings giving a unidirectional magnetising effect. This form of self bias introduces positive feedback or regeneration, since the bias is increased with an increase of input, and vice versa. This is known as intrinsic feedback and raises the gain of the amplifier. The actual D.C. bias winding may in this case be used to stabilise this self biasing effect by partly opposing it, and also to neutralise the effect of any continuous minimum signal input.

Magnetic amplifiers are not confined to D.C. applications but are used up to at least 2.5 Kc/s.

3.13 As a matter of interest the circuit of a 50V, 200A auto/manual rectifier with magnetic amplifier control is included at the end of this paper. A simplified circuit of the magnetic amplifier section is in Fig. 19.

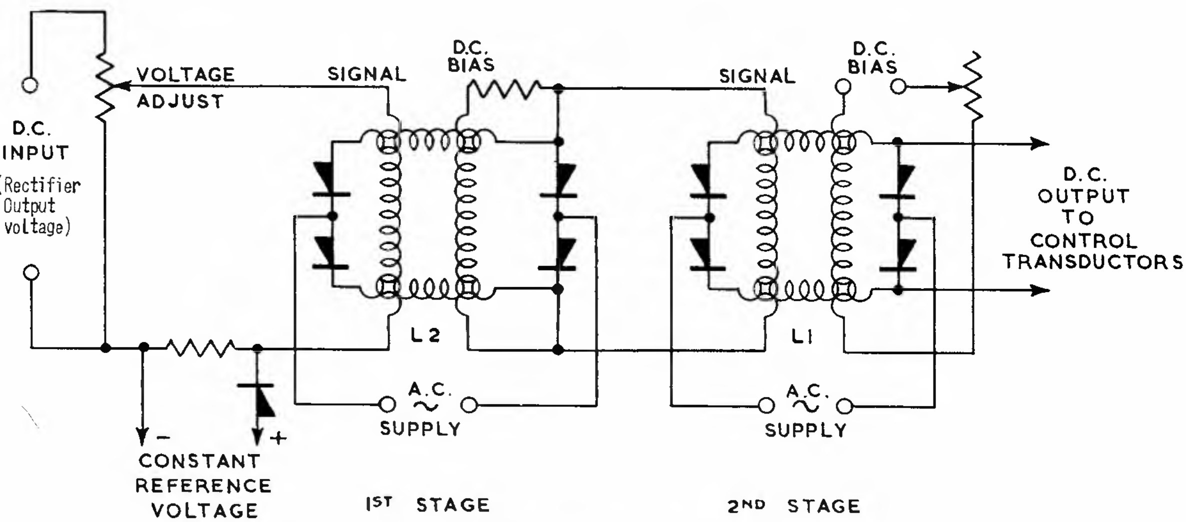


FIG. 19. TWO STAGE MAGNETIC AMPLIFIER (SIMPLIFIED).

The constant voltage reference circuit or regulator gives about 40V which is independent of mains variations.

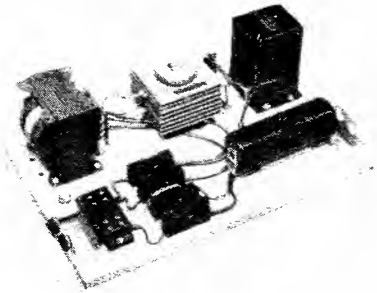
This voltage is fed to the signal winding of L2 in series opposition with a portion of the output voltage of the rectifier; thus a drop in rectifier output voltage gives an increase in signal input. The bias current is adjusted to counteract the self saturating effect of the two output coils. The D.C. output, rectified from the A.C. input, is then controlled by small changes of current in the signal winding. The gain of this stage is 40 db: input 1mA in 20 Ω, output 50mA into 200 Ω, and the coils fit into a 4012A transformer case.

The second stage L1 is fed from this output and operates in a similar way. The gain is 20 db with an output of up to 10 watts.

3.14 Eliminators. When rectifiers are used without batteries, or instead of power leads, they are called eliminators. Control may be auto or manual depending on the application; small eliminators of less than 1A output may have no externally variable control, only transformer tappings for initial adjustment. Examples of this are the eliminators used with subscriber's telegraph machine installations (output 50V + and 50 −) with C.B. P.B.Xs. (these eliminators may have an auxiliary secondary winding on the transformer to supply ringing current at 50 c/s). (See Fig. 20.) Some long line equipment installations use combined 24V and 130V eliminators.

Where used to supply speech circuits or audio equipment, eliminators have more filtering than rectifiers designed for floating service.

Much modern long line equipment has self contained rectifier power supply providing HT or anode voltage higher than 130V and no low tension D.C. (A.C. heated valves are used.) Being a part of the equipment these supplies are not called eliminators.



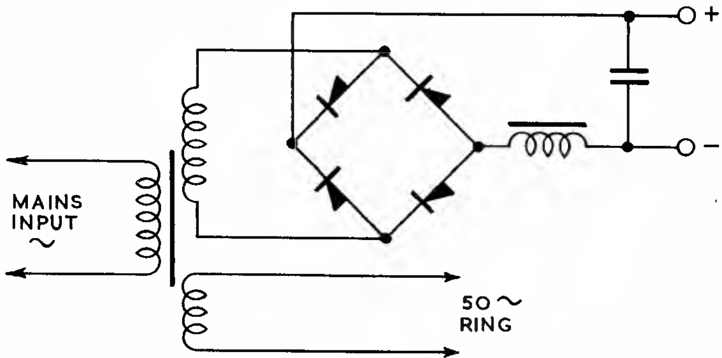


FIG. 20. P.B.X. ELIMINATOR.

4. MOTOR-GENERATOR SETS.

4.1 In the telecom field the term motor-generator set refers usually to an A.C. motor coupled to a D.C. generator, although where no A.C. supply exists it may refer to a generator coupled to a petrol or diesel engine.

4.2 Generators used in telephone exchanges and long line stations have outputs ranging from 10A to 1000A. The generators are coupled direct to 3 phase motors. Fig. 21 shows a typical power room of a large exchange where motor generator sets are installed.

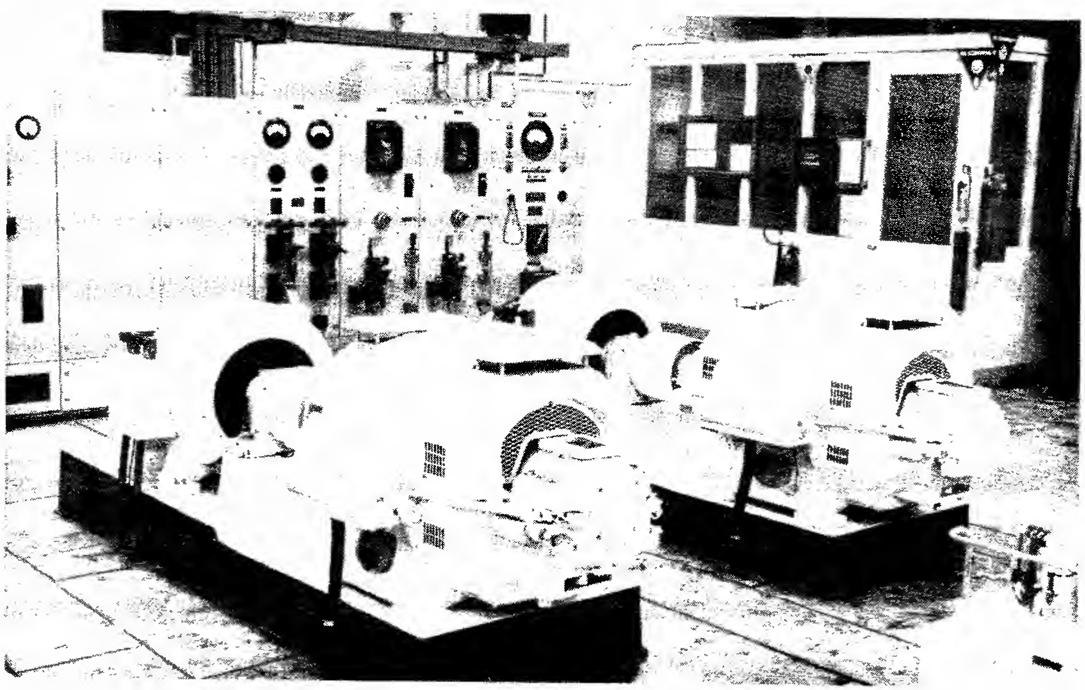
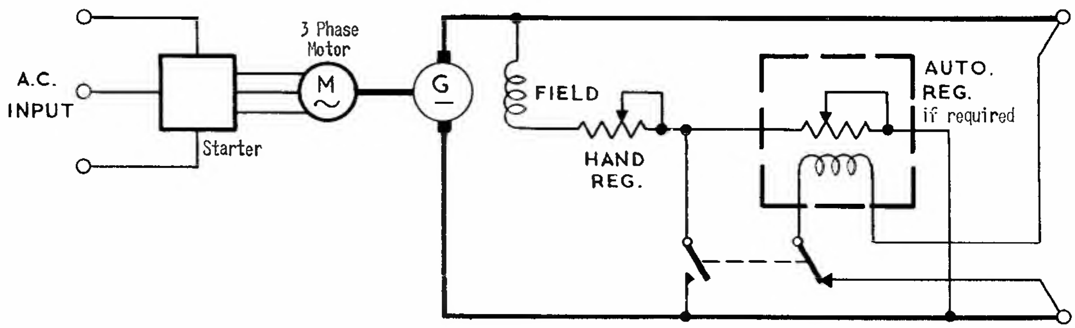


FIG. 21.

4.3 Generators for use with batteries are always self excited and of the shunt field type. Generators having series fields give a less stable output voltage and also may run at dangerously high speeds as a motor if accidentally connected across the battery. In some cases the machines are compounded slightly by means of small series field interpoles in order to improve commutation at varying outputs, or by diverter poles to give a more constant output voltage with varying loads. In all cases the shunt field is the predominant one.

4.4 Output control of motor generators is by rheostats in series with the field winding. A hand operated regulator is provided, and for full float working an automatic regulator is switched into circuit as required. Fig. 22 shows the basic principle.



BASIC ARRANGEMENT MOTOR GENERATOR SET.

FIG. 22.

4.5 Automatic voltage regulators for motor-generator sets. Several different types have been used but all operate on the same basic principle. The value of the regulating resistance is altered mechanically by a solenoid, or moving coil, which is connected across the discharge busbars. The arrangement is represented in Fig. 22. A slight fall in voltage causes the solenoid to reduce the resistance in the field circuit so that the generator output is raised to meet the demands of the increased load. A rise in busbar voltage has the reverse effect so that the generator output 'follows the load' with a minimum of voltage variation.

One early type of regulator has a pile of carbon discs which are compressed or decompressed by the movement of the solenoid armature.

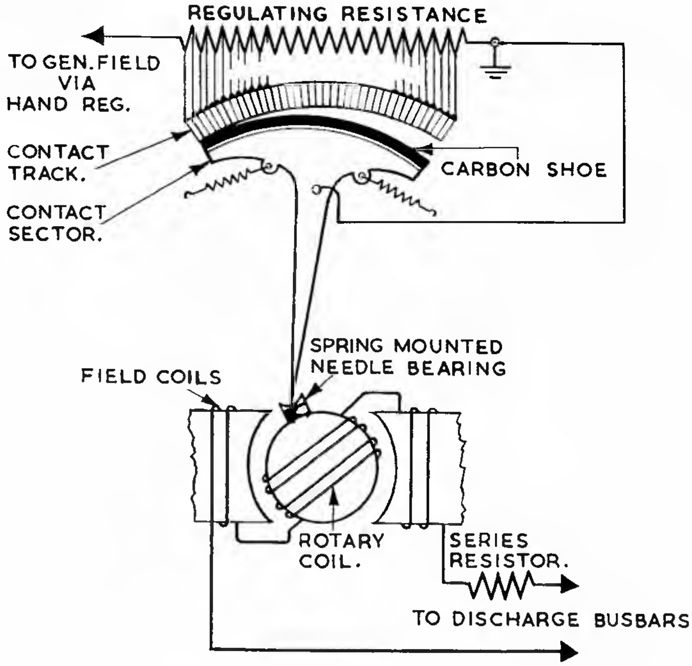
In another type a stack of pivoted contact bars is tilted by varying amounts to alter the resistance.

All types of electro-mechanical regulators incorporate a damping feature to prevent hunting which would be caused by over correcting first in one direction, and then the other, owing to the momentum, if the moving system were allowed to move too rapidly.

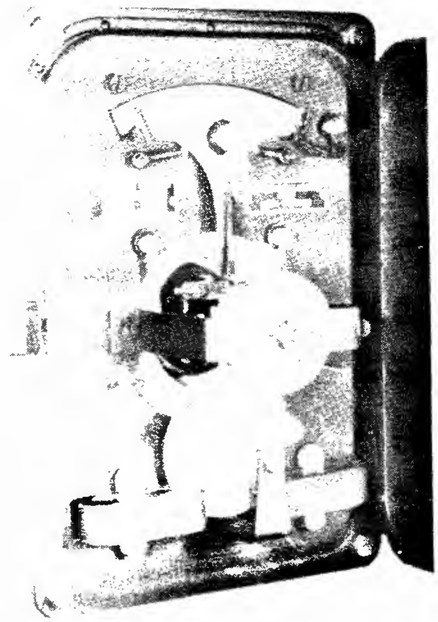
4.6 The Dynamometer type regulator (of Brown Boveri Co., Switzerland) has largely superseded the earlier types. Fig. 23a shows the principle of the device which is based on a dynamometer movement. The regulating resistor R is tapped and wired to a curved contact track of about 50 insulated segments. A metal sector with a carbon contact shoe is located and pressed into a groove in the track by means of springs. The lower end of the sector is connected by a needle bearing to the armature of the dynamometer movement.

With rotation of the armature in a clockwise direction (owing to an increase in busbar voltage) the sector rolls along the track moving the point of contact between track and sector to the right. This inserts more of the regulator resistance into the field circuit, to adjust the generator output to the reduced demand. A fall in busbar voltage has the reverse effect, the control springs of the armature acting to restore it in an anticlockwise direction.

The damping device, visible in Fig. 23b, consists of a light alloy disc geared to the armature to rotate between the poles of two permanent magnets. The tendency of the movement to respond to sudden voltage fluctuations is damped by the effect of eddy currents in the disc.



(a)



(b)

FIG. 23. DYNAMOMETER TYPE VOLTAGE REGULATOR.

4.7 A circuit breaker is provided in the charging circuit of a generator for protection against overload or reverse currents. The device is closed by hand when the generator is being switched on load, but opens the circuit automatically should the maximum output of the generator be exceeded, or if the generator voltage falls below that of the battery and the current flows in the reverse direction. The circuit breaker used in this case is known as the overload and reverse current type. The principle of operation of the circuit breaker is shown in Fig. 24.

The main contacts of the circuit breaker consist of a large brush of laminated copper. The auxiliary contacts, which make first and break last, prevent sparking at the main contacts.

The overload coil carries the full current from the generator. On overload currents the armature is attracted and 'trips' the release catch and the breaker opens smartly. The reverse current trip may be operated directly by two coils, one series and one shunt, or by a polarised relay with two coils. The circuit arrangements of the two types are shown in Fig. 25. The mechanism shown in Fig. 24 or similar types are now used, as the trip mechanism can release the breaker even if the handle is being held.

When the generator voltage falls below that of the battery (as a result of mains failure for example) the current is reversed in the series winding only. The magnetising effects combine to trip the breaker, either directly or by operation of the relay.

The adjustment of circuit breakers for reliable reverse current tripping is rather critical because even large generators will run as a motor on no load with quite a small current (as low as 3% of the output current). In certain cases modification of the circuits is necessary to ensure reliable operation on reverse current.

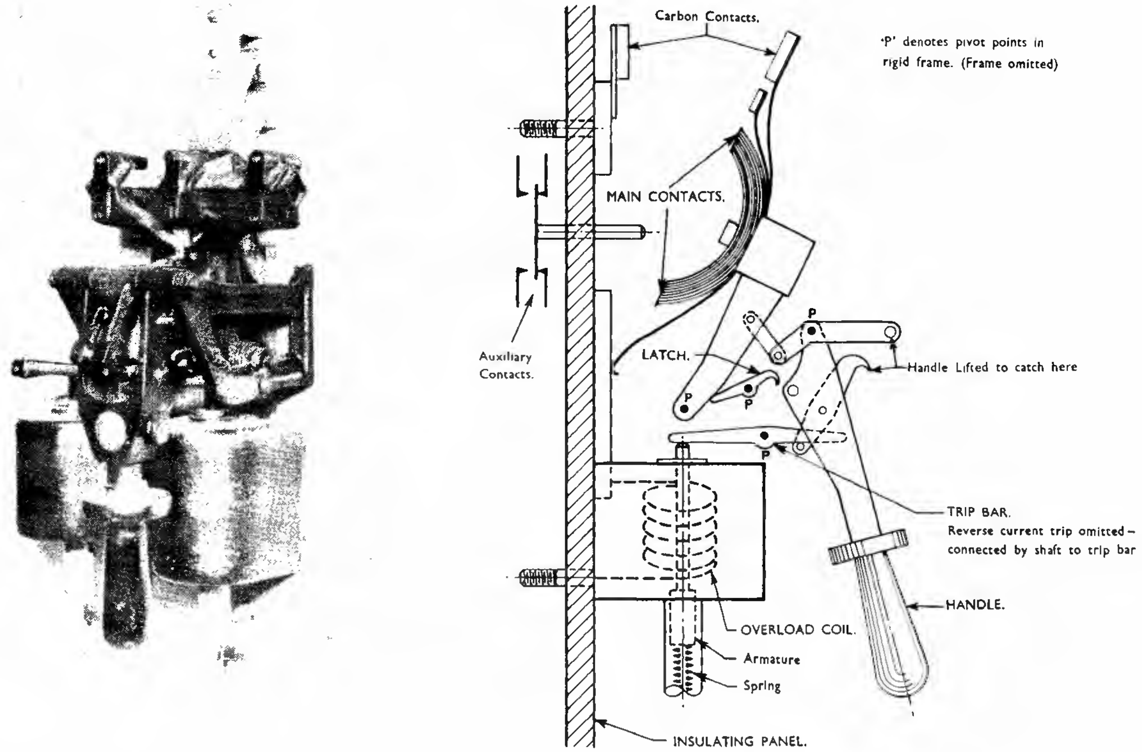


FIG. 24. CIRCUIT BREAKER.

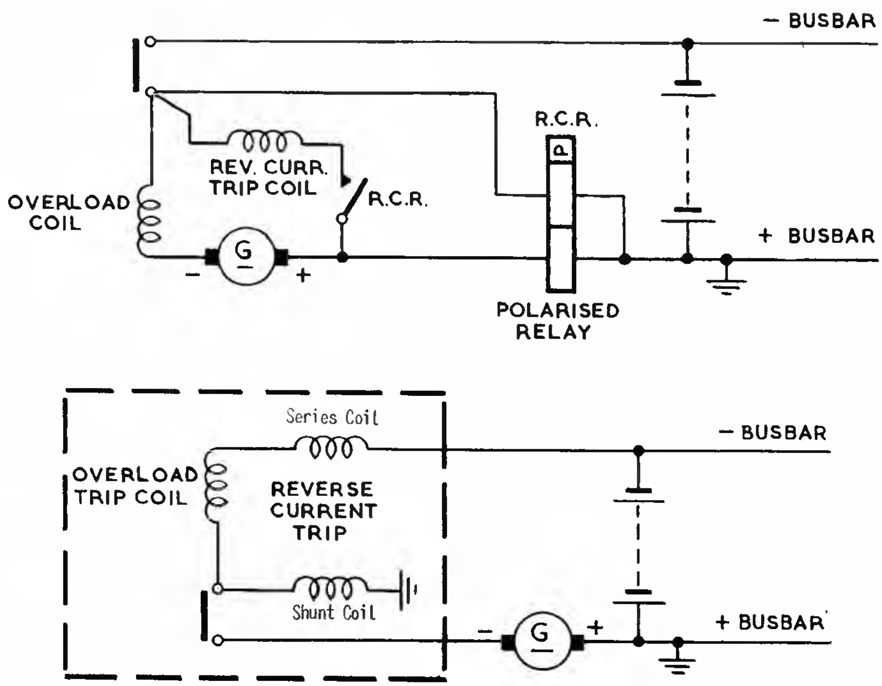


FIG. 25. CONNECTIONS OF CIRCUIT BREAKERS.

5. STANDBY PLANT.

5.1 There are several types of standby or emergency power plant. Where batteries are provided the standby plant is of the 'normally stationary' type being started up on mains failure. The control may be either manual or automatic.

Where equipment is mains operated without batteries, and continuity of service is required the standby plant is of the 'no-break' type. This applies to many modern long line, telegraph and radio telephone installations.

5.2 Before the 1939-45 war it was the usual practice to provide batteries of sufficient capacity to operate the equipment for the duration of any likely interruption. Engine generators were provided where the mains supply was unreliable. During the war some form of emergency plant was added to many stations. These early forms of standby plant usually consisted of petrol engines directly coupled to D.C. generators - one set for each voltage required. In many cases the engine was placed so that one of the normal motor generator sets could be belt driven from it.

5.3 Diesel Alternator Sets are provided as standby at all large stations and many smaller ones also. This has allowed the use of smaller batteries, a reserve capacity of 3 busy hours load being sufficient. For small stations with no standby, a few mobile sets may be held at a central depot.

The output of the alternators is fed via change-over switches or contactors to the normal conversion plant in place of the mains input. Essential lighting and power is also supplied from the standby alternator, and in some large buildings a skeleton lift service also.

Diesel engines are used because of lower fire risk and greater fuel economy than petrol engines. They may be water cooled or air cooled. The alternators are usually of the self regulating type to maintain the output voltage constant with variations of load.

5.4 Auto Start Standby. The modern trend has been toward standby plant with start, changeover (mains to standby), restoration (standby to mains) and stop, all fully automatic. In these cases a control cubicle is provided near to the machine which contains all the relays, contactors, etc. for the control. This includes protection for engine or alternator faults and a number of alarms also, so that the plant may operate for long periods without anyone in attendance.

The main facilities of the control are:

- On failure, or low voltage, of one or more phases of the normal A.C. supply, initiates starting of the engine after a suitable delay (adjustable from zero to 15 minutes or more).
- Isolates the starting circuit if the engine does not start in a reasonable time. Later units have a '3 cycle start' which means up to three attempts to start are made before finally isolating the start circuit.
- Stops the engine if the lubricating oil pressure does not reach, or falls below a safe value, or if the engine temperature rises above a safe level.
- Gives an alarm if the engine fails for any of the above reasons and also when the level of fuel reaches a point where approximately one hour of full load running time remains.
- Gives changeover to standby from the mains when the alternator output reaches the correct voltage.
- On full restoration of the mains supply, changes over the load from standby to normal after a suitable delay (adjustable), and stops the engine.

The minimum time taken for the standby set to replace the mains supply is of the order of 10-15 seconds. A typical automatic diesel-alternator set and control cubicle is shown in Fig. 26.

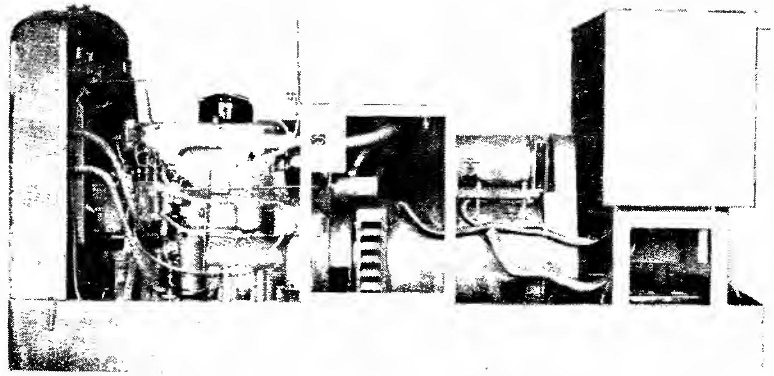


FIG. 26. AUTO START DIESEL ALTERNATOR.

5.5 No-Break Standby Diesel Alternators are in use with outputs ranging from 2 to 40 K.V.A. Fig. 27 shows a 20 K.V.A. no-break set. (The fairly large control cubicle is not shown).

Coupled together, and running continuously, are an A.C. mains connected motor, an alternator, a heavy flywheel and an electromagnetic clutch. Normally the alternator supplies the load and the clutch is disconnected.

When the mains fail, the flywheel continues to drive the alternator while the diesel engine is started and runs up to speed. The electromagnetic clutch is energised automatically to couple the engine to the flywheel and maintain the drive.

In some no-break sets a combined motor alternator is used so that while the mains are normal, the motor runs idle in parallel with the load, but when the mains fail it becomes an alternator supplying the load. The engine may be started by a separate D.C. motor and battery (24V) or by the inertia of the flywheel itself; in the latter case the clutch is energised immediately the mains fail.

A double engine set is sometimes used where there is no mains supply; one engine drives the alternator for one week, the second engine takes over for the following week or on failure of the first engine. Block diagrams for four different types of diesel no-break plant are given as a matter of interest at the end of this paper.

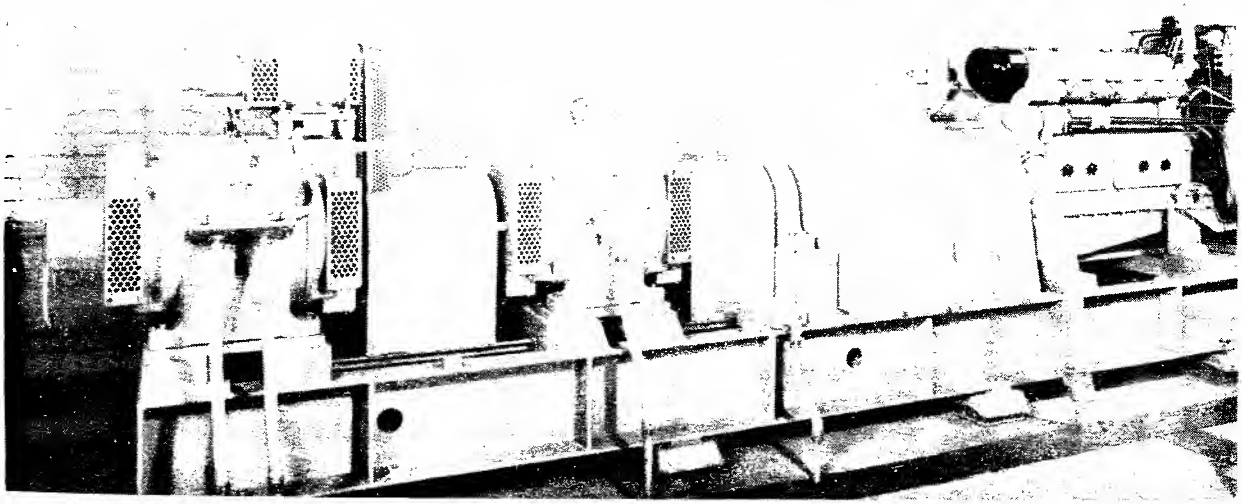
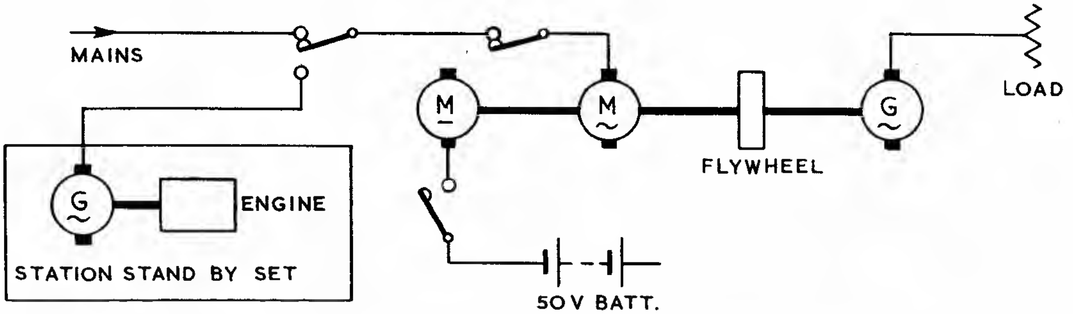


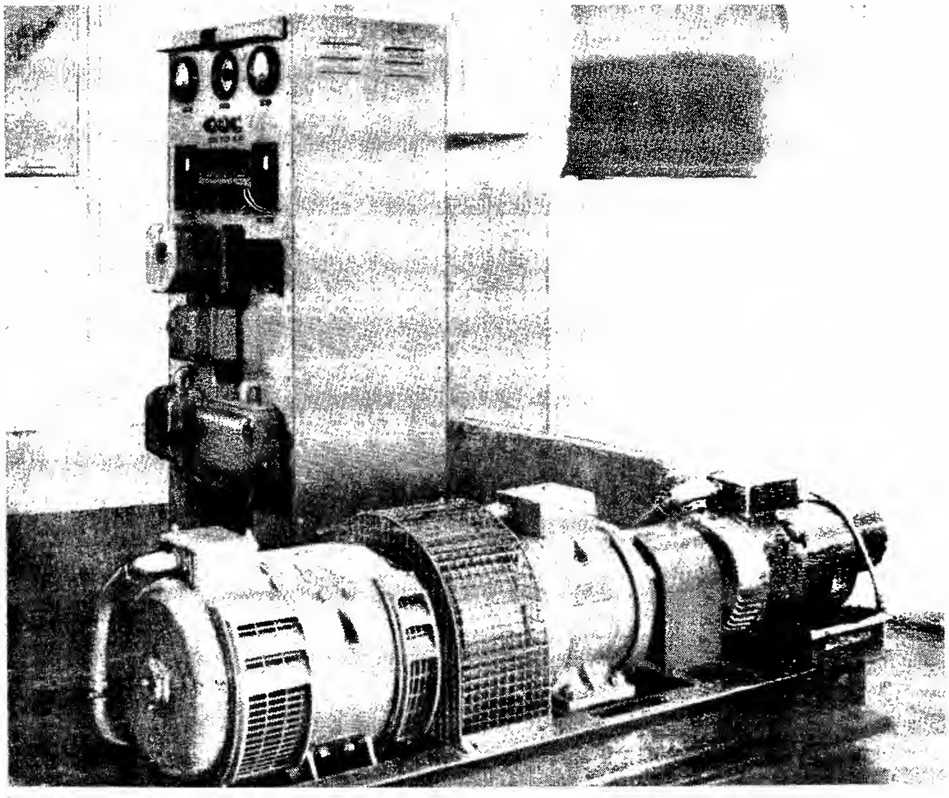
FIG. 27. TYPICAL NO-BREAK DIESEL ALTERNATOR STANDBY.

5.6 All Electric No-break Sets require a secondary battery of fairly large capacity. At combined telephone and long line stations the 50V exchange battery is used; otherwise a 63 cell (136V) battery may be specially provided. Fig. 28a shows the principle and Fig. 28b a typical 2 K.V.A. installation, including the control cubicle.

When the mains fail the set continues to run off the battery but only to bridge the short delay until the auto start standby restores the A.C. input. The flywheel is not essential and is not always included.



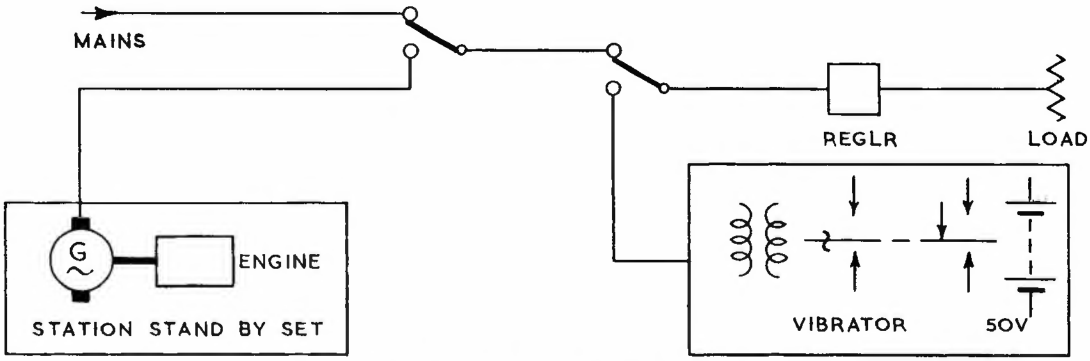
(a) Principle



(b) Typical All Electric Set.

FIG. 28.

5.7 Vibrator Inverters designed as no-break sets are also used where 50V exchange battery is available. However these do not operate continuously but start up and supply A.C. at mains voltage and frequency within 40 mS. They are made in 2 K.V.A. or 4 K.V.A. units. Fig. 29 gives the principle. The vibrator has up to 13 parallel sets of contacts. The inverted D.C. is fed to the primary of a transformer and the output is taken from the secondary.



PRINCIPLE OF VIBRATOR INVERTER NO-BREAK SET.

FIG. 29.

6. BUSBARS AND CABLES.

6.1 Connection between batteries, conversion plant, switchgear, and the equipment which constitutes the load, is in most cases by means of busbars of copper or aluminium.

The bars are jointed by means of bolted clamps or in some cases by means of bolts passing through holes in the bars; aluminium bars are sometimes welded. They are supported in the runs by means of insulated clamps bolted to the equipment racks, the ceiling or the walls.

In many Pre-2000 type exchanges and early long line equipment installations, stranded copper cables with terminating lugs were used instead of busbars. This method of distribution is still used in P.A.B.Xs., R.A.Xs. and very small long line stations.

6.2 All busbars, except the earth bars, are given a protective insulating covering throughout their length. This may be P.V.C. tubing, linen backed cardboard tubing, linen wrapping, or manilla paper tubing (for small bars).

The covering is a distinctive colour for each different potential -

50V −	blue
50V +	(earth) red (usually painted only)
24V −	green
130V −	(earth) black (may be painted only)
24V +	(earth) black (may be painted only)
130V +	gold.

Where P.V.C. covering is used, and this is preferred, it is applied to the bars in one of several ways:

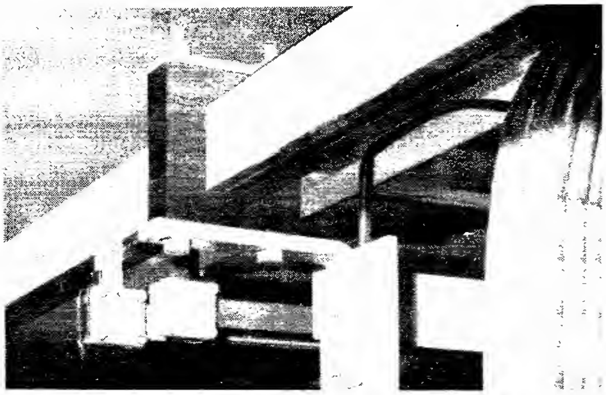
- Special P.V.C. tubing slipped over the bar and then shrunk to form a tight jacket by heating in a suitable oven.
- Use of a dilating fluid to slip the tubing over the bar which then shrinks to give a neat fit as the fluid evaporates.
- Coating applied by dipping or spraying. This is generally done in the workshops or by contract.

Although earth bars need not be insulated they may sometimes be covered in this way instead of by painting.

6.3 The size of busbar used is determined by the current to be carried. The maximum permissible voltage drop is the governing factor, but for short runs this may be further qualified by the temperature increase - a rise of 30°C being the maximum allowable. The maximum voltage drop is 1V to the most distant item of equipment.

Busbars are made with cross sections of from ½" x ¼" up to 6" x ½" in copper, and from 1" x ¼" to 6" x ½" in aluminium.

6.4 Close Coupled Busbars. In telephone exchanges a later method of busbar distribution is to bolt the bars on each side of a strip of insulating material. This close coupling reduces the inductance of the distribution system. The lower impedance of the supply to current variations results in a 'quieter' exchange; that is, the faint switching and impulsing noises generally audible to subscribers in silent periods are greatly reduced.



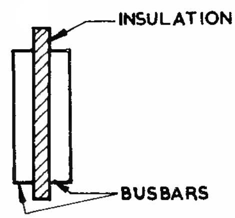


FIG. 30. CLOSE COUPLING OF BUSBARS.

7. SWITCHGEAR.

7.1 The exposed knife switches of polished copper which were mounted on the front of the black slate or sindango (composition insulating board) panels have disappeared from modern power rooms. Their place has been taken by 'dead front' type knife switches attached behind steel panels, and these in turn are being replaced in charging circuits at least, by A.C. contactors, controlled by a small toggle switch.

7.2 Knife Switches. Fig. 31 shows the two types of knife switch used on power boards and their dead front equivalent. The discharge switches are single pole, make before break for switching the load from one battery to the other.

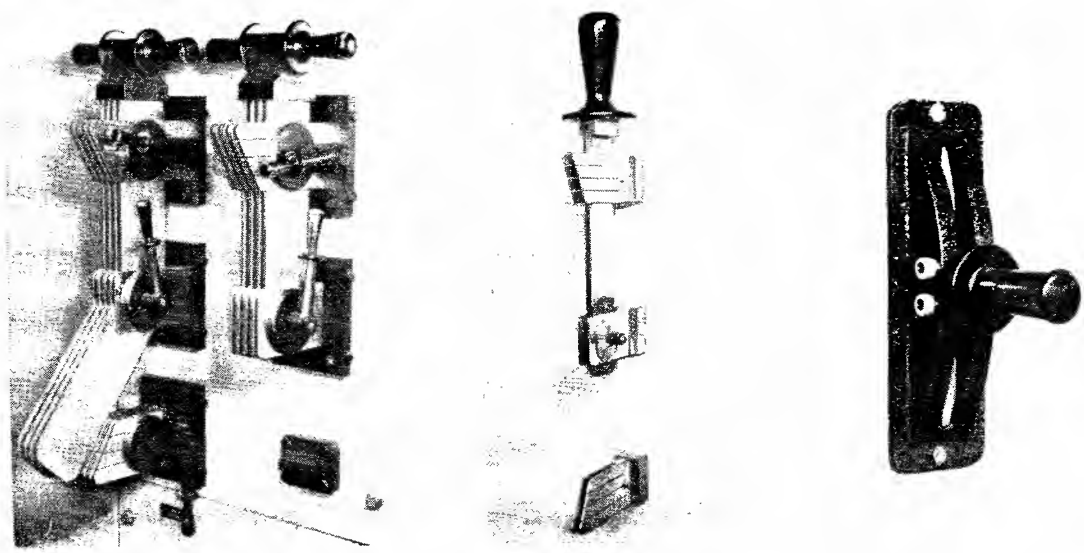
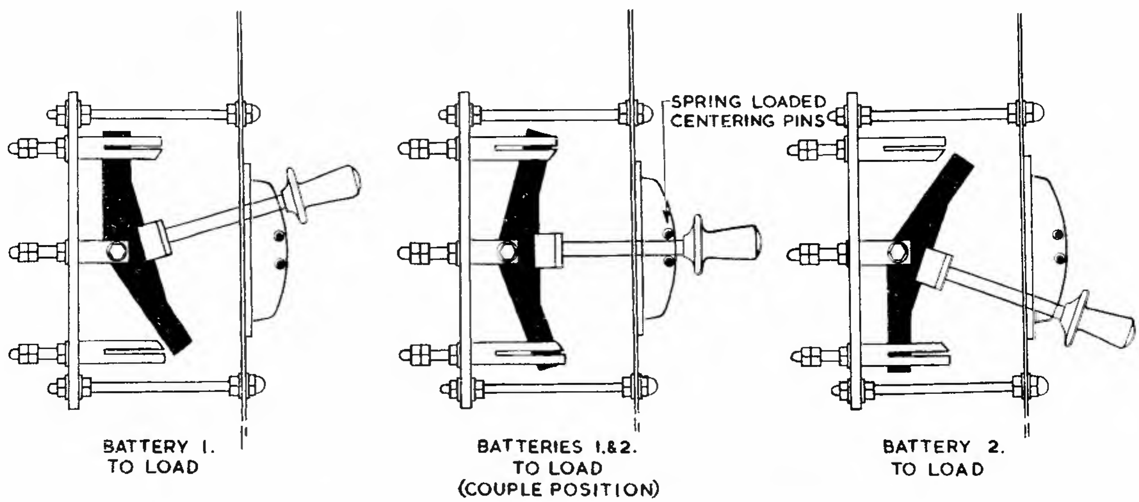


FIG. 31. POWER BOARD SWITCHGEAR.

When large discharge currents are involved a clamp is built into the fixed contacts to enable the fixed and moving members to be clamped tightly for minimum contact resistance. A single pole make switch may also be provided to parallel the two batteries.

The charge switches are single pole 2 way. With rectifiers they are included as an integral part of the cubicles as also are the contactors being used in their stead.

Fig. 32 shows that the principle of the dead front types is similar except for the insulated handle projecting through the escutcheon on the panel. Spring loaded locating pegs are usually included in the escutcheon which must be partially withdrawn by hand before the switch can be altered from the position where the centre input terminal is connected to the two output terminals in parallel.



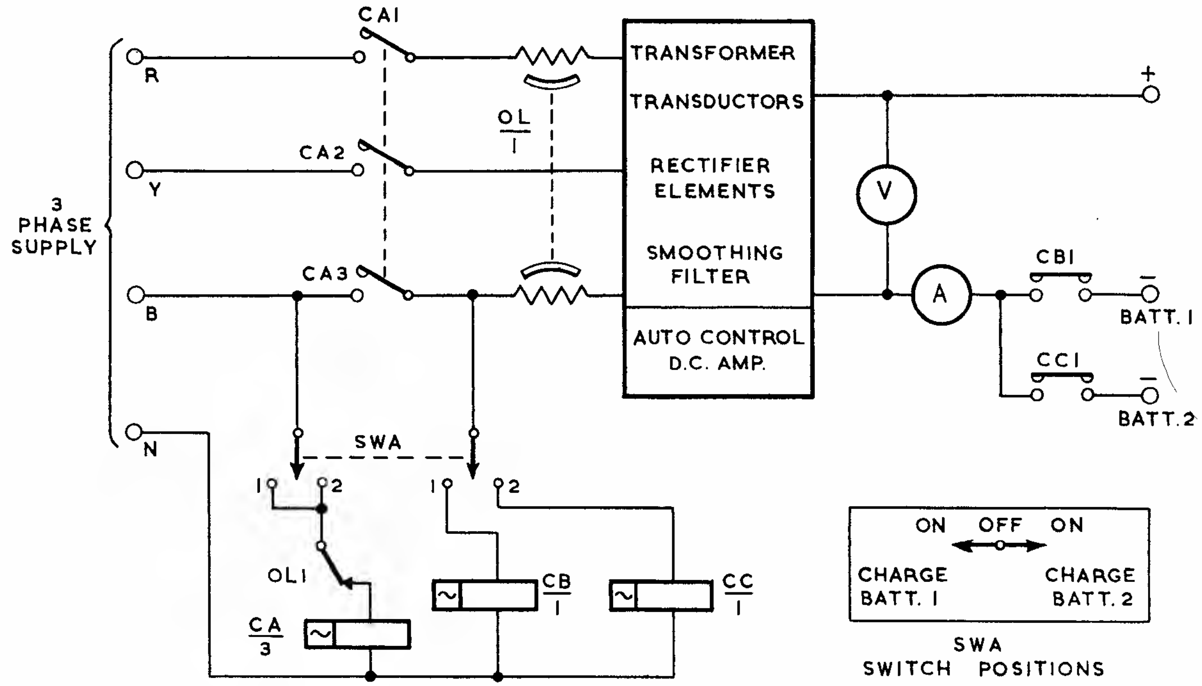
CONSTRUCTION OF "DEAD FRONT" SWITCHGEAR.

FIG. 32.

7.3 Contactors are A.C. relays with heavy duty contacts. They are used in place of manual switchgear on the input and output circuits of rectifiers, and for automatic changeover of plant loads from mains to standby.

Their use as an integral part of battery floating rectifiers greatly simplifies the front panel, improving the appearance; this can be seen in Fig. 16. As contactors may be controlled remotely they are placed in the best position for connection to the heavy current circuits they serve. A.C. input contactors often serve as circuit breakers, being released on overload by a thermal relay in the input. The output D.C. contactors allow for floating of either battery.

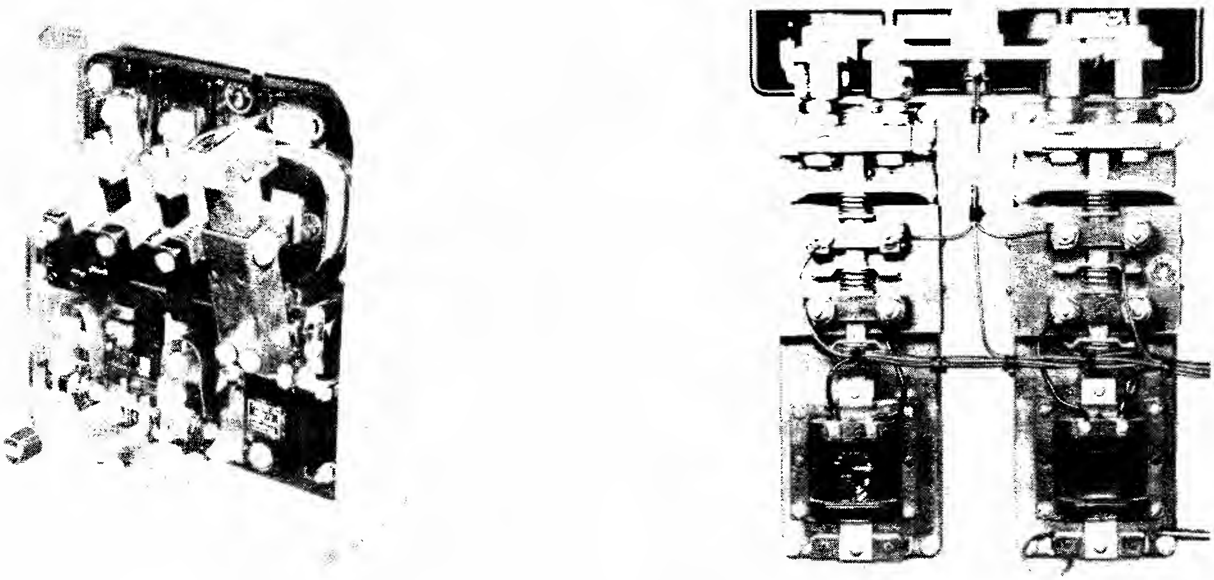
Fig. 33 is a typical arrangement; the manual control switch S.W.A. is a small 3 position toggle switch. The thermal overload relay has elements in two phases of the input via current transformers for the larger output rectifiers. Contactors may have a number of smaller auxiliary contacts for supervisory lamps etc.



TYPICAL CONTACTOR SWITCHING.

FIG. 33.

Fig. 34 shows typical contactors. Sparking at the main contacts is quenched by small permanent magnets which deflect the arc away from the contacts immediately it forms.



TYPICAL CONTACTORS.

FIG. 34.

8. FUSES AND CIRCUIT BREAKERS.

8.1 Contrary to what might be expected, the subject of electric fuses is a very extensive one and includes many details beyond the scope of this paper. (The British Standards Institution has issued no less than ten separate standard specification booklets, B.S.S., on fuses for various applications. The ones most applicable to telecom are B.S.646 - cartridge fuse-links rated up to 5A, and B.S.88 - for circuits of voltage ratings up to 660 volts.)

8.2 The more important definitions applying to fuses are -

Fuse-element - That part of a fuse which is designed to melt and thus open a circuit.

Semi-enclosed fuse - A fuse in which the fuse element is neither in free air nor totally enclosed.

Cartridge-fuse - A fuse in which the fuse element is totally enclosed in a cartridge.

Minimum fusing-current - The minimum current at which the fuse element in a fuse will melt. (Fusing at this current generally takes a considerable time.)

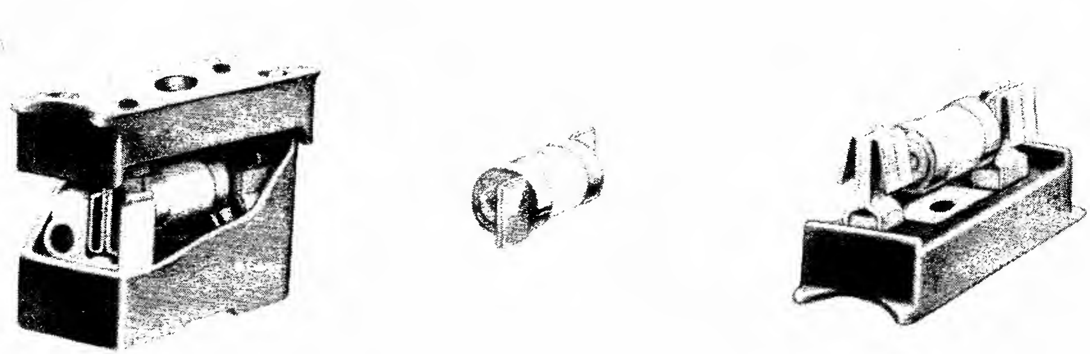
Current rating - The specified current that the fuse will carry continuously without deterioration.

$$\text{Fusing factor} = \frac{\text{Minimum fusing current}}{\text{Current rating}}$$

Breaking-capacity rating - The greatest prospective current (that is, short circuit current) that may be associated with the fuse under prescribed conditions of voltage or circuit characteristics (that is, power factor for A.C. or time constant, $\frac{L}{R}$ for D.C.); also called rupturing-capacity.

Voltage-rating - The highest voltage that may normally be associated with the fuse.

8.3 Cartridge fuses with totally enclosed elements are made to comply with specified ratings and characteristics to a degree not possible with semi-enclosed fuses having re-wireable elements, and for this reason are used in telecom power plant in preference to the re-wireable types. Fig. 35 shows a typical cartridge fuse. The cartridge itself, or the fuse-link to give it the correct name, consists of the fuse element enclosed in a tube of insulating material filled with a special arc-quenching compound such as chemically treated powdered quartz. Metal caps (and tags if required) form the fuse-link terminals. Many cartridge fuses give visual indication that the element has operated or 'blown'.



TYPICAL CARTRIDGE FUSE.

FIG. 35.

8.4 Breaking Capacity. Fuses are made in at least six 'categories of duty' with regard to their maximum breaking capacity, which range from prospective fault currents of 1000 amps. in moderately inductive circuits up to over 40,000 amps. in highly inductive circuits, and in at least three classes with regard to their fusing factors, which may be from 1.25 times the rated current up to any desired factor.

The term high rupturing capacity (H.R.C.) is a relative one but is applied generally to fuses suitable for duty in inductive circuits capable of prospective fault currents higher than 4,000A. For example, a circuit may have a prospective fault current of 10,000A because of the nature of the energy source and the conductors used. A 5A fuse could be used in such a circuit, but it must have a breaking capacity suitable to that prospective current even though on a short circuit fault the fuse may cut off in 5 milliseconds at 500A. A 5A fuse of only 1000A breaking capacity would not give reliable protection, particularly if the circuit or supply contained inductive components.

8.5 Operating time or fusing time of any fuse cannot be stated definitely as this depends not only on the class of fuse and the degree of overcurrent, but also on the ambient temperature and circuit conditions. A fuse having a minimum fusing current of say twice the rated current would generally take anything from several seconds to several minutes to operate at that current. This however, is not necessarily a bad thing and may be an advantage. Fuses are generally intended to protect against currents of a much higher order than twice the rated current, and for excessive currents caused by short-circuit fault conditions fusing times are very short, being as low as 6 milliseconds or less for fuses of up to 300A rated current. Also, when protection against moderate overcurrents is desired, circuit breakers of the thermal overcurrent or magnetic trip types do a much better job than a fuse and are easily reset. Where these are used it would be a disadvantage to have fuses that operated quickly at their minimum fusing currents. But the fuse must open the circuit before the breaker can operate on any currents which may damage the breaker contacts; also when fuses are in series the one nearest to fault must blow before the higher rating fuses nearer the energy source. This feature is known as 'discrimination' between fuses, or between fuses and circuit breakers.

Where low voltages are concerned, the actual resistance of a short circuit fault must be very low if large fuses are to operate in a reasonable time. For example, a 125A cartridge fuse of the H.R.C. type takes 6-10 minutes to operate at 250A and to obtain this current at 50V the circuit resistance including the fault must be as low as

$\frac{50}{250}$ or $0.2\,\Omega$, and as low as $0.16\,\Omega$ if the fuse is to operate in less than one minute!

A short circuit between a copper busbar and a steel rack is not likely to give so low a resistance.

The old practice of saying the fusing current of a fuse is twice the rated current does not therefore mean very much (with the possible exception of the familiar alarm type fuse), and may be either misleading or quite wrong for most fuses.

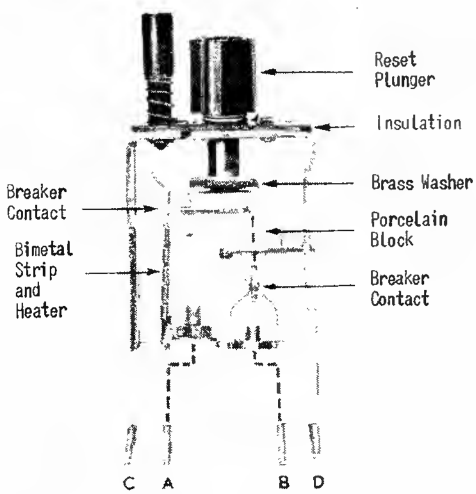
8.6 Fuses - Summary. In general, for fuses to be suitable components in a circuit they must be chosen from the available types and ratings with due regard to the type of circuit and the degree of protection desired.

In replacing fuses, it is not just enough to use a cartridge of the same current rating; the voltage rating, the breaking capacity rating (or duty) and the fusing factor class are also vitally important especially where the supply is of high energy capacity or the circuit highly inductive.

Fusing time will depend largely on the degree of overcurrent. Rapid protection only occurs if the fault current is many times the rated current, and where the fault and circuit conditions permit, the instantaneous current may rise to as high as 100 times the rated current before the circuit is opened.

8.7 Circuit Breakers of the miniature type are used in many auxiliary circuits instead of fuses, or in addition to fuses. Figs. 36a and b show the construction of a typical miniature thermal overcurrent circuit breaker - approximately actual size.

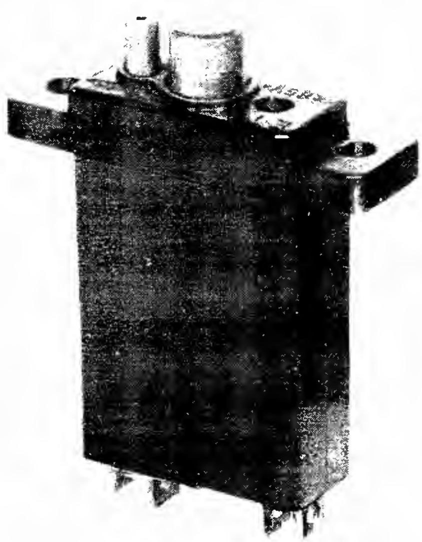
The heating element is wound on a bimetal strip but insulated from it by mica. On overcurrents the strip bends sufficiently to release the spring loaded plunger which then opens the main circuit A-B and closes an alarm circuit (if required) by means of a brass washer which bridges the outside conductors C-D. By pressing the plunger the breaker may be reset fully, or to an intermediate position which opens the alarm circuit without re-closing the main circuit; the bimetal strip latch engages the step in the porcelain block.



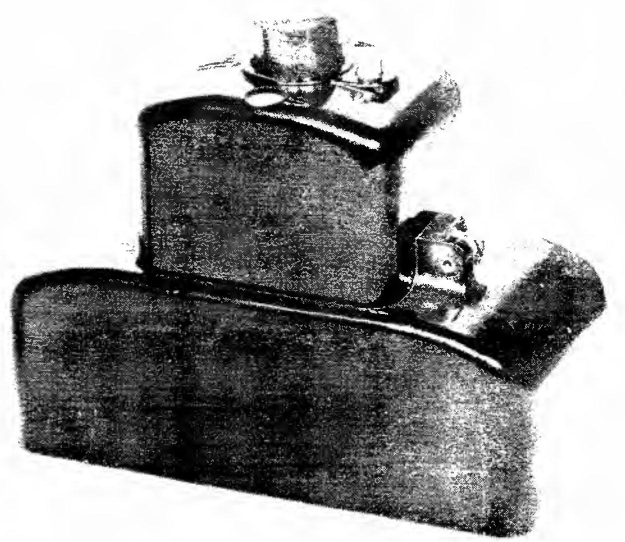
(a)

The manual release plunger is fitted only when required. The sizes range from 0.05A up to 25A rated current. Operating time is about 15-40 seconds at twice the rated current and 2-4 seconds at five times the rated current.

Fig. 36c shows another type of miniature circuit breaker which has both magnetic and thermal tripping mechanisms. Sizes range from 0.5A to 30A rated current in several types with a variety of thermal and magnetic tripping times. The magnetic trips give immediate release at from 3 to 7 times the rated current depending on the type and the protection desired.



(b)



(c)

FIG. 36. TYPICAL MINIATURE CIRCUIT BREAKERS.

9. RING AND TONE EQUIPMENT.

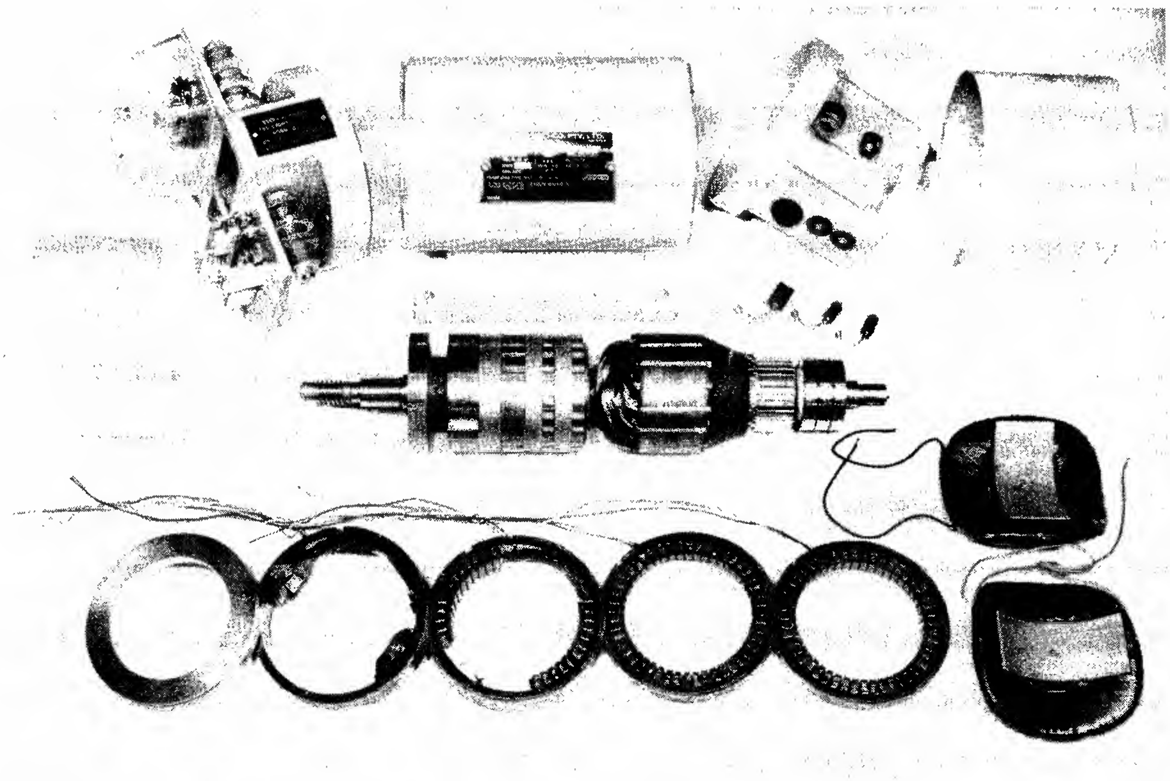
9.1 Ringing Machines. The ring current and service tones for most automatic exchanges are produced by a combined alternator and inductor tone generator. Before about 1950 it was the practice to have one machine driven by an A.C. motor from the mains supply and a second machine driven from the exchange D.C. supply as standby. Modern practice is to use two identical dynamotor type machines (D.C. motor and ringing alternator wound on a common armature). Fig. 37 shows the construction of such a machine.

The machines run at 1,000 r.p.m. and give an output of -

75-80V ringing supply at $16\frac{2}{3}$ c/s.
Dial tone 33 c/s (nominal).
Ringing tone - 400 c/s modulated by ringing current (interrupted).
Busy and N.U. tone - 400 c/s (interrupted).

A gearbox mounted on the end of the armature shaft rotates a transverse camshaft at 20 r.p.m. Springsets bearing on the various cams provide the interruption of the tones as well as interrupted and flicker earth pulses.

A number of machines in use have ringing frequency of 33 c/s or 25 c/s. Sizes range from 0.2A up to 4A of ring current output. Most exchanges use either 0.2A or 1A machines.



CONSTRUCTION OF TYPICAL RINGING MACHINE AND TONE GENERATOR.

FIG. 37.

9.2 The inductor tone generator section of the machine consists of an unwound multi-toothed rotor and a multipole stator. All necessary windings are on the stator. Both the rotor and stator assemblies are made up of iron laminations.

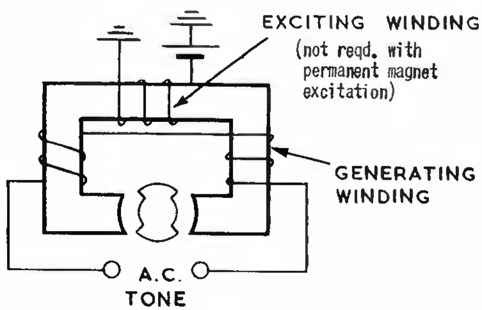
Fig. 38a shows the principle of this type of alternator. The magnetic circuit reluctance varies with the relative positions of the rotor and stator teeth. This varies the flux and A.C. is induced in the generating or pick-up windings. Magnetic excitation is from either a separate winding or a permanent magnet. One rotor disc and stator assembly are provided for each tone.

The frequency of the output will be one c/s per rotor tooth per revolution. For 400 c/s the rotors have 24 teeth and 24 slots of equal size. Usually two stator teeth and slots occupy the same space as one tooth and the adjacent slot on the rotor. In this case adjacent stator pole windings are in opposite directions so that the induced voltages are in series aiding. This is shown in the simplified arrangement of Fig. 38b. Where exciting windings are required the stator poles are arranged in two or four groups to form larger poles, some teeth being omitted to make room for the windings.

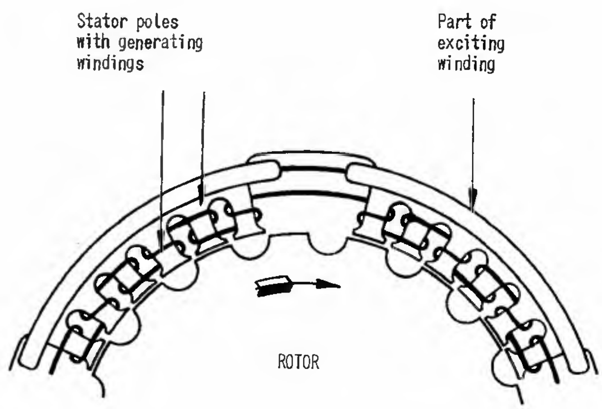
For dial tone the rotor has two small slots so that the two teeth occupy the greater part of the periphery. The stator has two small poles.

NOTE: While dial tone has a fundamental periodicity of 33 c/s it is not of sine waveform but owing to the relative size of rotor teeth and stator poles it is so rich in harmonics that most of the volume of the tone is in the 200-400 c/s range with appreciable level up to well over 1,000 c/s. This is necessary since the response of both telephone receivers and the ear to 30 c/s is very low and a pure tone of this frequency would be inaudible.

In earlier machines a rotor having 8 slots produced a 133 c/s note for ringing tone. This was found to be rather too low in frequency for satisfactory transmission over trunk channels using filters and was replaced by 400 c/s. Existing machines have been modified to derive busy and NU tones from the original N.U. tone stator, and ringing tone from the original busy tone stator.



(a) Principle



(b) Simplified Arrangement

INDUCTOR TONE GENERATION.

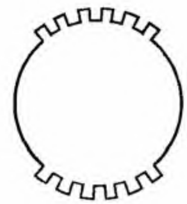
FIG. 38.

Modern machines have a permanent magnet included in the tone generator; the magnetic circuit of any tone excited by the magnet requires only a generating winding on the stator. In some machines having a magnet, all the tone circuits are excited by it and, in others, all except the ringing tone.

Modulation of ringing tone is achieved in one of the following ways -

(i) The stator is excited by a winding fed from the ringing current.

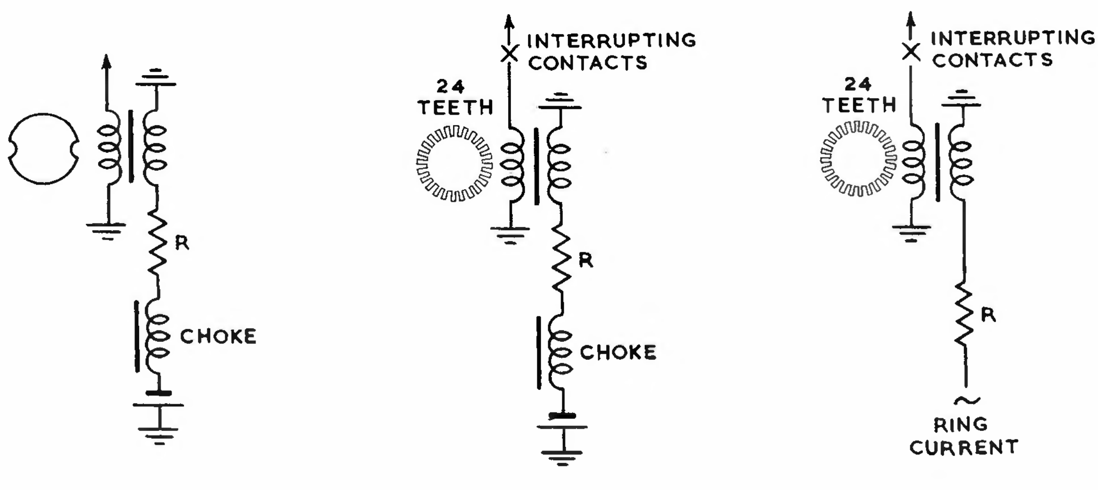
(ii) Permanent magnet excitation; the rotor has 12 teeth removed leaving two groups of six thus -



The stator also has two corresponding groups, and half the normal number of teeth. This has the effect of varying the 400 c/s tone at the ringing frequency.

(iii) Permanent magnet excitation, two separate stator and rotor assemblies for ringing tone producing different frequencies with the outputs in series; for example assemblies of 23 teeth and 25 teeth will produce the effect of 400 c/s modulated at $16\frac{2}{3}$ c/s.

The basic circuits for inductor tone generation are in Fig. 39. For tones excited by permanent magnet the exciting windings are omitted. The resistors R may be varied for initial adjustment of output level. With some machines, ring current to modulate the ringing tone is fed via a capacitor instead of a resistor. The D.C. excitation is fed via chokes to prevent the loss of tone power in the battery circuit as well as to exclude it from the battery. The busy tone stator and rotor assembly is a replica of that for N.U. tone; separate circuits however are used.



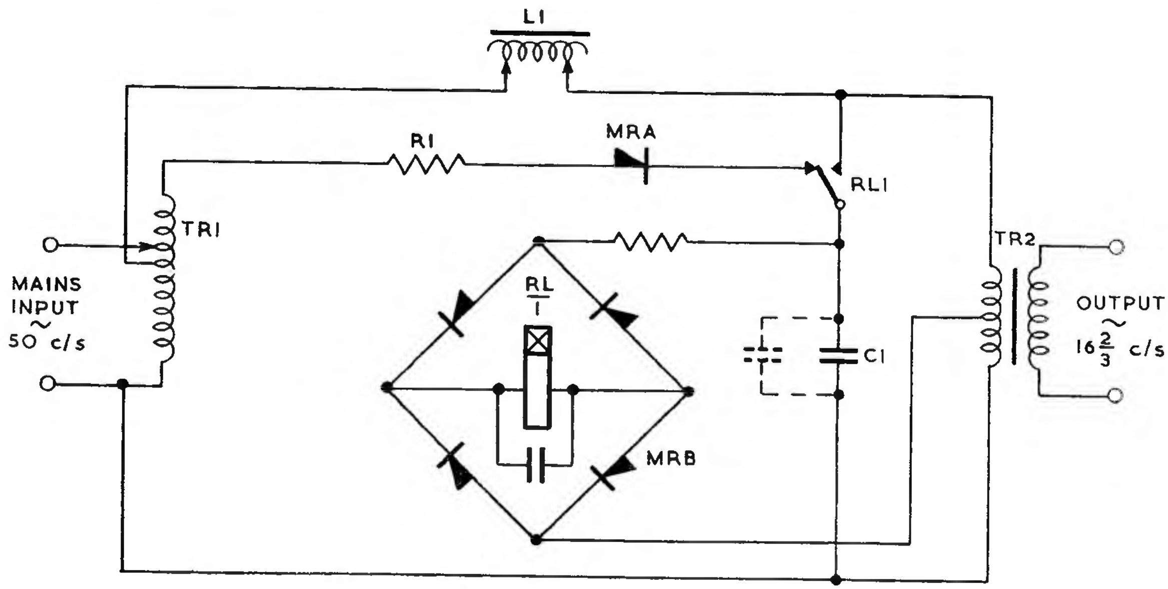
(a) Dial Tone. (b) N.U. or Busy Tone. (c) Ringing Tone.

FIG. 39. BASIC TONE GENERATION CIRCUITS.

9.3 Tone generators for 2 V.F. and V.F.T. tones also use the inductor principle. The D.C. motor sections of these machines have governors to keep the speed (and output frequency) constant.

9.3 The Sub-cycle ringing converter or sub-harmonic ringer is used at many manual exchanges to provide ringing current from the A.C. mains. With an input of 200-250V, 50 c/s the output is $16\frac{2}{3}$ c/s, adjustable between 20 and 90V.

Basically the principle is that of a $16\frac{2}{3}$ c/s resonant circuit, the oscillations of which are maintained by the 50 c/s input which is exactly 3 times the resonant frequency. Fig. 40 is a typical arrangement. The resonant circuit consists principally of C1 and the primary of TR2.



BASIC CIRCUIT OF TYPICAL SUB-HARMONIC RINGER.

FIG. 40.

When the unit is first switched on, the capacitor C1 charges from the high voltage connections of auto transformer TR1 in series with rectifier MRA and R1. Relay RL operates after a lag sufficiently great to ensure C1 is fully charged. RL1 completes the oscillatory circuit by connecting C1 across TR2 primary. Oscillations are maintained by pulses from the mains input via the self saturating choke L1. RL remains operated from a portion of the output tapped off TR2 and rectified by the bridge MRB.

9.4 Vibrator ringers and tone oscillators are commonly used at R.A.Xs. and P.A.B.Xs. instead of ringing machines. Interruption of the ring and tones is by means of the contacts of relays arranged to pulse in sequence, or relays controlled by a stepping uniselector with suitably strapped banks. Vibrating relays have also been used to produce tones but oscillators are preferred.

A great variety of machineless ring and tone circuits are in use but Fig. 41 is typical. The self-interrupting relay RV has a special spring-set in the form of a weighted reed which oscillates at approx. 20 c/s. This energises the two halves of the transformer primary alternately and A.C. is induced in the secondary. Circuits of this type are generally auto. start and stop so that they are not operating continuously during periods of no traffic.

9.5 Completely static ring and tone circuits have been developed using transistors and it is possible that in the future these will be used.

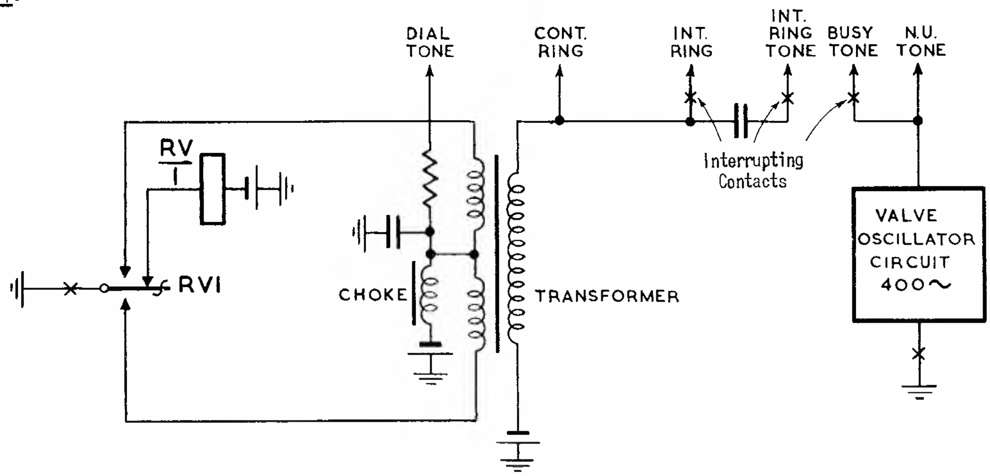


FIG. 41.

10. MISCELLANEOUS.

10.1 Meters and Shunts. Voltmeters and ammeters used on power panels are "industrial" grade instruments (one grade below "precision" instruments in the British Standard Specification), except the contact voltmeters with suppressed zero which are "precision" instruments designed to cover a small range with high accuracy (0.2V or 0.5V per division).

These voltmeters are connected permanently across the discharge busbars and referred to for accurate control of the floating voltages, which as previously mentioned, must be retained within the specified narrow limits if batteries are to be maintained in good condition.

The high and low voltage alarm circuits are connected to adjustable contacts in the meter, the voltages being indicated by means of red pointers one on each side of the indicating needle.

10.2 Ammeter shunts are designed to give a 75 mV drop at the maximum current for which the meter is calibrated. However some ammeters have a reversible scale plate with one side calibrated to twice the current of the other, for example, 15A and 30A, or 200A and 400A. These meters have a 37.5 mV terminal as well as one for 75 mV (and a common). This allows for increase in load as more equipment is added to partially equipped stations, without the need to fit a different ammeter and shunt. The scale is merely reversed and the meter connection changed from 37.5 mV terminal to the 75 mV terminal - see Fig. 42.

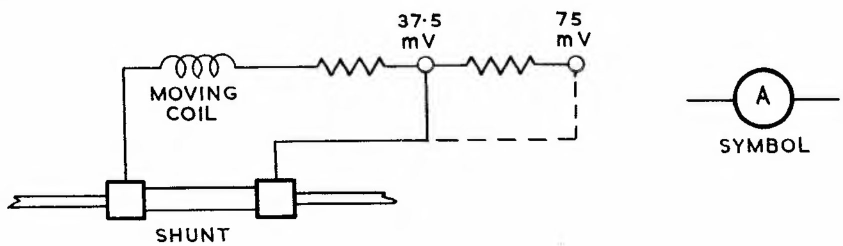
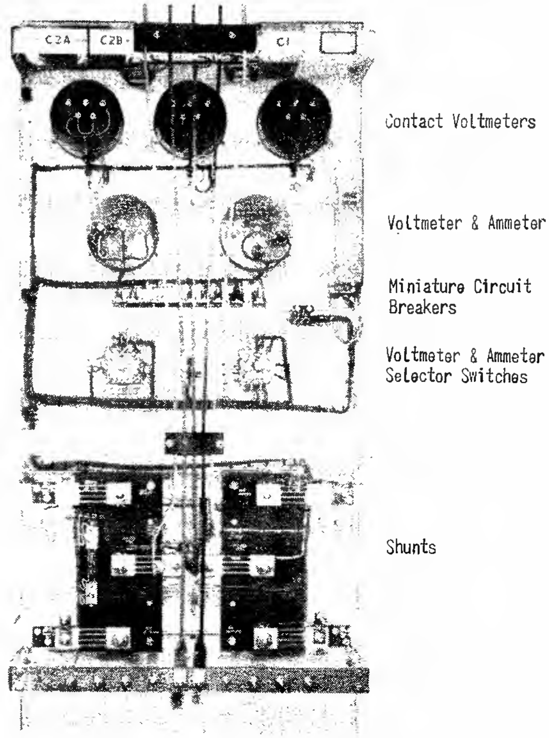


FIG. 42.

The one ammeter is often arranged to indicate currents in a number of circuits by switching from one shunt to another using a two pole multi-position rotary switch. The voltmeter is switched in a similar way. Where the current ranges differ the meter has two sets of calibrations on the scale, one in black and one in red.

Fig. 43 shows a typical arrangement of these various items behind a multi-voltage discharge panel. These panels, designed for use at combined telephone, telegraph and long line stations cater for the 50V −, 24V −, 130V + and 50V + supplies. This panel and other standard discharge panels are described fully in the paper "Power Plant, Telephone and Long Line Stations".

10.3 Hotwire vacuum relays are used for the control of contactors in some of the auto start and change-over circuits of standby plant, and similar applications where fairly heavy currents in inductive circuits are made or broken. Fig. 44 shows the construction. The operating current of up to about 50 mA heats the wire element which increases in length and allows the contacts to close. The whole is mounted in a vacuum tube which gives stable operation for long periods; at the voltages used the absense of gas around the contacts prevents any arc forming.



REAR OF DISCHARGE PANEL.

FIG. 43.

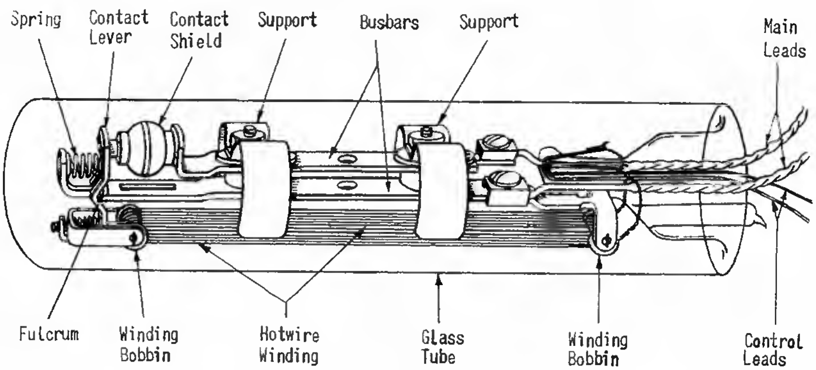
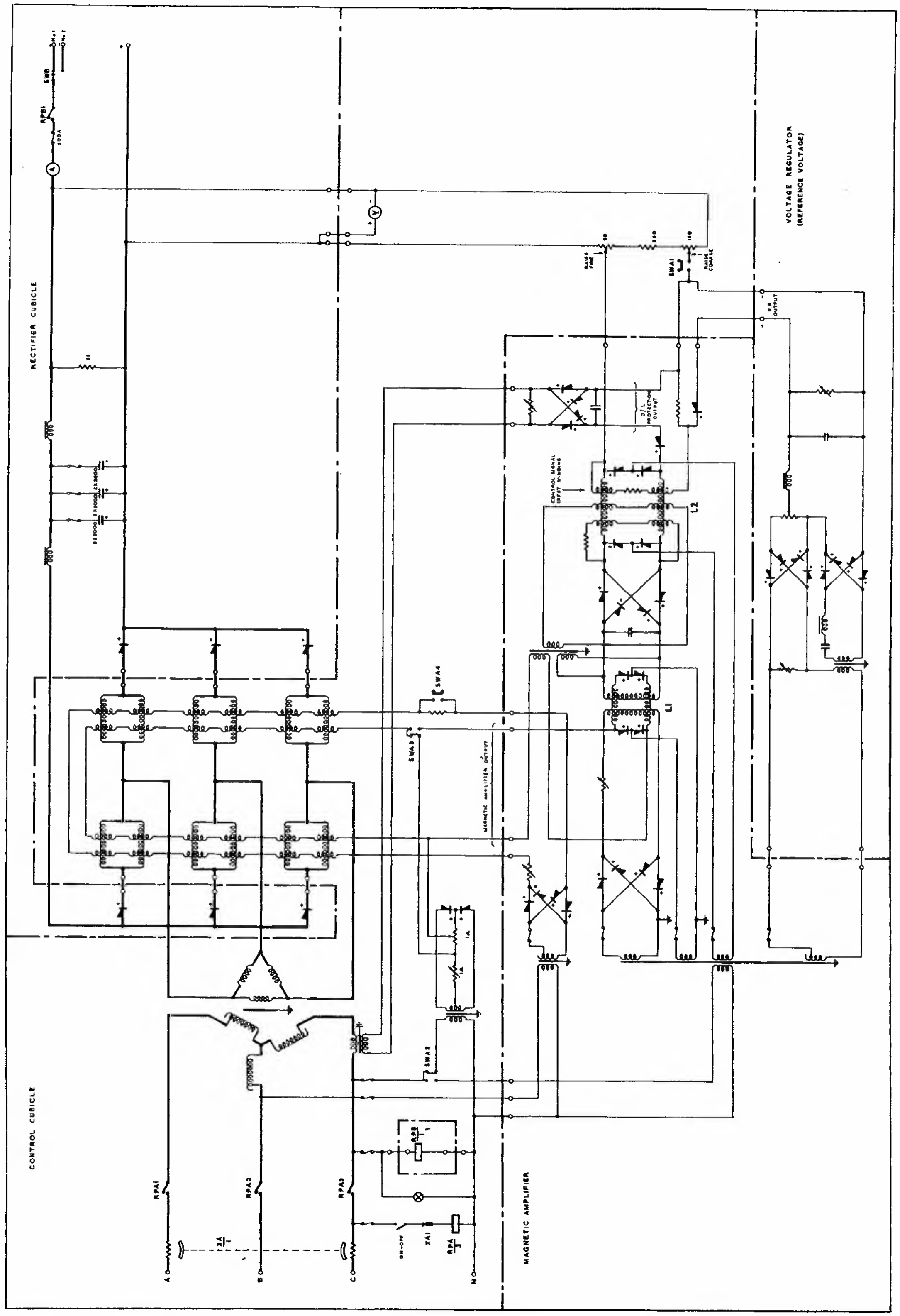


FIG. 44. HOTWIRE VACUUM RELAY.

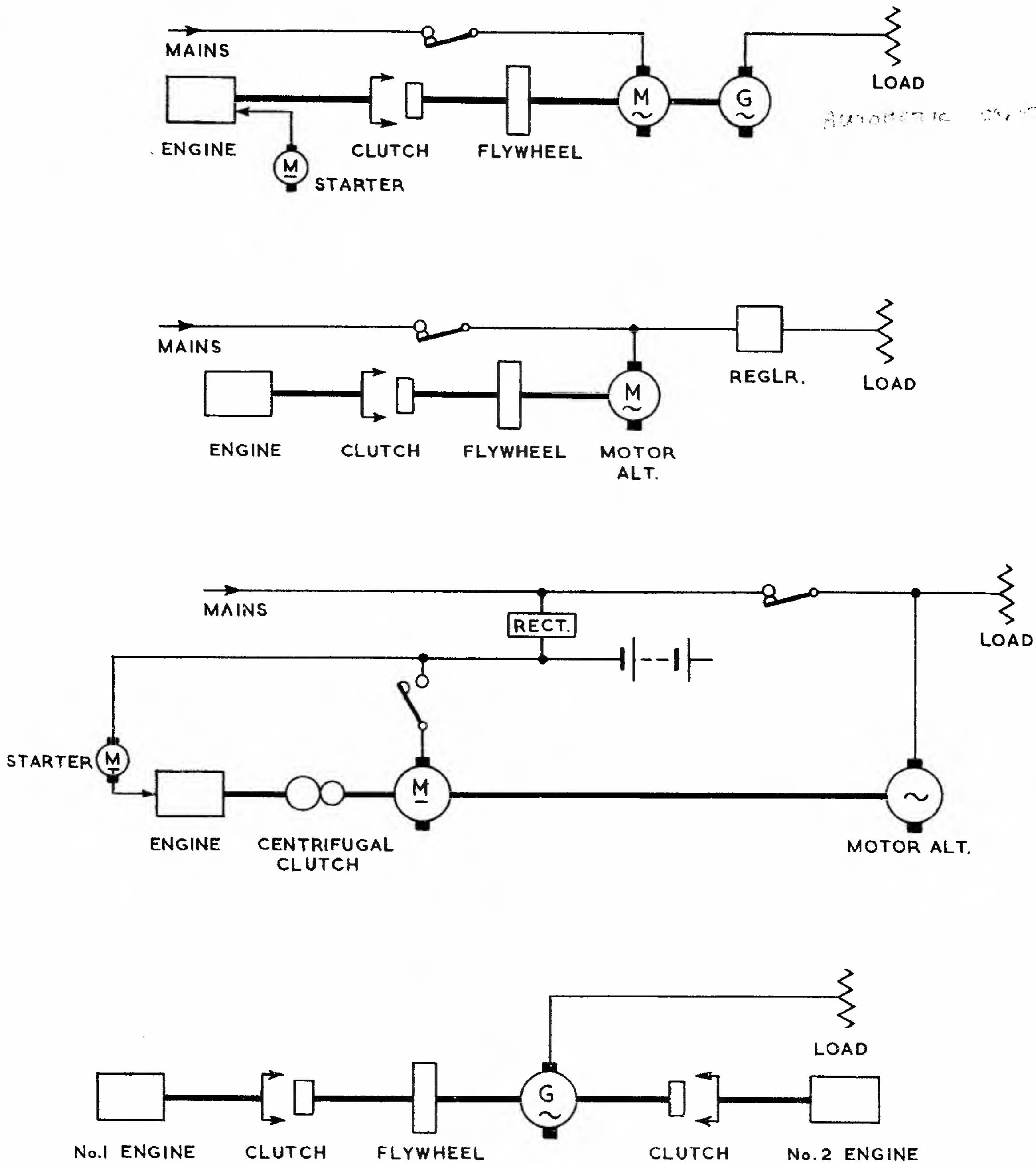
10.4 Water Purifiers or Demineralisers are sometimes used to obtain water suitable for batteries from water having dissolved impurities which would be harmful to them.

10.5 Solar Stills. Another method of obtaining pure water in areas without a suitable supply, is to distil impure water such as bore or well water in a still using heat from the sun.



RECTIFIER 50V 200A MAGNETIC AMPLIFIER CONTROL.

RECTIFIER 50V 200A MAGNETIC AMPLIFIER CONTROL.



TYPES OF DIESEL NO-BREAK PLANT.
(Refer to Page 21)

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12. TEST QUESTIONS.

1. In what ways do modern 'telecom' type enclosed cells differ from those designed for home lighting?

2. What type of filter would be used with a rectifier power supply required to have good regulation?

3. What are the ripple frequencies produced from rectification of 50 c/s supply by

   (a) half wave single phase rectifiers?

   (b) full wave three phase rectifiers?

   Draw a basic circuit for (b).

4. Explain briefly the principle of saturable reactor control of rectifier output.

5. With the aid of a simple diagram explain why amplified control gives more sensitive regulation of rectifier output than earlier forms of regulation.

6. With the aid of a simple diagram explain briefly the principle of a magnetic amplifier designed to give D.C. output with D.C. signal input.

7. Explain the principle of automatic voltage control of motor generators.

8. What safeguards are provided with auto start standby diesel alternators to permit their being operated unattended?

9. (a) With the aid of a block diagram explain briefly the principle of operation of one type of 'no break' standby set.

   (b) Where would such a set be used?

10. What are contactors and where are they used in power plant?

11. What method of spark quenching is used in modern contactors?

12. Describe a method of busbar distribution designed to lower the supply impedance, and explain why the method has this result.

13. Why are fuses made with different breaking capacities?

14. When miniature circuit breakers and fuses are connected in series, under what type of fault condition should each provide protection.

15. Describe how tones are generated in a modern ring and tone machine.

END OF PAPER.

THE AUSTRALIAN POST OFFICE

COURSE OF TECHNICAL INSTRUCTION

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

POWER PLANT
TELEPHONE AND LONG LINE STATIONS.

---

1. INTRODUCTION.

1.1 There are many similarities between the power plant for telephone exchanges and long line stations, and the modern trend in many cases, is to house telephone, long line and telegraph equipment in the same building and to design the power plant on a combined basis.

1.2 The paper "Power Plant Components" describes the construction and operation of the various items used to supply and distribute power and should be studied before, or in conjunction with this paper.

1.3 Improved and smaller components have allowed many new practices and simpler layouts to be used, so that the power plant section of a modern installation generally looks very different from its counterpart of 10 years ago. The change has been gradual so that there is no one standard circuit or layout. This paper deals therefore with typical installations and mentions the more important alternatives.

2. GENERAL.

2.1 Secondary batteries are a part of the power plant for practically all automatic and C.B. manual telephone exchanges; exceptions are a few small P.A.B.Xs. and many C.B. P.B.Xs. where mains operated battery eliminators are used.

Modern exchanges, manual and automatic, use 24 cell batteries, nominally referred to as 50V batteries. Duplicate sets are used except at the smallest stations.

2.2 At most long line stations, batteries of two potentials are used; 12 cells (24V nominal) for the valve low tension filament supply and auxiliary circuits, and 63 cells (130V nominal) for the H.T. or anode supply. Most stations have duplicate sets of batteries for both 24V and 130V supplies.

Many modern carrier systems have the D.C. supply as an integral part of the system and operate directly from the A.C. mains. (The valves generally have A.C. operated heaters and H.T. supply of 220V D.C.)

At small stations requiring 24 and 130V D.C. or at larger stations where much of the equipment is mains operated, combined 24/130V eliminators are being used without batteries.

2.3 Earthing of Power Supplies. D.C. power supplies always have one pole connected to earth. The reasons for this are -

(i) Fusing and switching may be single pole - only in the conductor above earth potential.

(ii) To prevent the risk of crosstalk and other disturbances, arising from foreign currents in leakage or capacity-unbalance paths. These would occur if lines and equipment were able to assume indefinite potentials with respect to earth. In telephony, therefore, a low resistance earth is essential to obtain a 'quiet' system.

(iii) To ensure prompt indication of insulation faults and assist in locating them. If the insulation to earth of any part of the system fails, a circuit is completed via the earth connection on the power supply. Through the operation of a fuse, relay, or other supervisory device the fault will generally become evident at once.

Without the earthed power supply the fault circuit could only be completed by some other faulty circuit; service would be affected only when both faulty circuits were in use. For example, an earth fault on one side of a circuit may not be apparent until an earth fault on another circuit results in a cross, and then only detected by testing both circuits together.

Even with an earthed power supply insulation breakdowns to any unearthed conductor give similar obscure troubles, and all equipment racks and frame-works are connected to the earthed pole of the supply; chance connection through fixing bolts, runways and tie-bars is not relied on.

(iv) An earthed supply is advantageous in a number of other ways, such as -

A return circuit of negligible resistance for P.B.X. power leads is provided by the earthed system of lead cable sheaths.

Earth return signalling is used on some types of junction lines.

When it is necessary to identify the separate wires of a pair away from the exchange, this can be readily done by noting their potential with respect to earth.

For reasons (i) and (iii) above, A.C. single phase supplies are also generally earthed on one side. As A.C. used in equipment is obtained either from the secondary of a transformer or generated locally (e.g. by ringing machines) this does not interfere with the mains, which may or may not have the neutral earthed at the consumer's premises.

2.4 The 50V main battery of telephone exchanges has the positive pole earthed in preference to the negative pole. This ensures that all lines and apparatus at other than earth potential are negative with respect to it. This greatly minimises troubles from the corrosive electrolytic effects of any leakage currents, since in electrolysis it is always the anode or positive electrode which is eaten away.

For example in leakage currents between wires and earthed framework, such as in a relay with an earthed core, it is not the fine wires of the winding which suffer but the framework, and the loss of metal there is negligible. If the wire were the anode however (negative pole earthed) the corrosion caused by even an extremely small leakage current would cause an open circuit of the fine wire in a relatively short time, possibly within a few weeks. Covered wires and cables in external plant would likewise be damaged wherever leakage existed.

In cases where a direct leakage (apart from earth) exists between components at different potentials, similar trouble can still occur particularly under unfavourable atmospheric conditions. This is the reason for tropic proofing of equipment.

A second reason for earthing the positive pole, is that partial earth faults show up more definitely when the conductor is negative to the surroundings. When the conductor is positive, the fault is liable to seal up owing to oxidation.

2.5 At long line stations the 130V supply is earthed at the negative pole and the 24V supply is earthed at the positive pole. In the early days of carrier telephony all thermionic valves were directly heated. The use of a filament battery having one pole earthed, meant all cathodes were at a fairly low potential with respect to earth. As valves must have the anodes positive with respect to the cathode in order to function, an anode supply with the positive pole well above earth potential is required - that is, with the negative pole earthed.

As a rule, valve filaments are operated in series which makes the cathode up to 24V above earth potential. If this potential is negative with respect to earth, it is in effect raising the effective anode to cathode potential for the valve, instead of subtracting from it, as would be the case if the cathode were positive with respect to earth. See Fig. 1a. The filament supply therefore has the positive pole earthed.

Fig. 1b shows that with indirectly heated valves all cathodes may be connected directly to the negative pole of the 24V supply giving an anode potential of 154V.

Since the 24V supply is used also for auxiliary circuits including relays etc., the positive pole being earthed minimises electrolytic corrosion as explained for the 50V exchange battery in paragraph 2.4.

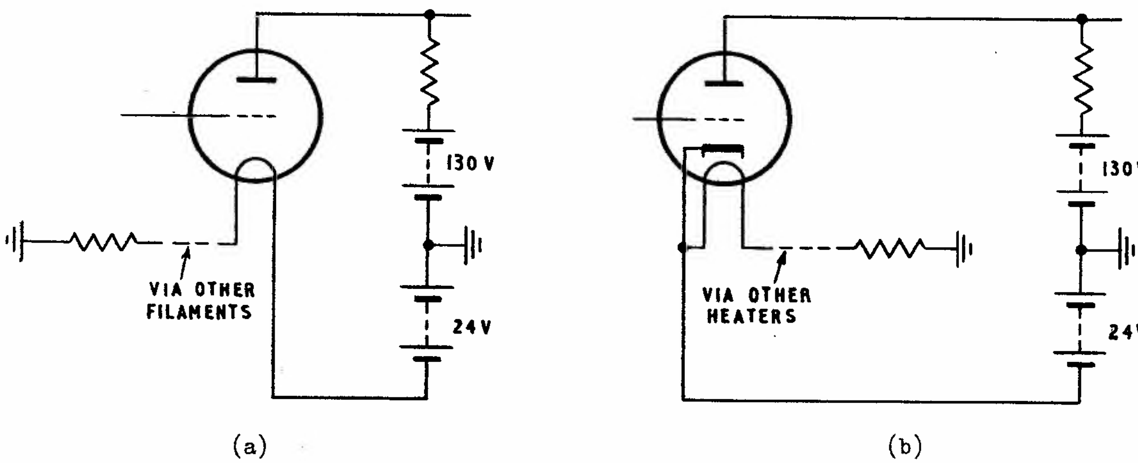


FIG. 1.

3. EXCHANGE POWER PLANT.

3.1 The sizes, numbers and types of components used for the power supply in exchanges (auto and C.B. country manual) is determined largely by the individual requirements.

In recent years static rectifiers have been used for A.C. to D.C. conversion. Motor generator sets were provided in practically all public auto exchanges up to about 1950, but since about 1955, rectifiers have superseded them for new installations. Exchanges cut-over between these dates have, as a general rule, at least one motor-generator set and one or more rectifiers. Rectifiers have been added to many of the earlier power rooms where the conversion equipment was originally motor generator sets only.

Apart from the smaller space required, modern rectifiers have a much higher conversion efficiency than motor generators, especially at a fraction of maximum output. (Typical figures are - full load, M.G. sets 70% efficient, rectifiers over 80%; $\frac{1}{4}$ full load M.G. sets 53% and rectifiers 70%. This means a big saving in energy costs especially as full discharge current is demanded from an exchange power supply for only a few hours each day.)

3.2 The enclosed batteries up to the 500 Ah size are now generally housed in cupboards. This practice together with the use of rectifiers has brought about a number of important changes in exchange power plant such as -

Smaller power rooms with batteries in the power room and no battery room, or

All power plant, except the standby machine, in the exchange equipment room, and

Ring and Tone equipment rack-mounted with the auto equipment, instead of table mounted in the power room.

Fig. 2 shows a typical power installation in the equipment room of a modern branch exchange. The cubicles may be arranged in a single long suite or in two suites as shown, facing each other. The following features are typical although details vary somewhat.

A.C. Panel or Cubicle. Where this is provided in line with the other panels it contains fuses and circuit breakers for the conversion plant; where a standby alternator is provided, manual change-over switches are generally fitted here. In many exchanges other A.C. circuits in the building are routed via this panel, and supply meters are also included.

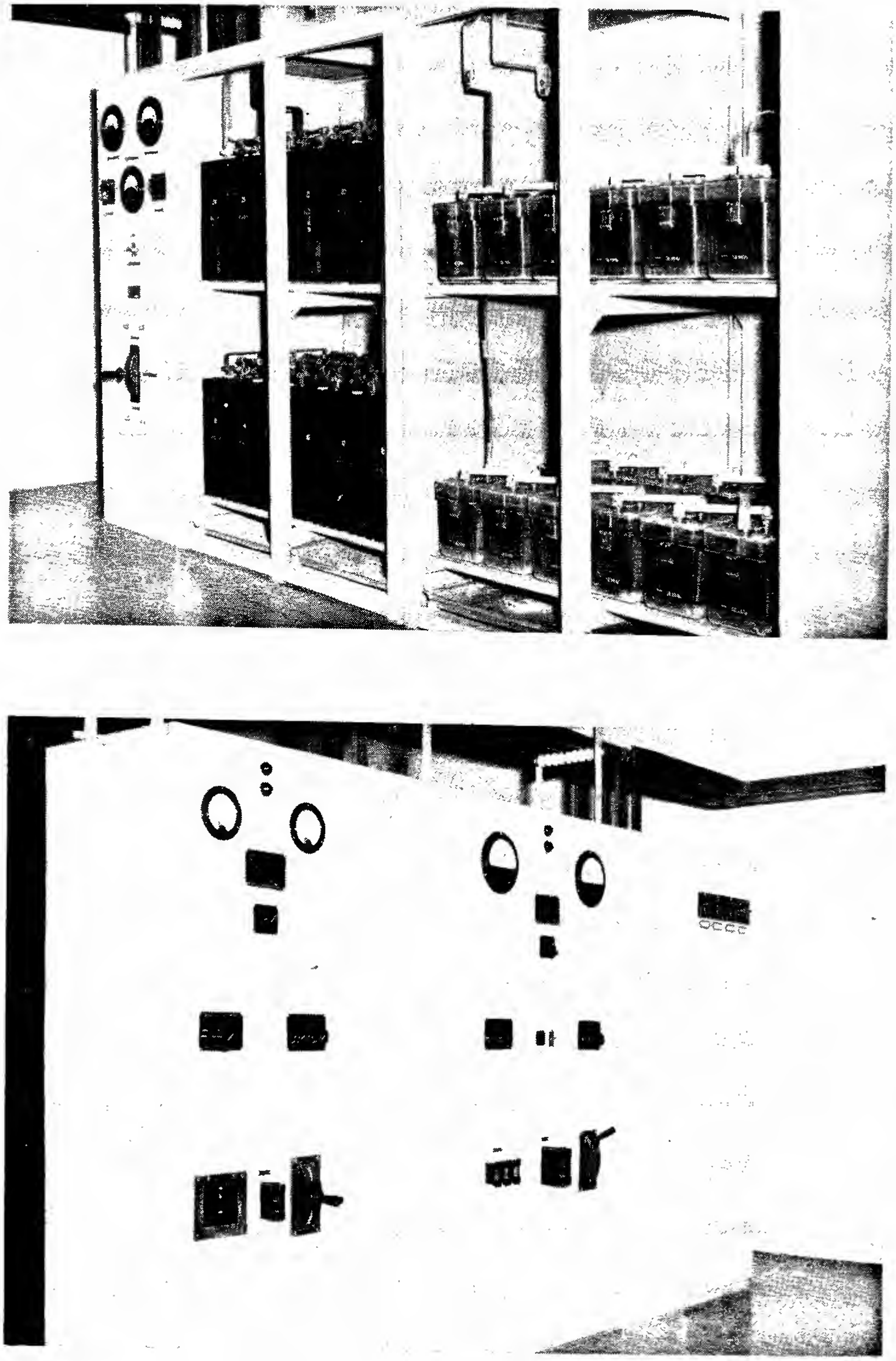
Rectifiers. Two or three auto-manual rectifiers are provided with outputs depending on the load demand. Space may be left for additional units. Each rectifier has its own output switchgear (charge battery 1 or battery 2) and its own ammeter and voltmeter. Voltage 'sensing' leads for the controller (or regulator) of each rectifier are taken from the discharge side of the power board, so that the voltage drop in shunts and switch gear is accounted for in the regulated voltage.

Battery Cubicles have removable panels back and front, but in Fig. 2 the front is left open to show the batteries. Special ventilation of the cubicles is not necessary with full float operation.

Discharge Panel. The general design has been more or less standardised for exchanges of up to 400A discharge. The details are in Fig. 3. The discharge switch is of the dead front type, make before break, and may be used to discharge the batteries coupled, or alternatively, to discharge either battery.

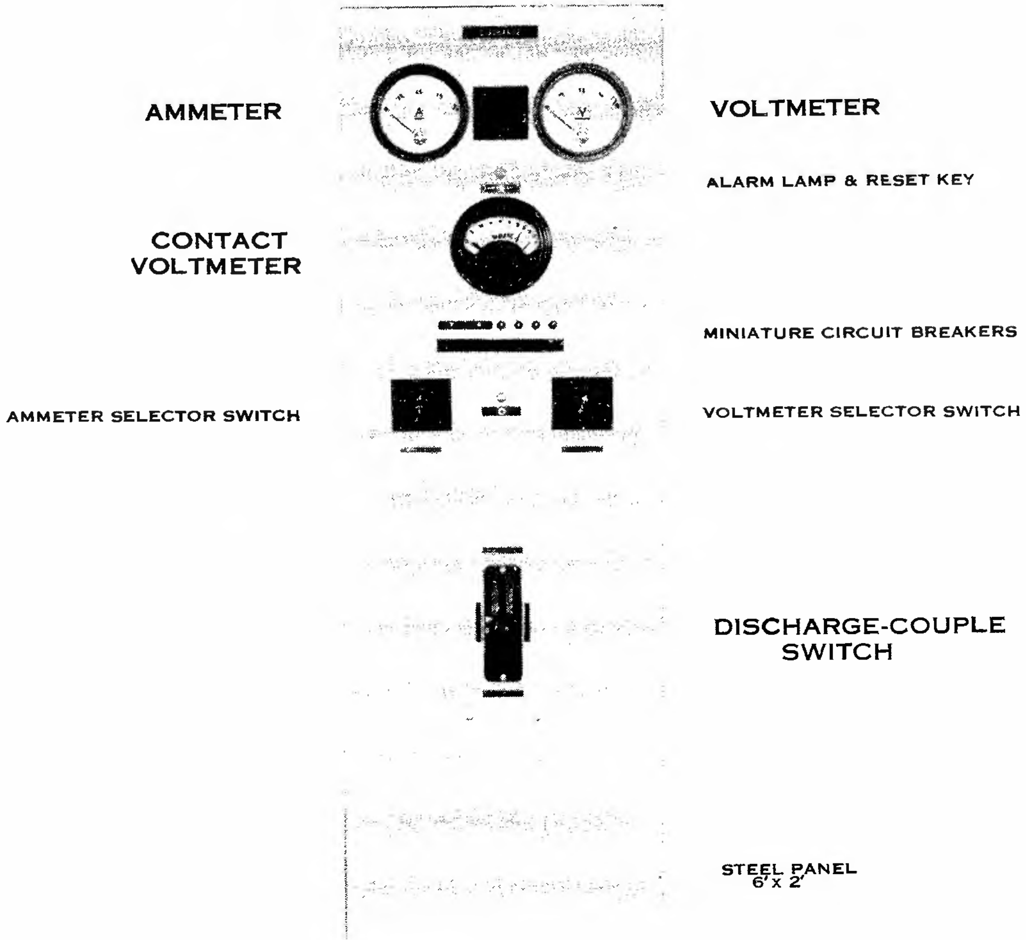
The miniature thermal over-current circuit breakers are used in the 50V + discharge circuit and a number of auxiliary circuits such as 50V emergency lights and voltmeter leads.

Between the ammeter and voltmeter is a metal plate on which is shown a simplified schematic drawing of the circuit elements.



POWER CUBICLES IN EQUIPMENT ROOM.

FIG. 2.



50V DISCHARGE PANEL.

FIG. 3.

3.3 The typical power circuit of a modern exchange is in Fig. 4. Some less apparent details of the arrangement are :-

The 50V positive supply is from an eliminator with dry cells as standby. Eliminator output of 1.5A is sufficient for most auto exchanges, but where sleeve control manual or telegraph equipment are also installed, a larger eliminator with automatic voltage regulation would generally be provided, or a positive battery of small secondary cells and floating rectifier. In some cases vibrator inverters are used as standby instead of dry cells.

The voltage alarm (Fig. 5) includes a delay of approximately 1 minute so that the high and low voltage contacts may be set for close limits, but transitory fluctuations beyond these limits do not cause an alarm. The Vth thermal relay is mounted on the yoke of the V relay. Once Vth operates, VS relay holds on VS1 via the reset key so that the alarm continues until the voltage is corrected and the circuit reset. The voltmeter contacts are protected from pitting by the 4,000 ohm limiting resistor, and also by MRA across V which dissipates the effects of self induction when the contacts break.

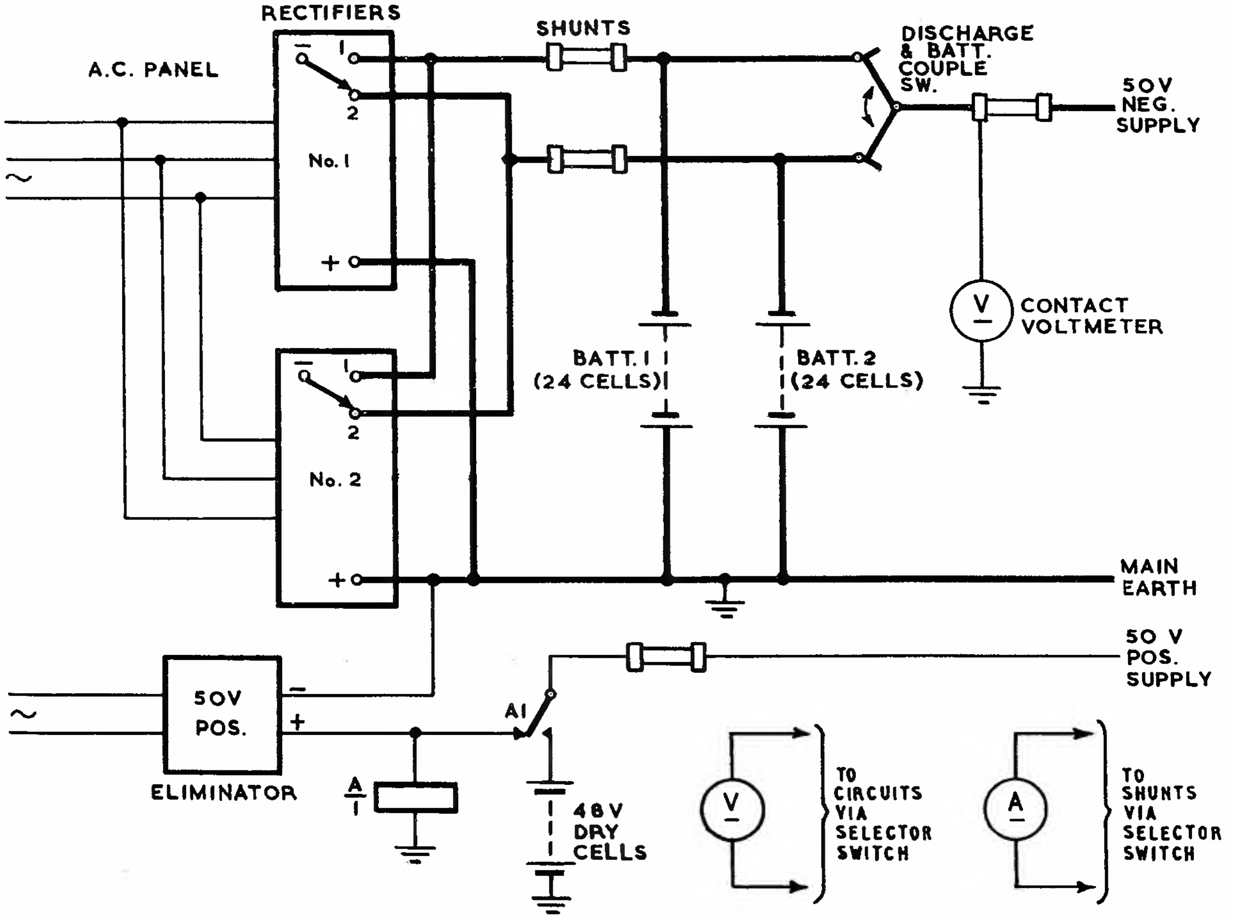


FIG. 4. TYPICAL POWER CIRCUIT.

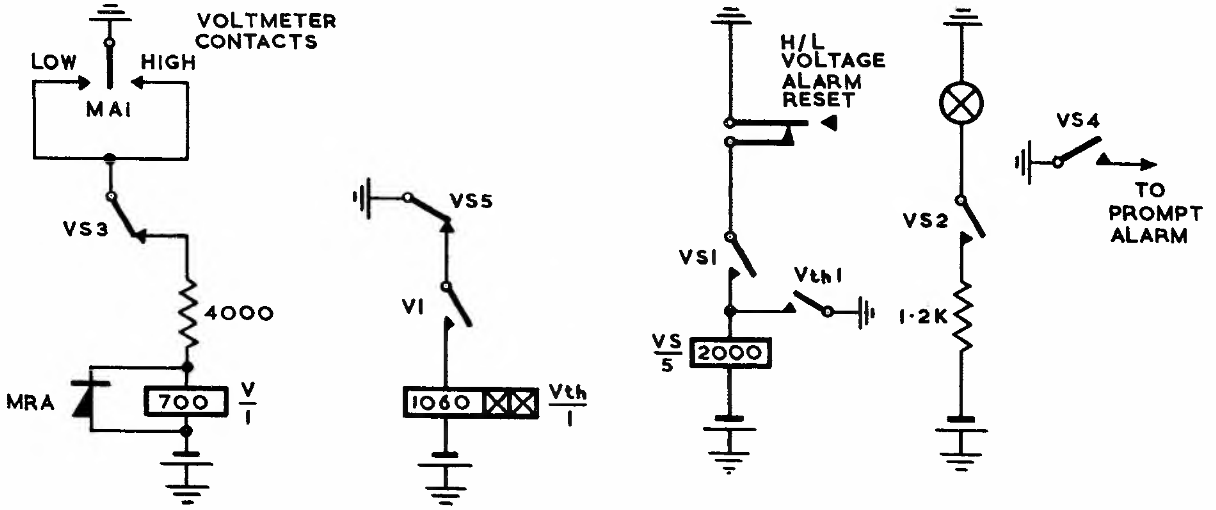


FIG. 5. TYPICAL VOLTAGE ALARM CIRCUIT.

3.4 Exchanges with motor generators and rectifiers. See Figs. 6 and 7.

In Fig. 6, note the motor generators, the ringing machines and the power board in the background. The rectifiers are mounted in line with the other power panels; one is visible on the left.

The power board in Fig. 7 is typical of exchanges installed before 1950. In this particular case the rectifier is situated in another part of the power room.

The switches and control equipment are bolted to slate or insulating board and a typical power board consists of -

Discharge Panel which includes -

Discharge switch, exposed type, single pole make before break. (A)
Battery couple switch, single pole make. (B) In some cases a duplicate discharge switch is used, in parallel with the first.
Voltmeter and selector switch. (C)
Differential ammeter and selector switch. (D)

Generator Panels, one for each generator, which include -

Circuit breaker. (E)
Charge switch exposed type, single pole 2 way (F)
Voltage regulator. (G)
Regulator switch, double pole 2 way, for switching from auto to hand regulation. (H) (The regulator and switch may be on another panel.)
Field rheostat, generally with two concentric hand wheels, one for coarse control and the other for fine control. (J)

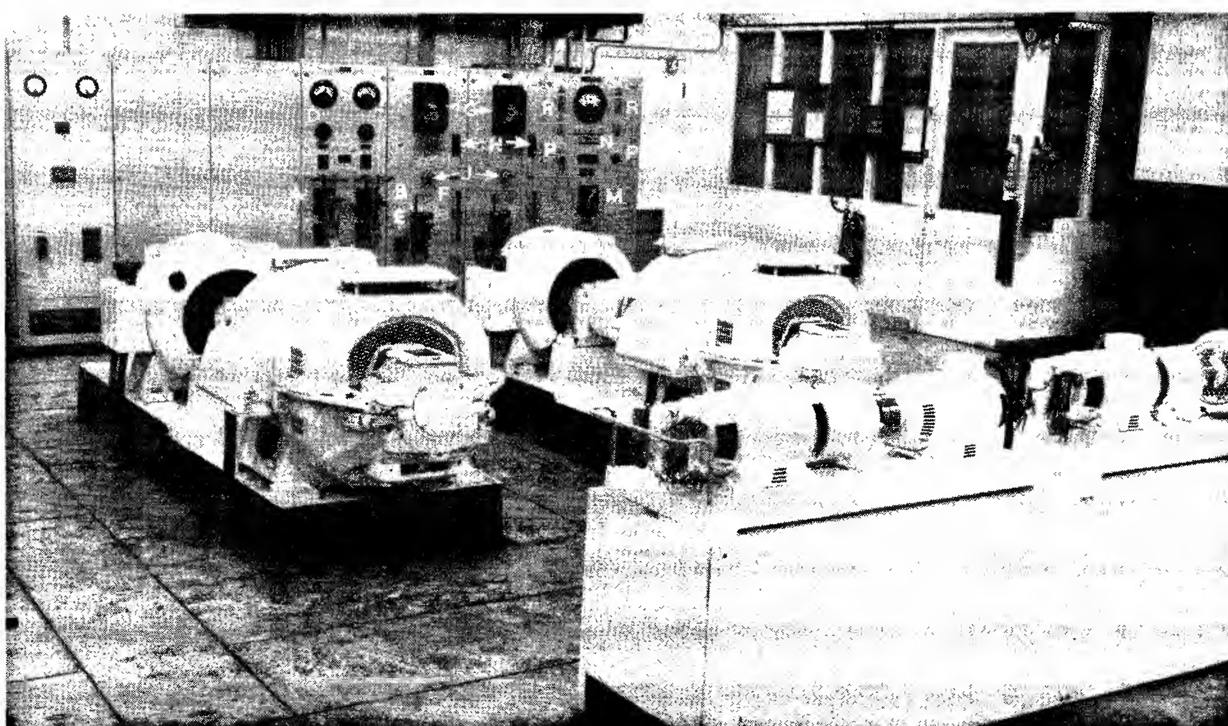


FIG. 6.

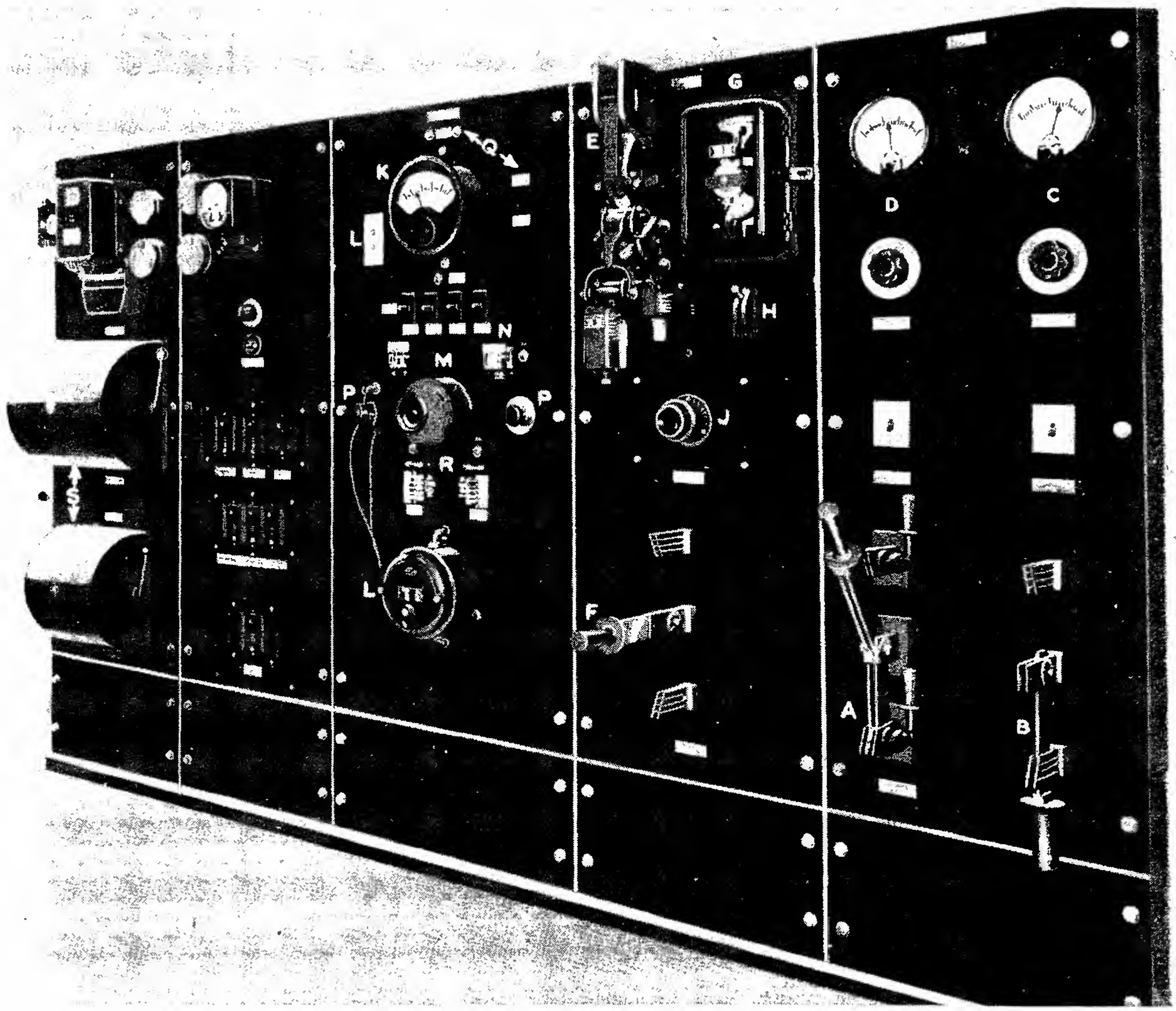


FIG. 7.

Ringer and Voltmeter Panel. This includes -

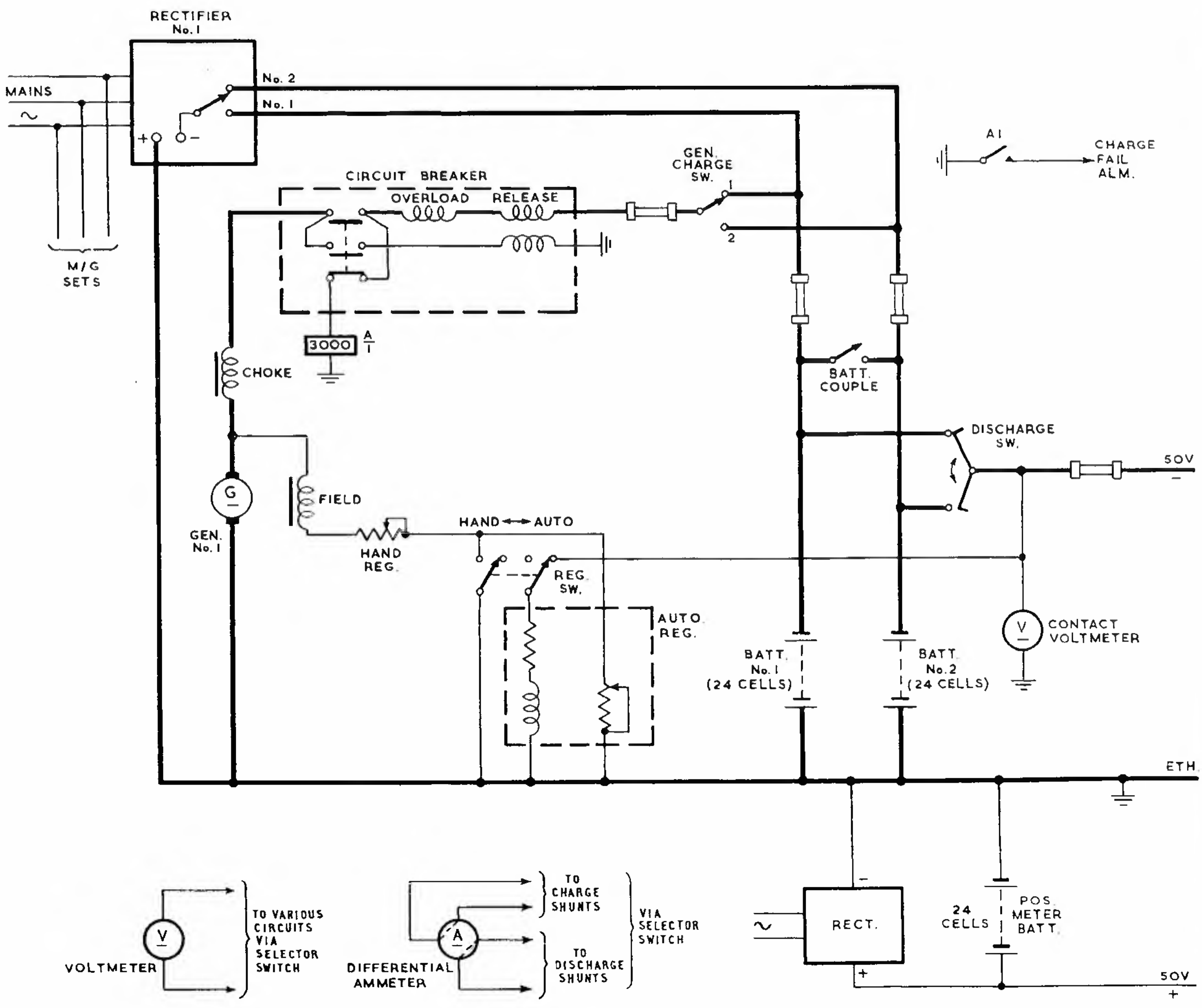
Contact voltmeter. (K)
Ringing machine control equipment; push button starters for each machine (L); special machine changeover switch with solenoid trip for automatic change over on failure of machine 1. (manual reset from 2 to 1) (M); ring fail test keys (N); head receiver and selector switch for monitoring tones (P).
Lamps and reset keys for voltage alarm and ring fail alarm (Q).
Miscellaneous alarm type fuses (R).

A.C. Panel. As described in paragraph 3.2 for modern exchanges. Note the manual switches in Fig. 7 for mains to standby change over. (S)

Fig. 8 is a typical power circuit (simplified) for an exchange having rectifiers and motor generators. Only one rectifier and one generator are shown; others are connected in the same way.

The differential ammeter may be switched with one coil across any of the charge shunts and the other across the discharge shunt. During floating the resultant charge or discharge current of the battery will be indicated.

The voltage alarm circuit is omitted, as it is very similar to the later circuit in Fig. 5, except that there is no thermal relay, and hence no delay before the alarm is sounded.



TYPICAL EXCHANGE POWER CIRCUIT.
(with motor generator and rectifier).

FIG. 8.

3.5 Power Distribution. In 2000 type exchanges busbars are used for power distribution. From the power board a main feeder follows the shortest convenient route to the equipment room where branch feeders serve the individual suites and racks of equipment. See Fig. 9. The busbars are classified as follows -

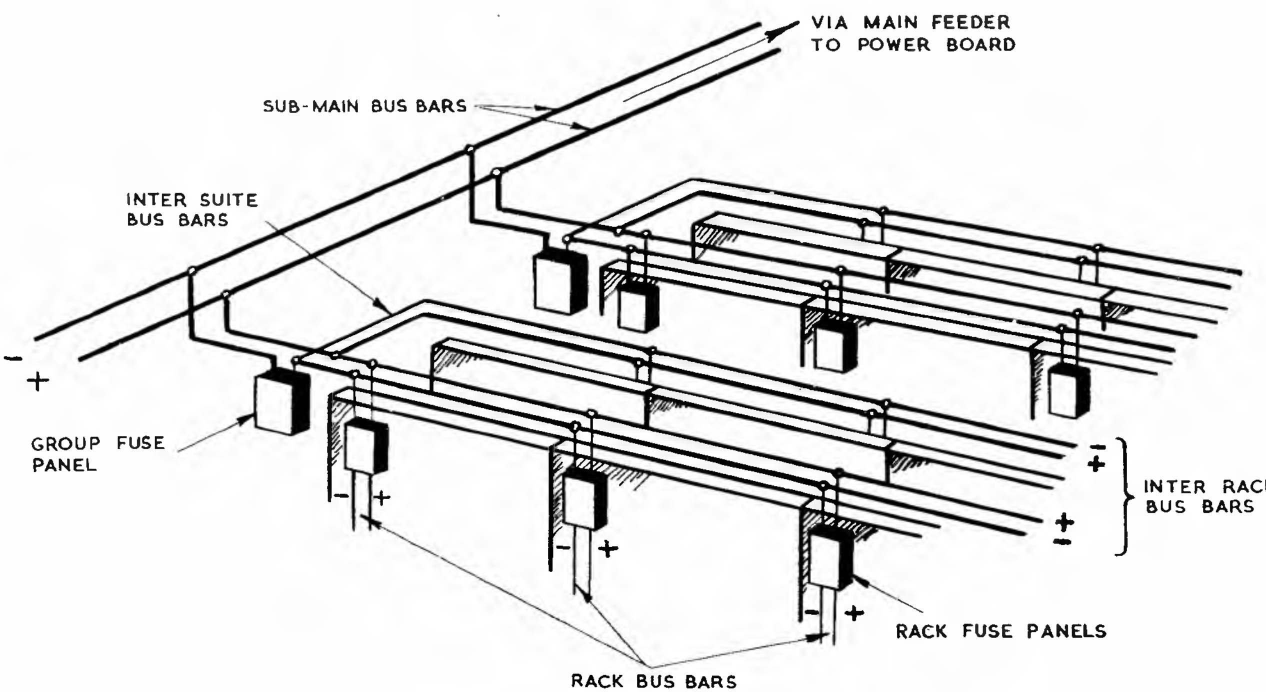
Sub-main busbars. These connect to the main feeder from the power board and run at right angles to the suites of racks in the main aisles of the equipment room.

Inter-rack and inter-suite busbars. These run along the top of the racks in a suite, and between adjacent suites served by a single tee off the sub-main busbars.

Rack busbars. These $\frac{1}{2}$" x $\frac{1}{4}$" bars run vertically down the left side of each rack. The rack fuse panels containing alarm type fuses serving the various shelves of equipment are screwed directly to these bars which are tapped for the purpose. The earth bar is supported by several brackets bolted to the rack. This connection is not insulated and each rack is separately earthed by this means.

The size of bar used for the main feeder, the sub-main and the inter-rack and inter-suite busbars varies with the size of the exchange. As the load carried by the bars decreases the size is reduced, the reduction being made at a branch.

The connection between the inter-rack and sub-main busbars is either direct or via a group fuse. Group fuses are fitted where the capacity of the battery exceeds 500 Ah. The group fuses are cartridge fuses fitted to an insulating panel in the form of a shallow box bolted to the side of the rack. The panel also contains a spare fuse with one side disconnected, and an alarm fuse. Typical ratings for group fuses are 75A and 125A. For the correct method of replacing group fuses see E.I. TELEPHONE Exchanges Auto. M 2000. With busbar distribution, fuses in the main feed from battery to power board are rarely used.



POWER DISTRIBUTION IN 2000 TYPE EXCHANGE.

FIG. 9.

4. LONG LINE POWER PLANT.

4.1 Long Line stations vary greatly in size from those having only one or two carrier terminals or repeaters, up to the main trunk centres in capital cities. Methods of providing power are also many and varied.

4.2 Duplicate sets of 24V and 130V batteries are generally provided; Fig. 10 is a typical power circuit of a long line station with duplicate batteries.

The manual control or auto/manual rectifiers have built in output-switching for connecting the charge to either battery. Voltage 'sensing' leads (to the controller or D.C. amplifier of the auto controlled rectifiers) are taken from the discharge side of the power board, so that the voltage drop in the shunts and switchgear is taken into account in the regulated voltage.

The by-pass electrolytic capacitors directly across the 24V and 130V supply busbars, lower the impedance of the supply to any high frequency voltages fed back from carrier equipment; this avoids undesirable coupling between systems via the common supply impedance.

The voltage alarm circuits for each of the contact voltmeters are identical to Fig. 4 except that the relays have resistance and turns suitable for 24V operation instead of 50V.

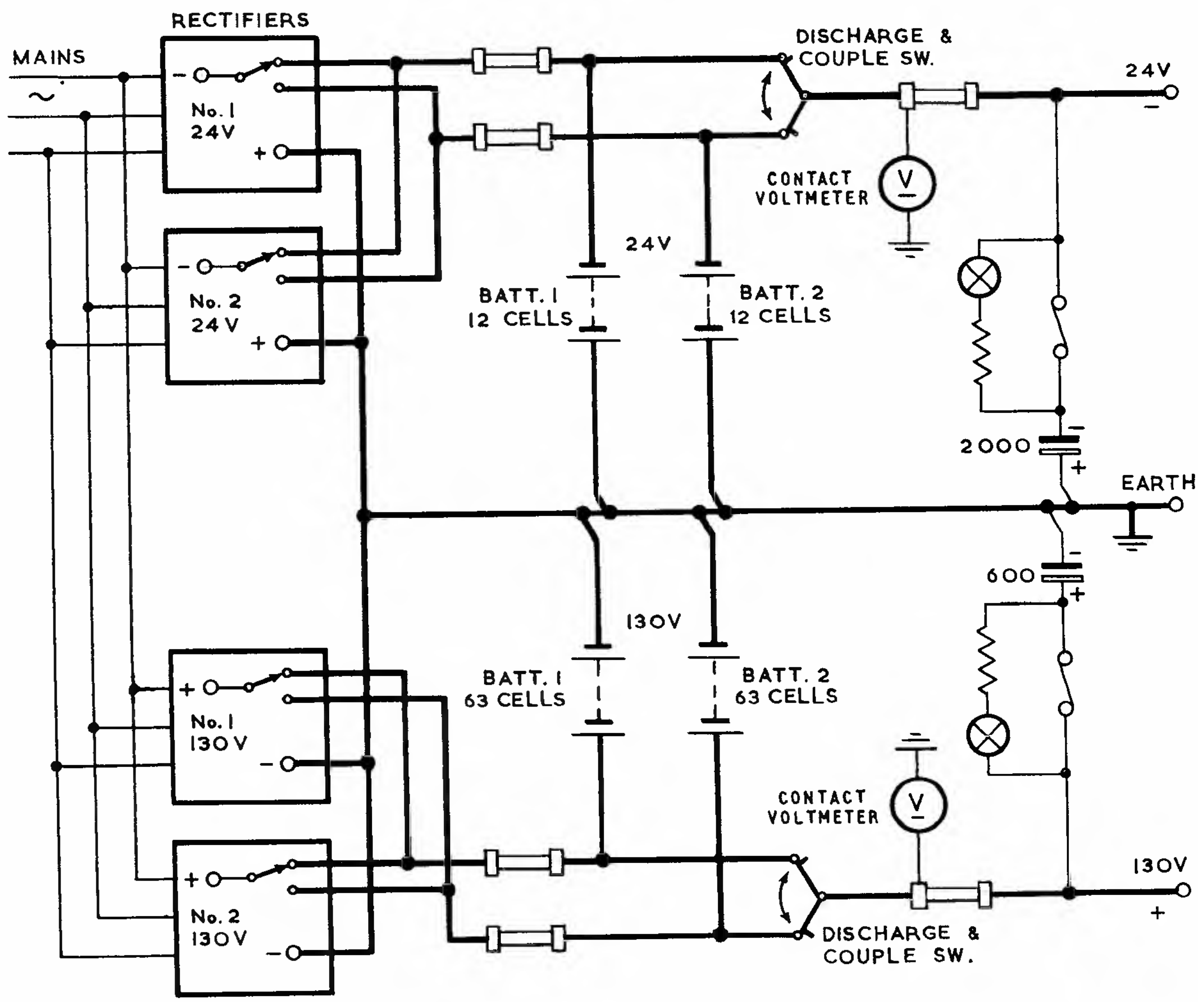


FIG. 10. TYPICAL POWER CIRCUIT LONG LINE STATIONS.

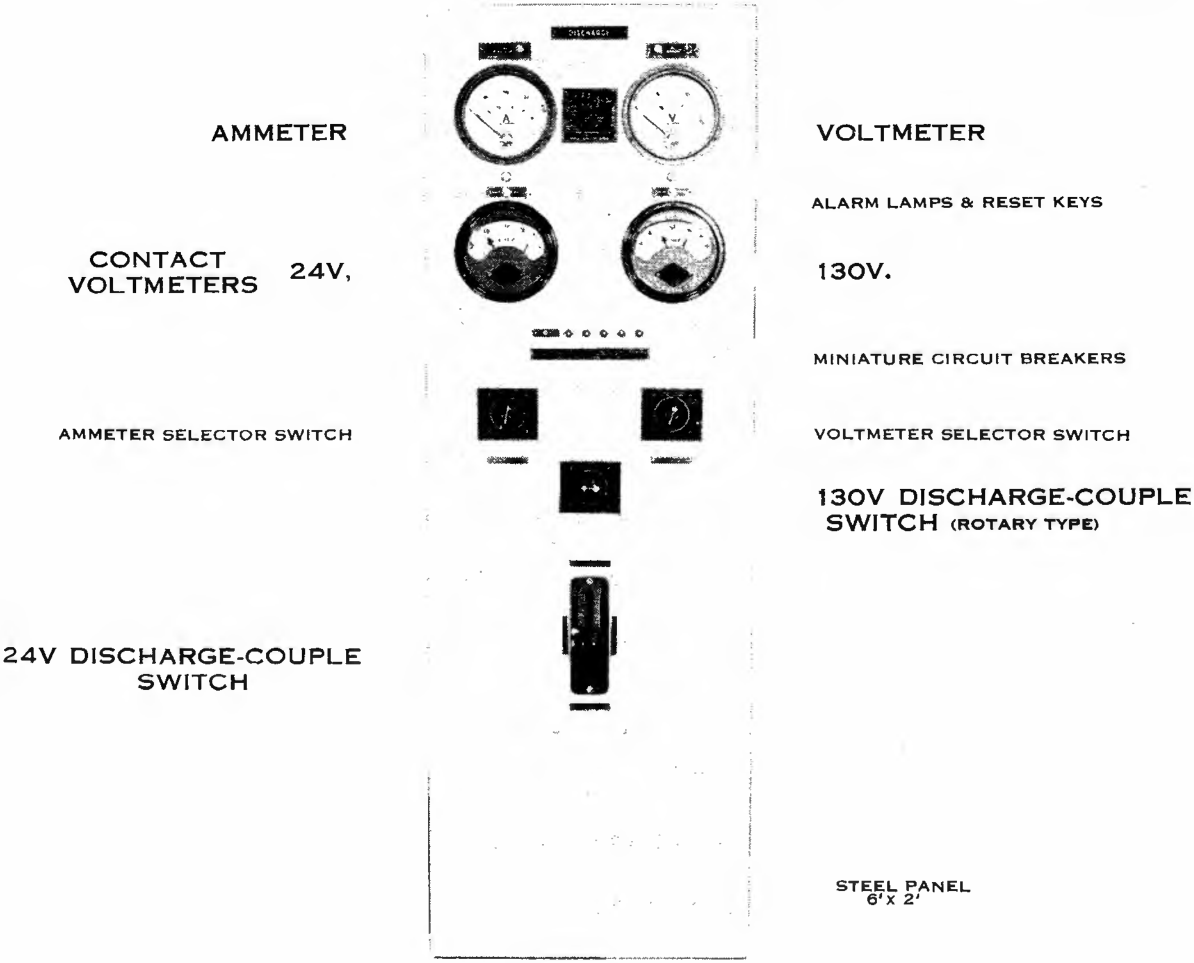


FIG. 11. DISCHARGE PANEL. 24V-130V.

4.3 For installations with duplicate sets of 24V and 130V batteries a standard discharge panel has been developed - Fig. 11. This is generally mounted in line with the rectifiers in a similar way to that used in modern exchanges.

Owing to the space required for 130V batteries (which are often open cells in glass containers) cabinets are not used to house the batteries; a separate battery room is provided. However 10 Ah enclosed cells recently introduced will greatly reduce the space needed for H.T. batteries.

500 Ah enclosed cells are being used for the 24V batteries, and where greater capacity is required a second parallel 'string' of cells may be provided in one or both batteries.

4.4 At stations where V.F. telegraph systems are provided, 50V- and 50V+ are used for the marking and spacing battery. This is obtained from the exchange supply when available or from a separate eliminator. Originally 130V- and 130V+ were used for marking and spacing with VFT systems. In this case there are usually three sets of 130V batteries. Double pole switching is provided so that each battery may serve with either pole earthed, or be isolated for refresher charges.

4.5 In some of the larger long line stations motor generator sets are used mainly for 24V. For floating, automatic regulators may be used although the load variation is usually small. The circuit in Fig. 8 applies equally well to stations where duplicate 24V batteries are operated from motor generator sets (substitute 12 cell batteries and omit the positive battery).

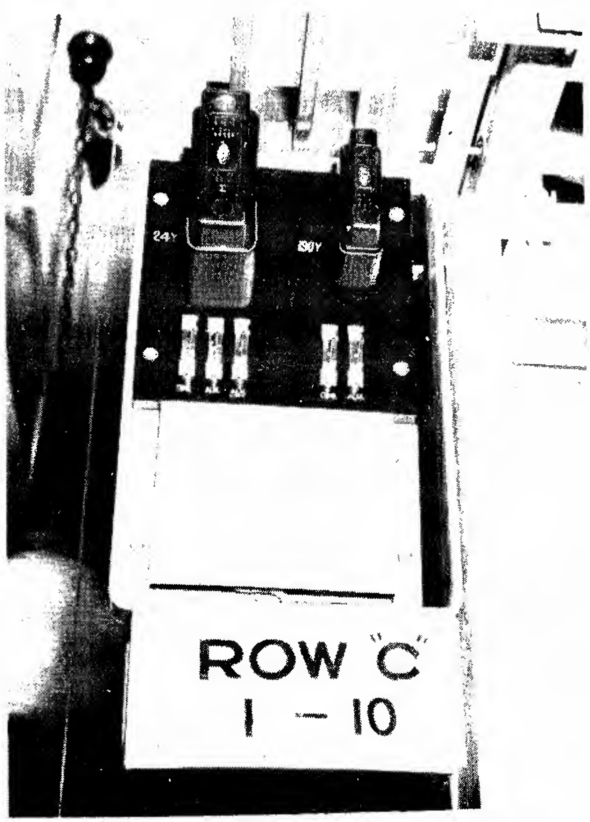
4.6 At several large stations and at many smaller ones, the long line equipment is operated without batteries. The equipment is either designed for direct connection to the A.C. mains, or 24V and 130V eliminators serve one or a number of systems.

Where there are sufficient channels to warrant it, or where there are very important circuits, standby plant of the no-break (or slight break) type is provided (see Section 7).

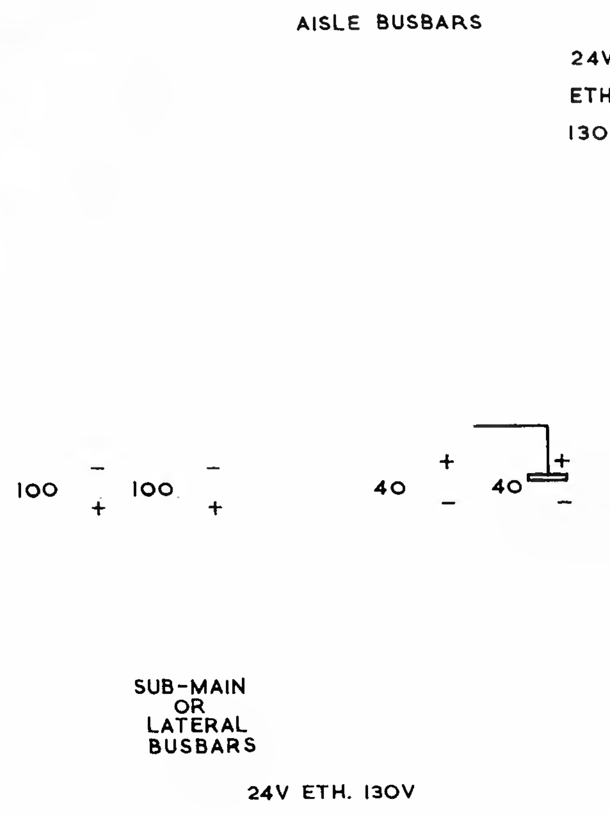
4.7 Many small stations have only one set of batteries (24V and 130V) and these may serve all of the equipment, or only some, the other items being served by small eliminators.

4.8 Power Distribution in long line stations is generally by means of busbars. Cables are also used, where there is very little long line equipment, or where for instance 50V positive and negative leads are required for one or two VFT systems only.

The main feed from the power board branches into busbar runs, either in the centre of an aisle with rows of racks on each side, or along the side of aisles with racks to one side of the busbars, (centre aisle assembly or side aisle assembly). From these aisle runs, short busbars connect to sub-main distribution panels on the end of a row of equipment racks. See Fig. 12a. These include cartridge fuses for both 24V and 130V supplies, a metal box containing capacitors connected across each of the supplies to further reduce the supply impedance at high frequencies for that row, and an alarm lamp panel. Fig. 12b shows the circuit elements (excluding alarm lamp circuits).



(a) Sub-Main Fuse Panel.



(b) Circuit Elements.

FIG. 12.

4.9 Trends. 130V batteries or eliminators for small stations may be superseded by transistorised DC - DC converters operated from the 24V supply. Where a 50V battery is available, a 50V - 130V converter would be more suitable, and together with A.C. operation of the heater circuits would also in some cases remove the need for a 24V battery. Since indirectly heated valves will operate for several seconds without heater current as long as H.T. is maintained, standby plant which takes over after a slight break will ensure continuity of service. However with the special valves used in some modern systems no break is essential.

Another likely use of the converters is 50V+ and 50V- supplies for VFT systems, operated from 24V.

5. COMBINED STATIONS POWER PLANT.

5.1 Many country stations have telephone exchanges (auto or C.B. manual), sleeve control trunk exchanges, and carrier terminals and repeaters. Modern practice is to design the power plant on a combined basis.

5.2 Where duplicate 50V, 24V and 130V batteries are provided and estimated maximum 50V and 24V drains do not exceed 300A the discharge panel in Fig. 13 is used. The circuit is the 50V circuit in Fig. 4 combined with the 24V and 130V circuit in Fig. 10, and alarm circuits for each of the three contact voltmeters as in Fig. 5.

For larger stations two discharge panels are used, one for the 50V supply (see Fig. 3) and one for the 24V and 130V supplies (Fig. 11).

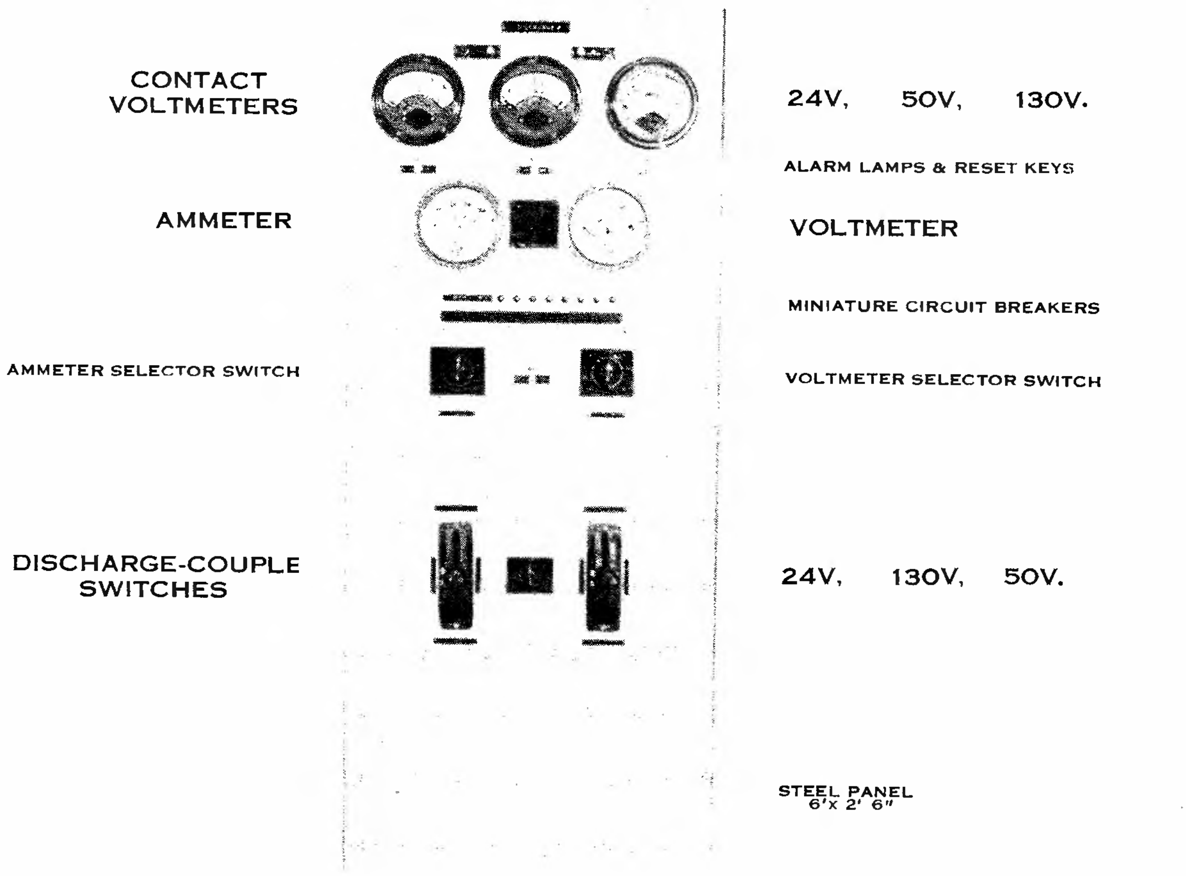


FIG. 13. MULTI VOLTAGE DISCHARGE PANEL.

6. OPERATION OF CONVERSION PLANT.

6.1 Floating. Where commercial power supply is available, batteries are operated continuously on a constant voltage float basis, that is, with the battery and conversion equipment connected in parallel across the load. Where two batteries of the same voltage are provided, these are coupled on the power board and floated in parallel. This lowers the supply impedance, and in the event of a mains failure the batteries share the load.

Floating is preferred to the earlier charge-discharge method of operating because :

- Energy costs are greatly reduced by supplying the load direct from the conversion plant; this avoids the losses incurred in converting the energy from electrical to chemical and back to electrical.
- The full capacity of the battery is available in the event of a power failure.
- Battery life is increased (providing instructions related to floating voltages etc. are strictly observed).
- There is negligible consumption of distilled water since the batteries are not allowed to gas.

6.2 For any particular battery the choice of the floating voltage limits is a compromise decided by several factors; the principal ones are -

The operating limits of the equipment.

Whether single or duplicate batteries are provided.

The voltage characteristics of the conversion plant.

Avoidance of unnecessarily high voltages which increase energy costs.

The character of the load.

The type of battery.

6.3 The operating procedures to be followed for each battery are laid down in relevant instructions. The floating voltage must be kept within the specified limits. Floating a battery outside the limits will seriously shorten its useful life. If the floating voltage is too low, the maximum battery capacity will not be available in the event of a power failure and in time the lead sulphate on the negative plates will become insoluble, resulting in a permanent loss of capacity. Too high a floating voltage will in time disintegrate the positive plates.

6.4 Generally speaking, floating at higher than 2.3V per cell results in overcharging, while floating at lower than about 2.1V per cell results in the battery discharging continuously.

Some batteries, such as meter batteries, are floated up to 2.3V per cell but this is too high for most batteries as the drop in voltage on supply failure would be too great for the equipment. A typical compromise is between 2.15V and 2.2V. This is well within the capabilities of the regulators of modern conversion plant. (See "Power Plant Components", Sections 3 and 4.)

6.5 Where the floating voltage is less than 2.2V per cell occasional "boost" or "equalising" charges are necessary. The frequency of these depends on the condition of the battery, but will generally be about once a year or more often where supply failures have allowed partial discharge.

The equalising charge, is not an overcharge or refresher charge in the old sense of the terms, particularly where modern telecom type enclosed cells are used. As the pure lead of the plates is very soft, gassing charges or overhigh floating voltages must be avoided as these in time, would disintegrate the positive plates.

Maintaining the battery at 2.3 volts per cell for a suitable period will fully recharge it. Where there are duplicate batteries, the one to receive the boost charge is taken off float. At small installations where there is only one battery, the battery can be floated at the high voltage for a time as the relatively fewer mechanisms can be maintained so that the increased voltage does not affect the operation of the equipment.

6.6 Charge-Discharge working. In the few cases where batteries are used and there is no commercial power, duplicate batteries are provided and charge-discharge working is followed. With this method one battery supplies the load while the other is re-charged; the batteries are changed over at regular intervals of one or more days, depending on the discharge rate. Each battery is given an equalising or extended charge at least once a month or more often, in accordance with the instructions for the particular installation.

6.7 To place a generator on load:

- Check that the generator field rheostat is in the minimum output (maximum resistance) position and that both the knife switch and circuit breaker are open.
- Start the motor in accordance with the instructions for the particular motor.
- Examine the generator brushes to see that they are bedded properly and there is no sparking.
- Check the voltage of the battery being placed on charge; set the voltmeter to indicate the generator output and advance the field rheostat slowly, until the voltage is 1 or 2 volts above that of the battery.
- Again examine the brushes for sparking; re-check battery and generator voltages; set ammeter to indicate the generator output.
- Close the circuit breaker first and then the generator charge switch; a small output current will be indicated on the ammeter.
- Advance the hand regulator until the generator is giving the desired output.

6.8 When the output is to be controlled by an automatic regulator, this is generally switched into circuit before the start of the above sequence. With certain regulators not compensated for temperate change, it may be desirable to switch them on to warm up, some time before starting the generator.

The generator is then connected to load as described above and as the hand rheostat is advanced slowly the regulator assumes control. The hand control is either fully advanced or set at some predetermined position marked on the panel.

6.9 To take a generator off load:

- Turn the field rheostat until the output current is reduced to approximately zero.
- Trip the circuit breaker. (In most cases the reverse current trip is so adjusted that the breaker will trip automatically at zero output or a very slight reverse current. If this is not the case it should be tripped by hand.)
- Open the generator knife switch.
- Turn the field rheostat to zero.
- Disconnect the mains supply to the motor by opening the main switch or tripping the starter release. Where the starter is of the type designed to restore on opening of the main switch, observe that it does so; if not automatic, restore by hand.
- Switch off the automatic regulator if in use.

This procedure, although it differs from that outlined in Maintenance Circular 36 is now the accepted practice.

6.10 Parallel Operation of Conversion Plant. Where the output of one generator or rectifier is insufficient for the load, units are operated in parallel. The total output is the sum of the separate outputs.

Only one unit is operated on auto control, (unless the rectifiers are designed to have load sharing characteristics) otherwise hunting may occur between units.

A scheme known as sequential switching of rectifiers is sometimes used. An auxiliary circuit containing a current sensing device in the input circuit of the first rectifier operates to switch on a second rectifier when the load on the first reaches say 90% of maximum output. The second rectifier is switched off when the load falls to well within the range of the first rectifier. The cut in and cut out values are adjustable.

7. STANDBY PLANT - CONTROL PRINCIPLES.

7.1 A control panel or cubicle is usually situated close to the standby machine and contains voltmeter and frequency meter for checking the output of the alternator. For auto start or no-break standby plant the control gear is also contained in the cubicle.

Most alternators have small D.C. generators as exciters, running on the same shaft as the alternator itself or belt driven from it. Modern alternators are self regulated against voltage variation on changing load. The frequency of output is determined by the speed of the prime mover which is accurately controlled by a governor.

7.2 Manual Control Engine Alternators. On mains failure the engine is started in accordance with the local instructions. (This may be delayed for a time where battery capacity is adequate, to avoid starting the machine for relatively short interruptions.) When the engine has reached running speed the alternator output voltage and frequency are checked. Operation of the manual switch or switches on the A.C. power board, or the standby control panel, changes the load from mains to standby. Fig. 14 shows a typical arrangement.

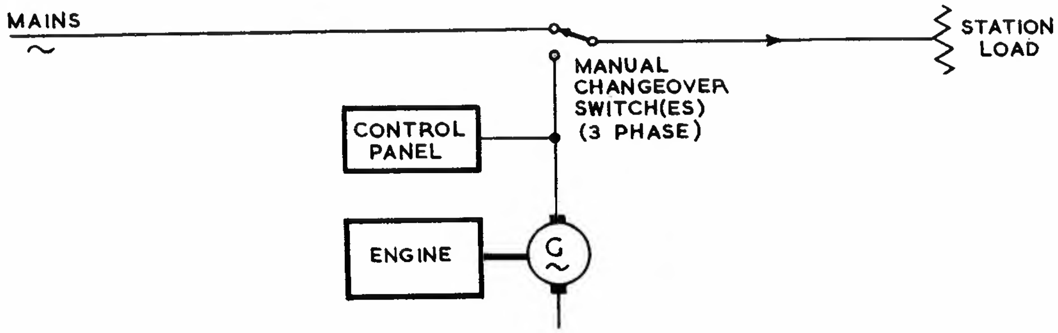


FIG. 14. MANUAL STANDBY CONTROL.

7.3 Where auto start standby diesel alternators are provided the arrangement of Fig. 15 is typical.

Failure or low voltage of one or more phases of the mains is sensed by the control circuit. The engine is started after a delay which may be from a few seconds to 15 minutes or more depending on requirements. When the alternator gives the required voltage a contactor (or contactors) switches the load to the alternator.

Restoration of the mains is sensed by the control; the contactors are released and the engine shut down after a delay. This delay is to ensure that the engine has been running for a minimum time (which may be several hours for large diesel engines) as short runs which do not allow full working temperature to be reached reduce engine life and efficiency.

Manual controls should not, in normal circumstances, be used for shutting down the engine in less than the minimum time.

Manual isolating switches are generally provided to facilitate maintenance.

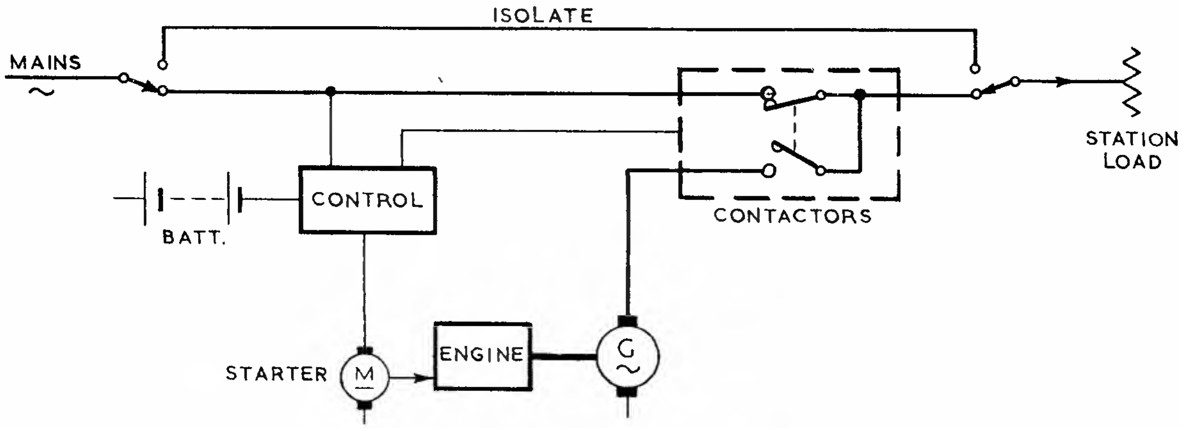


FIG. 15. CONTROL PRINCIPLE OF AUTO START STANDBY.

7.4 No-break Standby Plant. Block diagrams for the various types of no-break (N.B.) plant are given in the paper "Power Plant Components", the all-electric sets on page 22 and the diesel alternators on Page 37. As with the auto start sets (Fig. 15) mains failure is sensed by a control set which energises contactors to either start the engine and engage the clutch, or switch on the D.C. motor as the case may be.

Where there is a reliable mains supply, all-electric sets without a flywheel are preferred (as in Fig. 16). The D.C. motor is generally supplied from a 50V exchange battery but where there is no exchange a 136V motor supplied from a 63 cell battery may be provided. For remote stations without mains supply, dual engine alternators are backed up by normally stationary (N.S.) auto start sets.

Fig. 16 is a block diagram of a typical standby scheme for a combined station and shows how the A.C. load is divided into three categories, no-break, essential and non-essential in order to keep standby plant sizes to a minimum. Details of control sets are not included.

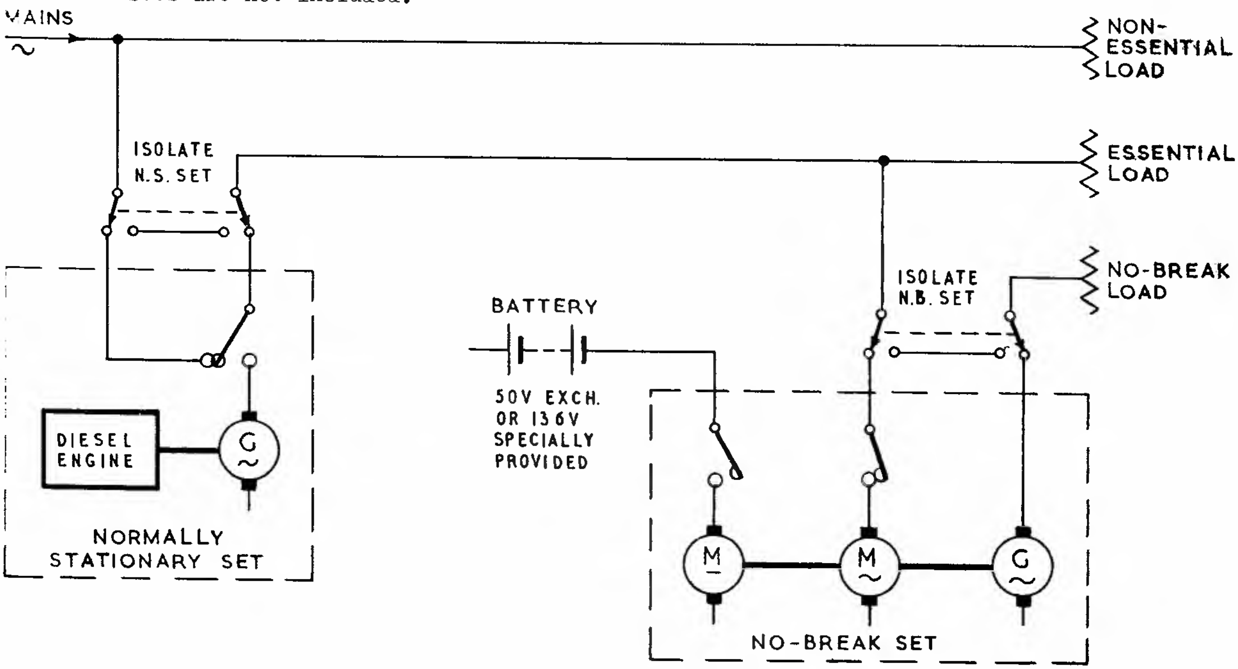


FIG. 16.

8. RING AND TONE SUPPLY.

8.1 In earlier exchanges the ringing machines are mounted on a table in the power room, one being driven by an A.C. motor from the mains, and the other as standby being D.C. operated. Change over to standby is controlled by a special switch on the power board ringer panel. See Figs. 7 and 8. This switch connects to a cam which operates the various springsets used for switching the output of either machine to load. In the "MACH. 1 " position the switch is spring loaded and held by a latch connected to a magnetic trip mechanism. Failure of Machine 1 causes tripping of the switch which restores to "MACH. 2 " position.

8.2 Modern practice is to have two D.C. operated ringing machines, rack mounted in the equipment room adjacent to the M.A.R. Fig. 17 shows a typical rack equipped with 1 Amp machines.

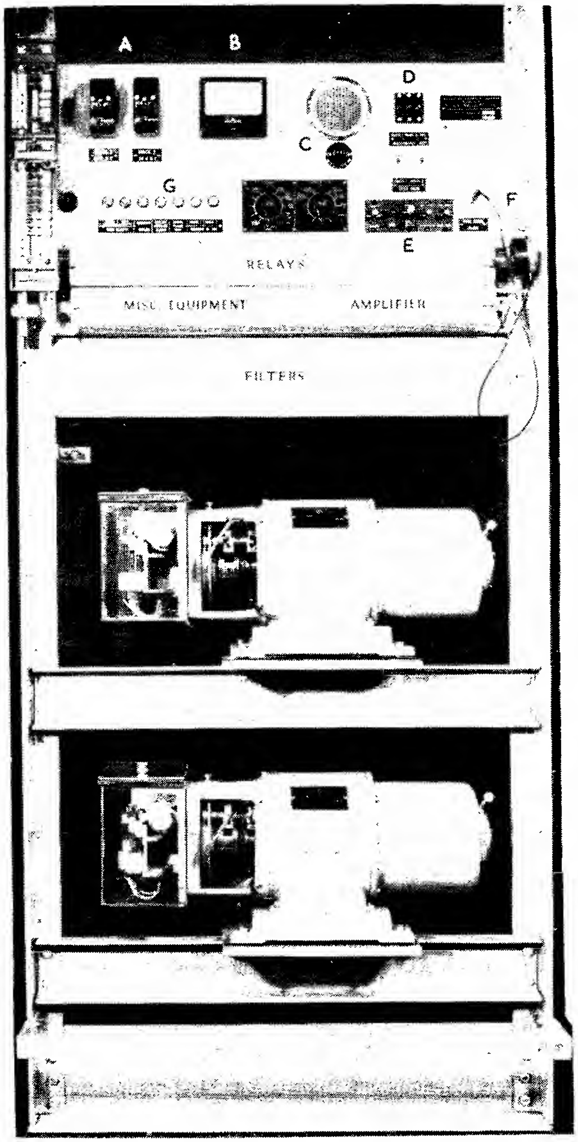


FIG. 17. RACK MOUNTED RINGING MACHINES.

Control and monitoring equipment is mounted above the machines. With most racks, either machine may be selected for duty with the other as standby (with some early racks change-over was automatic one way only). Output switching and control is by means of relays.

The control panel includes :

- Thermal/magnetic miniature circuit breakers in the motor circuit of each machine. (A)
- A combined voltmeter and ammeter with two selector switches, for checking tone voltages and ring current output. (B)
- A small loudspeaker fed by an amplifier for checking tones; a volume control. (C)
- Miniature thermal overcurrent circuit breakers in ring output and positive battery circuits. (D)
- Lever keys for control and testing. (E)
- Head receiver for checking tones. (F)
- Alarm Lamps. (G)

8.3 Circuit elements of the machine change-over control are in Fig. 18.

With Machine 1 on duty, the change-over relays are normal. The contacts of relays CA, CB, CC and CD are in the output circuits of the two machines. The contacts of relay CE complete the circuit of machine 1 motor when normal, and machine 2 when operated. When the key is operated to place machine 2 on duty CR relay operates; the CR contacts operate the five change-over relays CA to CE.

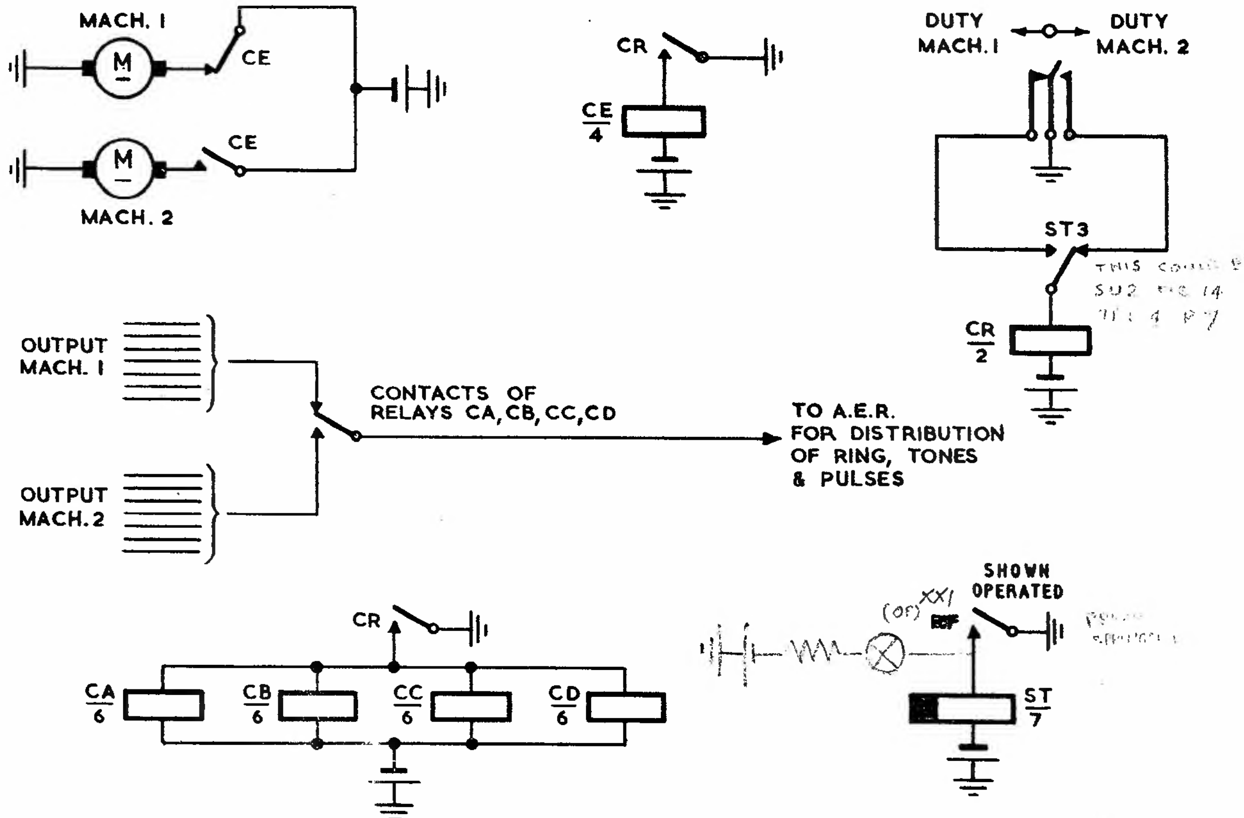


FIG. 18. CONTROL CIRCUIT ELEMENTS, RING AND TONE MACHINES.

The ring fail relay RF is normally held operated by contacts of four relays connected to the continuous ring output and the three interrupted ring outputs. Should there be a failure of any one of these four ring circuits RF will release and operate ST which will lock on its second winding.

ST3 changing over, operates CR if machine 1 is on duty, or releases CR if machine 2 is on duty. Relays CA, CB, CC, CD and CE operate or release to give the change over to the idle machine.

8.4 The interrupted ring current output is divided into three distribution circuits in order to equalise the load on the alternator. This is obtained from the continuous ring via three separate sets of interrupting springsets actuated by three cams on the machine.

The interruptions to the ring current are 0.4 seconds on, 0.2 seconds off, 0.4 seconds on, 2 seconds off; a complete cycle occupies 3 seconds. Fig. 19 shows how the load is distributed over the full 3 seconds.

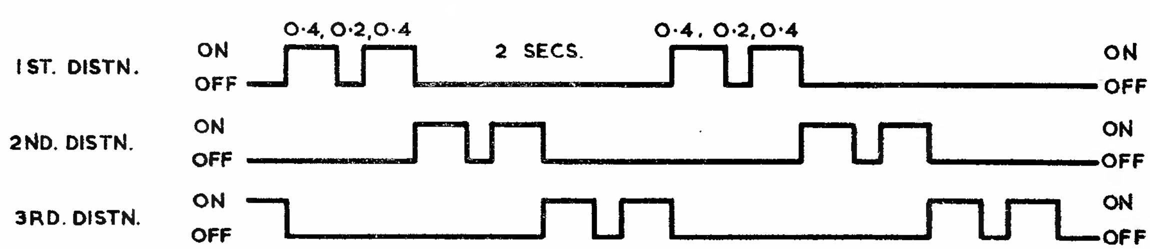


FIG. 19.

8.5 The tones and pulses from the machines are -

Ring tone 400 c/s modulated at ringing frequency, same interruption as ring current. (One distribution only.)

Dial tone 33 c/s (nominal) uninterrupted.

Busy tone 400 c/s interrupted 0.75 sec. on, 0.75 sec. off.

N.U. tone 400 c/s interrupted 2.5 sec. on, 0.5 sec. off.

Interrupted earth - 0.75 sec. on, 0.75 sec. off.

Flicker earth - 0.2 sec. on, 0.2 sec. off.

8.6 The interrupted tone circuits, ring tone, busy tone and N.U. tone have contact 'wetting' circuits using positive battery. This ensures a small D.C. in the interrupting contacts and prevents them developing high contact resistance. Fig. 20 shows a typical arrangement. Values of R and C are varied to suit different sizes of machine.

At the moment the interrupting contacts make, the charged capacitor C applies full 50V to break down any high resistance film which may have formed on any one of the series contacts in the circuit.

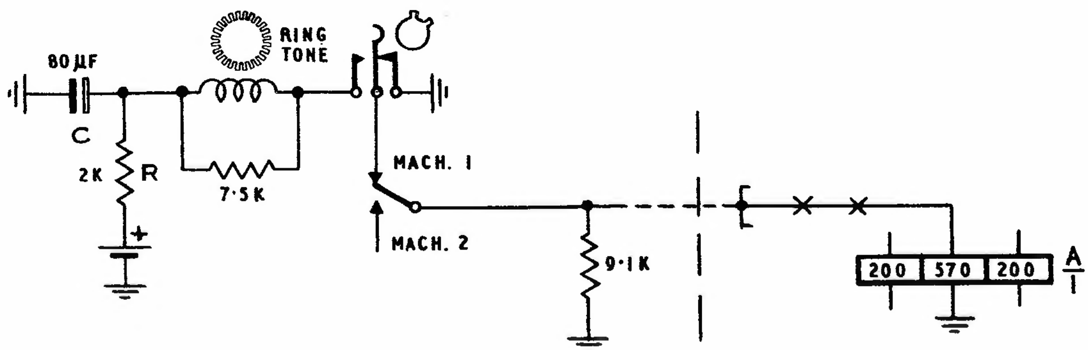


FIG. 20.

Some earlier circuits used negative battery for contact wetting but positive battery is preferred since the D.C. in the 570 ohm tone windings of A relays does not tend to demagnetize them. (Relays held via long loops have been known to release.)

The 7500 ohm resistor across the tone generating winding of the machine, and the 9100 ohm resistor to earth on the distribution leads are a spark quench because of the contact wetting D.C. in the inductive components.

8.7 Distribution of ring and tones for 2,000 type exchanges is dealt with in other papers of the Course.

9. TEST QUESTIONS.

1. (i) Explain why power supplies are generally earthed.
   (ii) Why are exchange batteries earthed at the positive pole?

2. Which poles of the low and high tension supplies at long line stations are earthed?

3. Give reasons for the choice of polarities given in Question 2.

4. By means of a simple circuit, show how the two long line battery supply potentials, are arranged in relation to the electrodes of indirectly heated valves.

5. In part of a carrier system six of the same type of valve are in use, yet the effective anode supply voltage is different on each one. Explain how this occurs.

6. Rectifiers are used for A.C. - D.C. conversion instead of motor generator sets.
   (i) Why are rectifiers preferred?
   (ii) Name the more important changes in power plant provision made possible by this.

7. What type of batteries are installed in the equipment room of some modern exchanges? Describe how such batteries are housed and operated to permit this.

8. By means of a simple circuit show how two rectifiers and duplicate batteries are connected to an exchange load via a typical discharge panel.

9. For what reason are the voltage "sensing" leads of rectifiers connected at the discharge panel instead of at the rectifier itself.

10. (i) What is the purpose of bypass capacitors across long line station power supplies?
    (ii) Where are these connected?

11. Name two alternative methods of power supply to long line equipment, where batteries are not provided.

12. Why is there a thermal relay in the voltage alarm circuit as used in modern power rooms?

13. Draw a simple schematic circuit of the arrangement of D.C. generator and generator panel equipment during full float operation with a varying exchange load.

14. Describe in general terms how power is distributed to a number of suites of equipment racks in either
    (i) A 2000 type exchange.
    (ii) A long line station using duplicate battery sets.

15. Why are duplicate batteries floated in parallel?

16. Why are batteries operated on continuous float wherever possible, in preference to the charge-discharge method?

17. Why is special care necessary in the operation of modern enclosed cells?

18. What are two important points to watch in the operation of modern enclosed cells?

19. What factors effect the choice of floating voltage for a particular battery?

20. List the steps in -
    (i) Placing a motor generator set on charge, and
    (ii) Taking it off charge.

21. With the aid of block diagrams describe the principles of change over control of the following types of standby plant.
    (i) Engine-alternator with manual control.
    (ii) Auto start diesel alternator.
    (iii) All-electric no-break set.

22. By means of a simple diagram show how non-essential, essential and no-break A.C. loads are catered for at a typical combined station.

23. (i) List the complete output of a modern exchange inductor tone generator.
    (ii) Which of these outputs are "monitored" by the control circuit to detect failure of supply.

24. Describe briefly the principles of automatic change over to a standby ringing machine.

END OF PAPER.

TESTING IN AUTO EXCHANGES.

---

1. GENERAL.

1.1 The object of testing the equipment in auto exchanges is to enable a high grade of service to be maintained with a minimum expenditure of manhours.

1.2 A new approach to auto exchange maintenance problems has arisen in the last few years, largely as a result of overseas investigation and experiment into the effectiveness of earlier maintenance and testing methods.

It was once held that the complex circuits and mechanisms would continue to provide a high grade of service to subscribers only by following a strict programme of "preventive" maintenance. This consisted of frequent testing of individual circuits sometimes under conditions more severe than those likely to be imposed by subscribers, to detect existing and potential faults before switches failed in service; routine examinations and overhauls were also a feature of preventive maintenance.

Service affecting faults occurred, however, in spite of all the effort aimed at prevention (and to some extent because of it, as the investigations revealed).

One alternative - detecting and correcting faults only after the equipment failed in service ("corrective" maintenance) was then, and still is, regarded as unsatisfactory, since the grade of service may drop seriously. On the other hand, it was found that disturbing a mechanism for routine overhaul, or examination, or after a severe 'marginal' test had revealed and 'unstandard condition', would often create an early fault which may not have occurred for a long time. This did not necessarily imply bad workmanship, but merely that it is generally unwise to interfere with adjustments of mechanisms 'bedded in' to a satisfactory working state, or even to remove dust covers. Air suspended dust and clothing fibres were proved to be the main cause of contact faults.

1.3 As a result of these findings and in keeping with overseas trends, the A.P.O. is evolving a system of "Qualitative Maintenance" - a system aimed at retaining the advantages of preventive maintenance without its defects.

Routine tests and examinations are done less frequently and ways are sought of predicting in advance just when the need for such routines will arise. This naturally varies with differing equipment items, with the position of switches in a grading (that is, early or later choices) and varies also from exchange to exchange.

1.4 Automatic routiners and manual test sets were originally designed for preventive maintenance; certain modification are necessary to make them more suitable testers for qualitative maintenance.

For detecting faults that affect service, short functional (not marginal) tests and end to end test calls are better methods and many routiners have been modified to provide these in addition to the more comprehensive marginal tests.

1.5 Automatic generation of test calls helps in exchange maintenance and units of B.P.O. design have been used in Australia for a number of years. Originally known as Artificial Traffic Equipment or A.T.E., these call generators are now named Traffic Route Testers or T.R.Ts.

Since they apply tests under the same general conditions as normal calls, T.R.Ts. are very useful for qualitative maintenance.

1.6 Manual test sets for testing switch performance are still provided, but where auto routiners are installed, they are not often used. However, manual test sets for internal trunk testing and meter testing are used in all exchanges.

There are about 40 different manual test sets for various types of auto exchange equipment including several for testing during exchange installation. Only a few testers in common use are dealt with in this paper. These are Test Set 17, Test Set 24 and Test Set 16A.

2. AUTO ROUTINERS.

2.1 Automatic routine testers are provided in large auto telephone and trunk exchanges. A routiner tests the functions of one class of circuit only, so that in a large exchange there are several routiners.

A large amount of additional work and wiring is needed to enable routiners to test thousands of individual items of equipment, but this is warranted because:

- the labour is much less than that for manual testing.
- routiners can be operated by a very small staff during the night or other periods of light traffic.
- being rack mounted, routiners readily incorporate the more complex tests such as relay timing, which are not so practicable with portable manual test sets.

2.2 Each routiner has two main parts -

The access unit.

The test unit.

The access unit and associated access selectors provides the link between the test unit and the equipment to be tested and, on a general routine, give the routiner access to all the items of equipment in turn.

The test unit applies a series of tests via the access equipment.

Keys are provided on the routiner for starting, access control and other functions. Fig. 1 shows a typical routiner - in this case a final selector routiner; other routiners are very similar in appearance, the access control equipment being identical in many cases.

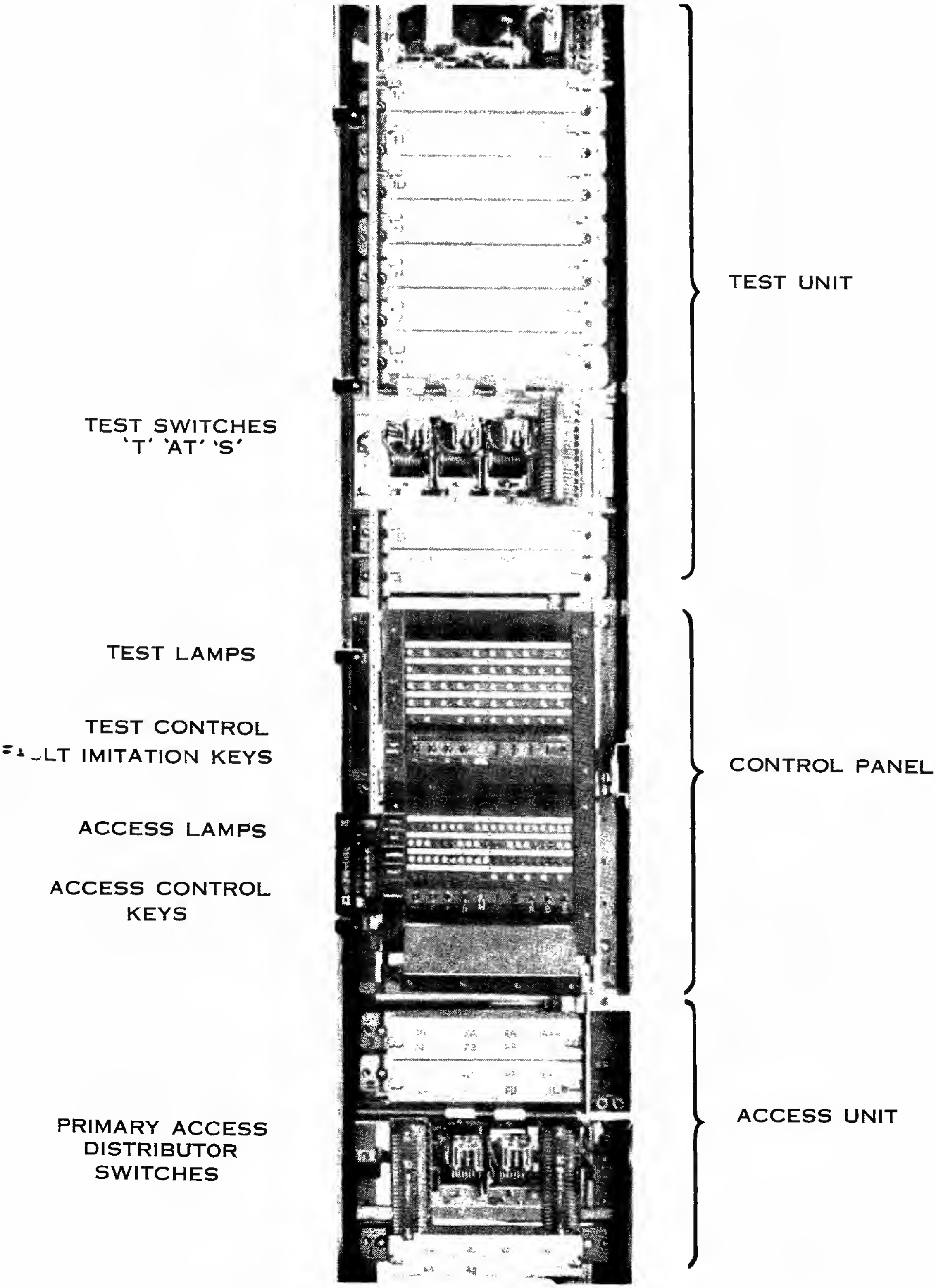


FIG. 1. TYPICAL AUTO ROUTINER.

The main types of auto routiners in 2000 type exchanges are -

Group selector routiners.

Final selector routiners.

Junction R.S.R. routiners.

D.S.R. routiners.

2.3 Facilities provided by a typical routiner are -

A sequence of tests to a selector or repeater, to check all its functions.

Lamp indication of the test being performed.

An alarm should the switch under test fail to pass any test.

Allows the testing sequence to be continued when a fault has been noted.

Busies the switch under test (except incoming selectors).

Returns busy tone to the caller on incoming selectors if the junction is seized while testing is in progress.

Camps on a busy switch until free, or until a 3 - 6 minute alarm operates.

Continuous testing of one switch when required.

Fault conditions may be applied to the routiner to test its operation (fault imitation).

Lamp indication when all tests are finished.

The routiner functions are altered automatically to test slightly different circuits, e.g. ordinary and P.B.X. final selectors.

Cancellation of tests not required (in some cases).

Short Routine facility (in some cases).

2.4 Since first introduced in the nineteen thirties, there have been several changes to all types of routiners, ranging from minor circuit modifications, to redesign of the access circuit and access equipment layouts.

The most significant change is the use of uniselectors as access switches; bimotional access switches are used with routiners installed before about 1947.

Fig. 2a shows in block form the principle of a routiner with bimotional access selectors and Fig. 2b shows one having uniselector access switches.

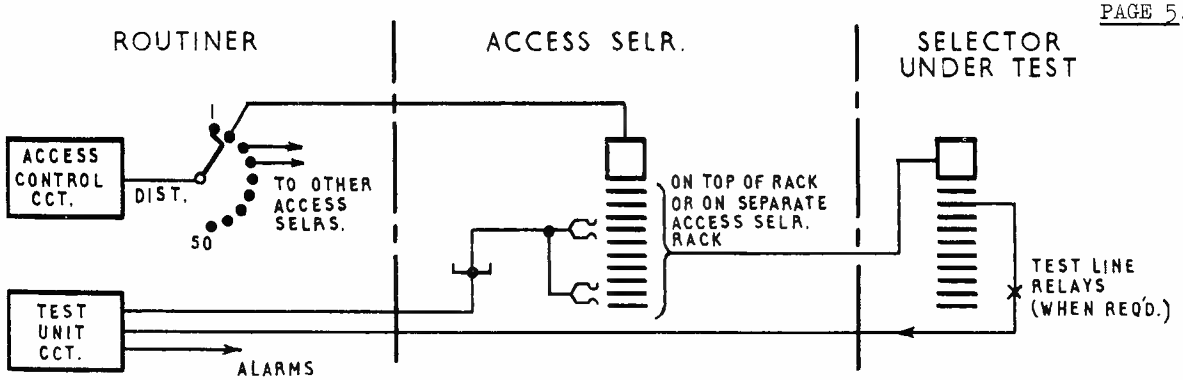
<u>Access selectors</u> are arranged in different ways, the methods succeeding each other as follow :-

Separate access racks having 6 bimotional, 100 outlet selectors.

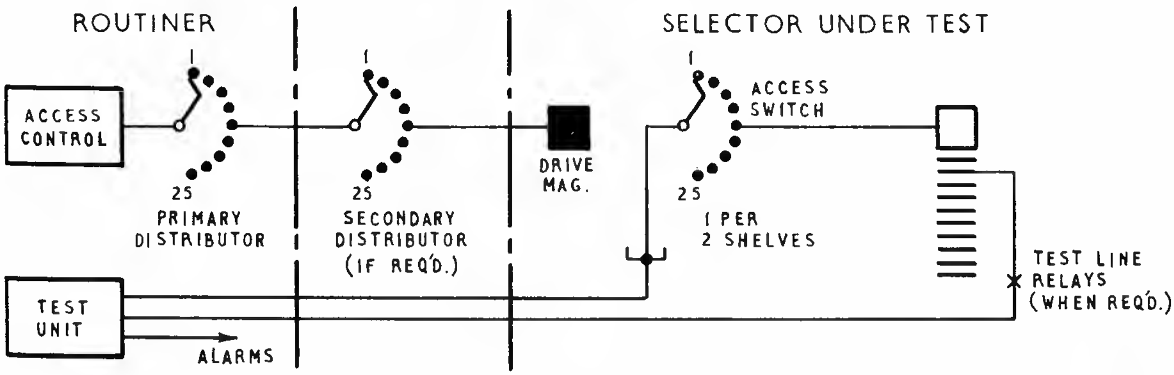
One bimotional access selector per rack of selectors or repeaters to be tested, mounted on top of the rack.

Access uniselectors, 25 outlet, 1 per 2 shelves, and mounted on the racks served; at the top of the rack for R.S.Rs. and D.S.Rs. and behind alternate shelves of group and final selectors. (Fig. 3).

The main reason for the changes was to reduce the amount of cabling.

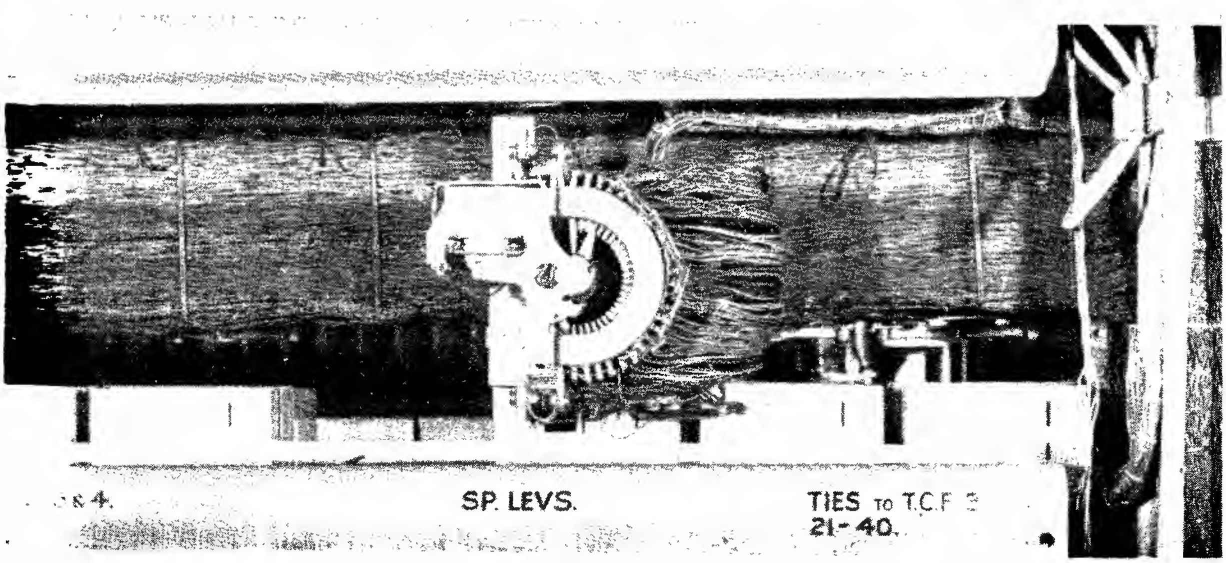


(a) Bimotional Access.



(b) Uniselector Access.

FIG. 2.



ACCESS SWITCH ON GROUP SELECTOR RACK.

FIG. 3.

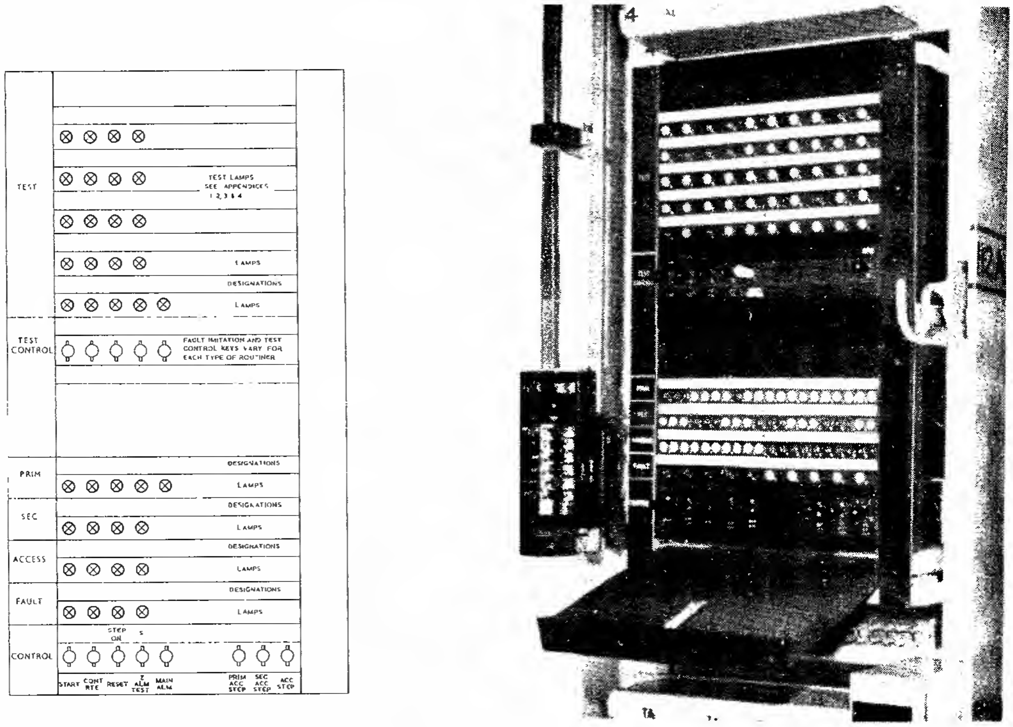


FIG. 4. TYPICAL ROUTINER CONTROL PANEL.

2.5 The Access Unit has the following keys for control and supervision of the testing; (from left to right). (See Fig. 4).

START With the access selectors at normal, operation of this key starts a general routine at the first switch. It may also be operated after the access selectors are positioned individually on a particular switch.

CONT RTE (Continuous Routine). To give continuous testing of one switch; when operated before the START key, enables the access switches to be stepped to a particular switch with the Stepping keys.

STEP ON Operated momentarily to step on to the next switch to be tested and restore the testing circuit to normal - usually after a fault is encountered.

RESET Operated momentarily to recommence testing on a switch during continuous routine.

ALARM TEST S & Z Checks the operation of the alarm circuits when operated in the S and Z directions in turn.

MAIN ALARM Operated to disconnect the routiner alarm from the main (audible) alarms of the exchange.

Stepping Keys to position the access selectors by hand after operation of the CONT RTE key and before operation of the START key.

Bimotional Access		Uniselector Access
DIST STEP	(Distributor Step)	PRIM ACC STEP (Primary Access Step) (or equivalent, such as RACK STEP).
ACC VERT STEP	(Access Vertical Step).	SEC ACC STEP (Secondary Access Step) (or equivalent, such as SHELF STEP).
ACC ROT STEP	(Access Rotary Step).	ACC STEP (Access Switch Step).

Access lamps above the keys indicate the wiper positions of the access switches. The routiners have an access chart on the routiner rack by which the outlets of the access switches can be converted to rack, shelf and switch numbering. However, on later routiners the lamps indicate the rack, shelf and switch directly, the access uniselectors being arranged for this facility.

.6 Test line relays indicated in Fig. 2 are required for group selectors and P.B.X. final selectors only.

Group selector test lines are the 19th and 20th outlets on level 9 (known as 1st and 2nd test lines). The test line relays are operated from the routiner to divert these outlets from their normal trunking back into the routiner. Fig. 5 shows the principle and a typical arrangement. When level 9 is a dead level, the P wires of these outlets are normally earthed.

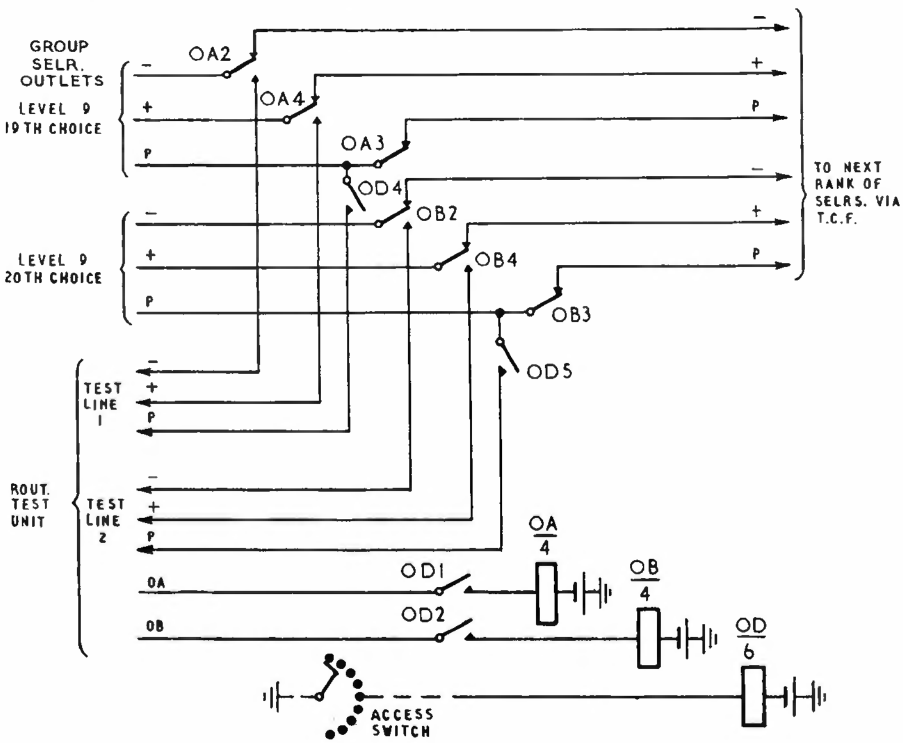


FIG. 5. TYPICAL TEST LINE SWITCHING.

Final selector test lines are the 11th step, level 9 in both hundred groups (that is, 1st test line is 9/11 with WS relay normal and 2nd test line is 9/11 with WS operated). No test line switching is necessary for these outlets.

To seize the 2nd test line of 2/10 P.B.X. final selectors, the selector is stepped 90 and drives to 9/11. Test line switching is provided on the P1 outlets of 90 and the P2 outlets of 99 and 90, 2nd hundred.) This is done in a similar way to that shown in Fig. 5.

The P2 wire of 99 is included in the test line switching arrangements in case 99 and 90 are the last two lines of a subscriber's P.B.X. group. During testing a test line relay contact earths 99 P2, temporarily converting it to the last line of the group. This prevents possible interference with the tests.

The OA, OB and OD test line relays are mounted on the right of group selector and 2/10 P.B.X. final selector racks. One set of these relays is provided for each 20 group selectors (2 shelves); originally, one set was provided for each graded group on level 9. Final selectors have one set per 200 line group.

2.7 The Group Selector Routiner. The main tests applied to a 200 outlet group selector are -

The A relay is tested for operation and release under marginal conditions.

The switch is then stepped to level 9, three times -

(i) Long line pulsing; 1st test line seized (19th outlet), combined time of CD (C) relay release and rotary drive checked; + and — wires tested for continuity and minimum resistance; even choice wipers checked to ensure they are open circuit.

(ii) Short line/low insulation pulsing; 2nd test line seized (20th outlet); CD release and rotary timing again checked; + and – lines tested for continuity and minimum resistance; odd choice wipers checked for open circuit.

(iii) Short line/low insulation pulsing; switch drives to eleventh step; busy tone and overflow metering circuit checked.

Each time the switch is released the P wiper is checked for continuity of the guarding earth. The last release of the switch is timed to ensure it is within the limits.

A complete test of one group selector takes about 30 seconds. In Appendix 1, page 25, the tests for group selectors are listed in order, with further details on the routiner functions.

2.8 The Final Selector Routiner. The main tests applied to 200 line final selectors are -

The A relay is tested for operation and release under marginal conditions.

The release time of the B relay is checked.

The selector is stepped four times to the 9th level, 11th choice -

(i) Short line/low insulation pulsing to 1st hundred test line free.

(ii) Short line/low insulation pulsing to 1st hundred test line busy.

(iii) Long line pulsing to 2nd hundred test line free.

(iv) Long line pulsing to 2nd hundred test line busy.

During these tests, all the other functions are tested - ring, ring trip, metering, reversal, busy tone, correct polarities of wipers, release timing, etc.

In the case of P.B.X. finals, the 2nd test line is reached by stepping 90 plus one P.B.X. drive pulse to 9/11. The routiner automatically modifies its functions slightly to suit ordinary or P.B.X. finals; suitable strappings in the access control circuit bring about the change.

Because of the additional functions of final selectors, the final selector routiner test unit is a little more complex than that of the group selector routiner. To test a final selector takes about 75 seconds.

Further details of the final selector routiner are in Appendix 2, page 26.

2.9 The R.S.R. Routiner. The main tests applied to auto-auto repeaters are -

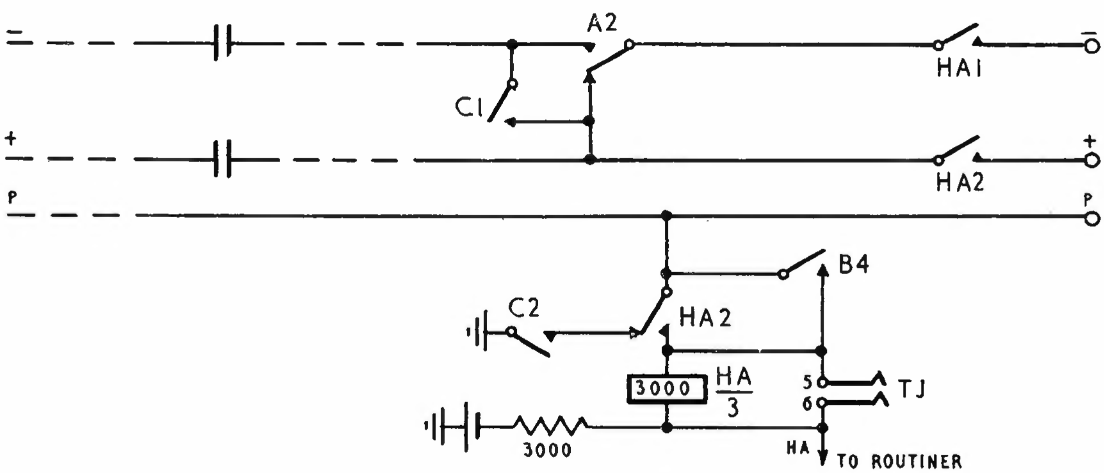
The A relay is tested, the junction line potentials checked, and on the release of the A relay, the guard-during-release feature of the relay set is checked.

The incoming lines are tested for correct potential and the relay set tested for pulse repetition with four different combinations of incoming and outgoing line conditions. A bimotional selector on the routiner rack responds to each of the repeated pulse trains by stepping to level 9, cutting in one step and then releasing.

Metering pulse and reversal are checked. By means of strappings in the access control circuit, the R.S.R. routiner discriminates where required between different types of repeater; auto-auto, auto manual, digit absorbing and conversion repeaters (to Siemens No. 16 auto exchanges).

During most of the tests the relay set is isolated from the junction by the HA relay in the repeater remaining normal; a short circuit is placed on it from the routiner to prevent its operation. See Fig. 6.

The complete series of tests on one R.S.R. takes about 20 seconds. Further details of the R.S.R. routiner are in Appendix 3, page 28.



PART OF R.S.R. CIRCUIT.

FIG. 6.

2.10 The D.S.R. Routiner. Because of the many functions of discriminating selector repeaters, the D.S.R. routiner is the most complex of 2000 type exchange routiners. The functions of each switch are tested -

as a repeater via the junction hunter.

as a selector on levels 1 and 9 to simulate an adjacent branch call.

Pulse repetition is tested with four combinations of incoming and outgoing line conditions, including long line and short line/low insulation. A bimotional selector in the routiner receives each of the repeated pulse trains and cuts into level 9, 1st step, before releasing.

The test lines used are the 24th outlet of the junction hunter, plus level 1 outlet 11, and level 9 outlet 11 of the selector.

The complete series of tests on a D.S.R. takes nearly 80 seconds. Further details of the D.S.R. routiner are in Appendix 4, page 32.

2.11 How the Tests are Applied. Although the test unit circuit of a routiner is complex, the circuit used in any one test is generally fairly simple. The complexity is due to the auxiliary functions of the routiner, together with the large number of individual tests. ("Auxiliary" refers here to such functions as stepping from one test to the next, signalling the access control to step on to the next switch, fault imitation and alarm signals etc.)

The number of test leads incoming to each selector or repeater from the routiner test unit varies: group selectors have 5, final selectors 4, R.S.Rs. 6 and D.S.Rs. 14. Fig. 7 shows the group selector arrangement which is typical. As the D.S.R. routiner has 14 test leads each D.S.R. circuit includes an RT relay whose contacts give the test unit 7 incoming access points in addition to 7 via the access uniselector. The RT is operated from the routiner via the access selector. Fig. 8 shows the principle. See Appendix 4 for more detail.

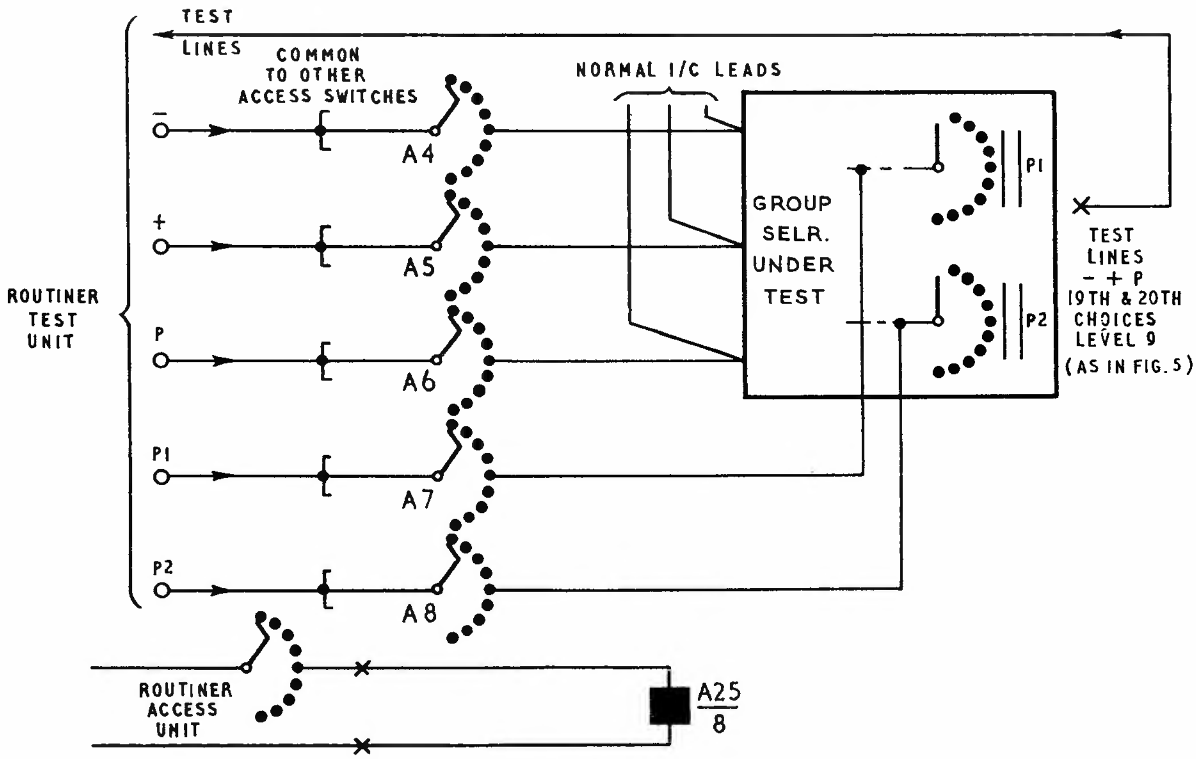


FIG. 7.

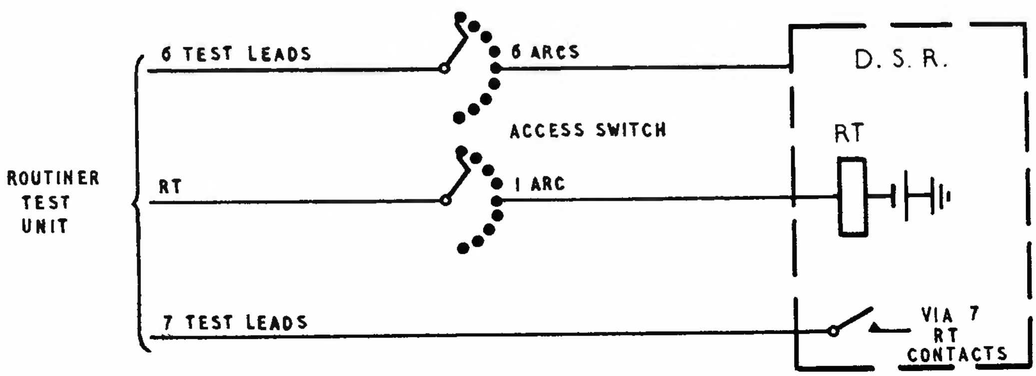


FIG. 8.

Test Switches. A routiner test unit includes three, 8 wiper, 25 outlet uniselectors known generally as the Test (T) Auxiliary Test (AT) and Send (S) switches. (See Fig. 1).

The circuits applying the individual tests are wired to the outlets of the T and AT switches as shown basically in Fig. 9. Most tests correspond to one outlet of the T or AT switch, although some tests occupy two or three adjacent outlets.

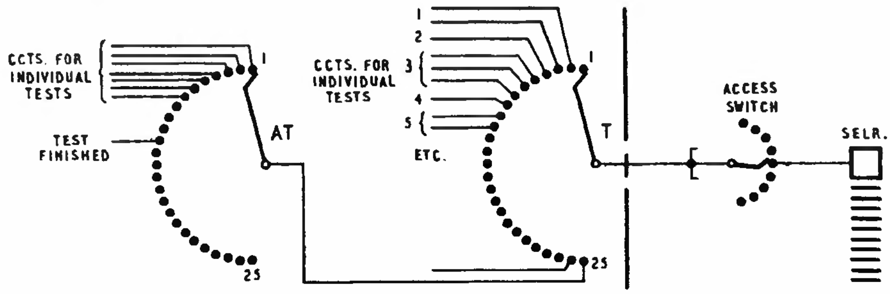


FIG. 9.

As a typical example, the "A Relay Operate" test of a group selector routiner is applied as shown in the simplified circuit of Fig. 10.

The T switch steps on from the previous test to position 5. The test lamp lights via wiper T2. The 2500 ohm loop via wipers T4 and T5 operates relay A. PX operates via wiper T6 and operates PY. PY4 opens the operate coil of PX. If the A in the group selector fails to operate, or through some other fault, earth is not returned on the P wire, PX will release and prevent the T switch magnet receiving the pulse to step on to the next test.

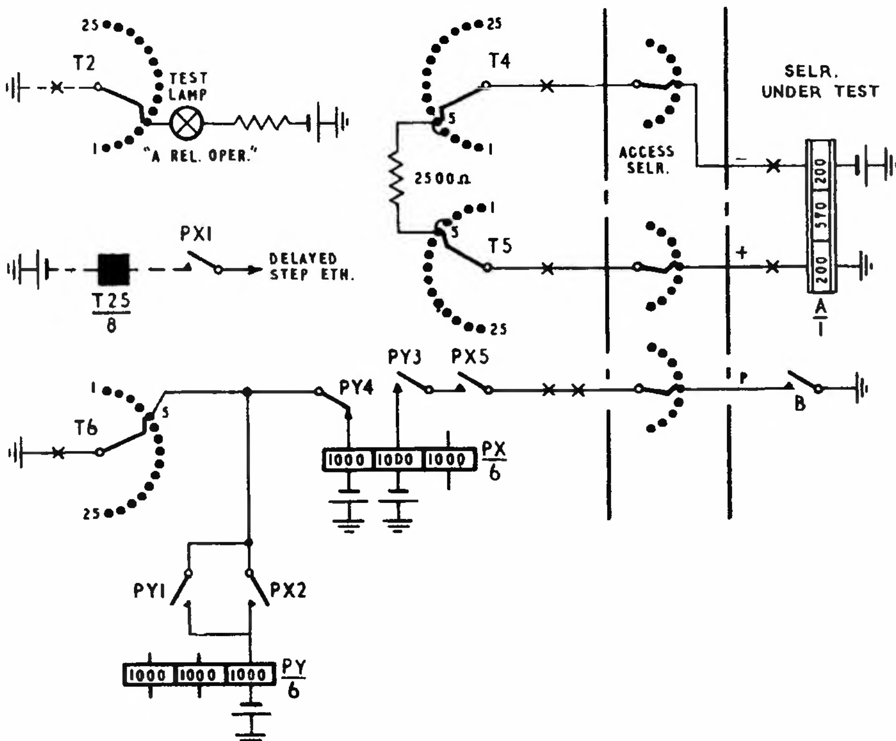


FIG. 10.

The S switch controls the 'dialling' pulses fed to the selectors during stepping tests, and for some other tests performs timing functions while stepping at a constant speed over an appropriate number of contacts. The actual dialling and timing pulses are produced by either –

An impulse machine mounted on the M.A.R. with a small constant speed motor and a series of cams and springsets for supplying several routiners with pulses, or

A relay interrupter circuit in the routiner itself.

The pulses provided are –

10 p/s, ratio, 1 make – 2 break for input to the A relays of selectors or repeaters.

10 p/s, ratio, 2 make – 1 break }
20 p/s, ratio, 2 make – 1 break } For the S switch magnet during impulsing and timing tests.

As an example Figs. 11 and 12 show the basic circuits for stepping group selectors to level 9 under long line conditions and seizing the first test line.

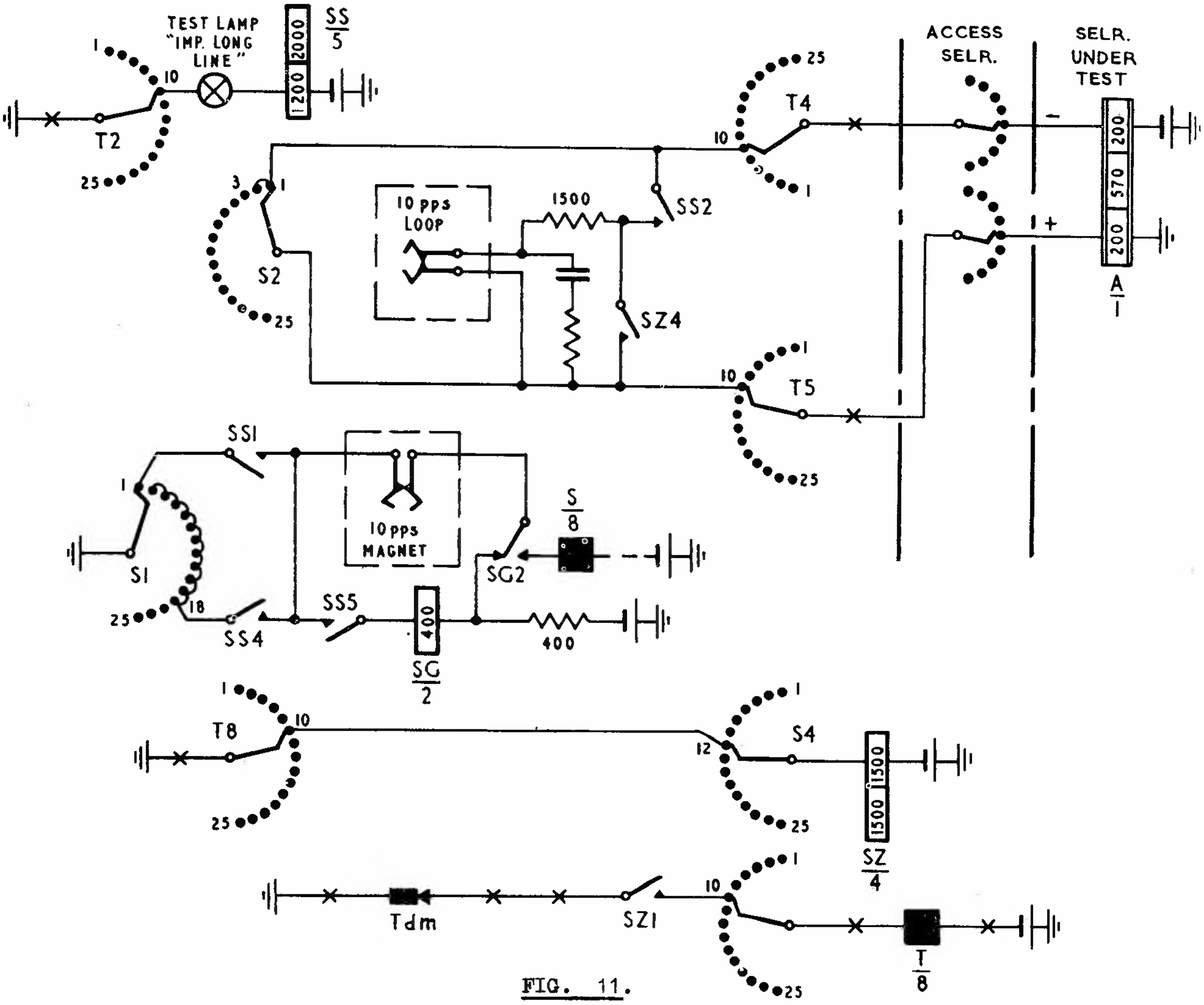


FIG. 11.

The T switch steps to position 10 and connects the long line loop to the selector. SS operates in series with the test lamp which lights. SG operates and connects pulses to the S switch magnet.

When S2 wiper reaches contact 3 the short circuit is removed from the pulsing loop, and the group selector steps. SZ operates when S4 wiper reaches contact 12, after 9 pulses have been sent. SZ4 stops pulses to the selector. The selector cuts in on level 9. SZ1 causes the T switch to step to position 11.

Referring now to Fig. 12, the group selector drives over all the early choices (both free or busy) by earth being placed directly on the P1 and P2 wipers from the routiner.

When the 10th rotary step is reached, earth fed via P1 contact and wiper P1 is returned on the test line to short circuit the bias circuit of VAA. High speed relay P operates and removes the earth from P1 wiper; the selector tests in to the 19th choice or 1st test line.

The timing of the CD relay release and rotary drive (not shown in Fig. 12) is performed by the S switch continuing to step at 10 steps per second. If the test line is not seized by the time S reaches contact 17 (about 600 mS) another relay is operated which gives an alarm and stops the routiner with the "C Timing" lamp glowing.

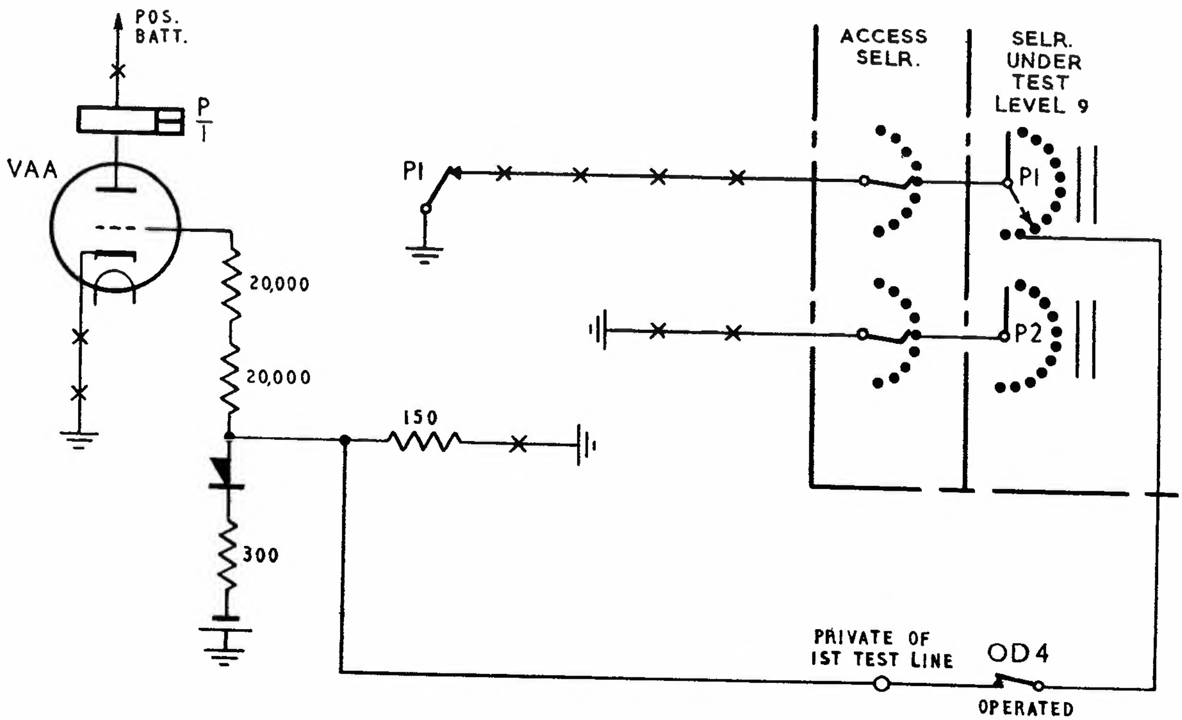


FIG. 12.

2.12 In this paper it is not practicable to describe all the tests; the examples given show how the test unit applies typical tests. An important point to note is that failure of any test prevents the completion of the circuit which normally steps the T or AT switch to the next test. Contacts of relays involved in the test complete the alarm circuits as required.

2.13 Miscellaneous.

When incoming selectors are seized over the junction while being tested, the routiner stops and must be reset before the testing can proceed; the subscriber receives busy tone. In a few cases, incoming junctions are provided with patching relays which operate from the routiner and provide a spare selector to the junction. Should a call be made via the spare selector while the normal incoming switch is being tested, the routiner is held at the end of the test, as the normal switch cannot be returned for service until the junction clears. This facility is rarely provided.

Modified Routiners. Many routiners have been modified to provide one or both of the following facilities -

(i) A short series of functional tests for group selector routiners, includes the stepping of the selector to any predetermined level from 1 to 0, and allowing it to test in to the first free outlet on that level. Alternatively, the outlet seized may be confined to either an odd or even choice, using keys to busy the P1 or P2 wiper.

The continuity of the P wire guarding earth is checked during the test and the polarity and potential of the outgoing +, − and P leads tested. This short test cycle is sufficient to ensure that the selector has switched correctly to the succeeding switch and has not tested into a busy trunk.

A strip of jacks is mounted above the control panel and wired to the test unit. A fibre plug inserted in one of the jacks determines the number of digits sent.

Using this "Functional Test" (or "Fast Test") facility, selectors are tested at the rate of about 400 per hour under conditions similar to those imposed during normal calls.

Alterations to the routiner are few, the additional equipment is mainly three keys, five relays and the strip of jacks.

(ii) A "Short Routine" cycle used in some States before the development described in (i) above, was applied to all types of routiners and this modification concludes the test of a switch after it has been looped, and released (the first few tests of an ordinary test cycle). This proves that a switch will step vertically and release on the first level, while maintaining correct polarities of the incoming +, − and P wires. In the case of R.S.Rs, correct seizure release and junction potentials are checked.

Group selector and D.S.R. routiners may be modified to serve as Traffic Route Testers. Details of this and other related access unit modifications are given in paras. 3.5 and 3.6.

With any of the above modifications the normal control keys and the access stepping keys function as described in para. 2.5.

2VF Relay Set Routiners. Automatic trunk exchanges and large automatic transit switching centres are equipped with auto routiners for testing the 2VF trunk line relay sets. In general, the principles outlined for 2000 type exchange routiners apply. Motor uniselectors are used and individual positioning of access selectors is by pulses from a dial on the routiner instead of by stepping keys. A motor uniselector operated at constant speed from the 50 c/s mains supply (via a step down transformer) is used for the large number of timing tests performed.

Auto trunk exchanges may also have auto routiners for other items of equipment; Sender routiners and Outgoing Junction routiners are two examples.

3. TRAFFIC ROUTE TESTERS (T.R.Ts.)

3.1 Traffic Route Testers have two main functions -

(i) To set up calls within an auto exchange or exchange network, and record the number of calls made and the number of unsuccessful attempts. From these figures an indication of the grade of service given the subscribers can be calculated,

or

(ii) to hold and trace unsuccessful calls so that faults may be detected.

3.2 T.R.Ts. of B.P.O. design are used in all the large automatic networks. The equipment is rack mounted and, in general size and appearance, is similar to auto routiners. Some T.R.Ts. are on 6'6" racks, others use the standard 10'6" rack; they are portable and can be used at different exchanges, being secured in their temporary position by a few fixing bolts.

3.3 Calls are set up via a maximum of 24 spare line circuits to a maximum of 25 spare final selector numbers; in sequence this gives 600 calling-to-called number combinations in a complete cycle. Fewer lines may be used if desired. Fig. 13 shows the principle of the T.R.T.

Connections are generally made by jumpers to the I.D.F. although the T.R.T. may be jumpered to the M.D.F. where this is more convenient. When some of the called numbers are in other exchanges, a three wire circuit back to the originating exchange is necessary. For this reason it is not generally practicable to include numbers in distant exchanges.

To use the T.R.T. for obtaining an indication of the grade of service only, a key (OBSERVE SERVICE) is operated and faulty calls are not held, but merely recorded on the faulty calls meter; the next call in the sequence is commenced immediately. With the key normal, the T.R.T. stops and gives an alarm when a call fails for any reason; the faulty call may be held independently and the T.R.T. stepped on to the next call, or alternatively, it may be stepped on after the call has been traced.

Several tests are performed for each call, in a similar manner to those made by auto routiners, with the exception, that the test conditions are not marginal, but are like normal subscriber-dialled calls.

Briefly, the tests are -

Supervision of the outgoing loop and P wire guarding-earth whilst the call is being set up.

A check of the ring, ring trip and metering functions of the final selector.

Lamps show the progress of the call and give indications of certain types of call failure. Additional facilities are :

- A distinctive tone may be applied to assist in call tracing (for example, pips of 400 c/s tone or clicks).
- A handset speaking point. Later models also include a monitoring amplifier and loudspeaker.
- Pulses may be released one train at a time to observe the performance of individual switches.
- A spare outlet of the outgoing access uniselector, connects to a test jack for direct connection to a first selector or uniselector when desired.
- Access stepping and continuous test keys enable continuous tests on items of equipment suspected of being faulty.

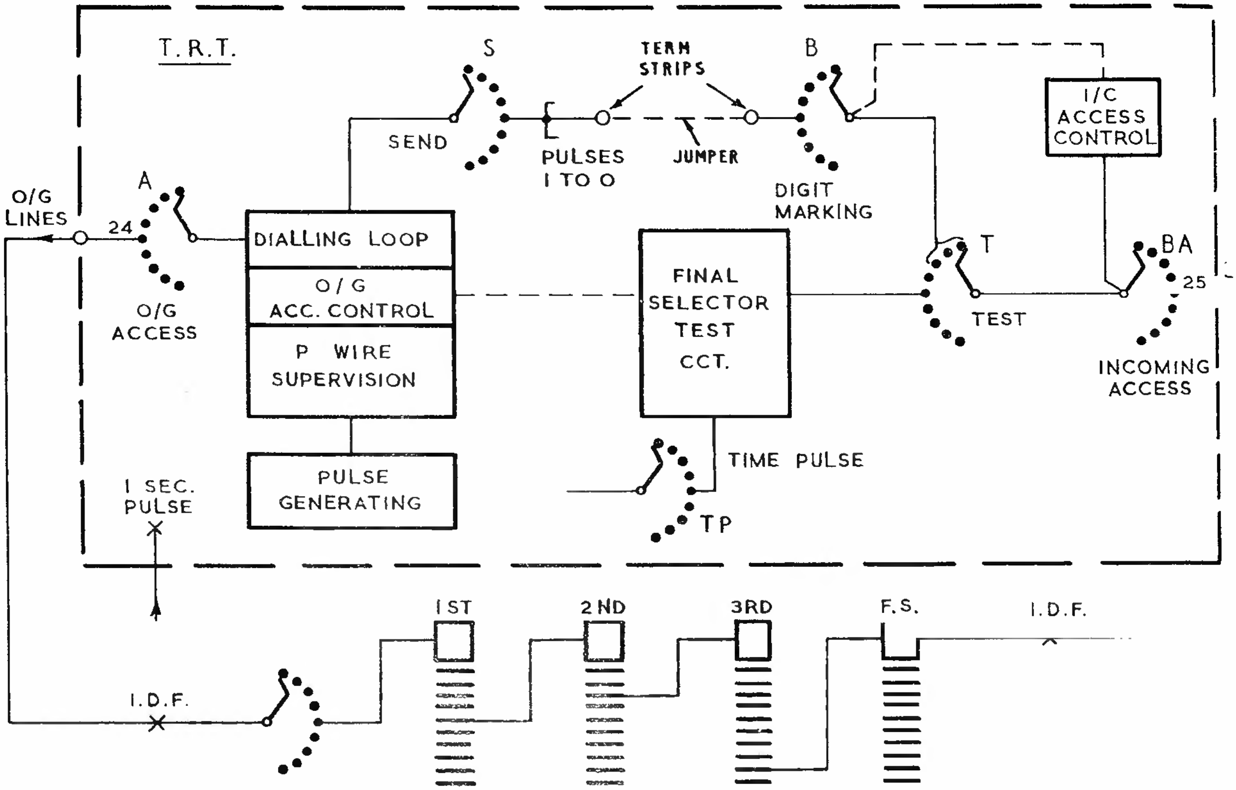


FIG. 13. PRINCIPLE OF T.R.T.

3.4 Basic Operation. The functions of the five uniselectors are :-

A – Outgoing access. Also provides lamp indication of the calling line, that is, lines 1 to 24.

BA – Incoming access. Also provides lamp indication of the called line, that is, lines 1 to 25.

B – Outgoing digit marking. Steps on after each call in unison with BA switch and allocates the digits to be dialled. Up to 8 digits may be sent; each arc and wiper of B switch in turn, marks the send switch (S) according to the number of pulses to be sent for the digit. The marking is set up for each called number by means of strapping on a terminal block.

S – Send. In accordance with the marking from the B switch, controls the pulses to the outgoing line, and also controls the interdigital pause.

T – Test. Applies the tests to the final selector on the called line. Provides lamp indication of the test and of certain causes of test failure. During sending, steps on after each digit and allocates the B switch arc which is giving the S switch mark for that particular digit.

TP – Time Pulse. Steps under the control of 1 second pulses and provides an alarm should a call not be completed satisfactorily within approx. 15 - 34 secs. after all pulse trains are sent.

The circuit principles are similar to those used in routiners. One important function not needed in normal routiners, however, is that performed by the sending circuit. This generates the called numbers having up to 8 pulse trains, in 25 combinations which are readily altered. The elements of this circuit are in Appendix 5, Page 32.

3.5 Auto Routiners Modified for T.R.T. Functions. T.R.Ts. of the type described above have two disadvantages -

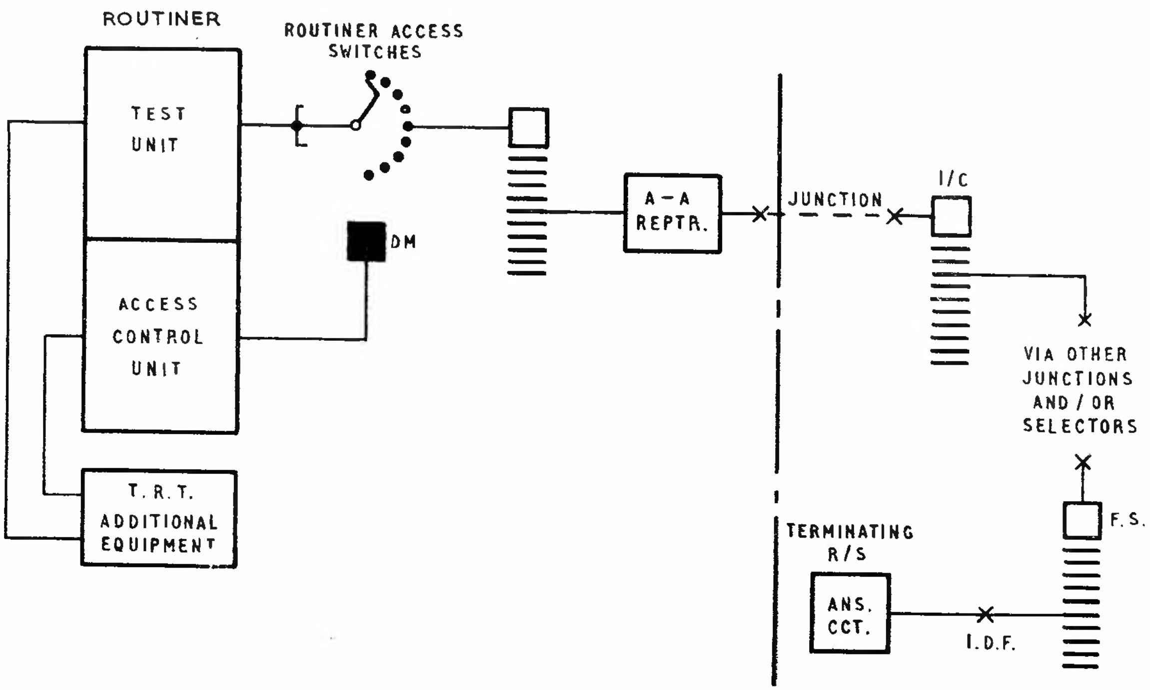
The amount of jumpering or wiring to connect the calling and called lines.

The difficulty of providing three wire circuits to other exchanges to include the whole of the network in the tests.

Some group selector and D.S.R. routiners have been modified to function as T.R.Ts. and have overcome these disadvantages. The main differences between the original and the modified routiner type T.R.Ts. are :

- Calls directed via the routiner access equipment, are made from one or a succession of 1st group selectors or D.S.Rs.; this eliminates the need for outgoing access wiring.
- Instead of wiring the called numbers back to the T.R.T., each called line terminates on a local terminating relay set which automatically 'answers' the call. By means of tones sent back over the connection, the answering circuit gives positive identification that the correct number has been seized, and signals the correct functioning (or otherwise) of the final selector. Fig. 14 shows the principle.

The additional apparatus is mounted in the spaces available on existing routiner racks, and consists of about 25 relays, two 8 level uniselectors, a jackfield or terminal strips for the easy changing of called numbers, and a simple electronic delay circuit.



MODIFIED GROUP SELECTOR ROUTINER AS T.R.T.

FIG. 14.

3.6 Additional access control facilities are desirable when using routiners as T.R.Ts.; they are also useful with routiners working normally, (principally group selector routiners). Access keys may be added which cause the access selectors to step over certain switches by marking them "unequipped" to the access control circuit (as though they were unequipped positions on the selector rack). In this way, testing is confined to certain switches or classes of switches as follow -

(i) Busy selectors.
(ii) Free selectors.
(iii) Local selectors.
(iv) Incoming selectors.
(v) Early choice selectors.
(vi) Late choice selectors.

Already means of checking off normals and permanents is given by (i). The access equipment camps on busy selectors until stepped on. The Technician monitors from the routiner. Free selectors are stepped over, being marked unequipped.

The remaining keys may be operated to give access to selectors as in (ii) to (vi) above, or in a combination of these groupings. For example; (a) calls may be made from all free, early choice, local first selectors, or (b) the early choice incoming selectors may be routine tested.

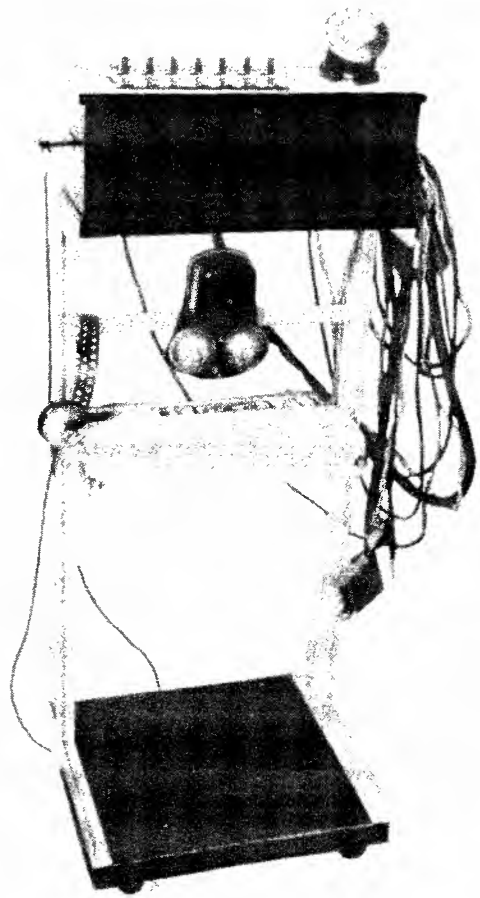


FIG. 15. TYPICAL MANUAL TEST SET.

4. MANUAL TEST SETS.

4.1 The uses of manual test sets for routine testing are described in E. Is. Therefore, the sequences of key and dial manipulation will not be dealt with in this paper except where referring to the basic circuit operation of some 2000 type exchange test sets.

A typical portable test set is shown in Fig. 15. Some manual test sets are rack mounted.

4.2 Final Selector Test Lines are wired to a test jack on the right of each group of final selectors. One test line is provided in each hundred (generally 90). Fig. 16 shows how the test lines are taken out of normal service and diverted into the Test Set 17. This applies to the –, + and P of test lines for both hundreds of 200 line final selectors; for P.B.X. finals an additional eight wires are required for various P1 and P2 wires. This gives a total of 20 wires and connection is by a 24 point plug and cord on the test set, to a 24 point test jack mounted to the right of each 200 group of final selectors.

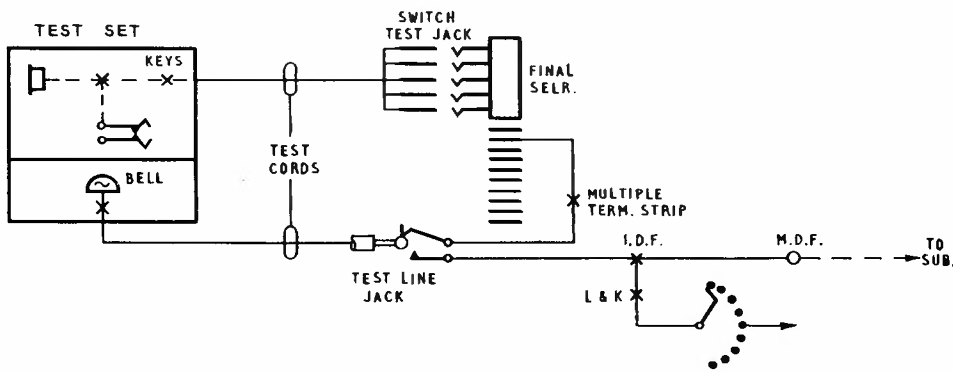
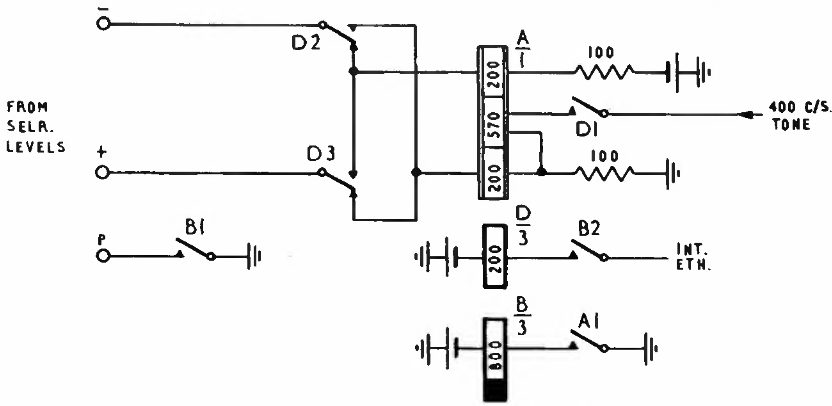


FIG. 16.

4.3 Reverse Battery and Tone Signal Circuit. (Fig. 17) When outgoing junctions are tested manually from R.S.Rs. or D.S.Rs., a call is made on each junction to the reverse battery and tone signal circuit in the distant exchange (generally by dialling 08). The relay set includes two circuits and is generally mounted on the miscellaneous relay set rack (M.R.S.R.).

When seized, the D relay responding to interrupted earth pulses, reverses the line and feeds pulses of 400 c/s or dial tone to the A relay; this provides a distinctive signal plus line reversals, to test the metering function of R.S.Rs. and D.S.Rs.



REVERSE BATTERY AND TONE SIGNAL CIRCUIT.
FIG. 17.

4.4 Test Set 17. This is a combined test set for all types of group selectors, final selectors and R.S.Rs. in 2000 type exchanges. See Fig. 18, (and E. I. TELEPHONE Exchanges Automatic M 2001, pages 18 to 28 for operating sequences).

The six point and two point plugs are inserted in the test jack of the selector - springs 1 to 6 and 9 & 10 respectively. When testing final selectors, the 24 point plug also is inserted in the test line jack.

The test line circuits remain complete via the contacts of TLA and TLB so that if a call should be in progress on one of the test lines, it is not disturbed. (As a rule, however, test lines are the multiple numbers of unit fee public telephones which do not receive incoming calls.) The TEST LINE SWITCHING key is operated momentarily, and if any test line is busy, the P1 earth short circuits relays TLA and TLB, preventing them from operating. With the test lines free, TLA and TLB operate and hold via TLA4, switching the test lines into the test set. The Test Number lamp lights.

On the outgoing side PN operates as long as the switch is free; when the switch is seized earth returned on the P wire releases PN. The low resistance to earth of relay PN guards the P wire between tests.

The LONG LINE or SHORT LINE key extends the dialling loop to the switch; the long line test gives 1500 ohms loop and the short line a 20,000 ohms low insulation. D operates and lights the Loop lamp at D1. When testing 200 line final selectors, the second hundred is selected by the EVEN TRUNKS key.

When testing 200 outlet group selectors, the switch is made to test in to either an odd or even choice using the BUSY UPPER or BUSY LOWER keys to place an earth directly on the P2 or P1 wipers respectively.

The TEST TRUNK key causes the test trunk bell to ring, as a check that the desired 2nd hundred of final selectors, or an even choice of group selectors has been seized.

During the release of a switch the P wire guard is checked on the Private lamp via the PRIVATE RELEASE key.

On the incoming side, final selectors test into battery behind the PL or PU relays, one of which operates and switches the appropriate test line to the answering part of the circuit. Should the two P1 wipers be short circuited, both relays will operate and PL3 and PU3 will trip the ring. Incoming ring operates the bell. The RING CUT OFF key trips the ring via 1200 ohms; DD operates in series with the called loop and lights the Called Loop lamp - providing the line potentials are correct.

Keys are provided to busy the test lines for testing the busy tone of final selectors.

The reversal from the final selector releases D, putting out the Loop lamp. The meter pulse from the final selector flashes the Meter lamp once. The TRANS TONE key causes BR to buzz; this tone is fed back to test the transmission feed capacitors.

For 2-10 P.B.X. final selectors the 1st hundred test line is 9/11; this is reached by dialling 90 and one P.B.X. drive pulse steps the switch to 9/11. The 2nd hundred test line is also 9/11, but is reached by stepping to 99, plus two P.B.X. drive pulses. The P1 and P2 connections are arranged to give this by earth applied via contacts TLA1, TLA2 and TLB2, battery applied by TLB1, and also by strapping on the final selector multiple terminal blocks. (Test lines referred to as "Lower" in Fig. 18 are of the 1st hundred and the "Upper" are of the 2nd hundred).

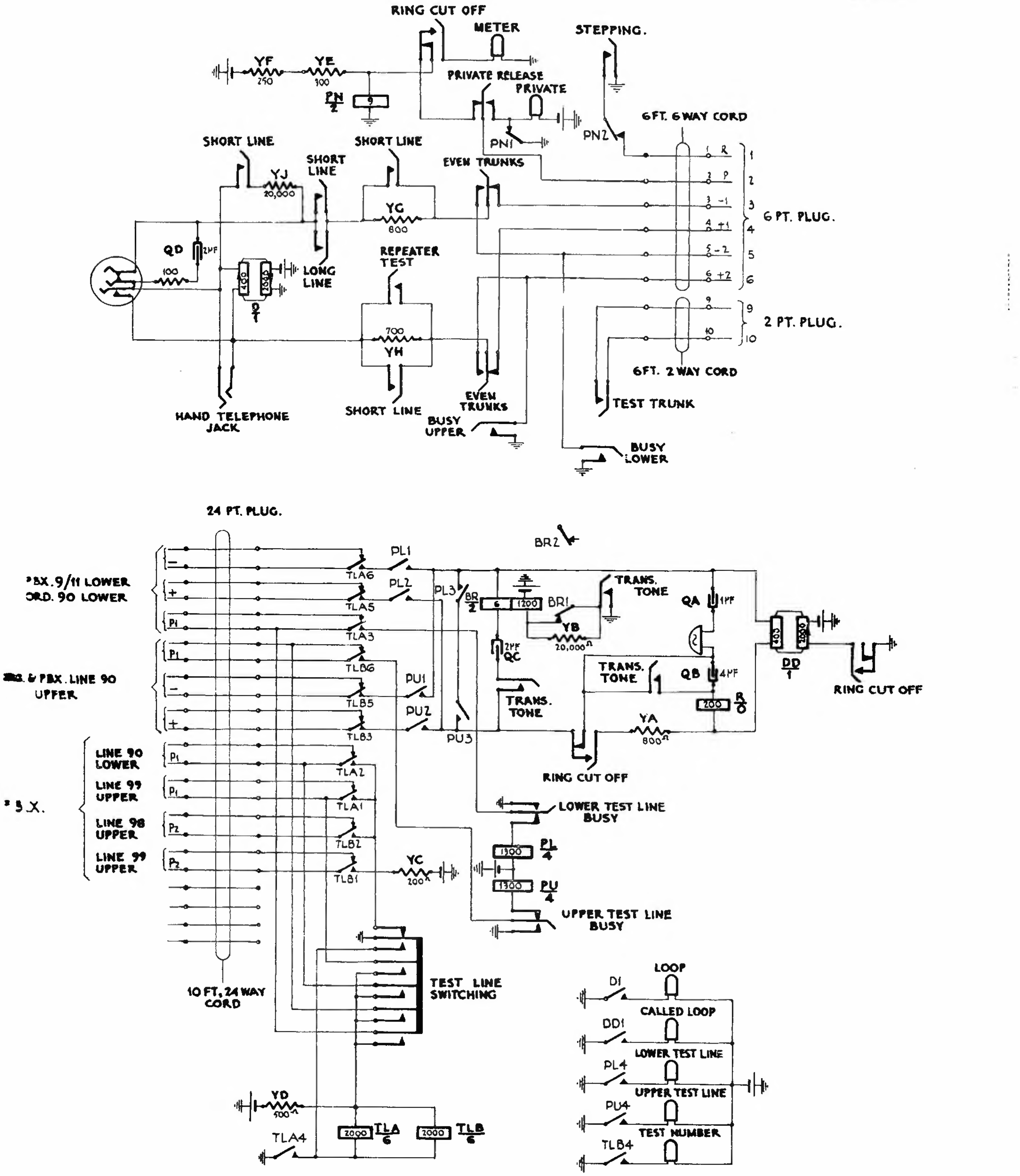


FIG. 18. TEST SET 17.

4.5 Test Set 24 is a combined test set for 2000 type D.S.Rs. and outgoing junctions.

Fig. 19 shows the testing part of the circuit. (Refer also to E.I. TELEPHONE Exchanges Automatic M 2001 pages 30, 31, 41 and 42). This test set may be used with hand dialling or with 'machine dialling' provided by an auxiliary circuit in the test set. The machine dialling circuit is not described in detail as in principle the circuitry is similar to that described for auto routiners, Fig. 11 page 12. A marking uniselector and a sending uniselector control the sending of up to four successive trains of digits. Keys are provided to alter the digits as required. For example, at a typical branch exchange, the test set may be arranged to send say 9608 for the local test number, 9508 and 9808 for adjacent branch exchanges, 908 for the main exchange and 08 for testing adjacent branch junctions with the D.S.R. stepping over the appropriate level. A 1ST PREFIX key selects the first prefix when required (9 or X in the above example). Five, two position keys designated A, B, F... to Y (or 1 to 0) select the desired second digit.

The pulses for machine dialling are from the common impulse cam machine on the M.A.R. (described in Para. 2.11) and wired to jacks on the selector racks.

The SD1 contact operates after the required number of pulses is sent. Contact TA1 serves the same function as the dial off-normal springs by shorting out the C relay and handset jack during sending.

The JUNC HUNTER key diverts the testing circuit to a 2 point test plug and an alligator clip. This enables junctions to be tested direct from the junction hunter. With the alligator clip on the junction hunter magnet coil, the STEP key is used to step the hunter over the junctions in turn.

When testing the selector functions the JUNC HUNTER key is normal. The P wire guarding earth is checked by the H relay and Release Trunk lamp; the metering pulse lights the Meter lamp. The JUNC GUARD key and associated lamp connecting to the junction hunter P wiper, check the operation of the junction guard circuit. The C relay and Reversal lamp check the reversal from the test number and also detect reversed junctions. When testing adjacent branch junctions via the selector levels, the STEP key is used to energise the rotary magnet momentarily for stepping on to the next outlet.

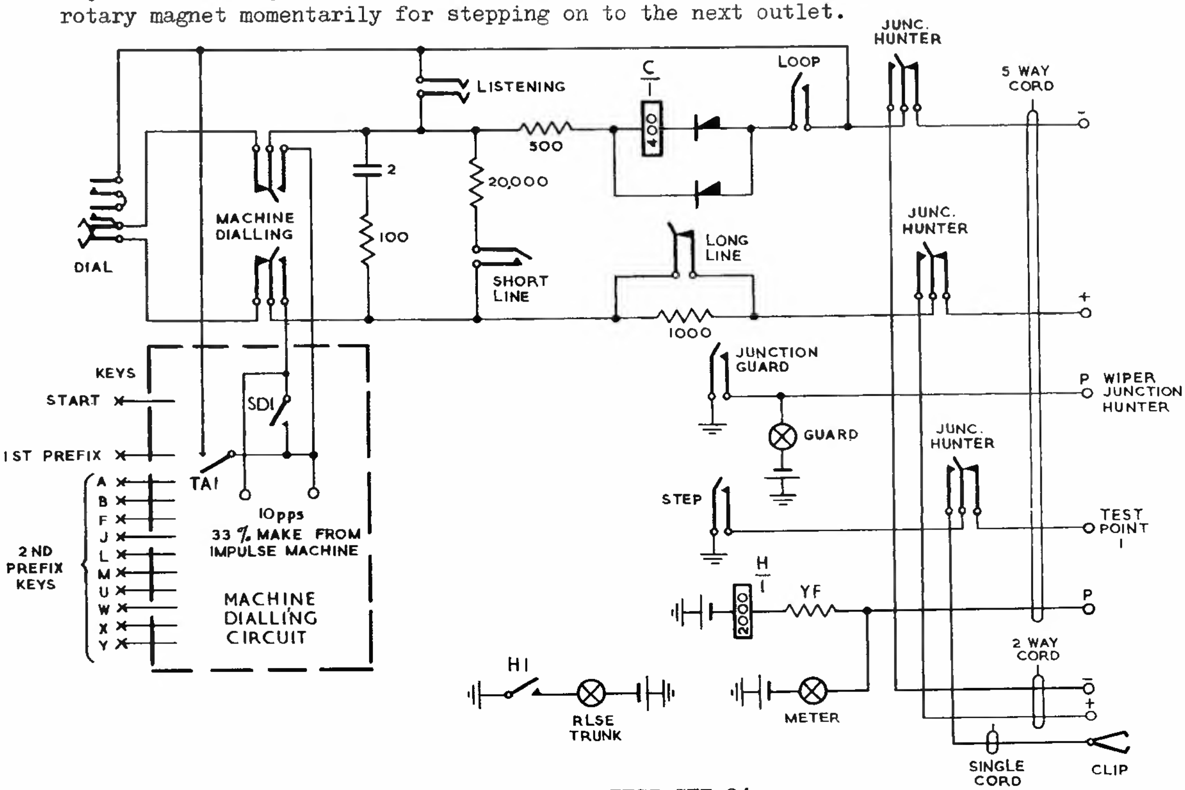


FIG. 19. TEST SET 24.

-.5 Test Set 16A. Meter Routine Test Set. This is mounted on one of the meter racks on a small panel about 6" high. Test Set 16A supersedes Test Set 16 which is portable. Test Set 16 requires more manual operations, and is slower. Otherwise the two test sets are similar. The use of Test Set 16 is described in E.I. TELEPHONE, Exchanges Automatic M 2001 Pages 47 and 48.

Fig. 20 is the circuit of Test Set 16A which is suitable for testing both the earlier meter circuit without individual rectifiers and the later meter circuit which includes a rectifier with every meter. As the latter arrangement is standard, this is described.

The key METERS W/RECT is operated; relay RM operates. Using the current test keys KTO and KTN in turn, the values of R1 and R2 respectively are adjusted to give the desired operate and non-operate currents on the test meter, the circuit of which simulates a meter in parallel with a K relay and uniselector magnet.

The meter is connected via the test jack and cord. Test jacks are multipled over the meter rack and each meter is provided with a test pin connected as shown. Key TEST (KT) is operated; SA operates in series with the subscriber's line circuit, wiper T2 and YT resistance. XT operates via SA1. PS commences pulsing by interacting with its own contact PS1; the pulse rate is about 4 per second, this being obtained by the effect of QC and the 500 ohm coil of PS. PS1 pulsing, steps the T switch 24 times to contact 25 where F operates in series with the meter.

While on contacts 2 and 3, wiper T2 connects XT to the Private. If the P wire is crossed with that of another number, the lowered resistance of two K relays in parallel (650 ohms) balances XT as a differential relay and it releases. XT1 operates the buzzer and prevents further stepping. During stepping SA holds via SB1 and F2. While passing over the even contacts between contacts 4 and 24, positive battery operate current is connected to wiper T2; this is disconnected on the odd contacts. An exception is contact 20 where a saturate current flows via YA 50 ohms alone, R1 being bypassed; this is followed by a non-operate current on contact 22. A correctly adjusted meter records 10 for the test cycle.

On contact 25 SB operates via wiper T3. Stepping ceases; SA releases. To recommence the cycle, the test cord circuit is opened momentarily by means of the press button. F releases; the switch homes to contact 1. SA re-operates; SB releases slowly and when SB2 closes, stepping recommences. (KXH & KXR test for correct adjustment of XT.)

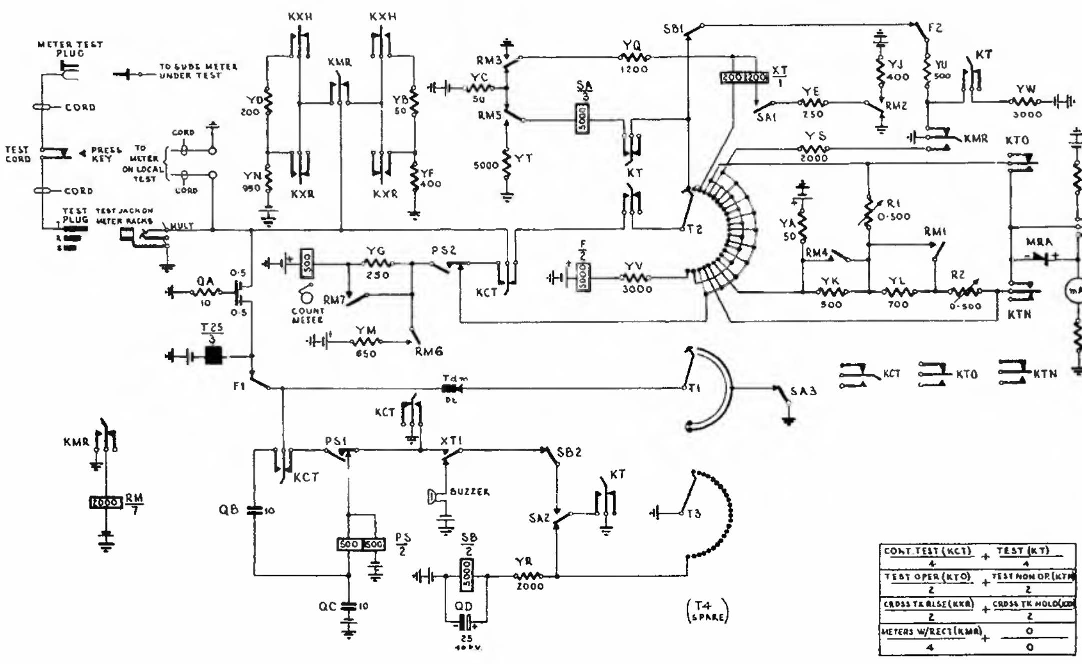


FIG. 20. TEST SET 16A.

5. REFERENCES.

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Vol. 3 No. 3 (1941) Standard Test Sets - W. King.

6. TEST QUESTIONS.

1. What are the two main parts of an automatic routiner?
2. By means of a simple diagram show how a typical routiner gains access to selectors.
3. Name the various types of auto routiner installed in 2000 type exchanges.
4. List the main facilities provided by typical auto routiners.
5. What are the two common types of routiner access equipment?
6. What happens when an incoming selector is seized via the junction, while it is being tested from an auto routiner?
7. List the selector test lines provided for - (i) A Group Selector Routiner, and (ii) A D.S.R. Routiner.
8. (a) On which auto routiner test lines is relay switching provided?

   (b) Why is test line switching necessary on the lines listed in answer to (a)?
9. With the aid of a simple diagram, explain briefly how a routiner applies a series of tests to a selector.
10. By what means are the required number of pulses sent from a routiner to a selector during stepping tests.
11. (a) What pulses are required by auto routiners?

    (b) How are they generated?
12. What are the two main functions of Traffic Route Testers?
13. With the aid of a diagram, explain the basic principles of one type of T.R.T.
14. (a) Explain how auto routiner equipment may be used in conjunction with traffic route testing equipment.

    (b) What are the advantages of modifications of this type?
15. With a simple diagram, show the principle of obtaining test lines for manual routining of final selectors.
16. Briefly describe the item of equipment used to return metering and supervision signals during the manual testing of junctions.

APPENDIX 1.

A.1.1 Group Selector Routiner - Typical cycle of Tests.

Resistance values given in the table are typical; slight variations may be found in different makes of routiner.

Lamp No.	Designation	Test
1	Start	
2	Busy	Tests incoming P wire for earth.
3	1ST Test Line Busy	Tests P wire of 1st Test Line for earth.
4	2ND Test Line Busy	Tests P wire of 2ND Test Line for earth.
5	A Relay Operate	Tests incoming P Wire for earth returned when A relay in group selector operates in series with 2500 ohms.
6	I/C +ve Line	Tests incoming +ve line to earth via 200 ohms (that is, the A relay winding).
7	I/C -ve Line	Tests incoming -ve line to Battery via 200 ohms (that is, the A relay winding).
8	A Relay Release	Tests that earth is removed from the P wire when A releases after the loop resistance is increased to 14000 ohms.
9	Loop	Tests incoming P wire for earth.
10	Imp. Long Line	Sends 9 pulses via 1500 ohm loop.
11	C Timing	Tests that the 1st Test Line is reached within 600 milli-seconds of pulsing, that is, checks the rotary stepping time plus the release time of the C relay.
12	1st Test Line Seized	Proves that the incoming line has been switched to Test Line 1.
13	+ve Continuity	Proves minimum resistance in +ve leg.
14	-ve Continuity	Proves minimum resistance in -ve leg.
15	2nd Choice Wiper Disconnect	Tests for absence of earth on 2nd Test Line +ve leg and absence of battery on 2nd Test Line P wire.
16	Release Guard	Checks earth on P wire during release of selector.
17	Loop	Tests incoming P wire for earth.
18	Imp. Short Line	Selector stepped to level 9 under short line conditions (13,000 ohms low insulation across loop).
19	C Timing	As in 11 above.
20	2nd T.L. seized	Tests that incoming line has been switched to Test Line 2.
21	+ve Continuity	Tests for minimum resistance in +ve leg.
22	-ve Continuity	Tests for minimum resistance in -ve leg.
23	1st Choice Wiper Disconnect	Tests for absence of battery on the -ve and P wires of the 1st Test Line.
24	Release Guard	Tests earth on incoming P wire during release of selector.
25	Loop	Tests earth returned on P wire when A relay is looped.
26	Imp. Short Line	Selector stepped to level 9 under short line conditions, with both test lines busy.
27	10th Contact	Proves that the P wiper has passed over the 10th contact on P2 bank.
28	Busy received	Tests busy tone on the 11th step.
29	Busy Tone	A Fault Imitation key stops the routiner when required to allow the Technician to listen to the Busy Tone.
30	P Wiper	Tests for earth on P1 wiper when selector is standing on last contact.
31	Release Timing	Tests release time of selector - from removal of the loop until earth is removed from the incoming P wire.
32	Routiner Held	Incoming selectors only; tests that junction is free before returning a switch to service (applies where a "patching" selector is used while regular selector is under test).
33		Test Finished.
	Additional Fault Lamps	
	P Unguard	Momentary open circuit P wire during certain tests.
	Release Fast } Release Slow }	Used in Conjunction with Test 31.

A1.2 Fault Imitation Keys

Busy Tone	Causes routiner to stop and allows quality of busy tone to be checked.
+ve and -ve Line	Simulates fault conditions on +ve and -ve respectively.
1st and 2nd T.L. Busy	Simulates busy test Line conditions.
Busy	Simulates a busy selector.

APPENDIX 2.

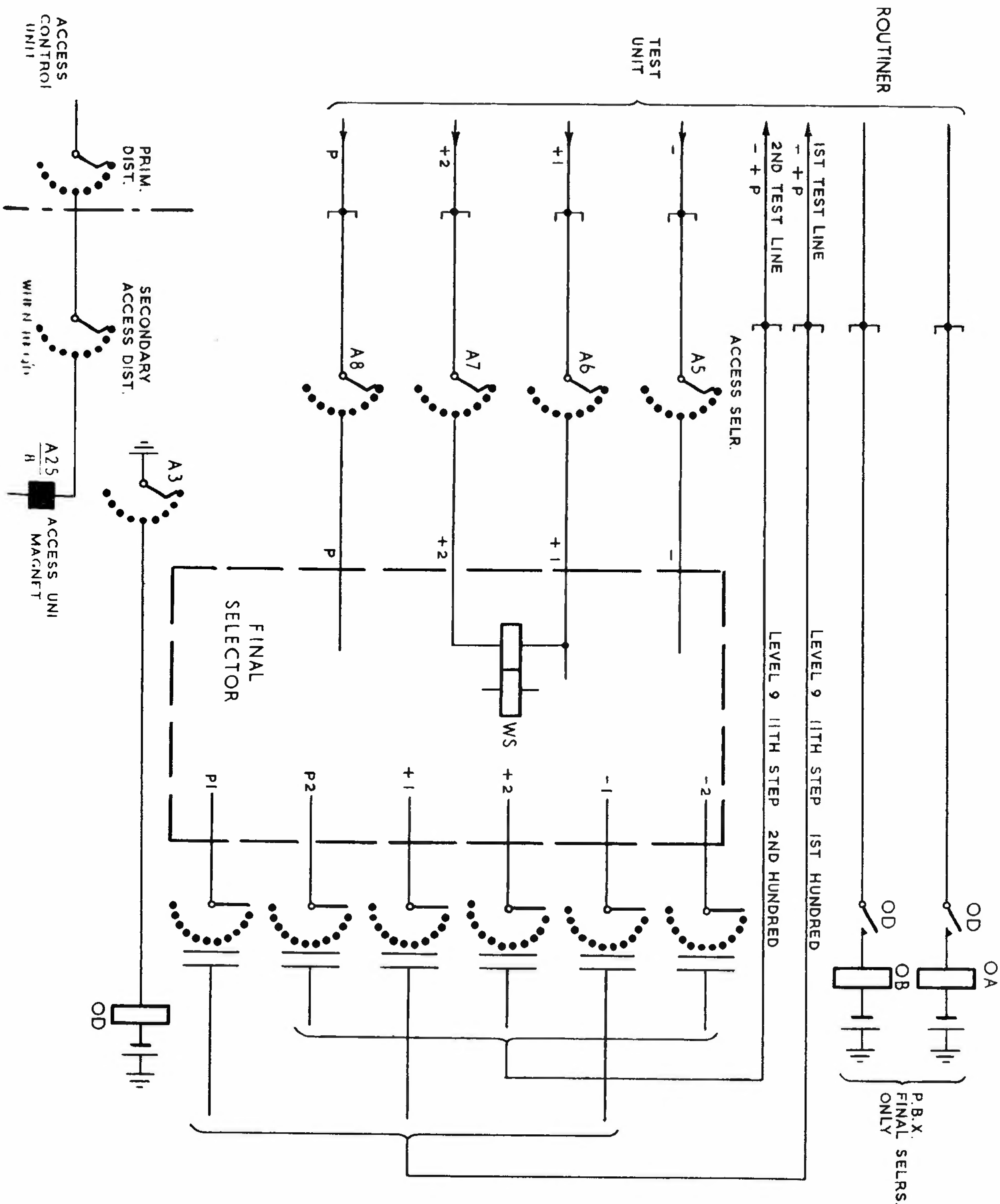
A.2.1 Final Selector Routiner - Typical Cycle of Tests.

Lamp No.	Designation	Test
1	Start	
2	Selector Busy	I/C wire tested for earth.
3	Incoming -ve Line	Tested for correct potential.
4	Incoming +ve Line	Tested for correct potential.
5	Guard	Final Selector tested for busy earth on P wire.
6	A Relay Release	A relay tested for release via 18,000 ohms.
7	A Relay Operate	A relay tested for operation via 3,000 ohms.
8	Release Timing	Release Timing of B relay tested.
9	Imp. Short Line	Selector raised to 1st test line on short line condition (1st 100 group no P.B.X. drive).
10	First Test Line Seized	Check that 1st test line is seized.
11	P wire Earthed	Test for earth on P wire of test line.
12	Ring	Test correct ringing signal and ringing current.
13	Ring Trip	Test operation of F relay.
14	Metering	Test application of positive battery.
15	Outgoing -ve Line 1st choice	Test for correct potential on 1st test line -ve.
16	Outgoing +ve Line 1st choice.	Test for correct potential on 1st test line +ve.
17	P 2 wiper	P2/1 wiper tested for absence of earth.
18	Last Party Hold	Check that selector holds when calling loop disconnected.
19	Release	Answering loop disconnected and release of selector checked.
20	Imp. Short Line	Selector raised to 1st test line as for No. 9. (test line busy)
21	Busy	Receipt of busy tone checked.
22	Wiper Disc.	Test that +ve, -ve and P wipers are not switched through.
23	Release	Calling loop disconnected and selector released.
24	Incoming +ve Line	The No. 2 +ve line tested.
25	Imp. Long Line (WS operated)	Selector raised to the second test line on long line conditions (2nd hundred group, P.B.X. drive from 90 to 9/11).
26	2nd Test Line Seized	Check that 2nd test line is seized.
27	P Wire Earthed	Test for earth on P wire of test line.
28	Outgoing -ve Line 2nd choice	Test for correct potential on 2nd test line -ve.
29	Outgoing +ve Line 2nd choice	Test for correct potential on 2nd test line +ve.
30	P 2 Wiper	P2/2 wiper tested for absence of earth.
31	Release	Answering loop disconnected and release of selector checked.
32	Long Line	Selector raised to 2nd test line on long line conditions, (2nd hundred group P.B.X. drive, test line busy)
33	Busy	Receipt of busy tone checked.
34	Releaee	Calling loop disconnected and selector released.
35	Test finished	Completion of test cycle.

<u>Additional Lamps</u>	
Private guard fail	Should P wire earth be momentarily removed during teets.
Incorrect metering	Metering at other than correct time.
Release timing slow	

NOTE :- The 1st test line ie reached by 9 vertical and 11 rotary pulses.

The 2nd test line is reached by 9 vertical, 10 rotary and one P.B.X. drive pulsee.



FINAL SELECTOR ROUTINER.
Typical Test Lead and Test Line Arrangements.
FIG. 21.

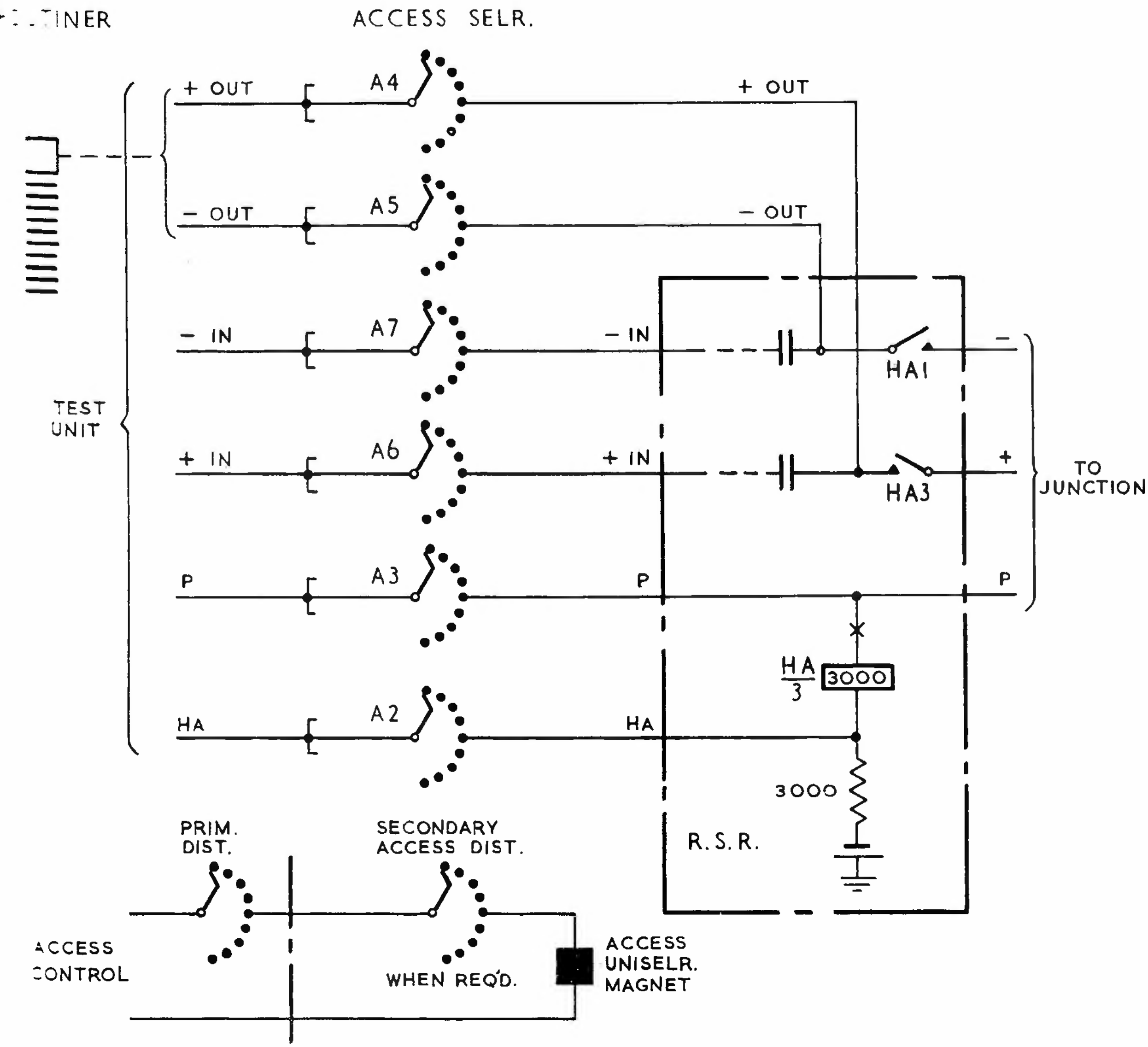
APPENDIX 3.

A3.1 R.S.R. Routiner - Cycle of Tests.

No.	Designation	Tests
1	Start	
2	Relay Set Busy	P wire tested for busy condition.
3	Junction Test	Relay set disconnected from junction and the junction line potentials checked.
4	HA Release (Release Guard)	Relay set released and the earth, open circuit, earth, disconnection sequence of the P wire during release is checked.
5	A Relay Operate	A relay checked for operation via 2,500 ohms.
6	I/C. -ve Line	) Incoming lines tested for correct potential.
7	I/C. +ve Line	)
8	A Relay Saturate	Saturate current applied via 50 ohms N.I.R.
9	A Relay Release	A relay released via 14,000 ohms.
10	Send and Receive	Pulse repetition tested on long line and short line/low insulation conditions as follow -

	Incoming Line	Outgoing Line
(i)	LL	LL
(ii)	LL	SL
(iii)	SL	LL
(iv)	SL	SL

No.	Designation	Tests
11	Called Sub Ans (Meter)	Check of Positive battery pulse on P wire.
12	Called Sub Ans (Supvy)	Check of reversal.
13	Transmission	With TRANSMISSION key operated transmission may be checked with buttinski.
14	Called Sub Flash	Relay set tested under 'called sub flashing' condition.
15	Timing Release	Release time of relay set checked.
16	O/G Loop	Outgoing loop of repeater checked.
17	Release	
18	Test finished	End of cycle.



R.S.R. ROUTINERS.

Typical In and Out Test Lead Arrangements.

FIG. 22.

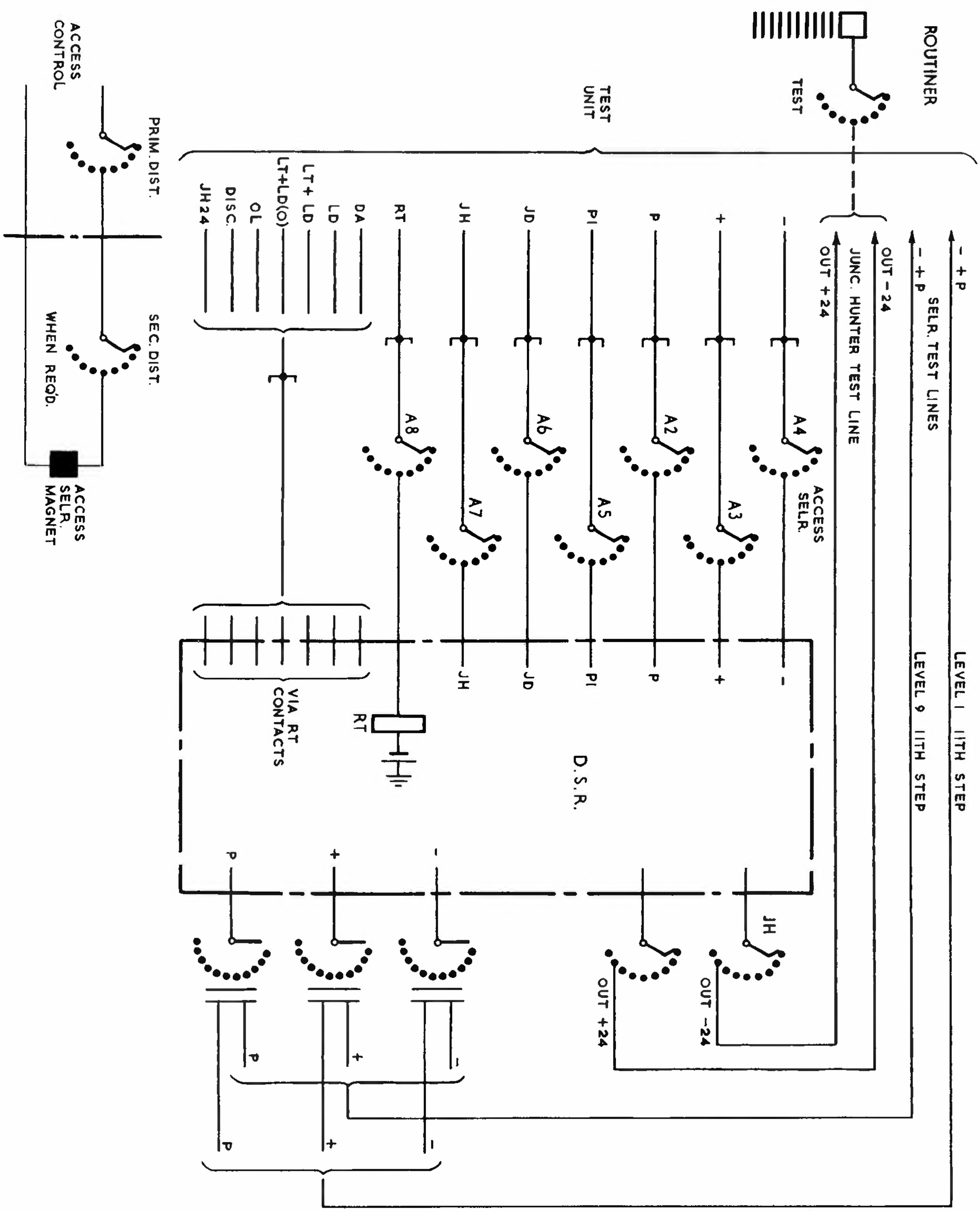
APPENDIX 4.

A4.1 D.S.R. Routiner - Typical Cycle of Tests.

Lamp No.	Lamp	Test
1	Start	
2	D.S.R. Busy	Tests incoming P wire for earth.
3	Test Lines Busy	Tests that test lines are free.
4	I/C -ve Line	D.S.R. seized, P wire tested, continuity and polarity of -ve line tested.
5	I/C +ve Line	Continuity and polarity of +ve line tested.
6	Sat. A Relay	A relay saturated via 50 ohms loop.
7	A Relay Release	A relay released via 6,500 ohms.
8	A relay op.	A relay operated in series with 1,500 ohms loop.
9	0 Level	Ten pulses sent to prove that the D.S.R. switches on outlet 1/11.) Not required when "0" level is not used for calling trunk operator.
10	Oper. Hold	Loop removed and operator hold conditions applied; the D.S.R. should hold.)
11	D.S.R. Release	Selector released.
12	Local 1st Dig.	The digit is dialled and absorbed; the D.S.R. releases.
13	Local 2nd Dig.	Nine pulses are sent and the D.S.R. tests into level 9, 11th step; the junction P wire is tested for absence of earth.
14	No Trans. Bridge	Tests that the lines are through without transmission bridge. (LS relay operated in D.S.R.).
15	P1 Wiper	Continuity of the P1 wiper (D.S.R. restores to normal).
16	Br. 1st Dig.	The Branch exchange 1st digit is sent and absorbed; the D.S.R. releases.
17	Br. 2nd Dig.	Nine pulses are sent and the D.S.R. tests into 11th step with LD and LT operated. A test of the selector hunting speed is made.
18	Send & Rec.	Checks pulse repetition under four conditions when sending digit 9. (i) 800 ohm loop across "IN" line, 1,500 ohm outgoing loop. (ii) 800 ohm loop across "IN" line zero outgoing loop, 20,000 ohm low insulation. (iii) Zero loop, 20,000 ohm low insulation across "IN" line, 1,500 ohm outgoing loop. (iv) Zero loop, 20,000 ohm low insulation across "IN" line, zero outgoing loop 20,000 ohm low insulation.
19	Called Sub. Ans (Meter)	Tests the positive battery (metering) pulse.
20	Called Sub. Ans (Supvy.)	Reversal checked.
21	Sub. Flash	Selector checked under called sub. flashing conditions.
22	Transmission	With the TRANSMISSION key operated, a transmission test of the feeding bridge may be made.
23	Release Timing	Checks the combined release times of relays B and BA in the D.S.R.
24	Main 1st Dig.	As for Branch call 1st Digit. (Test 16.)
25	Main 2nd Dig.	The digit is sent and junction discrimination occurs. The continuity of the test junction is checked.
26	D.S.R. Release	D.S.R. released.
27	Main 1st Dig.	Main exchange discrimination checked after digit is sent.
28	JH24 Busy Tone	Checks busy tone with all J.H. outlets engaged.
29	Busy Tone List	Quality of busy tone may be checked by the operation of BUSY TONE Key.
30	D.S.R. Release	D.S.R. released.
31	Dial Tone	Dial tone is automatically checked but may be heard by the operation of DIAL TONE Key.
32	Br. 1st Dig.)	A call is again set up for checking busy tone last contact.
33	Br. 2nd Dig.)	
34	Busy Tone	Busy tone checked for 2 complete cycles.
35	D.S.R. Release	D.S.R. released.
36	P2 Wiper	P2 wiper checked for continuity by sending "1" as a single digit Main Exchange call.
37	D.S.R. Release	D.S.R. released.
38	Test Finished	End of Test cycle.

ADDITIONAL FAULT LAMPS

Priv. Guard Fail	Momentary O/c. P Wirs during test cycle.
Incor. Meter	Premature metering or abnormal metering.
Relse. Timing (Fast)	The combined release time of relays B and BA less than 450 milliseconds.
Relse. Timing (Slow)	The combined release times of relays B and BA greater than 650 milliseconds.



D.S.R. ROUTINER.
Typical Test Lead and Test Line Arrangements.
FIG. 23.

APPENDIX 5. T.R.T. Sending Circuit Elements Fig. 24

A5.1 The outgoing line is looped via the Start key (KST 4) and wiper S3 of the send switch. The test switch T steps to contact 5 and SG operates via KST1, wiper T5, SZ2 and KST3. The S switch commences to step via SG4, the pulsing contacts, SZ2 and wiper T5.

When wiper S3 reaches contact 3, the short circuit is removed from the pulsing contacts in the outgoing loop circuit; pulses are transmitted to the first selector.

The number of pulses to be sent for the first digit is determined by the strapping between the block terminals wired to S4 arc and the B2 arc.

Suppose the first digit of one of the numbers is 6; then the terminal from the S4 arc for the digit 6, is jumpered to the terminal for the B2 arc contact corresponding to that particular incoming line.

When the S4 wiper reaches the contact for digit 6, earth from KST1 via wipers T4 and B2 operates SZ. SZ1 short circuits the loop pulsing contacts after the sixth pulse. SZ holds via SZ4 and wiper S2. SZ2 releases SG and by means of the strappings on S1 arc, the S switch returns home in three stages -

(i) drives to contact 14 via the S1 wiper and SG2 normal.

(ii) steps at 10 per second from contacts 14 to 21 via SG4 and SZ3 both operated.

(iii) drives from 22 to 1 (home) via SG2 normal.

At the commencement of stage (ii) SG re-operates in parallel with the S switch magnet and pulsing contacts; it then releases again when S1 wiper reaches contact 22 to begin stage (iii).

The time taken by stage (i) varies, depending on the number of pulses sent. The time taken by stages (ii) and (iii) ensures an interdigital pause of at least 800 mS.

The S4 wiper connects earth via wiper T8 to the T switch magnet which steps once. Wiper T4 extends earth to B3 bank to provide the marking for the next digit. When the S switch reaches home SZ releases; SZ2 re-operates SG. The S switch steps again at 10 per second, and in the manner described for the first digit, controls the sending of the second digit as marked by the connection between the wipers B3 and S4.

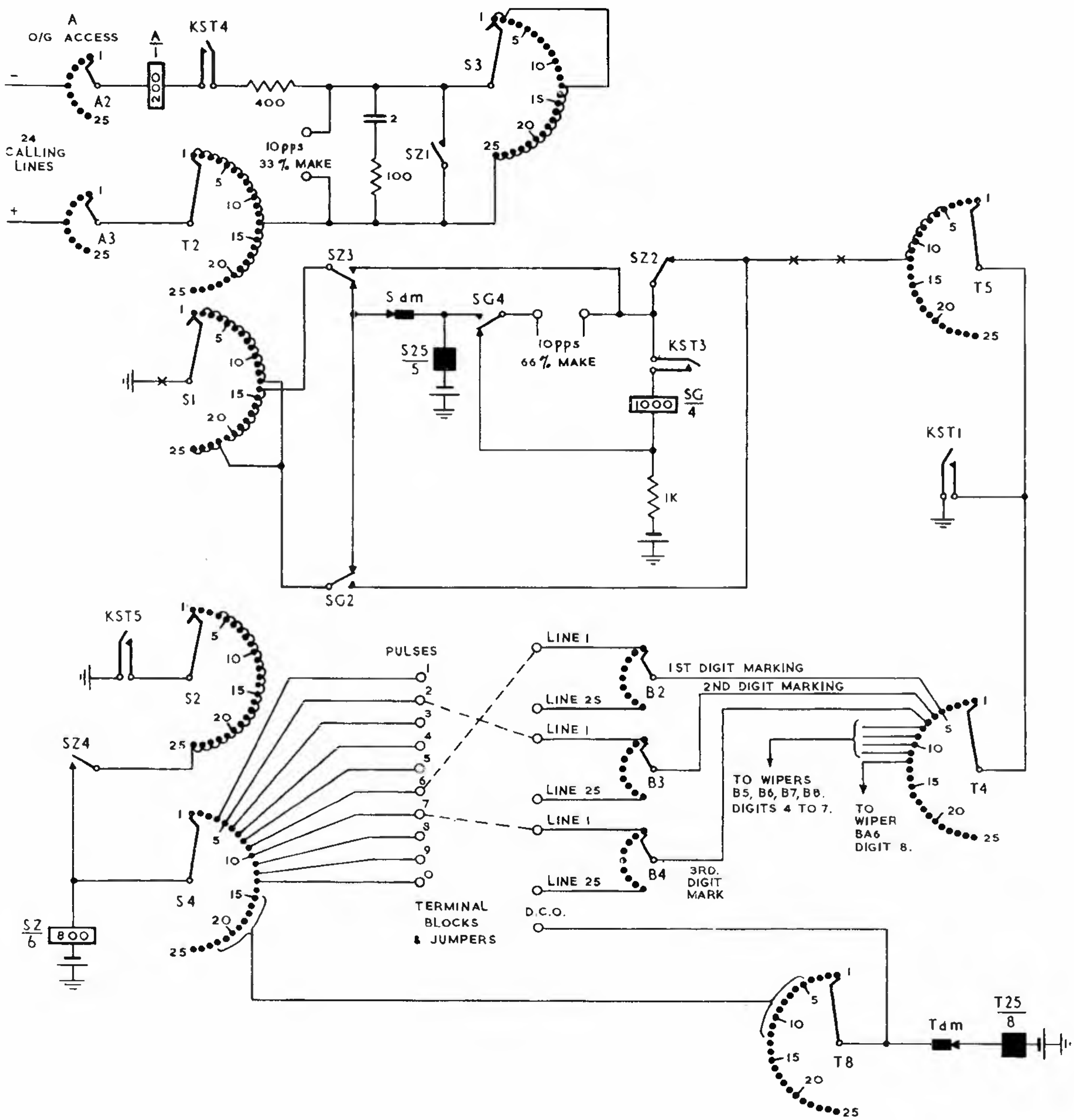
The same sequence is followed for all the digits, the T switch stepping on after each train of pulses is sent.

For the 8th digit marking a BA switch arc is used (the B1 arc is required in the incoming access circuit; the BA switch however, steps in unison with the B switch.

When numbers have less than 8 digits the appropriate terminals on the unused marking arcs are jumpered to the D.C.O. terminal instead of the S4 bank.

When the required digits are sent, the earth via wiper T4 to each of the unwanted marking arcs is extended via the D.S.O. terminal, to drive the T switch to position for the first final selector test (ringing).

To facilitate jumpering, each of the 'pulse' connections to the S4 bank (1 to 0) is taken to a set of ten commoned terminals. This allows the same digit to appear many times in the 25 calling numbers without undue congestion of jumpering.



TRAFFIC ROUTE TESTER.

Elements of Typical Sending Circuit.

FIG. 24.

END OF PAPER.

THE MOTOR UNISELECTOR AND HIGH SPEED RELAY.

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1. INTRODUCTION.

1.1 In the early nineteen thirties, Siemens Bros. of London developed a new type of uniselector having a large capacity bank, and a moving system which departed completely from the familiar ratchet mechanism.

1.2 It is a versatile switch and in Siemens No. 17 type exchanges the motor uniselector (M.U.) serves as line finder, group selector, final selector and for all auxiliary functions normally using bimotional selectors.

It is used for automatic trunk switching and also in the Teleprinter Reperforator Switching System (TRESS).

1.3 To meet the testing requirements of the motor uniselector, a high speed relay was developed at the same time. Since then, this relay and a number of other high speed relays working on the same principle have been widely used for other purposes, such as in automatic routiner test units, and trunk 2VF receivers and line relay sets.

2. DESCRIPTION OF MOTOR UNISELECTOR.

2.1 As its name implies, the switch is driven by a self contained electric motor. The armature rotates at a speed of over 3,000 r.p.m., and is geared to the wiper assembly, advancing the wipers at the rate of 200-220 contacts per second. This means that no less than 50 outlets can be covered in the dial interdigital pause.

The use of a constant velocity, non-reciprocating driving system greatly reduces noise and wear, and results in long service life with a minimum of attention. The smooth drive results in fewer parasitic noises, which usually arise from microphonic voltage changes caused by vibration of contact points of wipers, banks and feeders, during the ratchet operation of other switches nearby.

A motor uniselector is shown in Fig. 1.

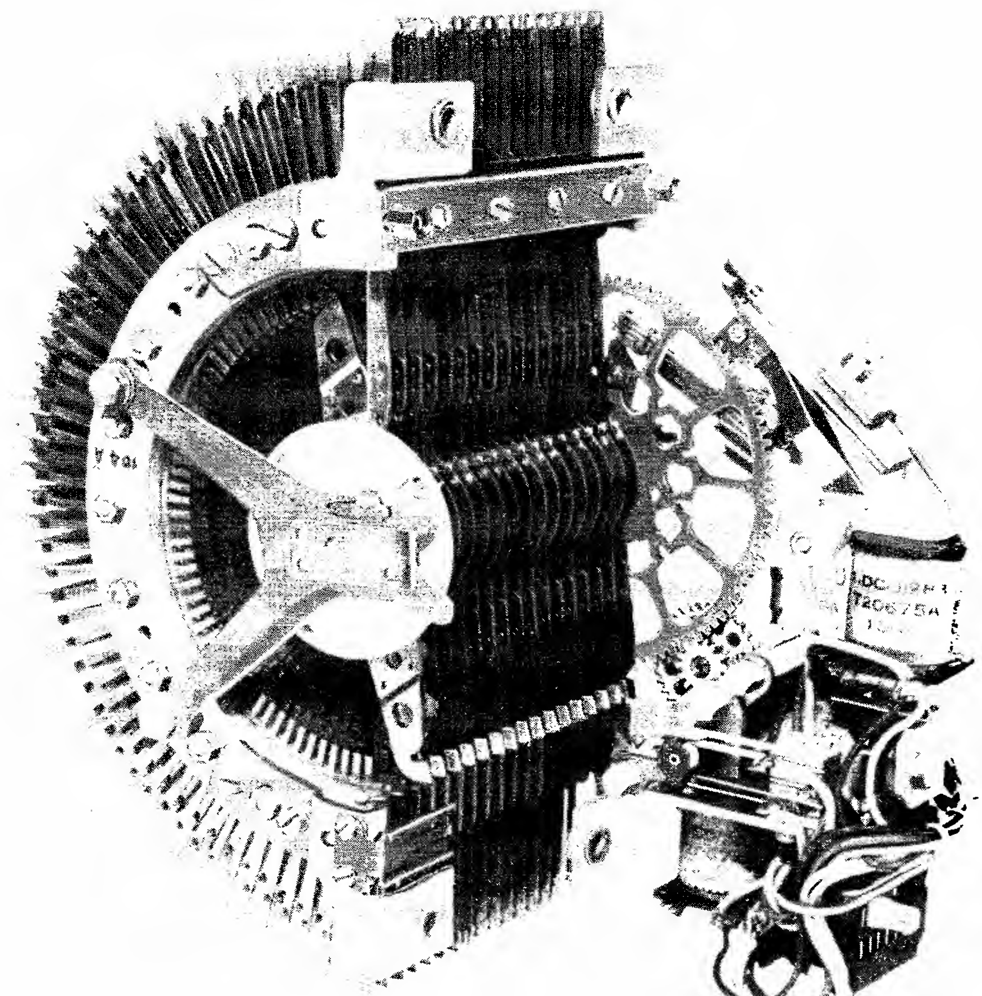


FIG. 1. THE SIEMENS HIGH SPEED MOTOR UNISELECTOR.

2.2 The mechanism is easily withdrawn from the bank and connection to the mechanism is by a wiring form of up to eight wires directly soldered to the component tags.

Jacking points, which are always likely sources of trouble are not used. Even if a perfect jacking system were available, its incorporation for maintenance purposes is unwarranted, owing to the low fault liability of the switch.

2.3 The bank capacity is 16 rows of 52 contacts each. The contacts are narrow with relatively large spacing between them. This, together with the shape of the wipers, prevents overbridging of speech circuits. The soldering ends of the contacts project about an inch rearwards, allowing the use of flat multiple cable. This cable fits into the gaps between the rows of contacts and consists of insulated multiple wire laid up between a folded tape. Transpositions are introduced to prevent crosstalk. Bared loops project from one edge of the cable and are hooked into slots at the ends of the bank tags.

Outlet cables terminate directly on to the bank at the end of each shelf of switches, as shown in Fig. 2.

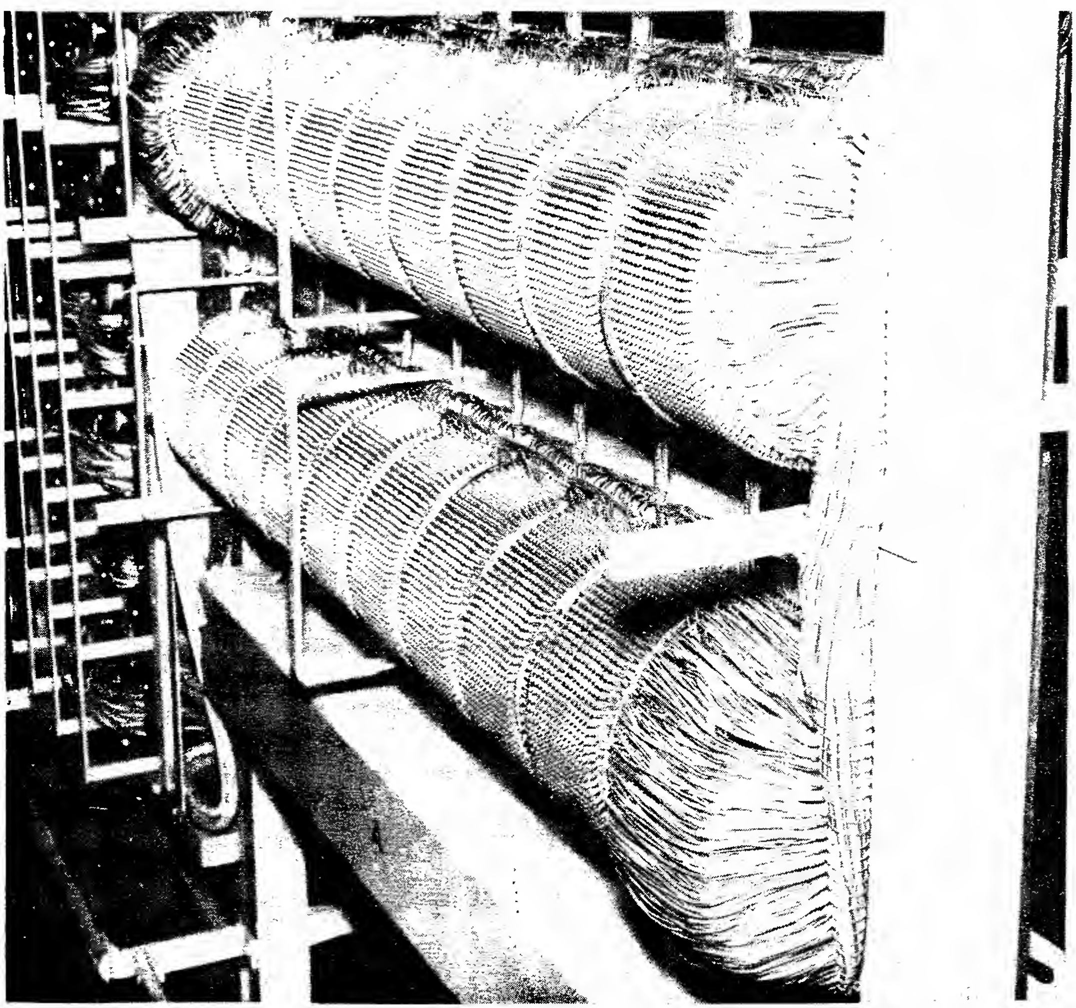
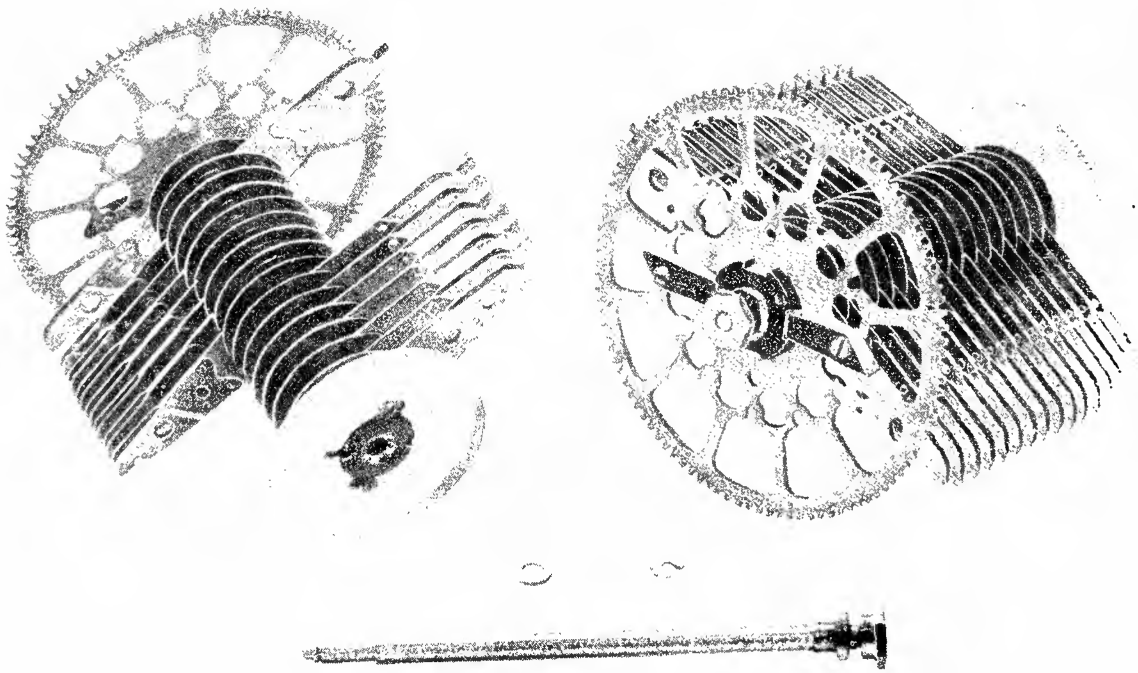


FIG. 2. BANK MULTIPLE CABLING.

2.4 The wipers are light and rigid. They are clamped in an assembly which includes discs for connection of the brush feed to the wipers. At one end a large toothed wheel transmits the drive and in conjunction with a separate latch assembly locates the wipers on the bank contacts. At the other end is the number ring. The assembly rotates on a steel spindle and is retained by a washer and circlip.

Many different wiper assemblies are made to cater for different circuit requirements. and wipers may be single-ended or double-ended. Fig. 3 shows two wiper assemblies.

When the wipers are required to be 'homing' a fibre cam (or cams) is fixed to the spokes of the wiper wheel to engage an off-normal springset after 360° (one cam) or each 180° (two cams).



WIPER ASSEMBLIES AND SPINDLE.

FIG. 3.

The brush feed in later models of the switch is from the top, each feeder being in the form of a wiper, and the disc on the wiper assembly slides between its leaves. Earlier models had feeders with double leaves engaging channels in the wiper assembly and the feed was from below.

2.5 The motor consists of two stator magnets set at 90° to each other, a specially shaped rotor mounted on a spindle between the magnets and a magnetic yoke, and an interrupter springset operated by fibre cams on an extension of the rotor shaft. The rotor has two main poles and two auxiliary poles. It has no winding, nor is any electrical connection made to it. Fig. 4 shows the rotor and interrupter springset a little larger than their actual size.

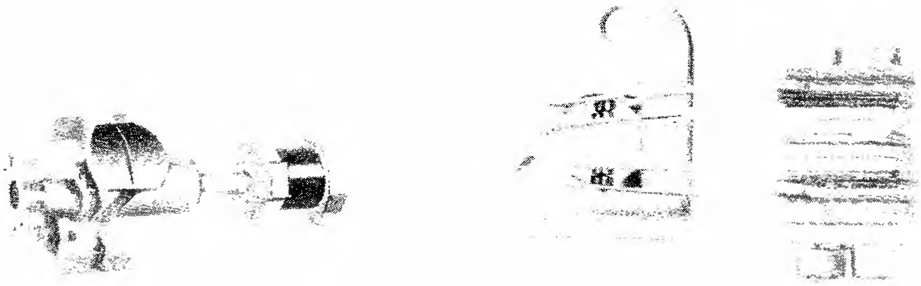


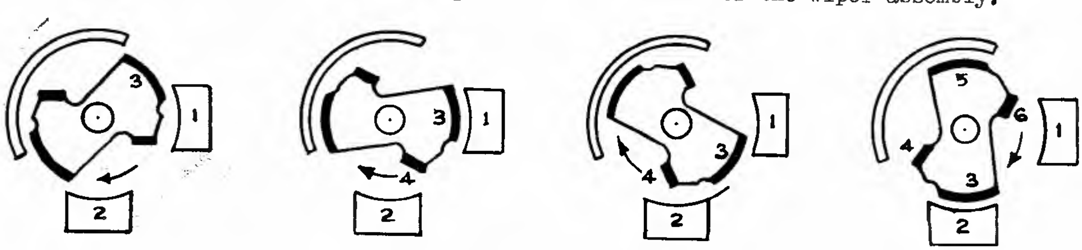
FIG. 4. ROTOR AND INTERRUPTER SPRINGSET.

OPERATION OF MOTOR UNISELECTOR.

3.1 The interrupter springs are wired in series with each magnet coil so that each is energised and opened at exactly the right instant to start and maintain the rotor torque. Fig. 5 shows the principle. In Fig. 5a, magnet 1 is energised and attracts rotor pole 3 causing clockwise rotation. At the position shown in Fig. 5b magnet 1 is disconnected and magnet 2 energised by break and make of their respective springsets; torque is maintained by attraction, first of auxiliary pole 4 and then of main pole 3 as it comes closer to 2 (Fig. 5c). At this stage auxiliary pole 4 has turned its narrow face toward the magnet so as not to shunt the flux path between 2 and 3 to any extent. At the position shown in Fig. 5d magnet 2 is opened and magnet 1 re-energised and attraction of poles 6 and 5 starts the next 180° of rotation.

So that the motor will start irrespective of its rotor and interrupter position, the interrupter springs are make before break, otherwise there would be a critical position in which both magnets would be open circuit. The magnetic circuit is completed by the yoke which is connected magnetically to the rear of the stator magnets via the frame. The fluxes from the two magnets act in opposite directions.

The rotor transmits the drive through its pinion gear to the idler gear which in turn has teeth meshing with the large wiper wheel on the end of the wiper assembly.



(a) (b) (c) (d)

FIG. 5.

The assembly is stopped and the wipers positioned on the bank contacts by means of a toothed latch engaging the wiper wheel teeth when the required outlet is reached. The latch is raised clear of the wheel by energising the latch magnet and is restored by strong springs when released.

Whilst this might at first appear to be a drastic way of stopping wiper movement, it actually is not so. The momentum of a system depends upon the product of its mass and the speed at which this mass is moving. In this switch the mass of the moving system is low, particularly as the distance increases from the axis, whilst the largest item, the wiper assembly, rotates at the comparatively slow speed of about 120 revolutions per minute. Kinetic energy is dissipated in the latch detail arm, which is a buffer device consisting of two bowed steel springs; these have a small amount of 'give'. (The effectiveness of the principle is proved by the long service life of wiper wheels and latch details.) The latch assembly includes a contact which closes the motor circuit when operated and opens it when released so that the motor cannot be energised with the latch engaged and vice versa.

3.2 Basic Circuit Action. Whether used as a line finder or as a group selector the testing principle is a straight search for battery potential on the outlet to be seized. Fig. is a functional diagram showing how the motor and latch circuits operate in position the switch. The action is summarised as follows :-

- The start contact is closed. This will be a contact of some relay associated with the switch.
- The latch magnet is energised. The latch detail is withdrawn from the wiper wheel and the latch contact closes.
- The motor functions and the wipers rotate.
- A free or marked outlet is reached and the test relay (described later) operates.
- The break contact of the test relay opens the latch magnet circuit.
- The latch opens, disconnecting the motor circuit.
- The latch detail engages the wiper wheel positioning the wipers on the selected outlet.

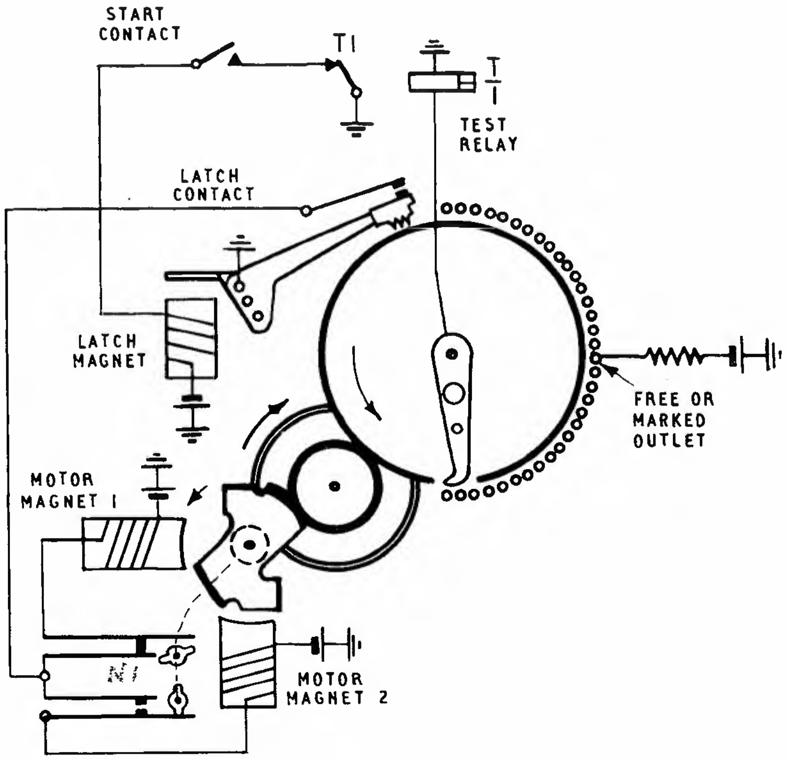


FIG. 6. EXPLANATORY DIAGRAM - ACTION OF MOTOR UNISELECTOR.

The latch armature release lag is a little over 2 mS. The break contact opening lag of the test relay is approximately 0.5 mS. The motor attains full speed within two rotor revolutions, after which its average operating current is 250 mA. When required, homing of the wipers is obtained by the off normal springs opening the latch circuit when the wipers reach the home position. The cam (or cams) attached to the wiper wheel controls the off normal springs; the test relay is not operated.

3.3 A typical schematic circuit is in Fig. 7. Battery is applied to the magnets via a release alarm circuit and test jacks 5 and 6. A spark quench is provided in each magnet circuit and this generally consists of a 3 in one capacitor can, screwed to the rack just above each switch, and having the resistors wired between the tags. Beneath the latch magnet is a spring, which when pressed upwards, earths the magnet circuit and so provides a ready means of checking the driving action.

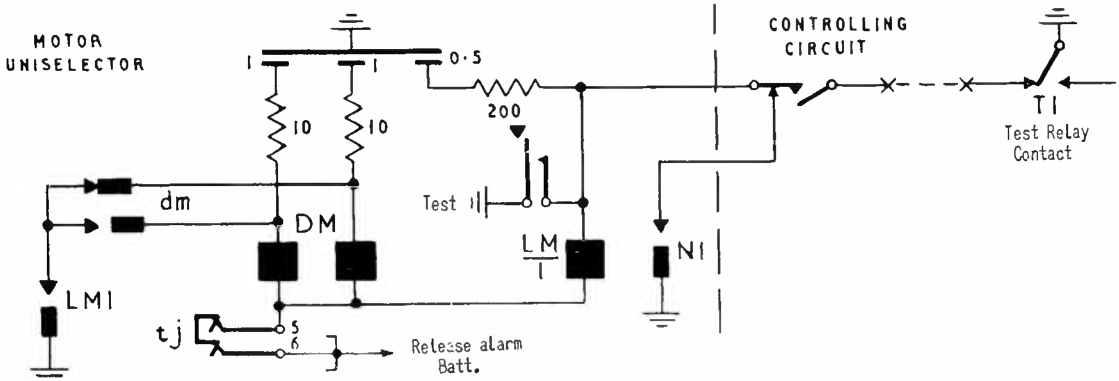


FIG. 7. M.U. TYPICAL CIRCUIT.

3.4 Fig. 8 shows the conventions used in circuits to represent the various arrangements of wiper assembly and banks. When a circuit requires 16 separate wiper connections, the number of outlets in one complete search is limited to 52. When eight wipers will cater for the circuit needs, an assembly is used having two groups of single ended wipers set at 180° apart, each group moving over separate sections of the bank; 104 outlets constitute a full search. There are two types of number ring for the 104 outlet switch, one is numbered straight and the other has 1 - 52 in black figures followed by 1 - 52 in red figures. The latter is more usual in Australia, being used on trunk selectors. Even if "home" and group busy contacts are set aside, there are always at least 50 or 100 contacts available for traffic if required. When four wipers per circuit are sufficient the switch capacity may be extended to over 200 by means of wiper switching. (See Fig. 16 also.)

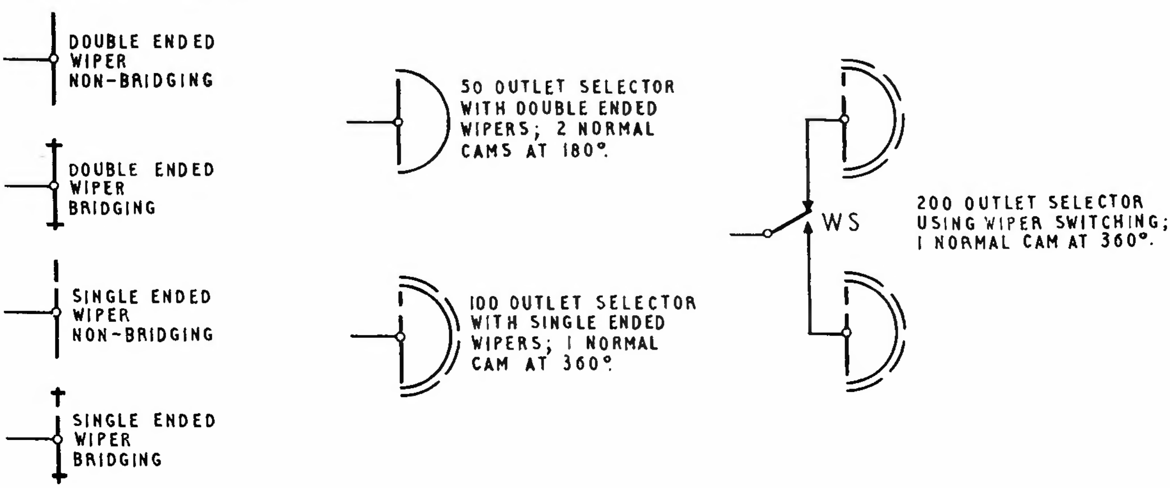


FIG. 8. M.U. CIRCUIT CONVENTIONS.

3.5 A number of minor modifications have been made to the mechanism since the first model was produced so that there are now three models in use - the types 1,100, 1,200 and 1,400. In the early model the interrupter springset was a single make-before-break contact unit operated by one cam. This was changed to the two separate break springs as in Figs. 4 and 6 and controlled by two cams. The method of mounting the springset is also different to facilitate adjustment.

The brush feed to the wipers was originally from the bottom. The type of feed now used is fixed at the top and facilitates removal and replacement of the mechanism. (In some cases motor uniselectors are mounted horizontally; this reference to top and bottom is for vertical mounting as shown in Fig. 1.)

The wiper assemblies were modified to take the new type of feed and the wipers themselves stiffened by having short leaves riveted to stampings of thicker material.

The types 1,200 and 1,400 are almost identical except for minor changes to the mounting of the interrupter springs and test jacks.

3.6 Adjustments. The following E.I.s apply -

TELEPHONE Exch. Auto. AD 5010 Motor Uniselector Mechanism - Siemens Type 1,100.

TELEPHONE Exch. Auto. AD 5011 Uniselector Motor Drive - Siemens Types 1,200 and 1,400.

It may seem a disadvantage not to be able to completely remove the mechanism for servicing, but a tool called an outrigger overcomes this. When attached to the bank the outrigger supports the mechanism with the wipers clear of the bank so that adjustments, lubrication and testing can be done. See Fig. 9.

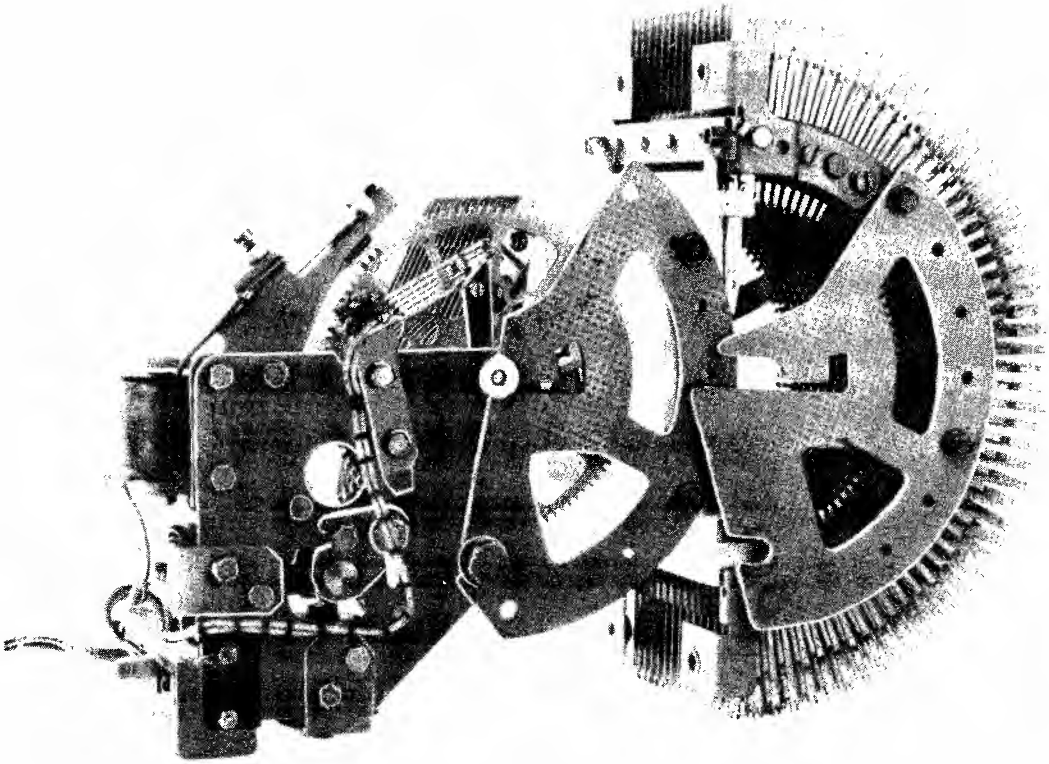


FIG. 9. MECHANISM IN OUTRIGGER FOR SERVICING.

4. HIGH SPEED RELAYS.

4.1 When the motor uniselector is searching, the time a wiper is on a bank contact is too short for a 3,000 type or similar relay to operate, and the single contact Siemens high speed relay was designed to meet this need.

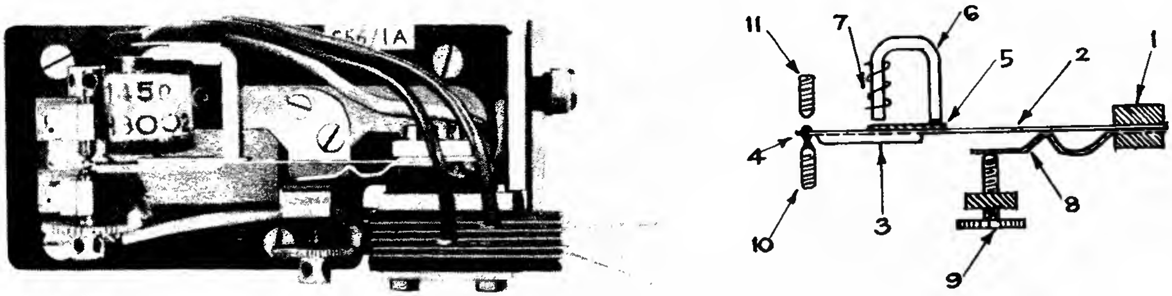
4.2 The chief characteristics of the high speed relay are –

Very low inductance.
Small moving mass.
Very short armature travel.

These factors combine to make the operate and release lags very short, and the relay when used in the test circuit of the motor uniselector will open the break contact in less than 0.5 mS after the P wiper first touches a free outlet.

It is important to note that the operate lag largely depends on the inductance of the circuit in which the relay is included; the lag increases as the inductance is increased.

4.3 Fig. 10a shows the relay and Fig. 10b gives the principle. Fixed block 1 carries phosphor bronze spring 2 which is stiffened by channelling at 3. A double-sided platinum contact is fixed at 4. The iron armature 5 is spot welded to spring 2. Coil 7 is approximately the same size as a receiver bobbin and is carried by yoke 6. When buffer spring 8 is compressed by the tensioning screw 9, it levers 4 and 10 into contact; at the same time, it keeps the armature and yoke in close contact at 5. When the relay is energised, contacts 4 and 11 close, and it is adjusted so that a small armature/poleface gap still exists. This allows the restore pressure 8 to combine with restore pressure in the channelled section, and this feature gives the relay its fast release.



(a) (b)

FIG. 10. HIGH SPEED RELAY.

4.4 Only one contact is fitted – a single changeover. Any additional spring load will, of course, alter the operate and release lags and the relay is not designed for the extra load.

Apart from its high speed characteristic, the relay gives good results when operated under marginal conditions, the small amount of armature travel ensuring that the flux density variation between normal and operated positions of the armature is less than that of other types of relays. This, combined with the relatively small amount of iron in the magnetic circuit, makes it possible, when desired, to have relays with quite small margins between the operate and non-operate current values; for example 26 mA and 22 mA respectively (not as MU test relay).

When used in the test circuit of a M.U., operate times are approximately 0.5 mS to open the break contact, and 1.5 mS to close the make contact. The release lag on disconnection is the same - 0.5 mS to break and 1.5 mS to make. The transit time of the relay is 1 mS.

4.5 The single contact relay is also made with two coils, the second coil being fitted on the other limb of the U shaped core. A variety of windings is available for both these types to suit different applications.

The relay occupies less space than a 3,000 type relay, and can be mounted on the same drillings in a 3,000 type relay base. Individual slip on dust covers can be fitted where necessary.

4.6 Double Contact High Speed Relays. The single contact and fairly low sensitivity, limit the use of the single contact high speed relay, and another relay was developed for applications where some operating speed could be sacrificed in favour of an extra contact unit, and increased ampere turns (for reliable operation in series with other circuit components or line loops).

Fig. 11 shows a double contact relay with two coils. This type is also made with one coil on the front limb of the core. The operating principle is the same as that described for Fig. 10 except that the core faces are wider, and twin armatures actuate two separate lever springs. Adjustment of make and break springs is by means of the springs supporting the ends of the make and break springs, instead of contact screws as on the single contact type. The relay occupies about the same space, and is mounted on the same drillings as 3,000 type relays.

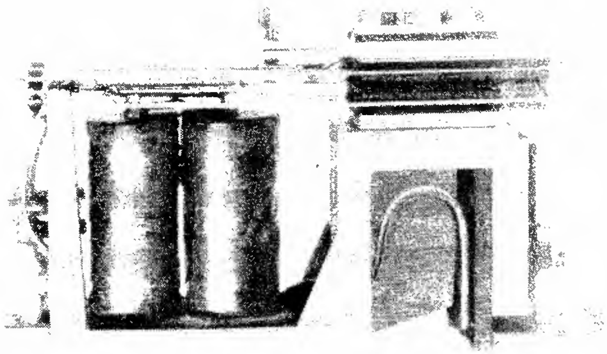


FIG. 11. DOUBLE CONTACT HIGH SPEED RELAY.

Because of the heavier windings and iron circuit the double contact relay is slightly slower to operate than the single contact type under similar conditions. However, it is still very fast - approximately 1 mS to break and 2 mS to make. Release is just as fast as for the single contact type.

4.7 Adjustments. The following E.Is. apply -

TELEPHONE Relays AD 5001	-	High speed relays single contact unit 3/401 and 3/402 adjustments.
TELEPHONE Relays A 1302	-	High speed double contact type relays 3/411 and 3/412.
TELEPHONE Relays AD 5002	-	High speed double contact type relays 3/411 and 3/412 adjustments.

. APPLICATIONS AND CIRCUIT PRINCIPLES.

5.1 The Testing Circuit. The same basic testing circuit is used in many M.U. applications. Owing to the high speed of search and narrow bank contacts, the wipers are contacting an outlet for only about 3 mS. In this time the high speed relay operates, and besides releasing the latch circuit, holds to the battery potential on the P wire and guards the outlet. Fig. 12 shows the circuit elements.

Relay T has two windings in series during testing. When a marked outlet is reached the relay operates to the battery on the P wire and the contact changing over opens the latch circuit and short circuits the 110 ohm winding of T. This guards the outlet by reducing the P wire potential to about 3V.

A rectifier in series with the 110 ohm winding of each relay ensures that at low potentials the test circuit resistance is too high, and therefore the current too low, for test relay operation. When testing a free outlet the potential across the rectifier is high enough to keep its resistance relatively low. Thus the voltage - resistance characteristic of metal rectifiers in the conducting direction provides an additional safeguard.

Should two motor uniselectors arrive at the same free outlet simultaneously double selection still cannot occur. Both test relays could operate in parallel but neither would hold since each 35 ohm winding shunting the other would prevent a large enough current in either relay. The two armatures would vibrate on their make contacts until out of step when one would operate and hold, and the other release allowing its switch to drive on in search of another outlet.

The P wire testing resistance is usually 550 ohms, although the margin of safety is such that the relay will operate through 1,000 ohms. However, it is essential that the test resistance be non-inductive, otherwise the test relay will not operate before the wipers have moved past the outlet.

Any outlet made open circuit through some fault condition is automatically busied.

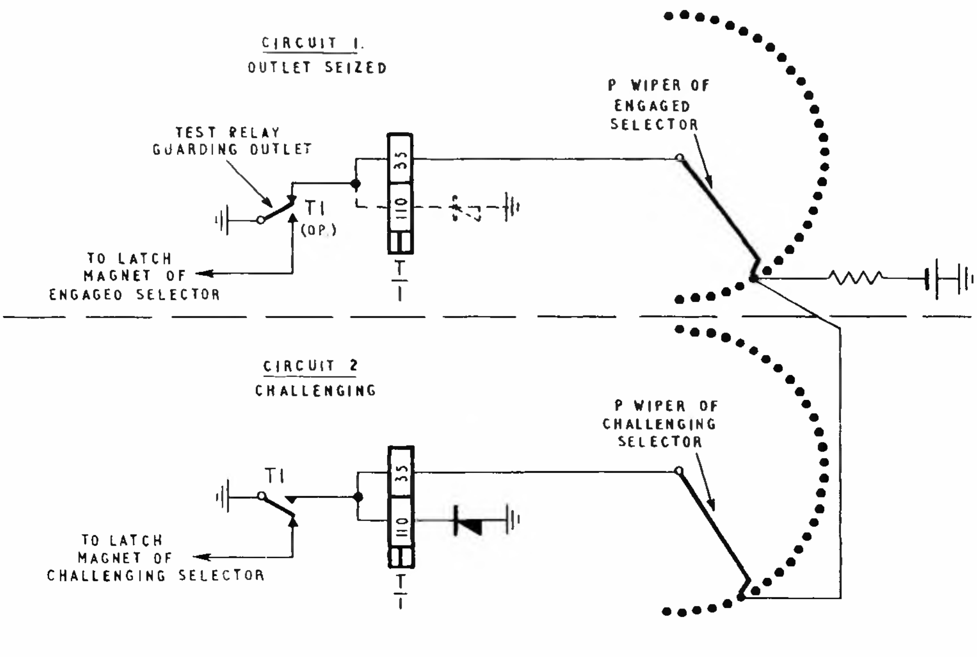


FIG. 12. OUTLET TESTING - CIRCUIT ELEMENTS.

5.2 Marker Control. Since it is not a step by step mechanism the M.U. cannot accept dialled pulses, and for all applications other than that of a line finder the information for group or digit selection must be fed in from an auxiliary marking circuit. This adaption to use the switch in step by step selection is known as "marker control".

5.3 Marking Uniselector or Digit Switch. With dialled pulses, the pulsing relay positions a ratchet type uniselector and this is used to mark a group of outlets on the M.U. bank. This requires the use of another testing bank and wiper on the M.U. and this is called the M (marking) bank and wiper in some cases, and G (group) in others. Fig. 13 shows the principle.

The incoming positive and negative wires connect to a normal type of pulsing circuit having A, B and CD relays, and also to the positive and negative wipers of the motor uniselector via switching contacts. The pulsing circuit directs the pulses to the D magnet of the marking (ratchet) uniselector which is positioned according to the digit received. The marking M bank of the M.U. is strapped to correspond with the groups connecting to the other banks, and each such group jumpered to the appropriate outlet of the marking uniselector or digit switch. The P wire is multipled and graded in the normal way along with the + and – etc., but the M bank is not (except as a special provision which is described later).

The testing circuit connects to a wiper of the digit switch and functions as described for Fig. 12, except that testing does not commence until the M wiper of the motor uniselector reaches the group selected by the digit switch. The first free outlet in the group completes the testing circuit.

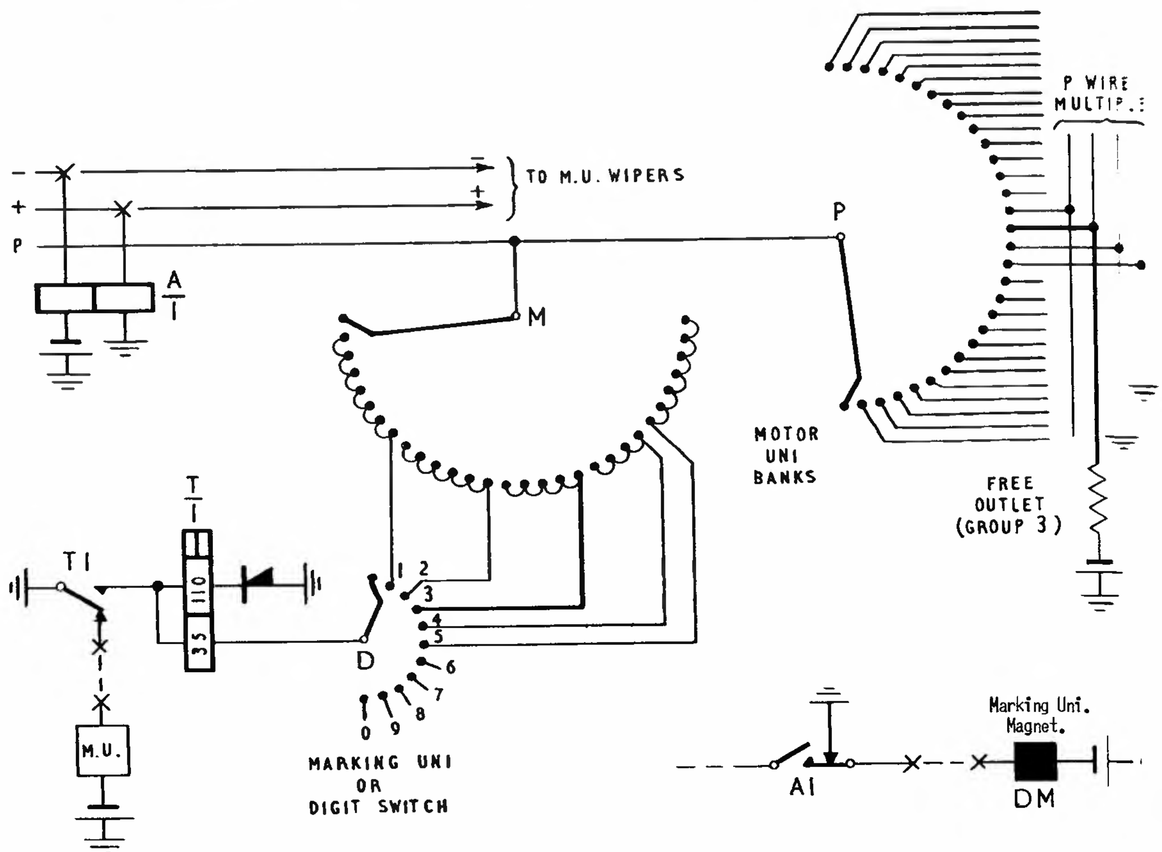


FIG. 13. PRINCIPLE OF GROUP SELECTOR WITH MARKING UNISELECTOR.

5.4 A wide flexibility of trunking is possible with the M.U. The available outlets (50, 100 or more depending on the bank and wiper arrangements) may be divided into any number of groups of any desired size up to 50 outlets per group. The minimum dial interdigital pause allows time to search up to 50 contacts; for groups of more than 50 contacts from the home position a scheme known as prepositioning is used. See section 5.9.

Usually the bank outlets are allotted to groups in sequence, but this need not necessarily be so. Groups may be arranged in any order and a group may be increased in size by commoning outlets anywhere in the bank provided the separation does not involve a search of more than 50 outlets.

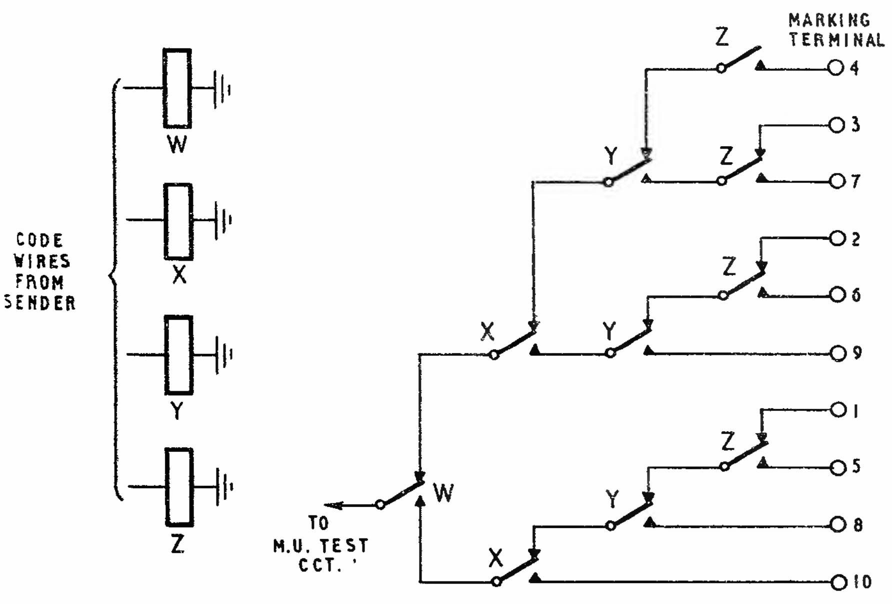
5.5 The marking uniselector may be any suitable 10 outlet or 25 outlet switch. With 2VF trunk switching selectors, a 25 point B.P.O. single coil switch is used.

With Siemens No. 17 exchanges the Siemens 1,700, 12 point uniselector is used. This is a very compact uniselector which fits into the control relay sets for motor uniselectors, and occupies the space normally required for four 3,000 type relays.

5.6 The Key Sender. Another method of group marking is to use a key operated relay circuit and contact 'tree'. This is done with the key sender equipment associated with cordless switchboards in automatic trunk exchanges, now in use at several large trunk centres. The sender has many functions not dealt with in this paper.

Each manual trunk position has a set of keys instead of a dial, and the operator keys the code by pressing the keys in sequence. This information is translated by the sender relays into the required digit for marking the banks of the M.Us. in the local automatic trunk switching network.

For 10 digits, 4 relays are used, each key being arranged to operate one or two of the relays to give a total of 10 different combinations. Fig. 14 gives the circuit elements of the contract tree and lists the code of operation for any digit.



CODE	
RELAY OPERATED	NUMBER
W	1
X	2
Y	3
Z	4
W,Z	5
X,Z	6
Y,Z	7
W,Y	8
X,Y	9
W,X	10

FIG. 14. TYPICAL CONTACT 'TREE' CONNECTIONS, CONVERTING CODE FROM FOUR RELAYS TO NUMERICAL MARKING.

The circuit elements of group selector search are in Fig. 15. The contact tree repla... the digit switch wiper and bank shown in Fig. 13. It is assumed the digit 6 has bee... keyed to operate relays X and Z.

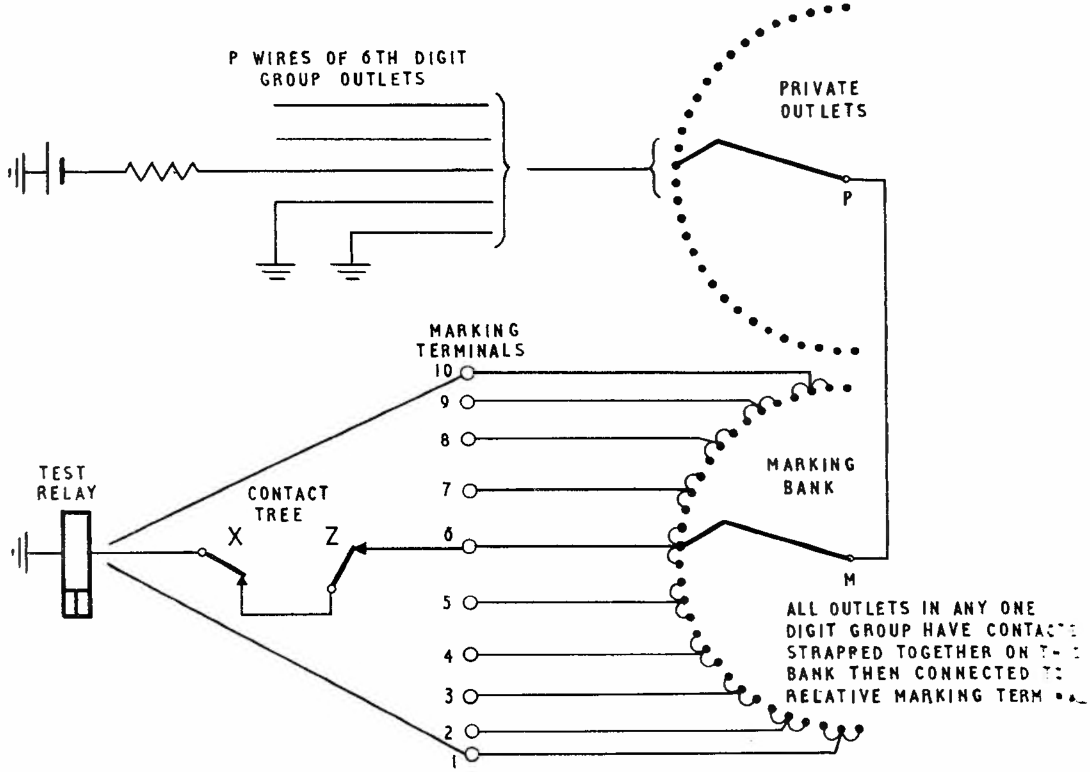


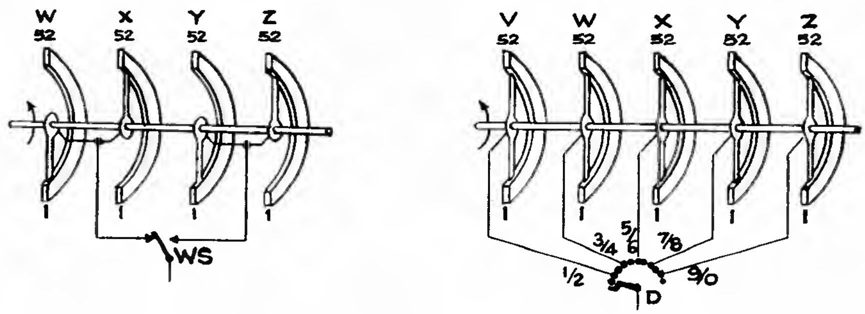
FIG. 15. GROUP SELECTION CIRCUIT ELEMENTS USING CONTACT TREE.

5.7 Telegraph Switching. When used as a group selector in the teleprinter reperforator switching system (TRESS) the marking is done by means of a contact tree; the code relays in this case are operated in a register which receives the routing code information in the form of a two letter signal recorded on a tape in the 5 unit telegraph code. The register translates this to operate the relays and give numeri... group marking; the circuit elements of Fig. 15 apply in principle.

5.8 Where 200 outlets are obtained with wiper switching the correct group of 100 outlets ... predetermined before searching commences by the operation or non-operation of WS rel... WS may be controlled by a signal from the previous selector or from an auxiliary ba... of the digit switch. (This latter method is sometimes used to obtain 250 outlets - five separate groups of 50 - the wiper switching being done directly by the digit sw... wipers.) See Fig. 16.

5.9 Prepositioning. Group selectors generally have more than 50 outlets, but the search during the dial interdigital pause is limited to 50 outlets as a free outlet must be found during this period.

When the group required is in the second half of the bank (corresponding with 1-52 ... the switch drives as soon as the digit switch has stepped far enough to indicate that the group is not in the first half of the bank. If the digit switch is still stepping when the M.U. wipers reach the end of the first half of the bank (52 black), it stops there momentarily, and then drives on to complete the search when the whole pulse ... has been received by the digit switch. This is called prepositioning and ensures that any outlet up to 100 contacts from the home position can be reached during the interdigital pause.



ADDITIONAL OUTLETS USING WIPER SWITCHING.

FIG. 16.

5.10 The M.U. as Final Selector. Selection of an individual line under the control of two digits may be arranged with two marking arcs and two digit switches (or contact trees). Fig. 17 shows the principle. In the Siemens 17 system however, all the final selectors perform both ordinary and P.B.X. final selector functions and the marking arrangements are somewhat more elaborate than shown.

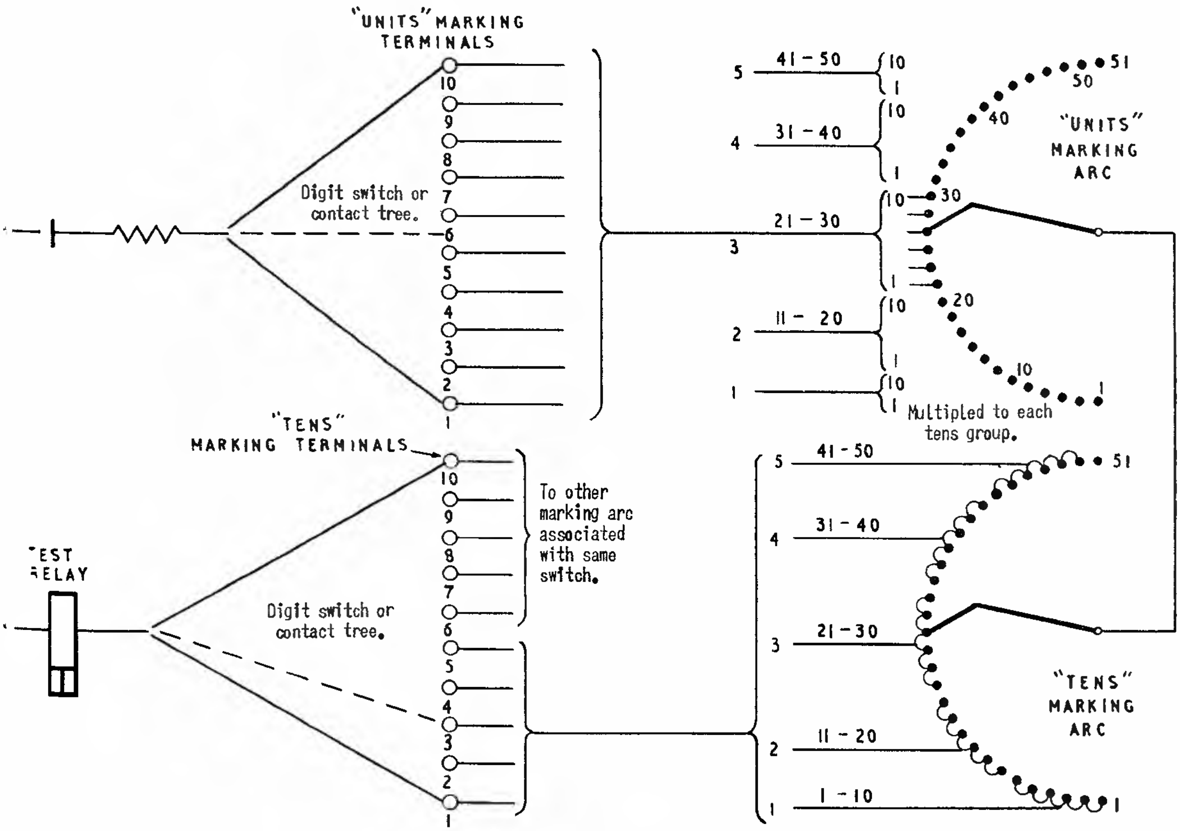


FIG. 17. SELECTION OF INDIVIDUAL LINE.

5.11 Common Control. In some cases each motor uniselector has an individual control relay set and marking uniselector. Often however, common control is used, one control set serving from three to nine M.Us. (or even more in the case of TRESS) depending on the traffic offered. The marker control system lends itself to this arrangement and a considerable saving in equipment results. Fig. 18 shows the principle. The individual relays per switch are reduced to 3 or 4 and the common control contains the digit switch (when used) and other relays. It is engaged only as long as required to position a switch; after the call is switched through to the next rank the common control is free to serve another switch in the group. While the control set is in use all selector circuits associated with it are busied.

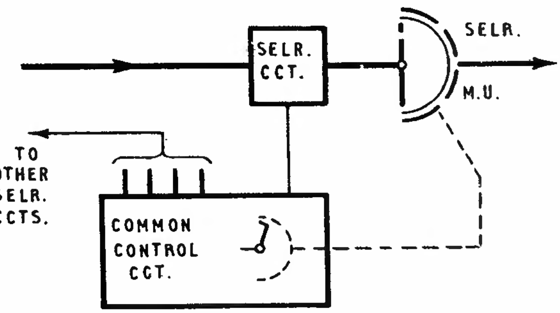


FIG. 18. PRINCIPLE OF COMMON CONTROL.

Where common controls are used the marking banks of the motor uniselectors are multiplied over all the switches associated with one common control, since only one switch in the group can search at a time. With individual controls however the M bank is not multipled.

5.12 The marking outlets of the digit switch are wired to a special tag strip mounted on the side of the M.U. bank. The strips are arc shaped like the bank. With common control there is one of these per control, but with individual control there is one per M.U. The strapped M bank tags corresponding to all the lines in a group are jumpered across to the appropriate digit terminal on this strip.

6. TEST QUESTIONS.

1. Describe in general terms the principle of operation of the driving motor used in the motor uniselector.
2. Briefly describe the operation of a motor uniselector in driving to and seizing a marked outlet.
3. Describe how 200 outlets are obtained from a motor uniselector.
4. Describe briefly the features of high speed relays which contribute to the very short operate and release lags.
5. Show how the test relay of a motor uniselector cuts the drive and guards the outlet in one operation.
6. With the aid of a simple diagram show how a motor uniselector may be used as a group selector.
7. Describe the function of a marking uniselector used with a motor uniselector.
8. Describe in general terms how a key sender circuit is used for marker control of motor uniselectors.
9. What is meant by prepositioning, and why is it necessary with some motor uniselector circuits?
10. Describe the principle of common control of selector circuits.

END OF PAPER.

C.B. AND SLEEVE CONTROL EXCHANGES.

INTRODUCTION.

1.1 With the increase in demand for telephone services in country areas after 1945, the advantages possessed by C.B. exchanges resulted in the conversion of many magneto centres to C.B. working.

1.2 The two main types of exchange are -

a multiple exchange having separate local and trunk positions, with the trunk positions of the sleeve control type.

a non-multiple exchange using combined "A" and trunk positions.

1.3 There have been many modifications since the first installation in 1948, however, it is not practicable to outline all arrangements at present in use and this paper describes typical details of the more recent installations.

1.4 Sleeve control trunk exchanges are also used where local subscribers are served by an automatic exchange. In many cases sleeve control trunk positions work in conjunction with 2VF trunk line circuits having trunk selectors for automatic switching of calls. These associated subjects are covered in the paper "Trunk Line Switching".

Issued 1959.

2. MULTIPLE EXCHANGES.

2.1 A typical multiple exchange is shown in Fig. 1. The switchboard carcases have an iron framework and no sides, adjacent positions being bolted together. The jackfield panels are spaced equally to extend seven panels over three operating positions.

At the rear are two shelves of cradles to accommodate up to 10 relay sets for the cord, position and other circuits. Multiple cabling to the jacks is supported on iron rods suspended between the framework and chains.

2.2 A complete exchange may be made up of the following positions:

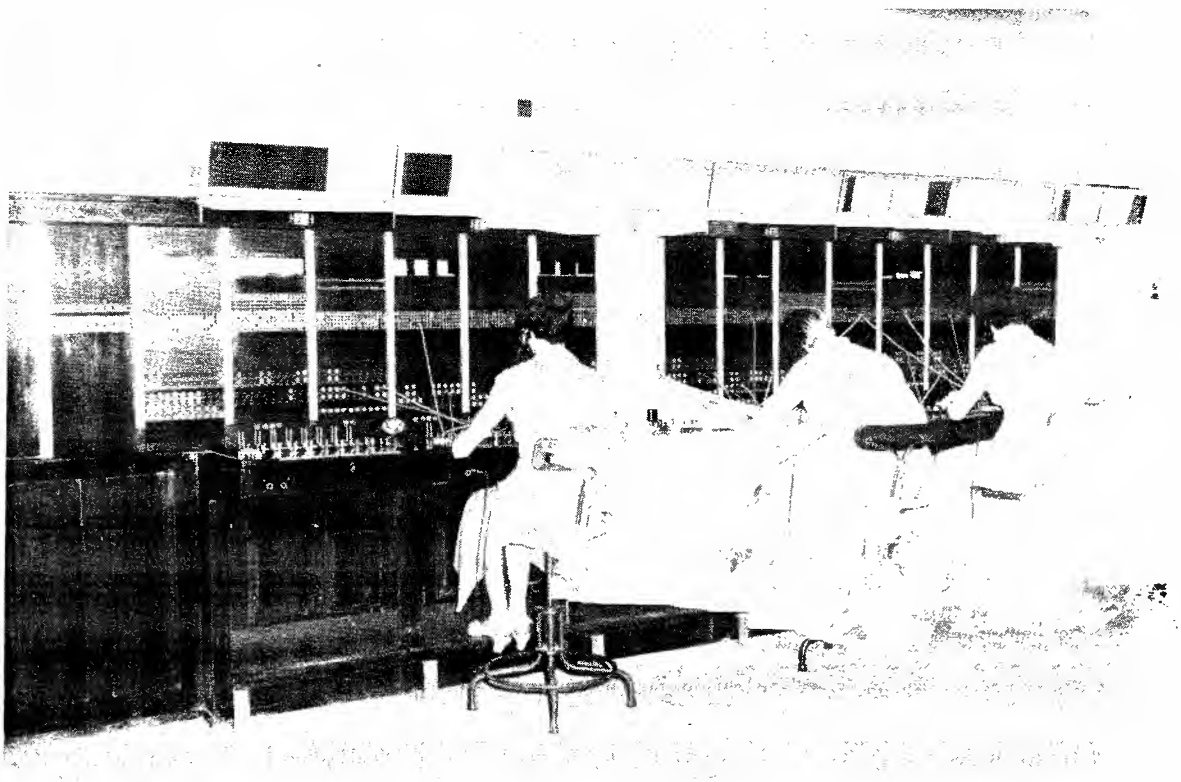
"A" positions for switching local and unit fee junction calls for up to 2000 subscribers.

Terminating trunk positions for switching in and out trunk calls from local subscribers and unit fee junctions (that is, calls terminating in the local area).

Through trunk positions for switching between trunk lines.

Composite trunk positions equipped for switching both terminating and through trunk calls.

Earlier exchanges usually had one Composite position as well as Terminating and Through positions. Later practice is to make all the trunk positions Composite.



TYPICAL MULTIPLE C.B. & SLEEVE CONTROL EXCHANGE.
FIG. 1.

2.3 The multiple for subscribers' lines consists of the required number of rows of jacks in strips of 20, a full appearance of all lines extending over either four or five panels, and making further appearances at the same rate over all the "A" positions and the Terminating and/or Composite trunk positions.

The original C.B. practice of having a separate local jack and lamp for each subscriber is no longer followed and a calling subscriber is answered at one of the multiple jacks. The calling lamps appear either on a strip directly under each jack strip, or in a lamp field separate from the multiple jack field and below it. There is only one appearance of the calling lamp for each subscriber's line.

The trunk lines are multipled over all the trunk positions with an appearance every four or five panels.

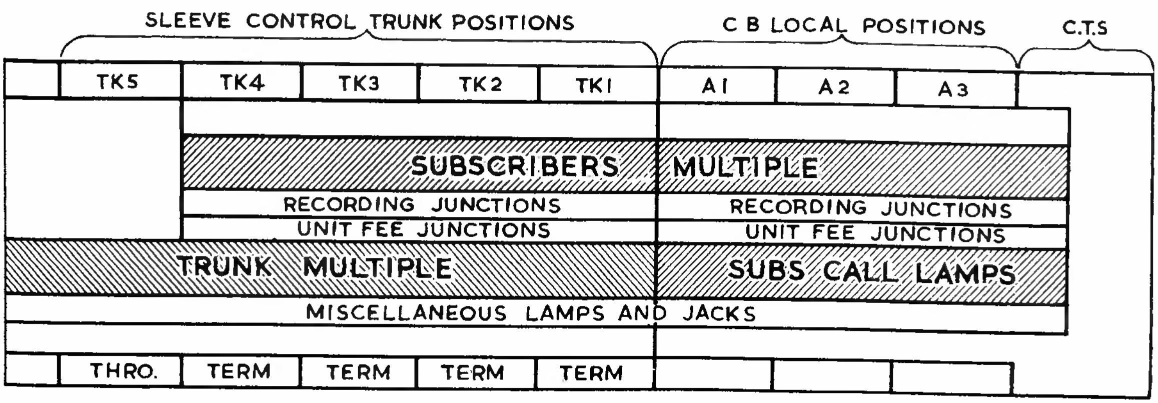
Junctions, miscellaneous services and recording junctions (a kind of transfer circuit) are also multipled as required. Fig. 2 shows a typical layout of lines at an exchange having three "A" and five trunk positions.

2.4 The boards may be placed in one suite, or in two or more separate suites as required to suit the room.

To facilitate the entrance of cabling, a cable turning section (C.T.S.) is generally provided in line with the boards. This is usually about three feet wide and from the front is similar in appearance to the operating positions except that the key shelf is blank or deleted altogether and the vertical panel is used for the mounting of miscellaneous keys, etc. Very often the C.T.S. has one panel of the jack and lamp field extending into it. This gives the adjacent position a full multiple appearance within easy reach. Fig. 1 shows the C.T.S. on the right.

As a rule the C.T.S. is on one end of a suite but it may be placed between the "A" and trunk positions, where this provides a more convenient cable entry.

To allow ease of extension, a cable storing section (C.S.S.) is usually attached to one end of a suite and consists of a dummy position about the width of one panel or larger. The multiple cabling for future positions may be stored in the space thus provided. As with the C.T.S., the C.S.S. or its equivalent generally contains one panel of the jack and lamp multiple field.



TYPICAL LAYOUT, MULTIPLE EXCHANGE JACK AND LAMP FIELD.
FIG. 2.

2.5 Line Circuits and common equipment are rack mounted in the equipment room which to simplify cabling is adjacent to the switch room. Subscribers' line circuits have 600 type L and K relays plate mounted; the usual size rack accommodates the relays, terminal blocks, fusing, etc. for 500 lines, plus up to 30 party lines. The subscribers meters are on standard exchange meter racks accommodating up to 1200 meters.

Trunk line and junction relay sets are of the jack in type. These are generally associated with the M.D.F. and the switchboard by means of jumpering on a separate trunk I.D.F.

2VF trunk line relay sets are on separate racks, and these may be associated with trunk selectors for automatic through switching (transit switching). The 2VF line relay sets are wired to the switchboard (and to trunk selectors when provided) via the common trunk I.D.F. Transit switching at sleeve control exchanges is described in the paper "Trunk Line Switching".

A miscellaneous apparatus rack (M.A.R.) contains ring and tone equipment, positive battery eliminator, exchange clock and miscellaneous supervisory and test gear - jacks lamps, keys, etc. A test panel may be mounted on the M.A.R.; in the larger exchanges a separate test rack is generally provided.

A separate battery room is used for duplicate 50V batteries. These are normally floated in parallel using a mains operated static rectifier.

50V positive supply for metering and supervisory functions is either from a small battery and rectifier, or an eliminator.

2.6 Operating at Multiple Exchanges. To assist in the understanding of functions and circuits at C.B. and sleeve control exchanges a brief outline of operating sequences follows -

Local Call. The calling sub. is answered on an "A" position Answer cord and extended to the called sub. or to a unit fee junction via the associated Call cord. If the unit fee junction is to an auto exchange or R.A.X. the "A" telephonist uses the dial key (one per cord circuit) and dial. The call is charged by depressing the meter key.

Subscriber calling a trunk line. The answering "A" telephonist extends the sub. to a Trunk position on a recording junction. Each terminating trunk cord circuit has one "Subs" cord and one "Trunk" cord (Section 6). The trunk telephonist answers the recording junction using a "Subs" cord and records details of the call on a docket. She then withdraws the "Subs" cord from the recording junction and if the call is to be given on demand overplugs in the subs. multiple to pick up the call. The recording junction is released and taken down on the "A" position. When the call matures after a delay, the sub. is recalled by the trunk operator via the multiple. The call is completed via the "Trunk" cord and timed with the clock associated with the cord circuit.

An Incoming trunk call is answered on a Terminating "Trunk" cord. If a local subscriber or unit fee junction is required, the call is completed via the "Subs" cord.

A Through trunk call is transferred to a Through trunk cord circuit, on the same or another position, depending whether the call is answered on a Composite or Terminating position.

With Composite trunk positions Through and Terminating traffic is handled on separate cord circuits, except where a later type Composite cord circuit is used for either type of call.

3. SUBSCRIBERS' LINE CIRCUITS.

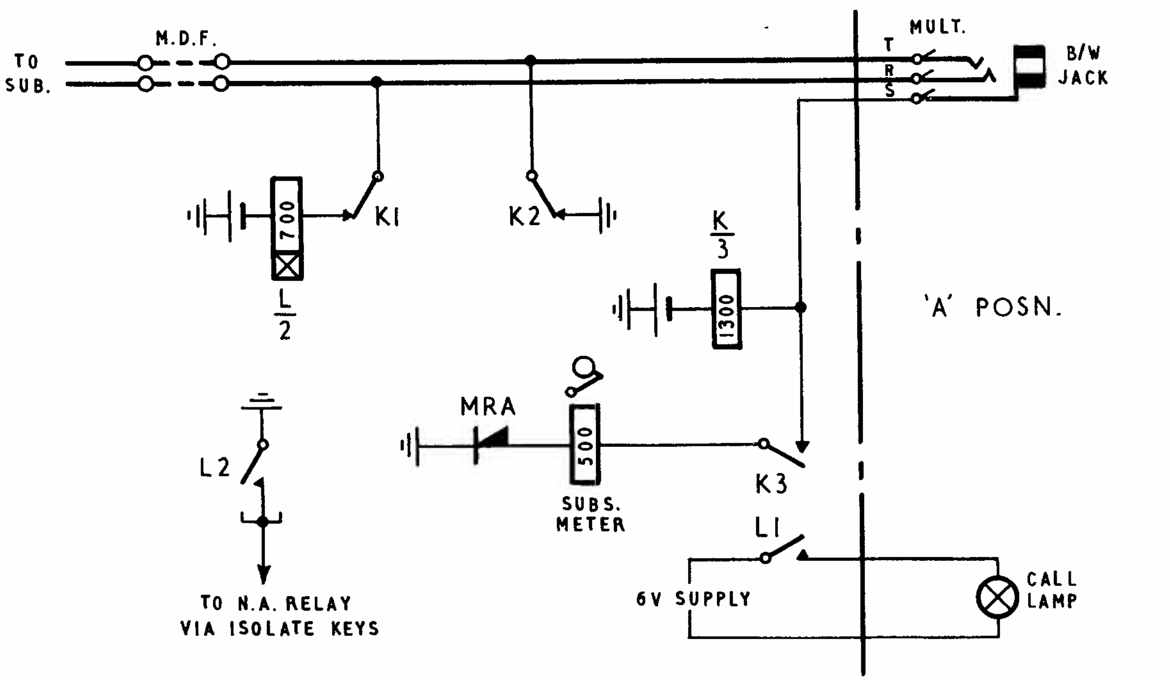
3.1 Practically every installation of a C.B. multiple exchange is a conversion from magneto working. Magneto country areas generally have a number of party lines, some with up to six parties on very long lines and in many cases part of the line construction is privately erected and maintained. To replace all these with exclusive pairs to departmental standards would be very costly.

Special line circuits, therefore, are provided to enable these lines to be given service by the new exchange.

Party lines generally have their multiple appearances separate from the exclusive services.

3.2 The regular subscribers' line circuit is shown in Fig. 3. Standard L and K relays are used. When the sub. loops the line, L operates; L1 lights the call lamp, L2 operates the N.A. if switched on. An answer plug inserted in one of the multiple jacks operates K to earth on the sleeve; K1 and K2 disconnect the L relay circuit; L releases. At the end of a successful call, the cord circuit meter key is depressed before the plug is withdrawn. Positive battery on the sleeve operates the meter via K3 and MRA.

The lamp supply is either 6V A.C. from a transformer connected to the mains, or from a 6V battery. Where A.C. is used, D.C. standby on mains failure is provided. This may be a 6V tap off the 50V battery. Isolating keys for tracing a caller operating a night alarm when the line lamp is faulty, are provided on both the line relay rack and in the switchboard room on the C.T.S.

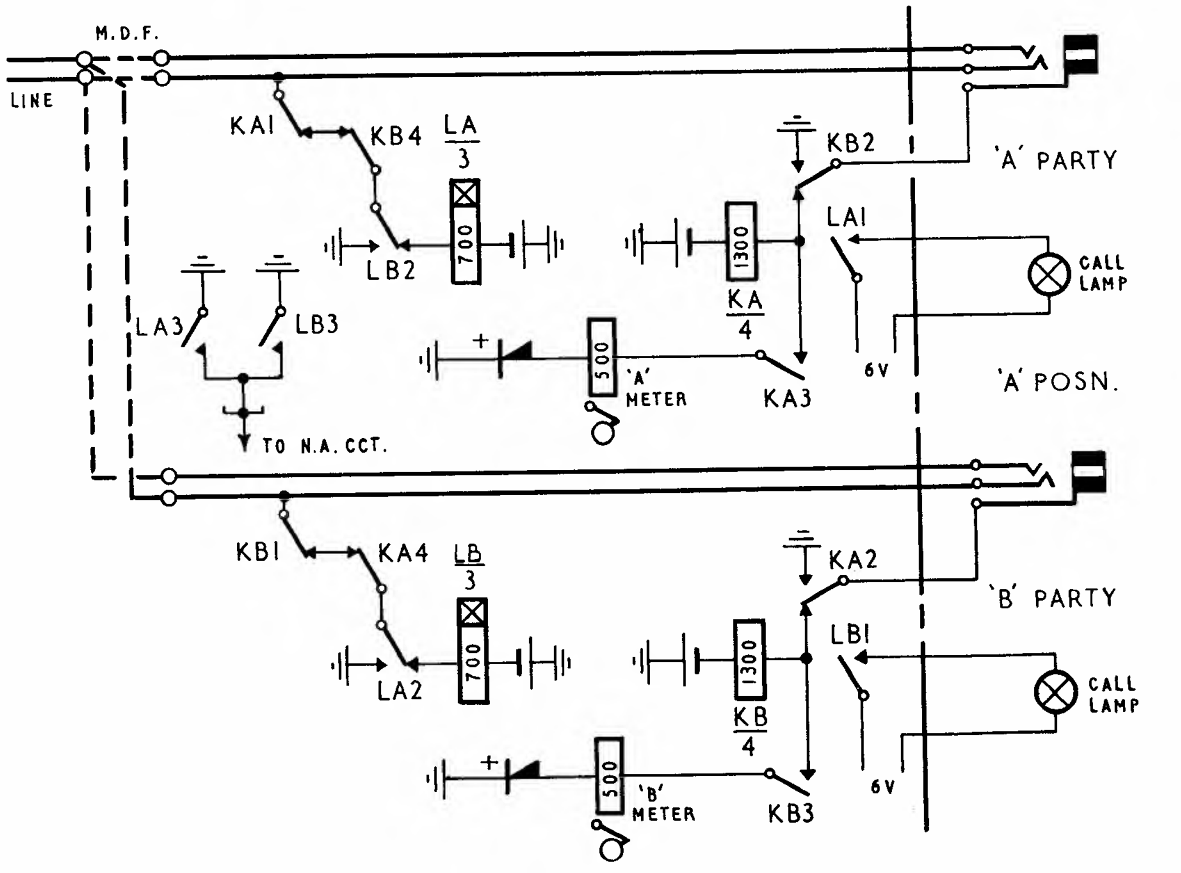


REGULAR SUBSCRIBERS' LINE CIRCUIT.
FIG. 3.

3.3 Two-Party Line, C.B. Signalling. (Fig. 4). Special telephones are used for each party. These have a call button, local battery and hand generator. Parties have separate multiple numbers and separate meters. Jumpers for "B" party are reversed on the M.D.F.

The calling party lifts the handset, presses the call button momentarily, and an earth is placed on either the "A" or "B" side of the line depending on which is the originating party. When the originator is the "A" party, relay LA operates and completes the lamp and N.A. circuits. LA opens LB and holds LA via the line loop to earth independent of the call button. KA operates to the answer cord sleeve and releases LA. KA earths the sleeve circuit of the "B" party jacks to provide for an engaged test.

Parties receive individual rings, one bell being operated over the A leg to earth and the other over the B leg. Calls between parties are made using the hand generators which are connected to ring earth return on the appropriate leg. The slow acting line relays do not respond.



TWO-PARTY LINE CIRCUIT C.B. SIGNALLING.
FIG. 4.

3.4 Multi-Party Line C.B. Signalling - Separate line relays and meters are not provided. Individual party calls are entered by the operator on a card. The regular line circuit (Fig. 3) is modified slightly as shown in Fig. 5. Metallic circuit code ring is used from the switchboard and between parties. Parties call the exchange by earthing the B leg with a call button to operate L which then holds to the loop via L3.

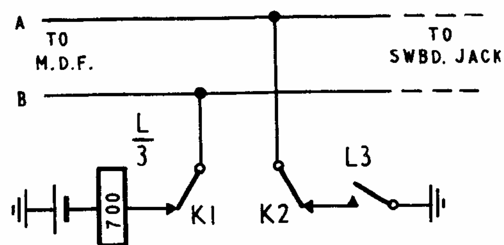


FIG. 5.

3.5 Line Circuit for Long Lines, Magneto Signalling, (Fig. 6) - For long lines (exclusive or party lines) the high loop resistance and probable low insulation resistance would make C.B. signalling unreliable. Magneto telephones are used and an auxiliary relay set is jumpered in between the M.D.F. and a slightly modified line circuit. For party lines code ringing is used, and outgoing calls from the parties are recorded on a card.

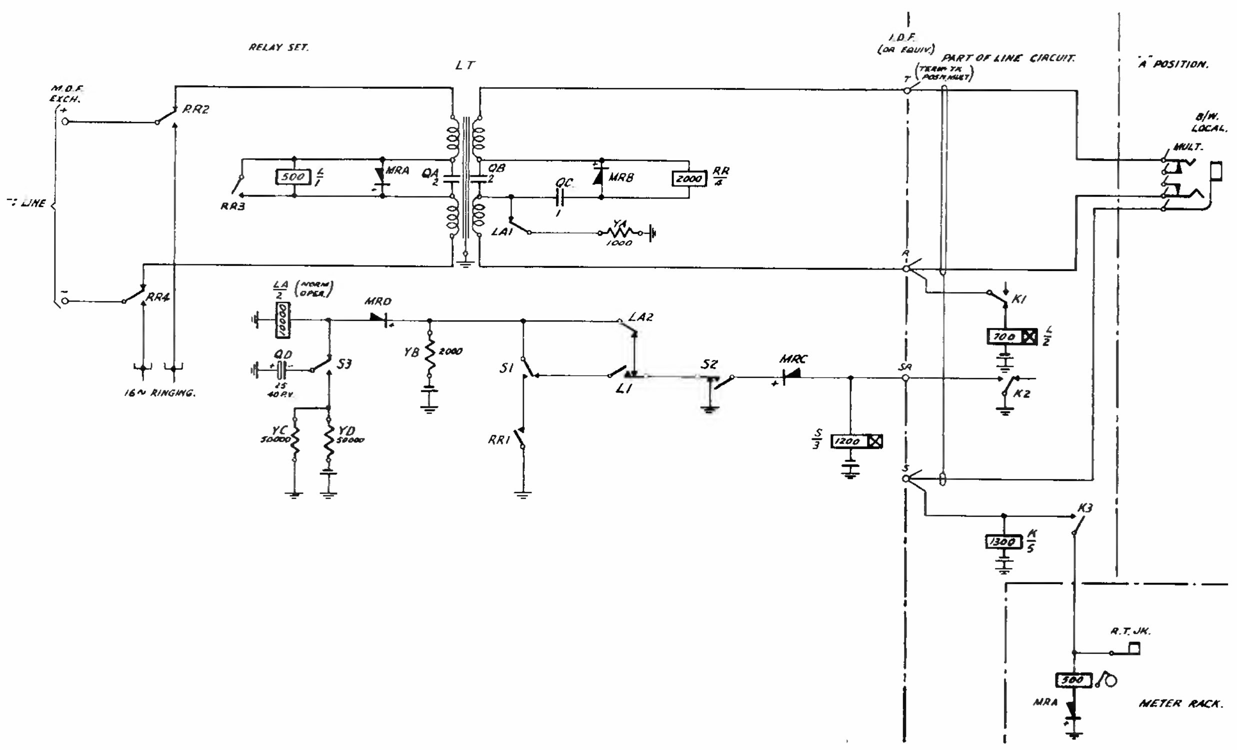
To call the exchange a party must ring for at least 3 seconds. L (aux. R/S) operates. L1 extends earth at S2 to short circuit relay LA which is normally operated. LA releases in about 3 seconds after discharge of capacitor QD through it; MRD prevents discharge via S2. LA1 releasing operates L (line cct.) which lights the call lamp. LA2 maintains the short circuit on LA after the release of L.

Telephonist answers; K operates, K2 operates S. S2 extends earth at K2 to maintain the short circuit on LA. 1,000 ohm earth at LA1 holds the cord circuit supervisory A relay during the call. (See Fig. 8.)

Sub. ringing off; L operates, removing the short circuit from LA at L1. LA operates and LA1 removes earth to initiate calling party cleared supervision on the cord circuit lamp. The plug is withdrawn; K and S release. S3 releasing places QD across LA. During the call however, S3 had allowed QD to recharge to 25V. (QD shunting LA while uncharged could cause its release.)

On outgoing calls to parties; K and S operate. RR operates to the outgoing ring. RR1 and S1 release LA; S3 and MRD allow fast release of LA. The short circuit on LA is maintained for the duration of call by LA2, L1, S2 and K2. RR2 and RR4 repeat the ring to line, and RR3 prevents L operating during the ring.

When the circuit is used for exclusive services QD is disconnected.



LINE CIRCUIT FOR LONG LINES.

FIG. 6.

4. "A" POSITIONS.

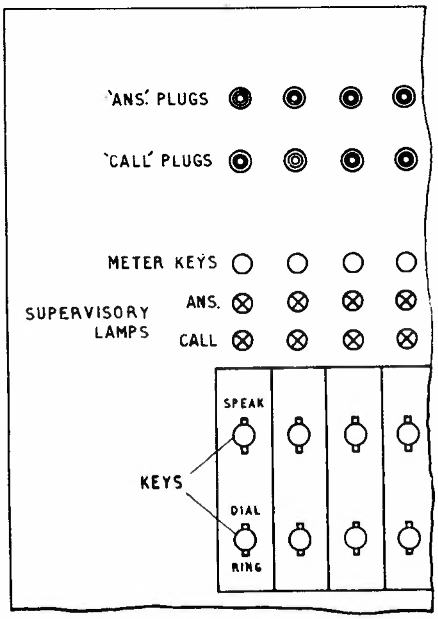
4.1 "A" positions have 16 cord circuits and the key shelves are arranged as shown in Fig. 7. The cord circuit relays are contained in 8 relay sets jacked in at the rear of each position; the position and telephonist's circuit apparatus is in another relay set.

4.2 The cord and position circuits are shown in Fig. 8. The cord circuit has a Stone transmission bridge with the relays A and D also controlling the answering and calling supervisory lamps at A2 and D1 respectively. Relays SA and SC remain operated for the duration of the call, completing the lamp circuits at SA1 and SC2.

SC1 when normal, connects the tip of the answering cord to one primary of transformer ET for the engaged test when the telephonist touches the plug tip on the sleeve of a called line jack. Any engaged line is close to earth potential (85 ohms to earth via SA or SC of another cord circuit) and a click is given to testing telephonists.

For calls on auto unit fee junctions, the dial circuit is connected to the T and R of the call cord via KD1 and KD2. Dialling into the junction relay sets is via + battery pulses on T and earth on R. A dial O.N. contact short circuits the second ET primary during pulsing. With the dial normal supervision is provided between digits.

Before the cords are restored at the end of an effective call the meter key is pressed. Positive battery operates the caller's meter in series with relay M, relay SA and the sleeve of the plug and jack. M1 lights the meter pilot lamp and M2 operates the effective meter included in the circuit to register the total number of effective calls handled. A separate ineffective meter key is used to record the number of calls answered which cannot be completed immediately (called party engaged, etc.).



ARRANGEMENT OF "A" POSITION KEY SHELF.

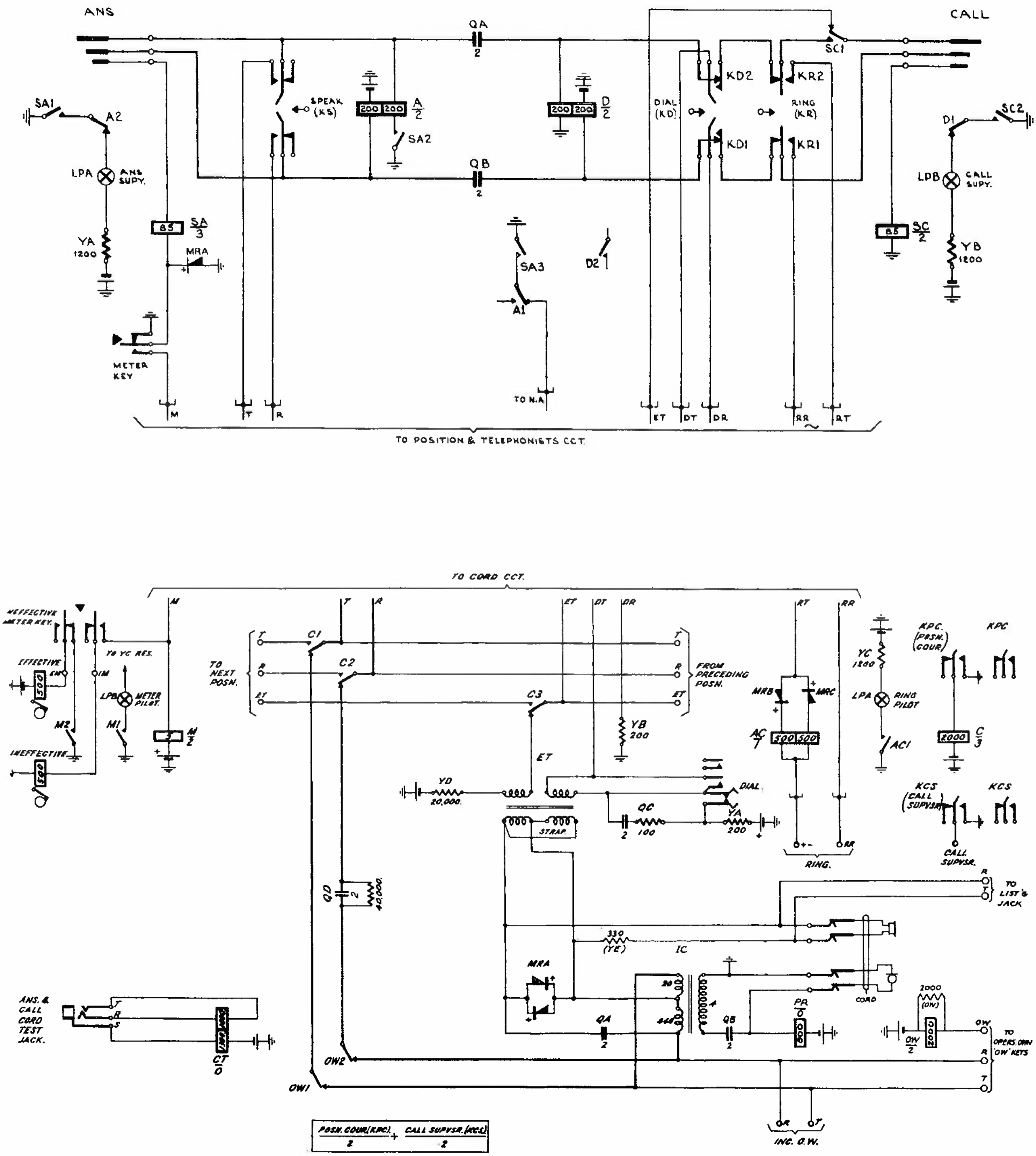
FIG. 7.

4.3 The A.C. relay in series with the ringing commons lights the ring pilot lamp at AC1, to indicate that ring is going to line.

Positions may be coupled to the adjacent position by operation of KPC. This operates C whose contacts switch the T, R and ET commons of the cord circuits from the local telephonist's circuit to the next position.

Order wires are provided where necessary to facilitate traffic handling. Operation of any order wire key connects the telephonist's circuit to the receiver circuit of the other position and operates OW, which isolates the telephonist's circuit from the cord circuit T & R commons.

4.4 Recording Junctions are a simple transfer circuit, jack ended on both "A" and trunk positions. Busy lamps on "A" positions and a call lamp on trunk positions are controlled by relays in the sleeve circuits of both jacks.



"A" CORD CIRCUIT AND POSITION CIRCUIT.

FIG. 8.

5. SLEEVE CONTROL PRINCIPLES.

5.1 The main types of trunk line are :-

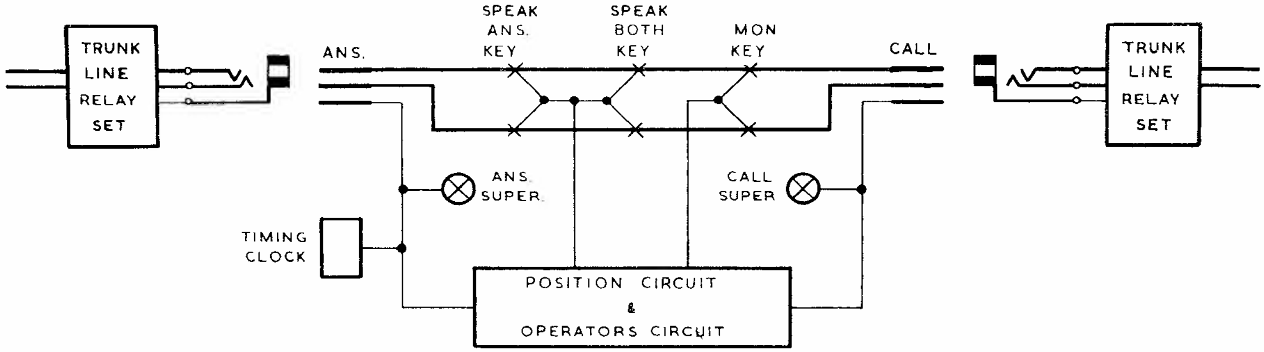
Generator signalling (magneto trunk lines).
Auto dialling or D.C. signalling.
Voice frequency and 2VF signalling (physical or derived circuits).

5.2 If the trunk lines were terminated directly on jacks in a similar way to the subscribers' lines, several different types of cord circuit and different operating procedures would be necessary for their interconnection and connection to subscribers.

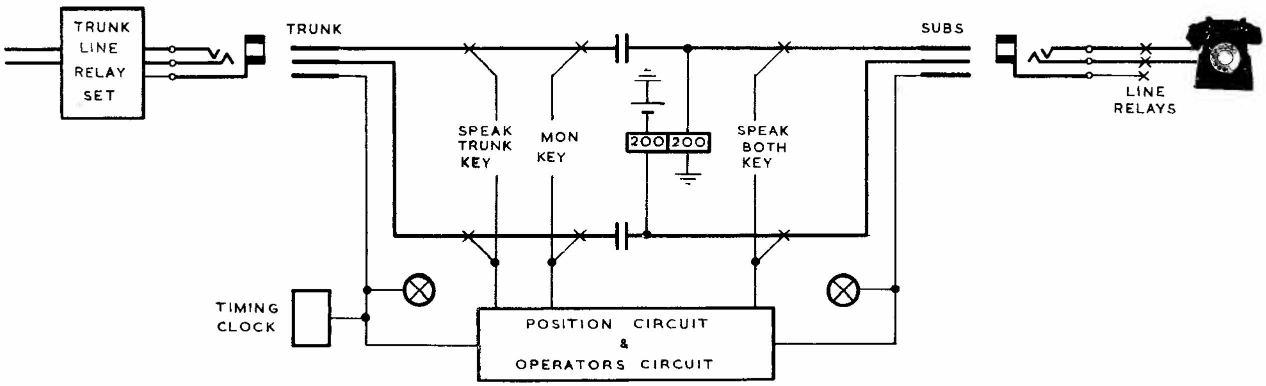
Each trunk line therefore, is terminated on a trunk line circuit providing signalling and terminating facilities suitable for that particular trunk line, but controlled from uniform cord and position circuits. This enables the Through trunk cord circuit to be reduced to a simple form. Fig. 9a shows the basic elements.

The cord circuit supervisory lamps are controlled from the trunk line circuit relay set over the sleeve wire; the trunk line circuit is also seized and released from the cord circuit via the sleeve wire - hence the term sleeve control. This distinguishes trunk cords from "A" cord circuits which, for want of a better term, are called bridge control, as supervision is controlled by the transmission bridge relays.

Each Terminating trunk cord circuit therefore, has a sleeve control "Trunks" cord and a bridge control "Subs" cord. Fig. 9b shows the basic elements.



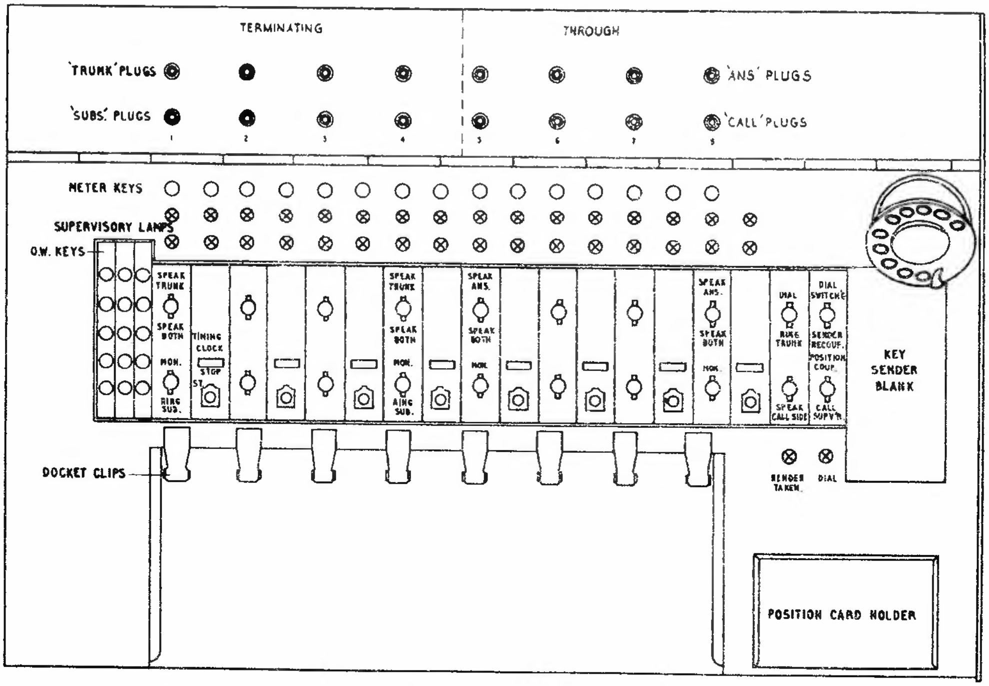
(a) Elements of Through trunk cord circuit.



(b) Elements of Terminating trunk cord circuit.

FIG. 9.

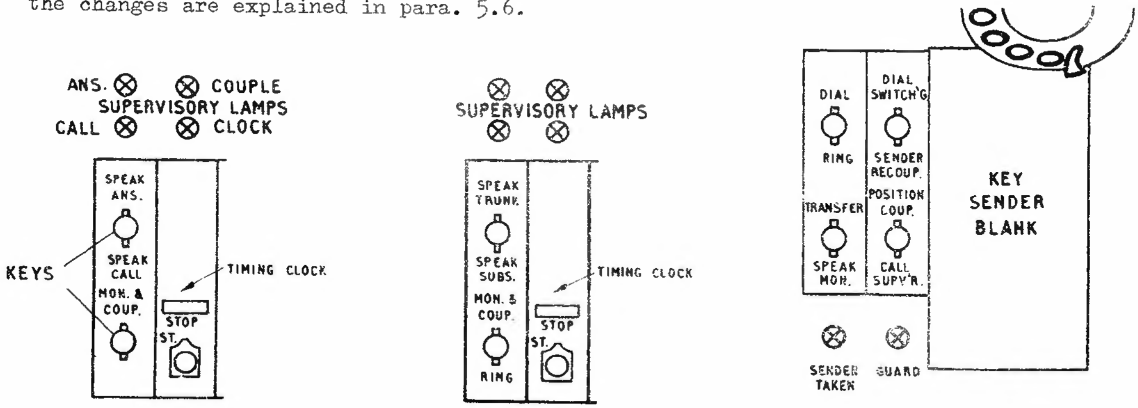
5.3 The cord circuit functions are kept simple by transferring all trunk line signalling functions to a common set of position circuit keys to the right of the cord circuits. Fig. 10 shows a typical arrangement of a Composite trunk position key shelf having four Terminating and four Through cord circuits. The operation of the position keys, DIAL, DIAL-SWITCHING or RING in conjunction with any one SPEAK key, directs the appropriate signal from the position circuit, through that cord to the trunk line circuit which responds accordingly for that line. Where necessary, loop pulses from the dial or key sender follow the same path and are converted to battery or VF pulses when so required.



COMPOSITE (TERMINATING/THROUGH) TRUNK POSITION - KEY SHELF.

FIG. 10.

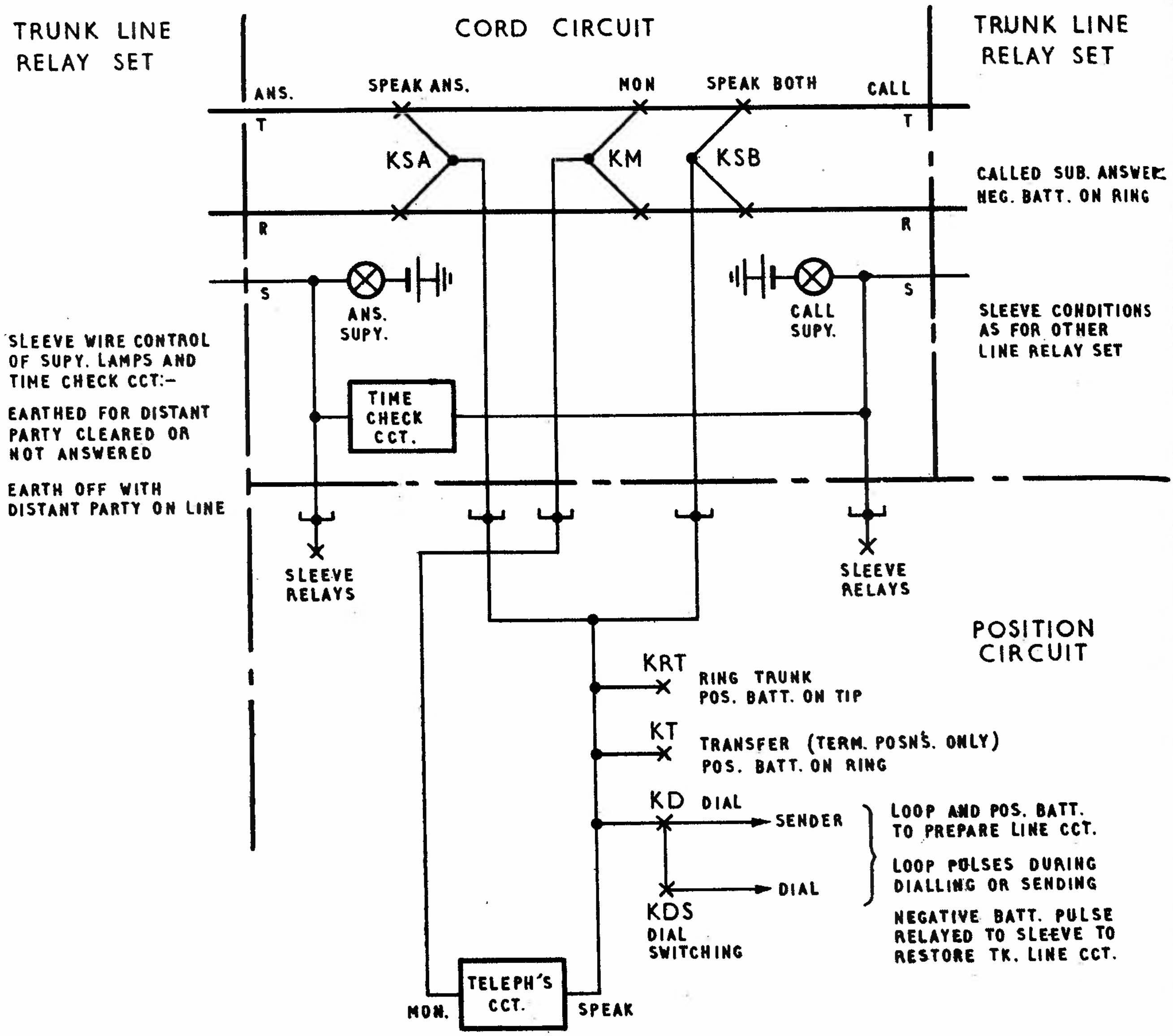
Before 1955 some of the circuit functions were different and the cord circuits were designated as shown in Figs. 11a and 11b for Through and Terminating positions respectively. The position circuit keys were as shown in Fig. 11c. The reasons for the changes are explained in para. 5.6.



(a) (b) (c)

EARLIER ARRANGEMENTS.

FIG. 11.



SLEEVE CONTROL KEY FUNCTIONS - CORD AND POSITION CIRCUITS.

FIG. 12.

5.4 Principal circuit conditions and the cord and position circuit keys used to apply them are represented in Fig. 12. Typical circuits are described later.

Note that D.C. signals from the position circuit RING and DIAL keys are merely routed by the SPEAK ANS key to the trunk line relay set on the Answer cord and by the SPEAK BOTH key to the trunk line relay set on the Call cord.

Fig. 12 represents a Through trunk position but the same conditions apply to the "Trunks" cord of Terminating cord circuits; the SPEAK ANS key becomes SPEAK TRUNK.

5.5 Other features of the cord and position circuits are:

- Engaged test is provided on both cords.

- Operation of the SPEAK ANS key (or SPEAK TRUNK of terminating circuits) divides the answering and calling sides of the cord circuit.

- The SPEAK BOTH key operated alone does not divide the circuit, but leaves the caller in circuit while the telephonist speaks or listens on the called line. The telephonist however, may exclude the caller at any time while speaking on the called side by operating the SPEAK CALL SIDE key; this divides the circuit. Also, operation of a RING or DIAL position key together with the SPEAK BOTH key, divides the circuit.

- A VF termination is provided for the isolated side of the cord circuit whenever it is divided.

- The switching, dividing and terminating functions are done by relays controlled by the speak keys instead of directly by the key contacts. The circuit is arranged to prevent the operation of two speak keys simultaneously on the same position from being effective.

- In the telephonist's circuit a high impedance monitoring circuit using a valve or transistor amplifier allows the telephonist to monitor one call while using a speak key to dial or ring on another circuit. This facility is known as "overlapping".

- A timing clock is provided with every second cord circuit on Through and Terminating trunk positions and generally with every cord circuit on Composite positions. The clock is started by the telephonist but stops automatically when the parties clear.

5.6 On the early type trunk positions having the key arrangements shown in Fig. 11, the SPEAK BOTH keys were called SPEAK CALL on Through positions and SPEAK SUB on Terminating positions. Operation of any speak key divided the circuit which locked in the divided condition until the operation of the MON key, then known as MON & COUPLE.

The SPEAK CALL SIDE position key was then SPEAK MON, allowing the telephonist to speak to both parties, via the cord circuit MON & COUPLE key. (The SPEAK BOTH key now provides this facility.)

In 1955 the circuit was changed to provide the "caller in circuit" and "overlapping" features described above. Many of the earlier installations have since been modified to give the new facilities.

A more recent modification is to provide cord circuit meter keys on Terminating and Composite positions. These apply + ve battery to the "Subs" cords for metering of short haul calls. That is, instead of preparing a docket for a two or three unit fee trunk call, the telephonist presses the key the appropriate number of times every three minutes.

5.7 Composite positions may have four Terminating and four Through cord circuits, or two of one and six of the other depending on the traffic to be handled. The Composite position circuit works in conjunction with either type of cord circuit.

A Composite cord circuit has been developed. Each cord circuit is normally a Terminating circuit but may be changed to Through condition for the duration of a call by operating the TRANSFER position key (re-designated THRO TRUNK) while speaking on the incoming trunk line.

6. TRUNK POSITIONS.

6.1 The trunk multiple jacks are in strips of 10, mounted together with two strips of 10 lamps for call and busy lamps.

2VF signalling trunks require separate incoming and outgoing jacks and these are generally arranged as shown in Fig. 13a. Where 2VF trunk lines comprise the greater part of the total number of trunk lines connected, it is usual to provide two jacks for all lines in the same way to give uniformity in operating procedure. Non - 2VF trunk lines then have the incoming and outgoing jacks commoned. In many cases, outgoing jacks only are multipled, the incoming jacks, one per line, being divided between the several positions.

Where there are only a few 2VF lines these generally occupy the lowest part of the multiple, with the other lines above having a single bothway jack (Fig. 13b).

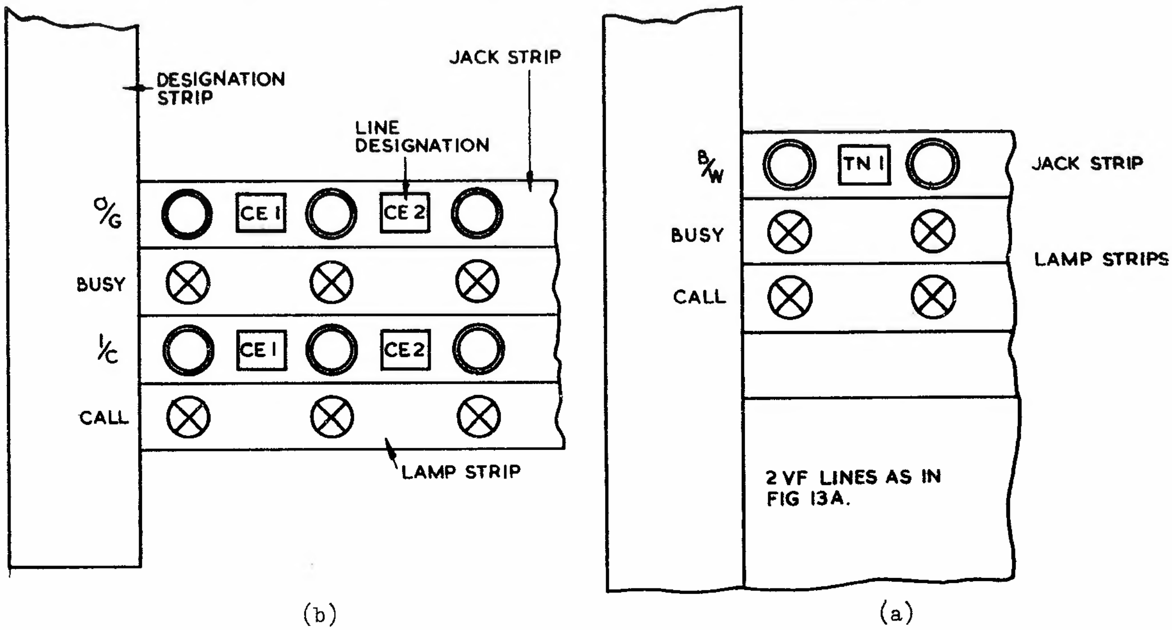


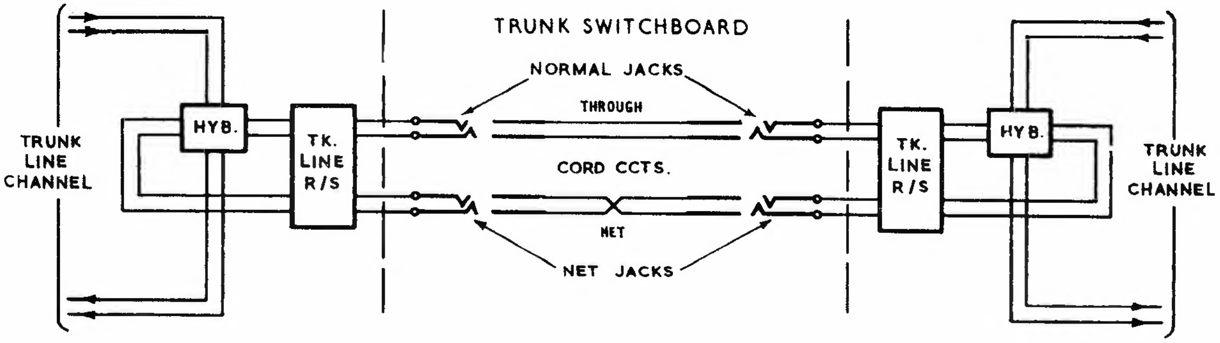
FIG. 13. TYPICAL TRUNK MULTIPLE ARRANGEMENTS.

6.2 Four Wire Switching. Carrier channels and trunks with terminal amplifiers may be switched four wire instead of two wire by switching the hybrid network terminals together in a 'tail eating' arrangement. This reduces the through switching loss and improves stability.

On the early boards network jacks were provided for such lines on Through positions, and up to four pairs of network cords were fitted between the regular cords. These were to be put up by the telephonist on connections between four wire trunks. See Fig. 14.

The trunk line relay set includes the hybrid network termination; this is disconnected by relay contacts, only when the call is through switched 4-wire to another trunk line. Telephonists rarely used the facility however and with later installations net jacks and cords are not generally provided. When provided, the network jacks are on a strip directly above the O/G or B/W jacks for the lines; a network pilot lamp provided on the position glows if the telephonist neglects to disconnect the net cords along with the normal cords.

Four wire trunk line relay sets are still provided where applicable because when four wire trunks are through switched by trunk selectors, network connections are made automatically at the same time. (See paper "Trunk Line Switching".)



FOUR WIRE SWITCHING - MANUAL.

FIG. 14.

6.3 Call timing is done by clock B.P.O. No. 44. These are provided, one for every second cord circuit on Terminating and Through positions and one per cord circuit on Composite positions. The operator starts the clock by hand when conversation between parties connected to the associated cord circuits has commenced. It then operates in conjunction with the cord circuit as follows:

- Indicates to the operator on two numbered discs the duration of the call in minutes and tenths of a minute.

- Causes the associated meter lamp to light at 2.8, 5.8 and 8.8 minutes after the start, and then to go out again at 3 and 6 minutes respectively. When the calling line clears the clock stops automatically and indicates the total time of the call, until reset manually by the operator to read 9.9. (The first pulse brings the clock to 0.0.)

- Connects pip tones to the circuit (if provided) at 2.8, 5.8 and 8.8 minutes to notify the parties that a further 3 minute period will start in 12 seconds. The 'pip tones' are 3 pips of tone at 1 second intervals (usually 900 c/s).

- Causes the meter lamp to flicker after timing up to 9.0 minutes. It is reset to zero and restarted if the call exceeds 9 minutes.

The clock works on the principle of the subscriber's meter. The operating solenoid responds to 6 seconds (1/10 minute pulses) and auxiliary cams operate springsets for the lamp and pip tone circuits. For illustration of a clock and a description of the time check circuit see page 20.

Further information on the clock No. 44 can be obtained from Engineering Instructions TRAINING miscellaneous Notes A.1200, and TELEPHONY Exch. Manual AD.1010.

6.4 A key sender circuit may be provided to operate with the trunk position circuits instead of the dial. A blank panel is provided on the key shelf to accommodate the sender keys.

The DIAL key in the position circuit connects the sender circuit (a number of senders are shared by all positions) and the two keys DIAL and DIAL SWITCHING operated together connect the dial into circuit. Without senders the usual practice is to strap the springs of KDS (dial switching) so that the dial is brought into circuit using the DIAL key alone.

6.5 Figures 15, 16, 17, 18 and 20 are typical sleeve control trunk switchboard circuits. The position circuit shown is a Composite one designed to operate with either Through or Terminating cord circuits.

Through Cord and Position Circuits (Figs. 15 and 16). With the Speak keys normal the supervisory signals from the trunk line relay set are fed directly to the lamps via the sleeve wires. With KSA or KSB operated, the contacts of relays SKA or SKC respectively divide the sleeve circuit and divert it to the position circuit, where the FA relay responds to the signals and controls the lamp at FA1. TA relay will hold to higher resistance earths in the trunk line circuit not intended to light the lamp or operate FA.

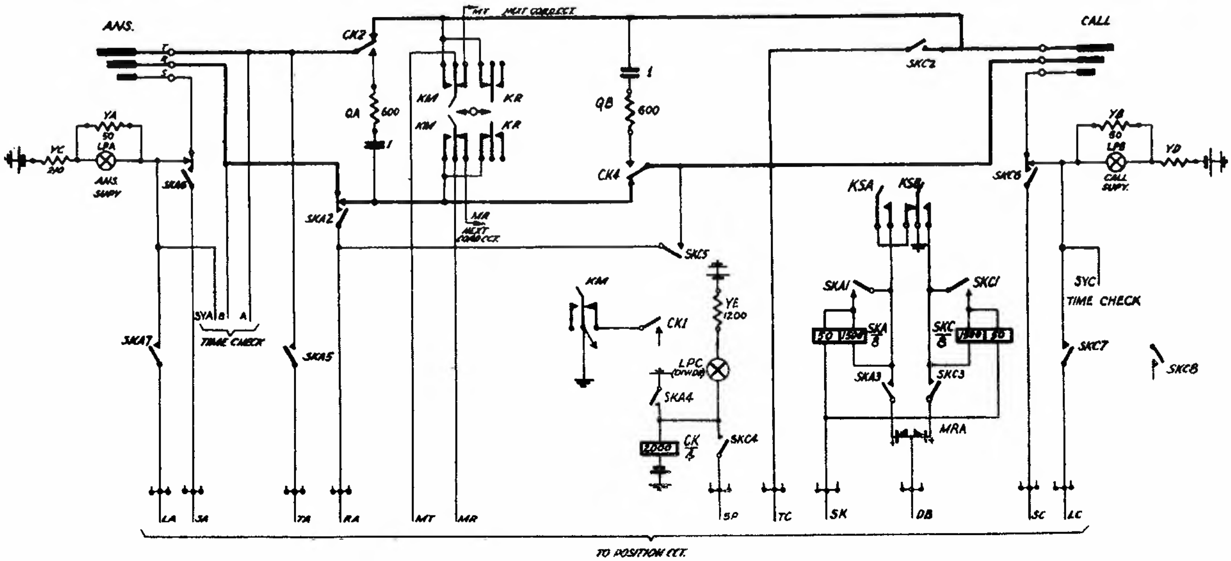


FIG. 15. THROUGH TRUNK CORD CIRCUIT.

Relay CK operates via SKA4 to divide the T & R of the cord circuit and terminate the call side at CK4. SKC4 will operate CK only if an earth is supplied from the position circuit on the SP lead by KD, KRT or KSC.

The operating path of SKA and SKC in each cord circuit is via the common resistor R3 (390 ohms) in the position circuit. After one relay operates on both coils in series, the 1500 ohm coil is short circuited leaving the relay to hold on the 50 ohm coil. This increases the voltage drop in R3 so that no other cord circuit SKA or SKC relay can operate in parallel with the relay already holding. The rectifier MR1 prevents interaction between SKA and SKC circuits when the key is moved quickly from SPEAK ANS to SPEAK CALL.

For ringing out on generator signalling trunk lines, or ringing forward after dialling on 2VF trunk lines, the KRT applies positive battery on the Tip to either cord depending on whether SKA or SKC are operated. Relay PB operates if the circuit is complete and lowers the resistance by placing the second coil in parallel at PB1.

Dialling on Trunk Cords. KD and KDS are operated, relays DA and DB operate; their contacts provide a loop between TA and RA leads via retard RA, at the centre tap of which positive battery is applied via PB1 and DA5 to prepare the trunk line circuit. When the dial is pulled off normal DK operates; the circuit is altered to a plain loop via the dial pulse springs, RA and positive battery being removed at DK2 and DK3. DB1 holds SKA or SKB in the cord circuit even if the telephonist restores the speak key while the dial is returning to normal.

At the end of the dialling KD and KDS are restored, releasing DA, followed by DB slowly. During the slow release of DB a pulse of negative battery is applied to the sleeve wire via R4, DB6 and DA8 to prepare the trunk line circuit for the next stage of the call.

Between digits DK releases and PB operates slowly. The operate lag of PB ensures that the WS relays of final selectors have time to operate and hold before the positive battery is applied behind the loop.

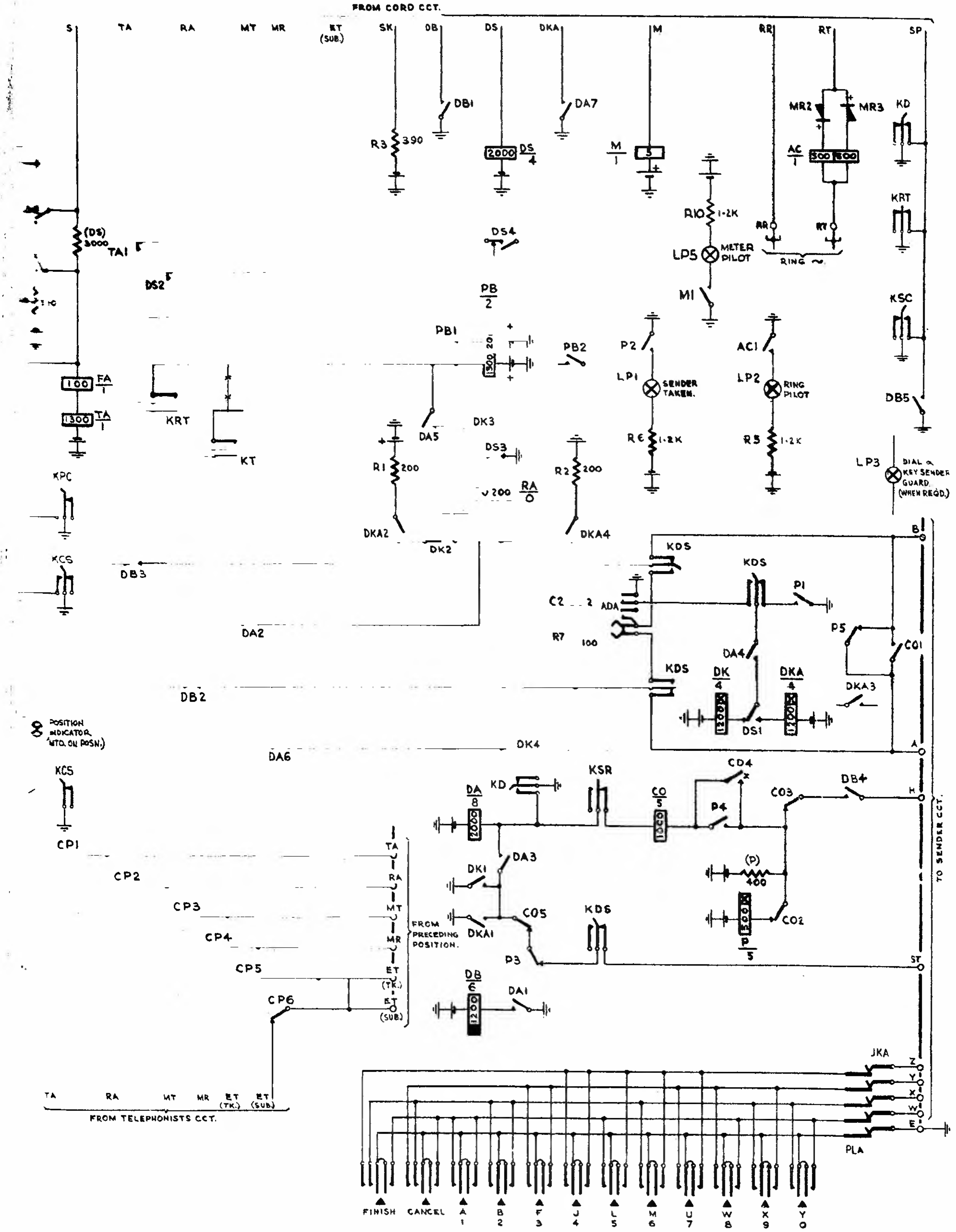


FIG. 16. TYPICAL COMPOSITE (TERMINATING/THROUGH) POSITION CIRCUIT.

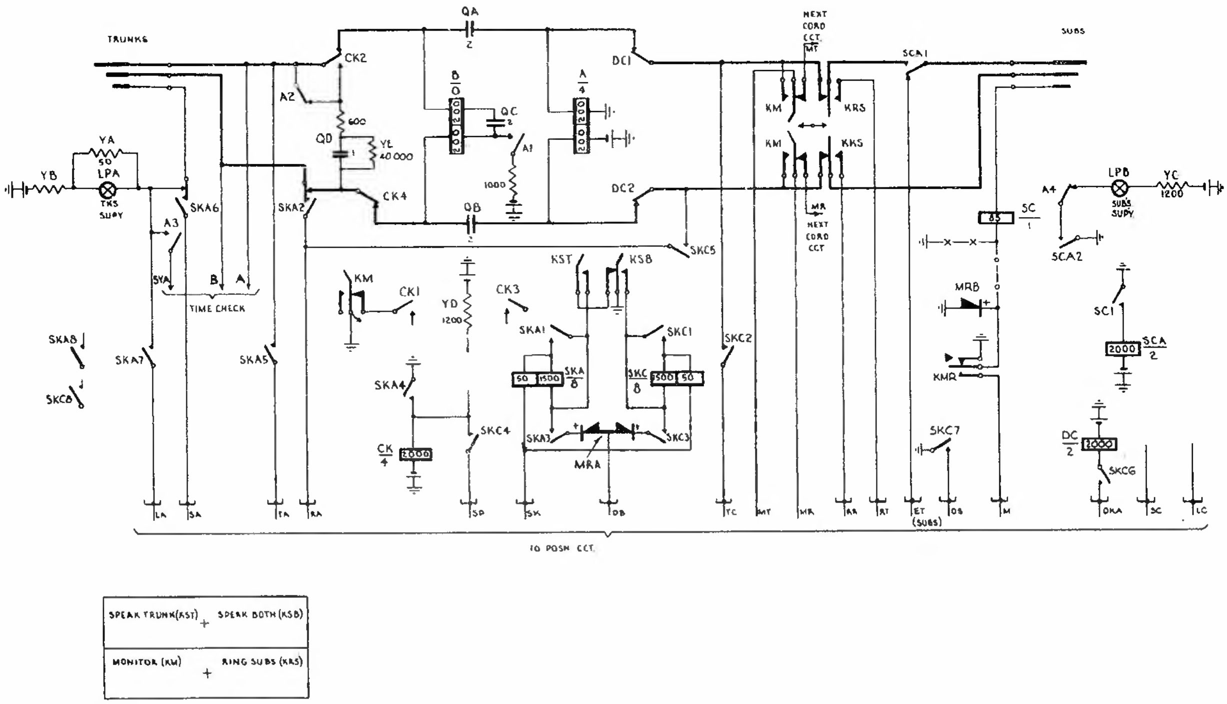
Terminating Cord Circuit. (Fig. 17) has many circuit details identical to the Through cord circuit, especially the "Trunks" cord.

Relay A provides transmission feed to the subscriber. The "Subs" supervisory lamp is controlled by A4. Battery returned on the Ring of the "Trunks" cord via A1 and one coil of B retard provides called party supervision to the trunk line relay set (utilised only by 2VF trunk line circuits). The timing clock is stopped by either the removal of earth on the "Trunks" cord sleeve or by the circuit being opened at A3 when the subscriber clears. A2 normal, completes a VF termination for the trunk line until the subscriber answers, and after clearing.

The SPEAK TRUNK key divides the cord circuit at CK2 and CK4 by the operation of CK at SKA4; CK2 also terminates the trunk line. The SPEAK BOTH key operates SKC, but CK does not operate to isolate the "Trunks" cord unless there is an earth on the SP lead from KSC or KD in the position circuit (SPEAK CALL SIDE and DIAL respectively).

Engaged test on the subscribers' multiple is provided by the ET lead to the engaged test transformer in the telephonist's circuit (Fig. 18) via the position circuit.

For dialling out on unit fee auto junctions the DC relay in the cord circuit is operated from DA7 in the position circuit. DC1 and DC2 divide the cord circuit and isolate the "Trunks" cord and transmission feed. Relay DS in the position circuit is operated by SKC7 in the cord circuit. With the dial keys thrown, DKA operates via DS1 instead of DK, changing the dialling circuit to give earth pulses on the Ring via DKA4 and the dial, plus positive battery on the Tip via DKA2 (DA and DB are operated as for call out on Trunk cords). An A relay in the junction relay set receives the pulses.



TERMINATING TRUNK CORD CIRCUIT.

FIG. 17.

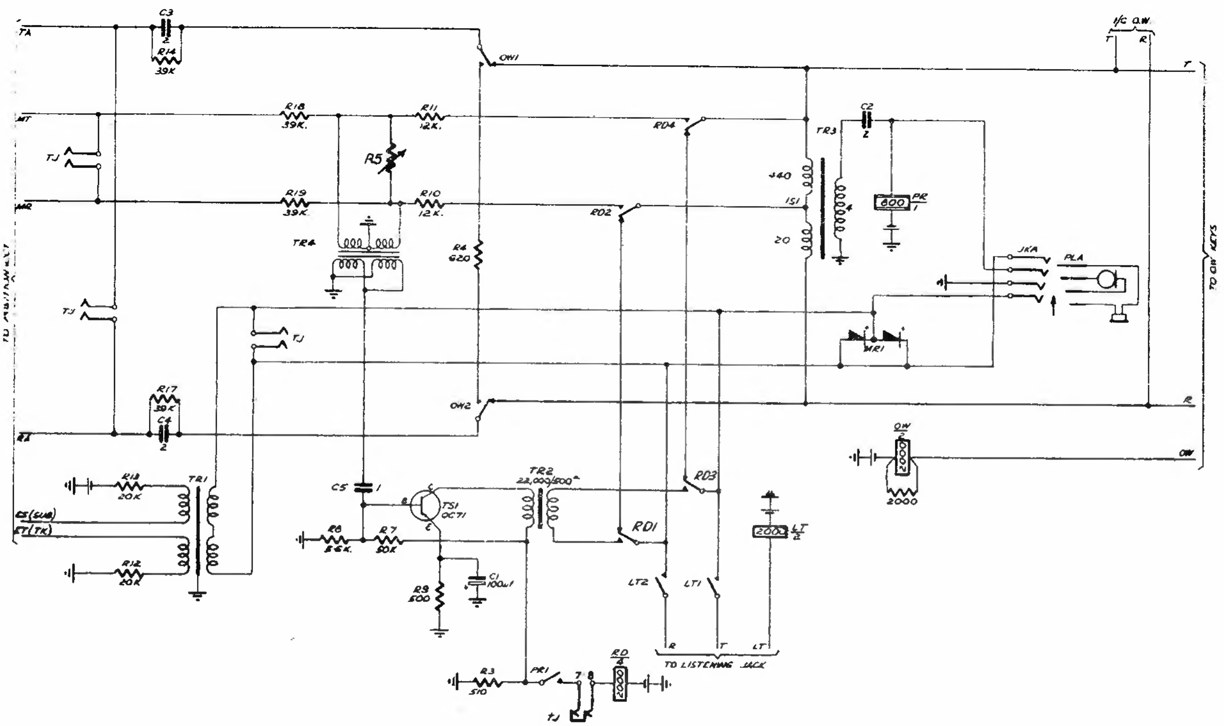
Telephonist's Circuit. Fig. 18 shows a typical telephonist's circuit using a transistor receiving and monitoring amplifier. When a telephonist's head-set is inserted PR operates. PR1 applies a potential to the amplifier circuit and operates RD. The RD contacts connect the receiving circuit via the amplifier.

Incoming speech on the T & R wires is applied to input transformer TR4 via the attenuation bridge consisting of R10, R5 and R11. The amplified signal from TS1 is fed to output transformer TR2 and thence direct to the receiver via RD1 and RD3.

Signals on the monitoring wires MT & MR are fed to the input transformer TR4 via the other half of the attenuation bridge consisting of R18, R5 and R19. A telephonist may monitor on one circuit while setting up a call on another circuit using the Speak key. Because of the attenuation bridge the coupling between MT & T, and MR & R is negligible, so there is no interference between the two circuits. This is the overlapping facility.

Should the amplifier fail, the flag is removed from test jacks 7 and 8 of the relay set and RD releases, connecting the receiving circuit direct to the receiver. This makes the monitoring circuit inoperative until the fault is cleared.

Engaged test signals are fed to the receiver direct via transformer TR1.



TYPICAL TELEPHONIST'S CIRCUIT.
SLEEVE CONTROL TRUNK POSITION.

FIG. 18.

Time Check Circuit. A B.P.O. No. 44 timing clock is shown in Fig. 19 and a typical time check circuit in Fig. 20. The 1/10 minute cam and springs are not shown in Fig. 19 as they are behind the one minute cam and springs. The Restoring key is a purely mechanical arrangement to reset the mechanism to 9.9 after a call. Turning the START key however, locks the Restoring key in the up position so that it cannot be pressed accidentally during call timing.

When the START key of a clock is turned, an earth is fed via the ST lead to start the pulse and tone distribution circuit. Relay TP (one per position) pulses to the six second earth pulses. TP1 (one contact per clock) pulses SY relay to battery behind the cord circuit supervisory lamps, via the routine test jack, SP4 and KS springs. SY1 pulses DM of clock which steps from 9.9 (home) to 0.0 and thence to 0.1 and so on, every 1/10th of a minute. At 2.8 minutes, cams associated with the units and tenths number discs operate springs which connect earth from KS to operate PP relay and light the clock supervisory lamp. PP1 and PP3 connect the pip tones to the T & R of the cord circuit to warn the caller that the three minute period will expire in approximately 10-12 seconds. At 2.9 minutes PP releases and at 3 minutes the clock supervisory lamp goes out.

If the call continues the same cam springs operate at 5.8 and 8.8 minutes. At 9.0 minutes, the minute cam springs 6 and 7 make and operate relay SP. SP holds via SP3. SP2 connects flicker earth to the lamp advising the telephonist to reset and restart the clock.

Whenever the parties clear, the battery on the SYA or SYC leads changes to earth; as SY can no longer pulse, the clock stops. Originally an SYA lead to the Answer cord sleeve only was provided, so that the party connected by the Answer cord had to clear to stop the clock. With the addition of the SYC lead to the Call cord sleeve, either party clearing stops it. R1 and MR1 prevent unwanted coupling between the sleeve wires themselves.

Clocks are routined quickly by plugging a cord into the routine test jack and operating the master routine test key on the CTS. Flicker earth pulses (150 per minute) are applied to relay FL. One of the FL contacts pulses SY via the routine jack auxiliary springs. At 2.8 PP operates; PP2 stops the pulses and the telephonist may monitor the pip tones. Momentary pressing of a spare order wire key connected as shown allows all clocks being tested on the position to restart and release their respective PP relays.

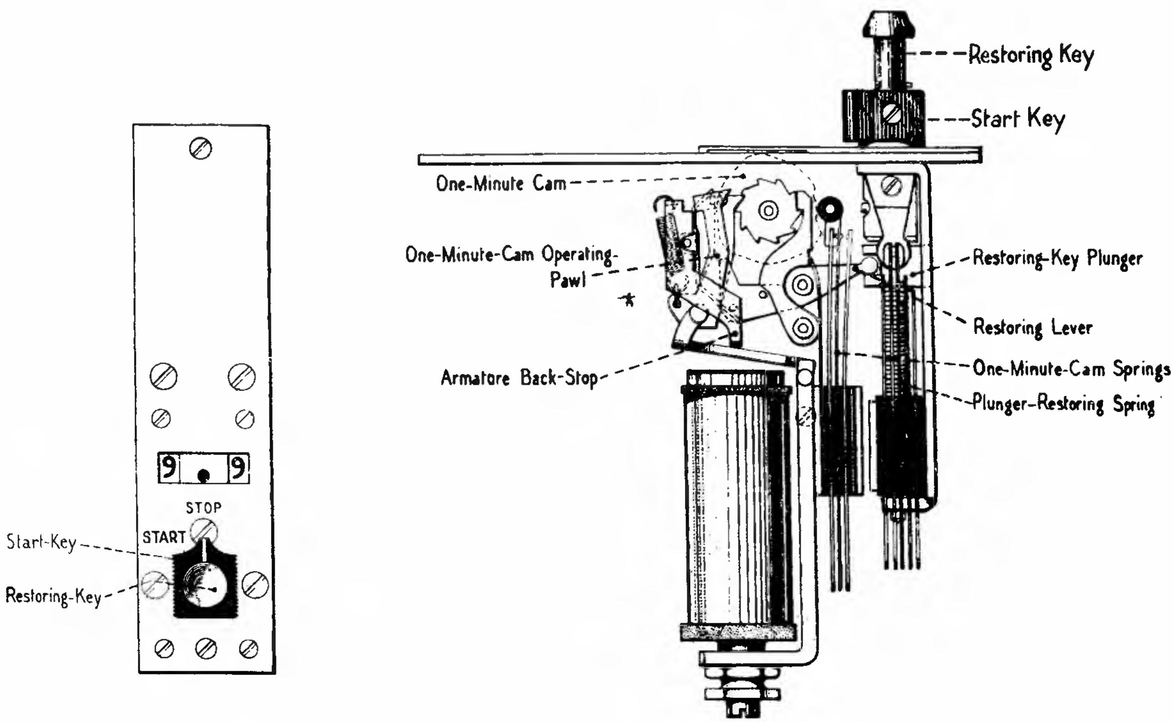
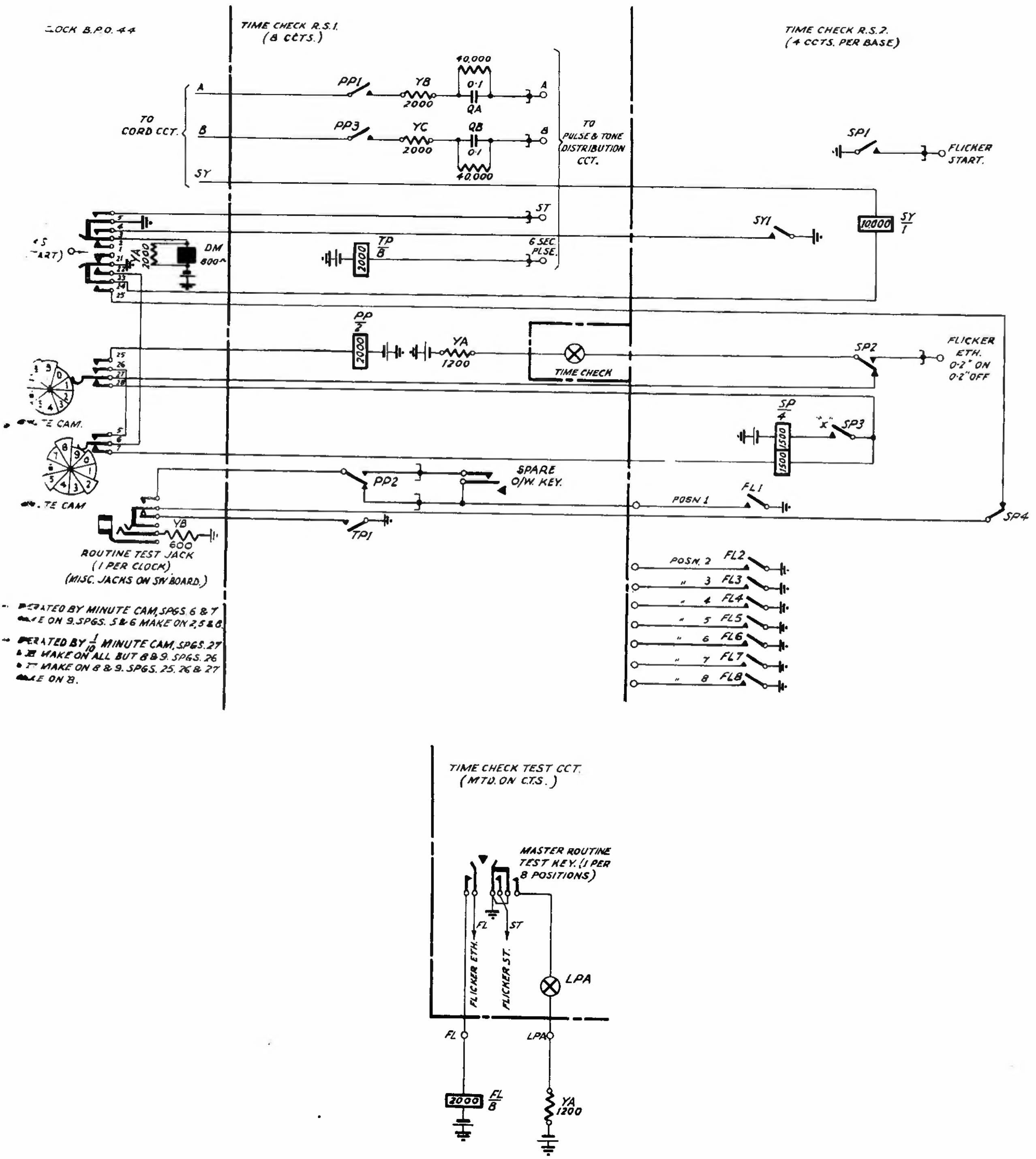


FIG. 19. TIMING CLOCK B.P.O. NO. 44.



TYPICAL TIME CHECK CIRCUIT.
SLEEVE CONTROL TRUNK POSITION.

FIG. 20.

7. TRUNK LINE CIRCUITS.

7.1 As outlined in Section 5, the various trunk lines (generator signalling, auto dialling, and 2VF signalling) terminate on relay sets designed to operate in conjunction with the sleeve control cord and position circuits. However in this paper it is not practicable to discuss the variety of circuits which result from the division of trunk line circuits into additional categories of bothway, incoming and outgoing, either for 2 or 4 wire switching.

2VF trunk line circuits are explained in complementary paper "Trunk Line Switching".

7.2 Auto Dialling Trunk Lines. (Fig. 21). When an exchange has only Composite trunk positions, the separate connections shown for Terminating and Through multiple jacks are not required; bothway jacks on Composite positions are connected as shown for Terminating positions via the S relay, etc. This applies also to Fig. 22.

Outgoing Call. Sleeve relay S or M operates in series with the cord circuit supervisory lamp which lights. The operation of S or M causes the operation of two relief relays not shown, SR and SSR, whose contacts perform various busying and holding functions. Before dialling, positive battery behind the dialling loop operates relay DC over the Tip wire; DC locks. The T & R from the jack are extended to the outgoing + and — wires. Loop pulses position the distant selectors.

When the dial key is restored, the pulse of negative battery on the sleeve operates SA which locks, releases DC at SA3 and completes the speaking path at SA1 and SA2. The called party answers, the reversal operates D, and the earth on the sleeve wire is replaced by 5,000 ohms earth. This puts out the cord supervisory lamp but will hold relay TA if the speak key is operated. D1 applies battery via 2,000 ohms to the Ring side, which, passing back via a Through cord circuit, is applied to the incoming trunk line relay set to initiate the answer signal to the originating station (applies to 2VF 'Answer' signal).

When the called party clears, D releases, an earth on the Sleeve lights the supervisory lamp and battery is removed from the ring.

At stations with trunk selectors, through calls may be switched directly. When a selector seizes the relay set, GS operates and diverts the outgoing + and — wires.

Incoming Call. The incoming ring operates L. LA operates and locks, lighting the call lamp on a Terminating or Composite position at LA5; LA6 operates SA. S operates when the trunk plug is inserted and its relief relay SSR releases LA.

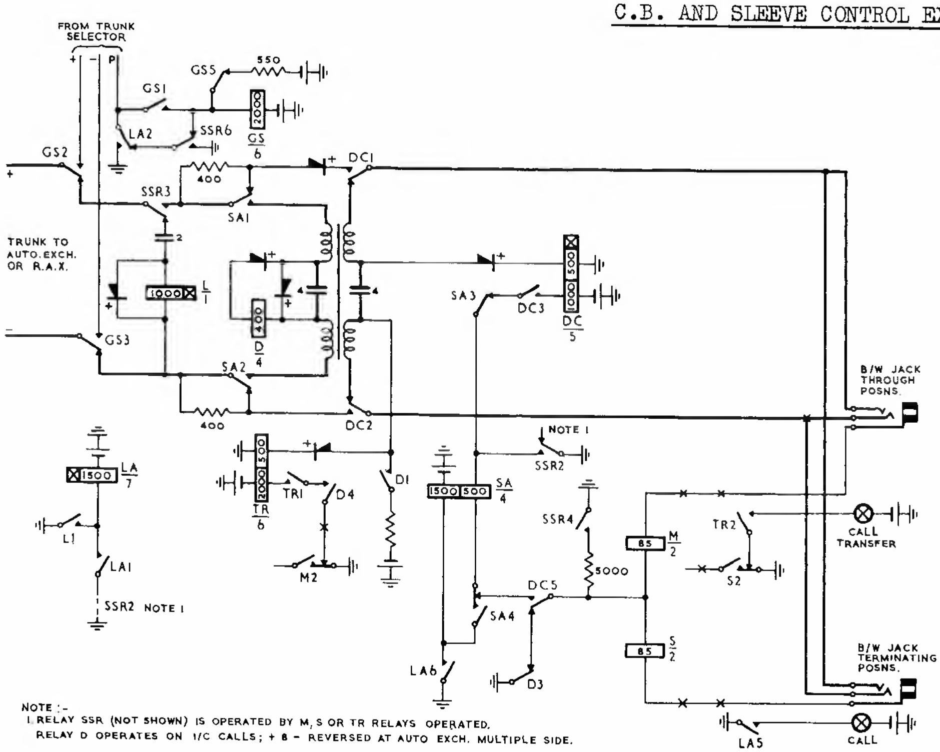
The + and — wires are arranged in the distant auto exchange so that D operates on incoming calls. When the caller clears D releases and provides supervision.

When the call is to be through switched, and there are separate Terminating and Through positions, the Terminating telephonist operates the TRANSFER key in the position circuit (Fig. 17); positive battery on the Ring operates TR. TR locks and lights the call lamp on the Through position at TR2 (after the Terminating cord is withdrawn and S2 released).

7.3 Generator Signalling Trunk Lines. (Fig. 22). Supervisory signals are fed back over the Sleeve in series with M or S, one of which holds for the duration of the call. Relay SS, not shown, is a relief relay operated by either M or S operated.

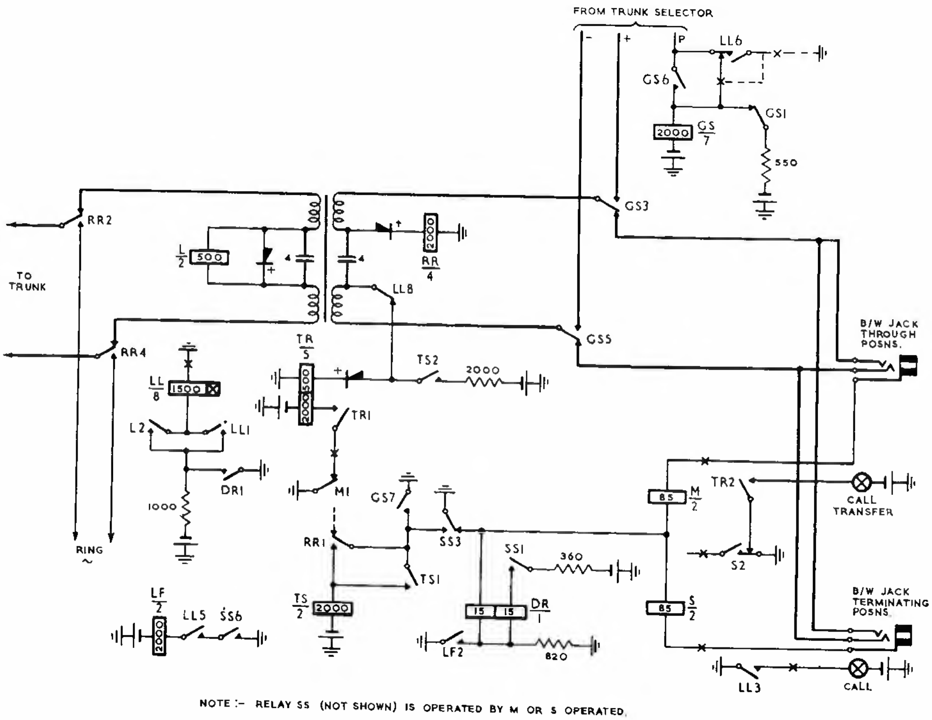
Outgoing ring from the position circuit (Fig. 17) or from an incoming 2VF line circuit via the trunk selector, operates RR by positive battery on the Tip. RR2 and RR4 connect ringing current to line. TS operates and locks to return answering supervision to incoming trunk line circuits via the leg or Ring. (This is necessary at this stage as no signal is returned over the trunk when the distant exchange answers. 2VF line circuits respond to give correct supervision during subsequent conversation.)

Incoming ring operates L. LL operates and locks, lighting the call lamp at LL3. DR is a differential relay balanced until the telephonist comes across the line with a Speak key. The telephonist answers, S, SS and DR operate. DR1 releases LL. DR releases when the Speak key is restored. A ring off or recall on the trunk reoperates L and LL. LF operates and applies a 15 ohm earth to the sleeve to light the cord circuit supervisory lamp. In the case of a recall, DR operating restores LL and LF.



SIMPLIFIED TRUNK LINE CIRCUIT - BOTHWAY TO AUTO.

FIG. 21.



SIMPLIFIED TRUNK LINE CIRCUIT - GENERATOR SIGNALLING.

FIG. 22.

7.4 Junction circuits to exchanges in the unit fee area are designed to work with the "A" position cord circuits and the "Subs" cord of Terminating circuits.

Relay sets of junctions to auto exchanges are a form of manual to auto repeater; an A relay in the junction circuit responds to the pulses from the cord circuit and repeats them to line. On incoming calls the meter pulse from the cord circuit operates a relay to give a reversal on the incoming + and – wires. Supervisory conditions, that is the auto sub answering or clearing, are relayed to the jack side of the circuit to control the transmission bridge supervisory relays A or D in the cord circuit.

Generator signalling junctions are a form of ringing repeater with facilities similar to those given by the subscriber's line circuit shown in Fig. 6.

Junctions may be connected to the trunk selector multiple for automatic switching of through calls direct to the particular exchanges served. This is arranged in a similar way to that shown in Figs. 21 and 22.

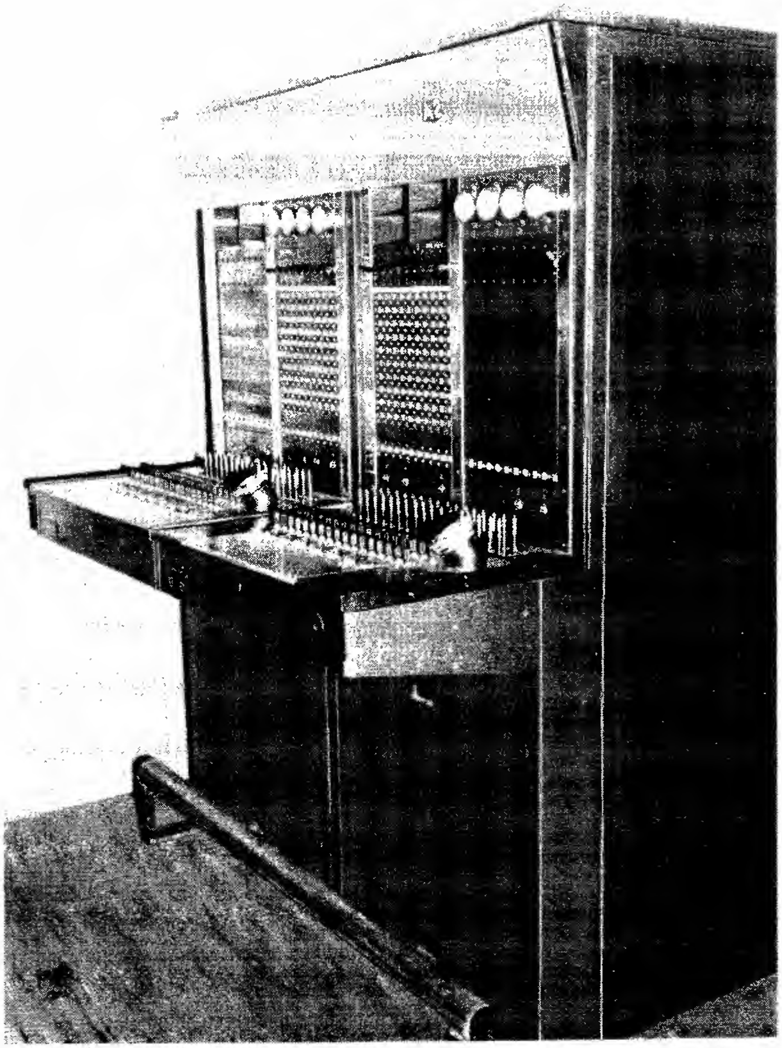


FIG. 23. A C.B. NON-MULTIPLE EXCHANGE.

8. NON-MULTIPLE EXCHANGES.

8.1 For exchanges having too few subscribers to warrant a multiple exchange, a non-multiple, combined "A" and trunk position was designed in the A.P.O. and the first of these installed in 1948. The ultimate capacity of an exchange is three positions, but usually not more than two are provided initially as a centre having sufficient subscribers or traffic for three positions would normally require a multiple exchange. Fig. 23 shows a CB non-multiple exchange having two positions.

8.2 Each position is equipped for a maximum of -

200 subscribers
18 trunk lines (2 wire)
16 cord circuits
(1 network cord circuit was provided on some early boards having 4 wire trunk line circuits).

The trunk line circuits are not the sleeve control type and the same cord circuits are used for local and trunk connections. However two of the cord circuits are intended for through trunk connections as this gives a lower switching loss than by using the normal cords.

Ten relay sets for the 14 regular cord circuits, 2 trunk cord circuits, position circuit and pilot and N.A. circuit are jacked in at the rear of the switchboard.

8.3 A relay set rack is provided to accommodate trunk line, party line and miscellaneous circuits. When a separate equipment room is not available, the relay set rack, together with the M.D.F., battery cabinet, rectifier and trunk equipment, such as line transformers and patching jacks, may be in the same room as the switchboard.

8.4 Subscriber's Line Circuit (Fig. 24). Individual line relays are not provided and the sub's. call lamp is in series with the line (a similar arrangement to the extension circuit of the A.P.O. C.B. P.B.X., CE.250). The lamp current is adjusted to correct limits by strapping the 300 ohm series resistance with line loops exceeding 300 ohms.

A line pilot relay LP is common to every 50 lines; this is more reliable than having only one pilot relay for all the lines as the combined leakage resistance of a 100 or more open wire lines would leave too small a margin between the operate and release current values of the relay. The LP1 contacts operate a position pilot lamp and relay PP. PP1 lowers the resistance in the calling circuit to light the call lamp. The termistor in series with the 500 ohm coil of each LP relay prevents momentary (swinging) earth and short circuit faults from operating LP.

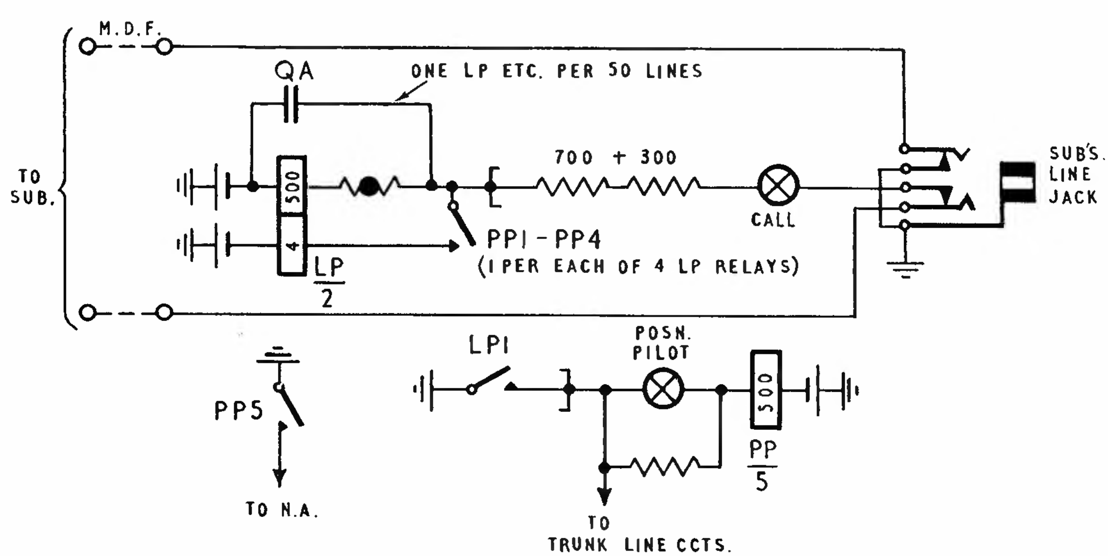


FIG. 24. SUBSCRIBER'S LINE CIRCUIT.

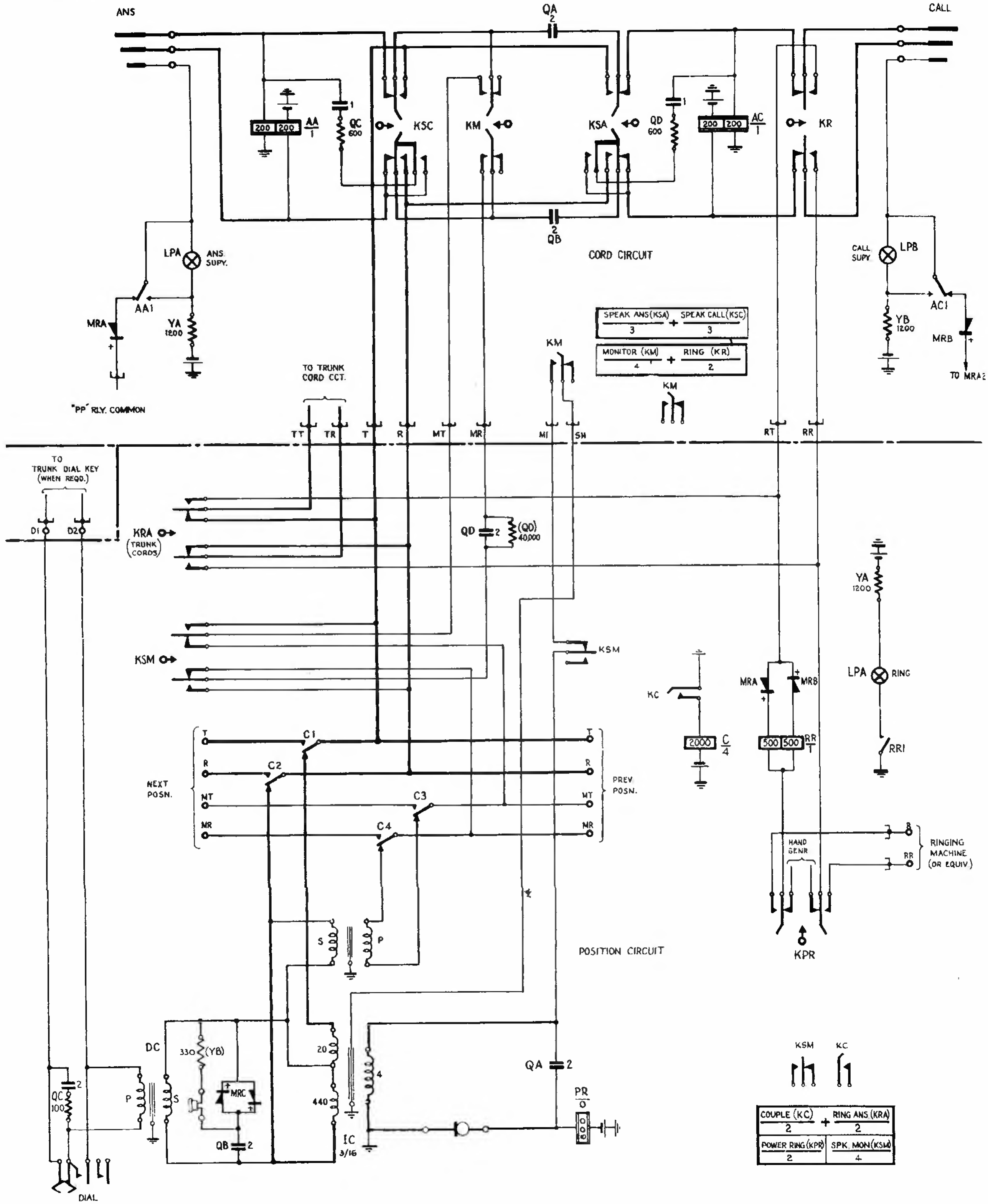


FIG. 25. CORD AND POSITION CIRCUITS.

8.5 The Cord and Position Circuits (Fig. 25). A conventional bridge control arrangement is used with separate SPEAK ANS and SPEAK CALL keys giving dividing facilities, plus a MON key for each cord circuit. The position circuit includes a SPEAK MON key to allow the telephonist to speak to both parties together.

A dial is provided, but there is no common key for dialling over the cord circuit; any auto junctions or trunk lines are provided with an individual dial key.

A supervisory alarm at the completion of calls is provided by AA1 and AC1 normal, extending the sleeve earth from the line circuits to the PP relay (Fig. 24) via the rectifiers MRA and MRB.

8.6 The Trunk Cord Circuit (Fig. 26). Non-multiple exchanges are generally terminal exchanges seldom requiring through switching of trunk to trunk connections. The trunk cord circuits however provide a lower loss path than by using the regular cord circuit.

Speaking, dividing, monitoring and ringing facilities are the same as for the regular cord circuits. With keys normal the T & R conductors are a direct connection between the Answer and Call cords.

The Trunk Line Circuit (generator signalling) is shown in Fig. 27. Where auto dialling or 2VF signalling trunks are provided local circuits and modifications are used.

A Ring key per line is provided above the subscribers' jack field. A measure of supervision is given by the L relay at contact L2. A ring off from the distant end operates L, which opens the loop holding the cord circuit relay (AA or AC) at L2. When the through trunk cord circuit is used (Fig. 26), battery at L2 operates the CL relay which lights the supervisory lamp at CL1. CL locks via KM contacts and the earth on the sleeve. The telephonist checking to see whether the signal is for clearing or recall, releases CL with KM.

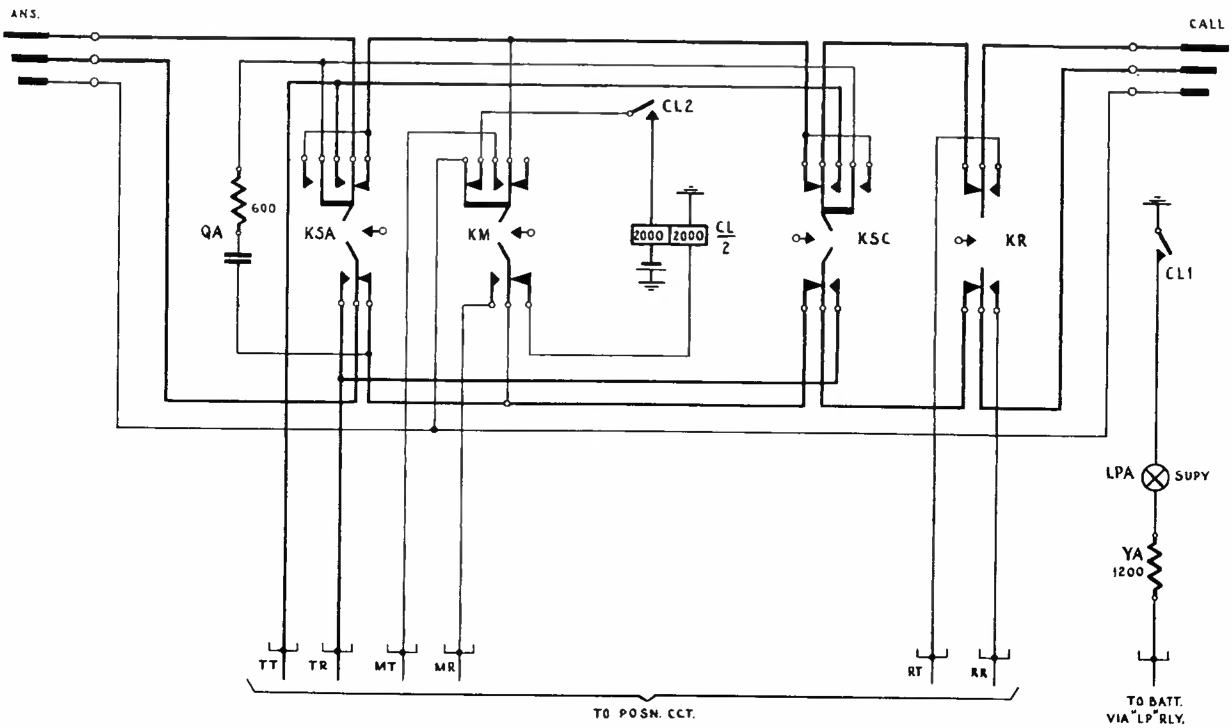


FIG. 26. TRUNK CORD CIRCUIT.

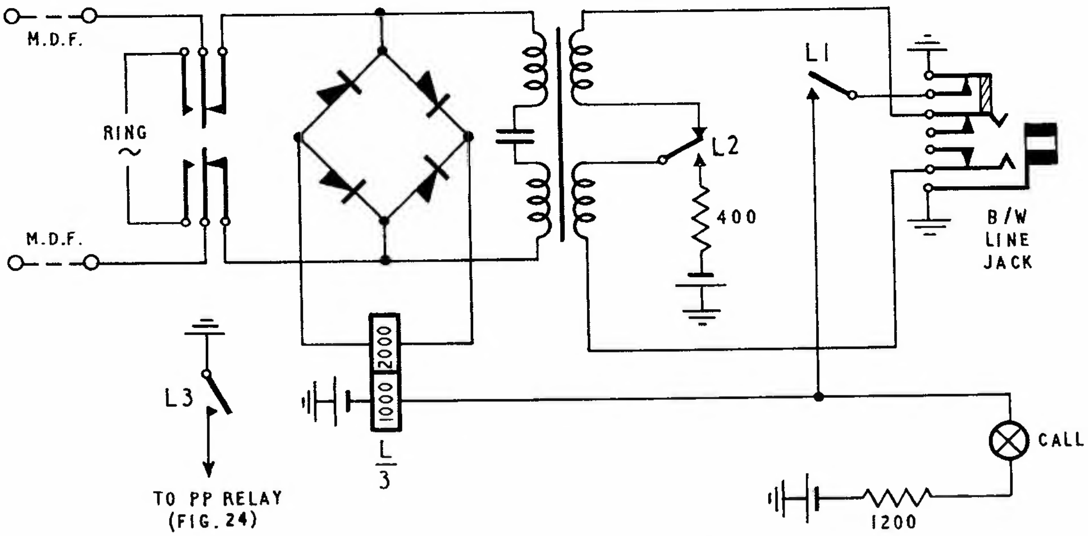


FIG. 27. GENERATOR SIGNALLING TRUNK LINE CIRCUIT.

9. REFERENCES.

Telecommunication Journal of Australia Volume 8, Nos. 1, 2, and 3.

10. TEST QUESTIONS.

1. What types of operating positions are installed at C.B. country exchanges?
2. What type of manual position is provided at a large country centre where the local subscribers are served by an automatic exchange?
3. What apparatus would you expect to find in the equipment room of a large C.B. multiple exchange?
4. Outline briefly how the following types of call are handled by the telephonists at a C.B. multiple exchange -

   (i) Local call between two subscribers
   (ii) Subscriber making a trunk call
   (iii) Incoming trunk call to a local subscriber
   (iv) Through call manually switched between two trunk lines.

5. Name an alternative method of switching Through trunk calls to that described in answer to Question 4(d).
6. Why are some magneto subscribers' lines retained in C.B. country areas?
7. How is an ordinary subscriber charged for a local call at a C.B. multiple exchange? Include a brief description of the circuit principles.
8. What additional equipment, if any, is necessary to give service on the following types of subscribers' lines?

   (i) Two party line, C.B. signalling. (ii) Multi party line, C.B. signalling. (iii) Very long magneto party line.

9. With the aid of a simple sketch showing the main circuit elements, describe how each of the following is achieved with an 'A' position cord circuit at a C.B. multiple exchange -

   (i) Metering. (ii) Supervision. (iii) Ringing out.

10. Why are trunk lines switched by a different type of cord circuit to that used for subscribers.
11. Show by means of a simple sketch the basic principles of Terminating and Through cord circuits.
12. Briefly, what circuit conditions are applied to the trunk line circuit when dialling out on a Through trunk cord circuit.
13. What is meant by 'dividing' the cord circuit and when does this occur on one particular type of sleeve control cord circuit?
14. What is meant by the term Composite as applied to Trunk positions?
15. Describe briefly the circuit principles and conditions in ringing out on a generator signalling trunk line circuit.

END OF PAPER.

THE AUSTRALIAN POST OFFICE

COURSE OF TECHNICAL INSTRUCTION

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

TRUNK LINE SWITCHING

1. INTRODUCTION.

1.1 Automatic handling of trunk calls on a fairly large scale commenced in Australia in 1939 with the installation of an automatic trunk exchange in Melbourne.

In conjunction with this, 2VF signalling was introduced. This system provides a comprehensive range of signals for setting up, supervising and releasing calls using two voice frequency tones of 750 c/s and 600 c/s (X and Y tones) divided into pulses of different lengths. Dialled pulses converted to tone can be passed over a succession of trunk channels for long distances, and then reconverted at the distant end to operate switching equipment.

1.2 With the expansion of the Australian network, and with the extra channels provided by carrier systems, 2VF terminal equipment is used on all major trunk routes, and also at many small exchanges. At capital cities and at most of the large country switching centres, trunk selectors are provided for automatic switching of calls.

1.3 With the development of the trunk network in this way, more calls can be completed by the originating operators. This together with the extension of multi-metering and the introduction of new types of signalling and switching systems will eventually realise the goal of nation-wide subscriber to subscriber dialling.

Issued 1959.

MANUAL POSITIONS - MODERN TRUNK EXCHANGE.

FIG. 1.

2. OPERATING METHODS.

2.1 Modern trunk exchanges and the methods of operating them are designed for rapid handling of calls. The following is a list of the more important features of trunk exchange provision and operating policy, which since their introduction have greatly increased paid time on trunk channels.

(i) Demand working. At one time practically all trunk calls were completed by 'delay' working - subscribers booked calls with one telephonist who entered the details on a docket; the trunk operator recalled the subscribers in turn when the trunk lines became available. With demand working the telephonist who answers the subscriber sets up the call while the subscriber 'holds the line'. The less efficient delay working is used only when the trunk routes are congested and waiting time would be excessive.

(ii) Sleeve control trunk switchboards for country centres. These corded trunk positions have access to a full trunk multiple, and, where the local exchange is C.B., to a full subscribers' multiple also. Although trunks and junctions of several different types terminate on these boards (2VF, generator signalling and DC dialling) the circuits are designed to avoid complex connecting procedures. All 'through' connections are handled by one type of cord circuit.

(Sleeve control trunk switchboards are described in the paper "C.B. and Sleeve Control Exchanges".)

(iii) Automatic trunk exchanges with cordless manual positions are provided at several centres. (See Fig. 1.) Once called semi-automatic, these exchanges are automatic in the sense that the calls are routed and switched by switching equipment which is key controlled from the manual boards. Automatic trunk exchanges are described in Section 6 of this paper.

(iv) Automatic transit switching. A large proportion of trunk calls are now completed with the services of one telephonist at the calling end. For instance a trunk operator in Cairns, North Queensland, may dial directly a subscriber in Perth. Such a call may for example, be switched through the 2VF trunk selectors at Brisbane, Melbourne and Adelaide. Free trunk channels for successive stages of the call, are selected in the pauses between the digits of the routing code dialled, in the same way as junctions in a city network. (Extensive use of transit registers and alternate routing however, will alter this in the future. See Appendices 6 and 7).

(v) Auxiliary facilities and aids for handling the large volumes of traffic converging on the trunk exchanges of the large coastal cities. These include :

- Queueing of incoming calls
- Call Storage. To maintain demand working, calls for trunk routes which are temporarily congested may be 'stored' for a short period to avoid reverting to delay working.
- Suspense operating positions. These deal with calls which cannot be completed on demand for reasons like 'called party absent' etc.
- A delay supervision desk with lamp display showing the condition of every route. Several other facilities are provided by this desk allowing oversight of the functioning of the exchange as a whole.
- Handling of dockets by means of a pneumatic tube system.

These auxiliary facilities are described in Section 6.

3. THE SWITCHING NETWORK.

3.1 Australia's trunk line network is divided into switching centres which are classifie[illegible] as follow and designated on the routing maps as shown in Fig. 2.

A Terminal Exchange is an exchange which performs no through switching of inter-exchange trunk lines.

A Minor Switching Centre switches the final routes for terminal exchanges only.

A Secondary Switching Centre switches the final routes for Minor switching centr[illegible] and also, if required, Terminal exchanges.

A Primary Switching Centre switches the final routes for Secondary switching centres and also if required, Minor switching centres and Terminal exchanges.

A Main Switching Centre switches the final routes for Primary switching centres and also, if required, Secondary switching centres, Minor switching centres and Terminal exchanges.

The Final Choice (or backbone) route consists of the trunk lines connecting switch[illegible] centres with their parent switching centres of higher order.

Superimposed on the system of final choice routes is a network of Early choice or Direct (high usage) routes. An early choice route is one for which one or more alternate routes are provided. It gives a preferred direct link between any two centres.

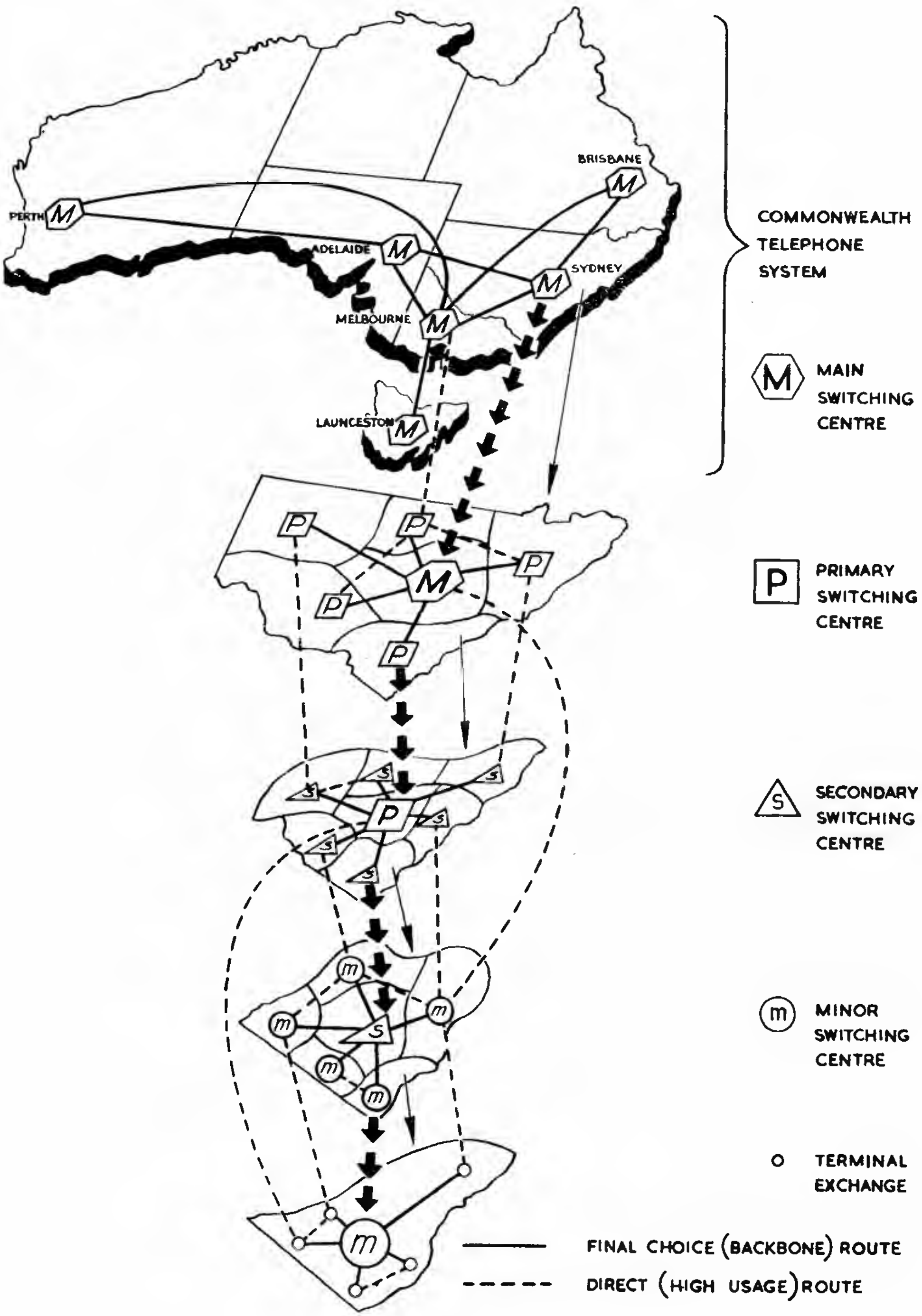
3.2 Extensive use of automatic alternate routing is a feature of the new trunk switchi[illegible] plan which embraces the ultimate goal of subscriber trunk dialling. Register con[illegible] of the setting up of calls provides for one or more attempts to complete the connection via other switching centres as the more direct routes are found to be congested.

The plan provides for a maximum of 9 trunk lines connected in tandem. Further info[illegible] on alternate routing is given in Section 6 (page 31) and Appendix 6, page 45.

3.3 Transmission Performance. To ensure that satisfactory transmission is obtained whe[illegible] any telephone in Australia is connected to any other, performance standards have [illegible] specified for all classes of lines - trunk lines, junction lines and subscriber's exchange and extension lines (Reference 1, page 37).

Subscribers' local line limits take into account such factors as types of telepho[illegible] average levels of room noise and classes of line plant. (Appendix 1, page 38).

3.4 The line equivalent or attenuation of trunk lines is determined individually, so th[illegible] with any combination of connections in tandem, satisfactory transmission, stabili[illegible] and freedom from echo is achieved. Attenuation pads inserted to provide design [illegible] may, when necessary, be switched out so that the overall attenuation between any [illegible] exchanges rarely exceeds 15 db. Further details are in para. 5.12, page 20 and Appendix 4, page 42.

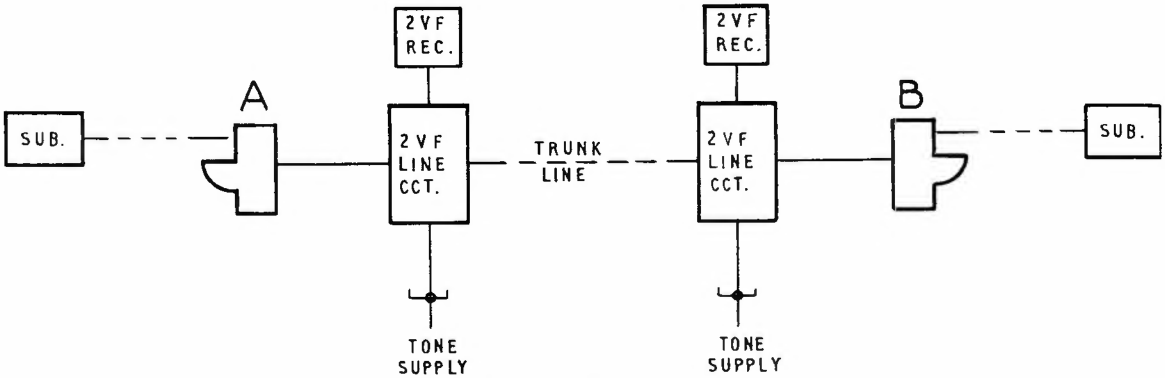


TRUNK SWITCHING NETWORK.

FIG. 2.

4. 2VF PRINCIPLES.

4.1 The basic trunk circuit equipped for 2VF signalling is shown in Fig. 3.



BASIC 2VF TRUNK LINE.

FIG. 3.

The trunk line may be a physical pair or any type of derived circuit designed for speech transmission. Each trunk line has a separate 2VF receiver and trunk line rel.. set or sets.

With this equipment and the 2VF signals, a range of positive supervisory control facilities is provided, such as is obtained by DC signalling and dialling in C.B. networks. For example when both stations A and B are the trunk switchboards for C.B. manual or auto subscribers, the supervision at each end extends to the subscribers' switch hooks; that is the cord circuit supervisory lamps go out when the distant subscriber answers and light when the subscriber clears.

If one end is a magneto exchange, say B, supervision at A extends as far as the B operator only. Two lamps per line at the magneto board give a certain amount of supervision.

The 2VF relay sets at one end or both ends may be associated directly with an incom.. trunk selector (for example a motor uniselector). Digits are dialled to obtain dir..-connection to other trunk lines, local subscribers, or the manual switchboard. Fig. . shows the basic idea.

The automatic switching of trunk lines in tandem is known generally as transit switching. The details of 2VF transit switching are covered in Section 5. However full supervision is still given with any number of trunks in tandem.

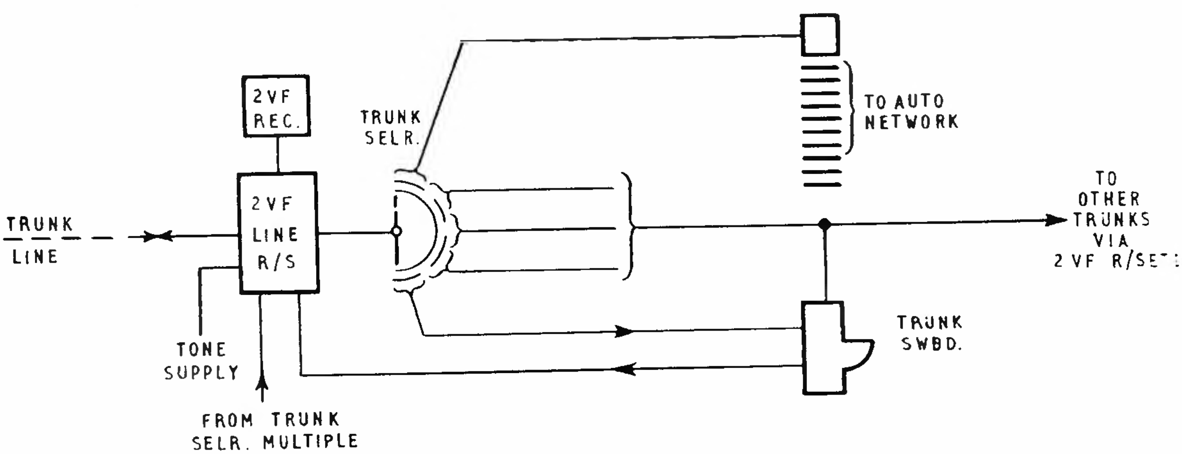
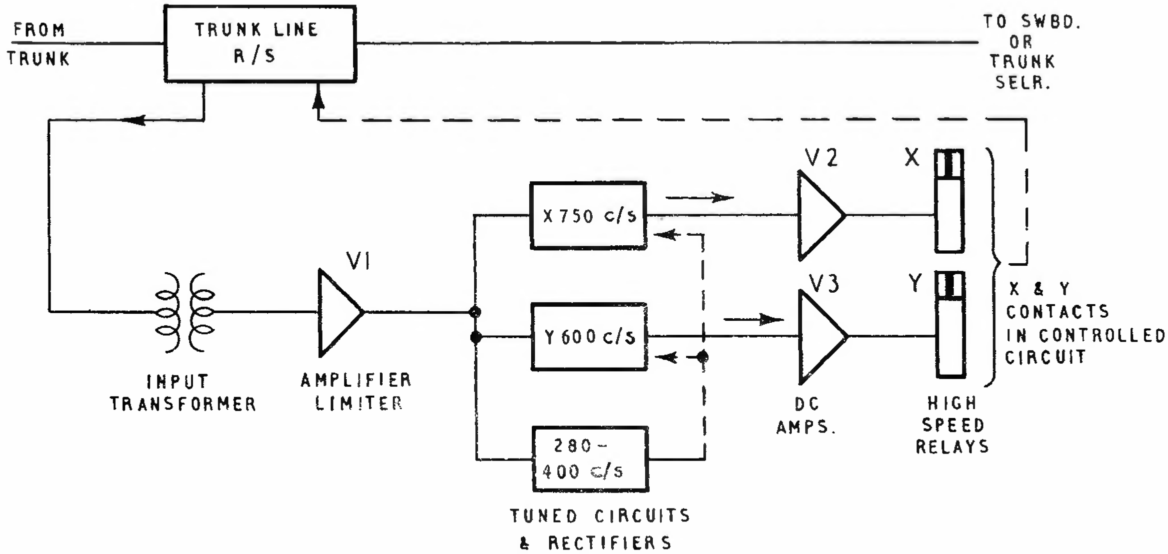


FIG. 4.

..2 The 2VF Receiver has fairly high impedance and is bridged across the circuit at all times except while tones are sent from the local end. It converts pulses of X or Y tone into D.C. pulses of equal duration. It gives reliable operation over a wide range of tone signal level and at the same time is sufficiently immune from false operation on X and Y tone frequencies present in speech. (Complete immunity is not necessary, as further safeguards are provided in the 2VF relay set to prevent false receiver operation of short duration affecting the connection).

The principle of the receiver is shown in block form in Fig. 5. (See also Appendix 2, Page 39.)



BLOCK DIAGRAM 2VF RECEIVER.

FIG. 5.

VF signals from the line are fed via the input transformer to the amplifier-limiter valve V1 which is arranged so that variations in input level have little or no effect on the output. In the output circuit of this valve are three resonant circuits, two sharply tuned to 750 c/s and 600 c/s for selecting the X and Y signals, and the third broadly tuned to 340 c/s which is midway between the subharmonic frequencies of the X and Y tones.

The outputs of the 750 c/s and 600 c/s tuned circuits are rectified in voltage doubler circuits and fed to the grid circuits of valves V2 and V3 respectively. During an X or Y signal pulse the respective grid is driven positive and the valve which is normally biassed to cut-off, then conducts to operate a high speed relay in the output circuit. The output of the 340 c/s tuned circuit when rectified, drives the grids negative to counteract the effect of any 600 c/s or 750 c/s frequencies present in speech or in the harmonics of service tones.

The X and Y resonant circuits are tuned to a narrow bandwidth of 45 c/s (22½ c/s each side of the nominal frequency); this allows for correct operation over channels which may be slightly out of synchronism, and for slight variations in the X and Y tones themselves.

The contacts of the X and Y relays control circuits in the 2VF trunk line relay set.

4.3 The 2VF signals used in Australia and their functions are represented in Fig. 6. The nominal pulse lengths and intervals are shown in milliseconds. A 10-20% tolerance applies to most signals.

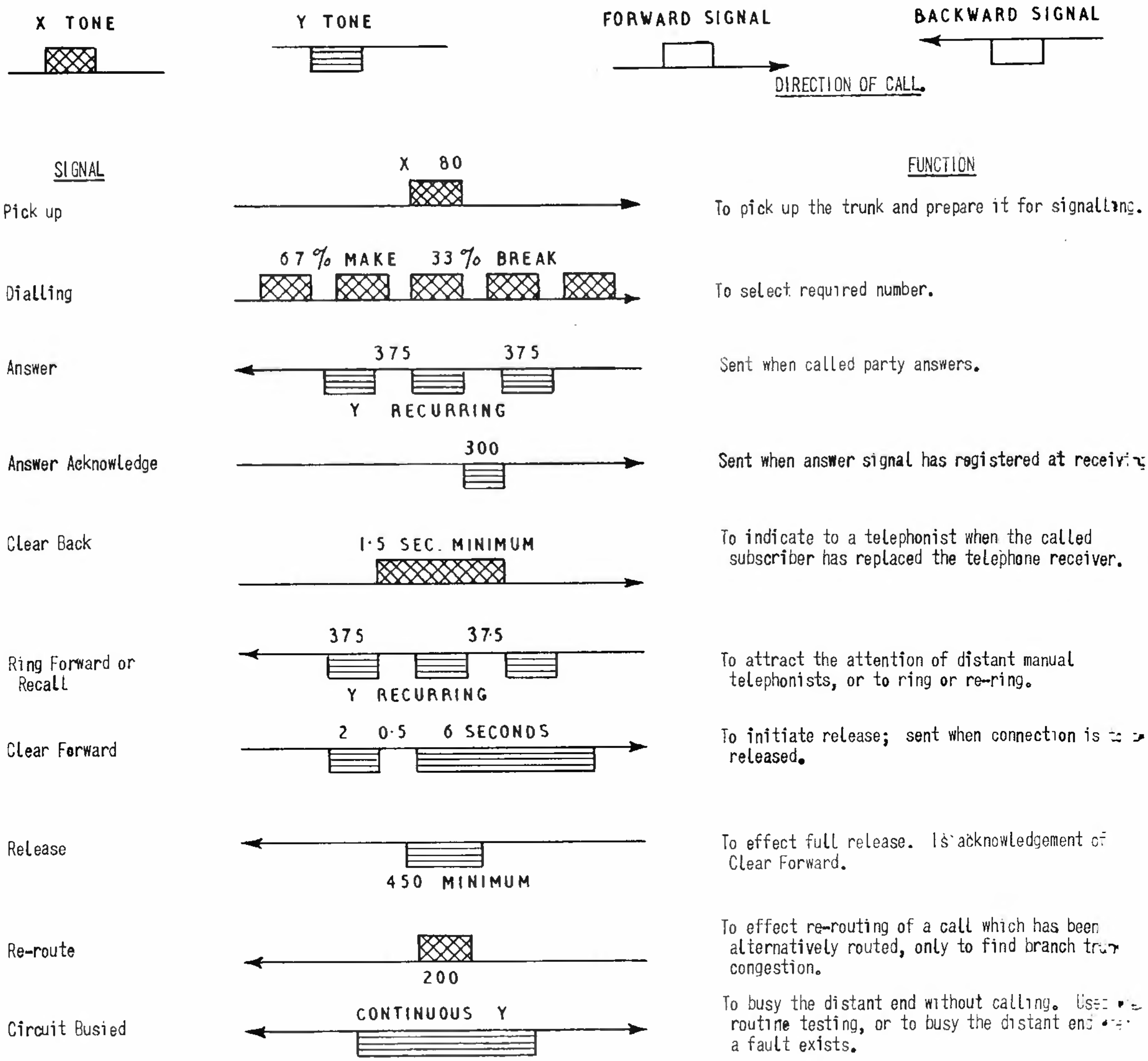
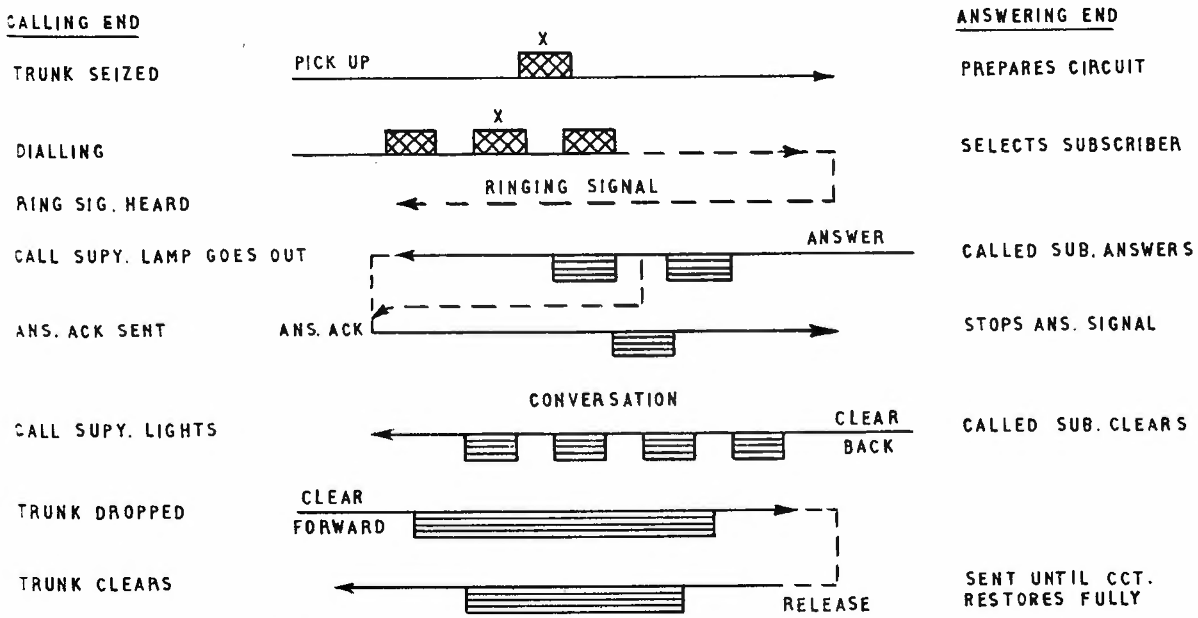


FIG. 6. 2VF SIGNALS.

While the Answer signal is a recurring tone pulse, in practice the Answer Acknowledge signal is generally returned in the first pause following the first pulse of the Answer tone. Clear Back is also a recurring signal; it continues until stopped by either a Ring Forward or a Clear Forward. Clear Back is identical to the Answer signal but the two are not confused as the outgoing 2VF relay set has switched its [illegible] to a different condition after the Answer Acknowledge.

The Clear Forward signal is composed of two pulses, the second one much longer than the other. In nearly every case the first pulse of 2 seconds is sufficient; the distant 2VF relay set acknowledges this with the Release signal in the interval, and the 6 second pulse is not transmitted. The main use of the second part of the Clear Forward signal is to ensure release of the distant end in the face of NU tone, which can block the 2VF receiver for as long as 5 seconds.

Fig. 7 shows the tone sequence in establishing a call direct from a country exchange to an automatic subscriber in a distant centre. The incoming 2VF relay set has an associated trunk selector as in Fig. 4.



TONE SEQUENCE FOR SET UP AND RELEASE OF CALL DIRECT TO AUTO SUBSCRIBER.

FIG. 7.

4.4 Tone Supplies. The X and Y tones are produced by two oscillators except at larger switching centres where inductor tone generators are provided. The tones are pulsed in the 2VF line relay set, their duration being timed by the operate or release lags of relays for the single pulse signals, by interrupted earth pulses for the two recurring signals, and in certain cases by a stepping uniselector for 2 + 6 seconds Clear Forward. Where tone oscillators are used a relay set interrupter provides the interrupted earth, and where tone machines are provided an interrupting cam is used. The nominal pulse length of the interrupted earth is 375 mS on, 375 mS off, or 750 mS for the complete pulse.

4.5 2VF Trunk line relay sets are available to work in with different types of trunk exchange and can be bothway, incoming or outgoing circuits to suit -

(i) Main switching centres -
including an incoming trunk selector (MU) associated with each I/C and B/W relay set. (Generally known as 'Main End' circuits.)

(ii) Sleeve control country exchanges -
I/C and B/W relay sets are jumpered to separate trunk selectors when required.

(iii) Magneto transit switching centres -
I/C and B/W relay sets are jumpered to separate trunk selectors when required.

(iv) Magneto exchanges -
B/W only, no trunk selector access.

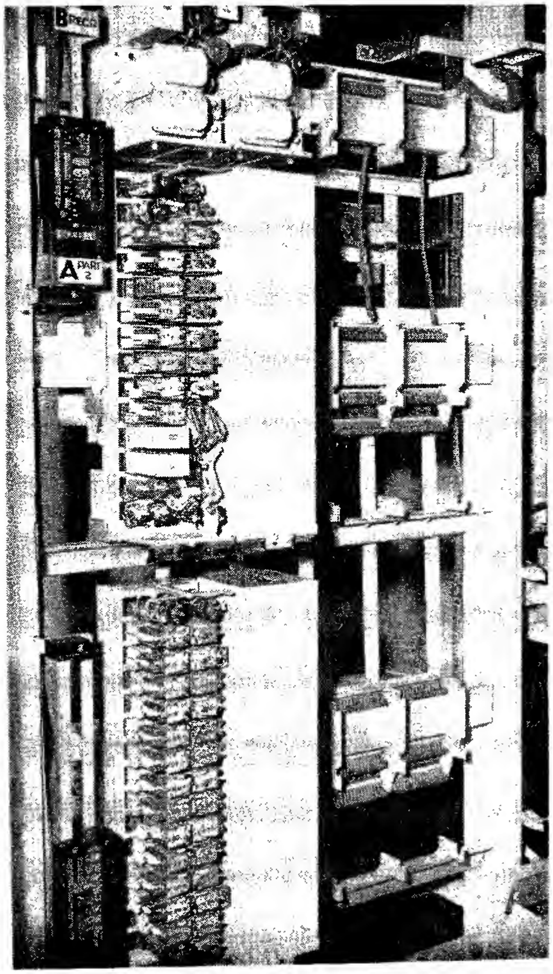
In the first three cases the 2VF trunk line circuit for each line consists of 2 large relay sets plus the 2VF receiver. They are then called part 1 and part 2 of the trunk line circuit.

Fig. 8 shows part of a 10 line 2VF rack at a sleeve control exchange with the covers of the first circuit removed. In all, these relay sets have forty 3,000 type relays, four high speed relays, a 25 point uniselector, plus a number of resistors and capacitors. The 2VF receivers are directly above the part 2 relay sets for the two lines.

As far as sending and response to 2VF signals is concerned, the various 2VF trunk line circuits have the same functions and similar circuit elements. Relay sets at main end and magneto transit centres are of the same size and general appearance to those in Fig. 8. Magneto transit centres use the same 10 line or 20 line racks as sleeve control centres.

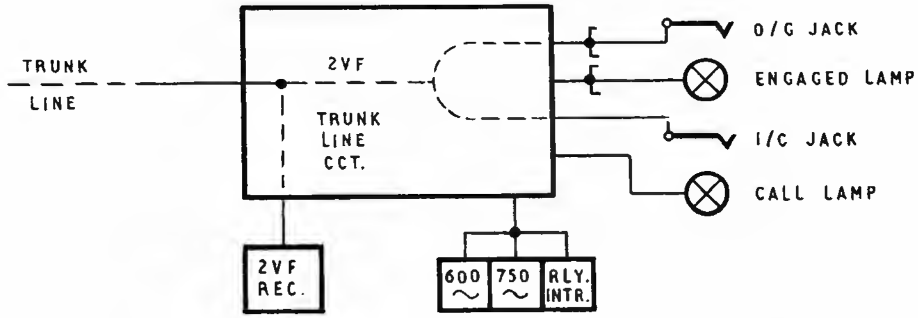
4.6 The switchboard termination of bothway 2VF trunk lines consists of separate incoming and outgoing jacks and two lamps as shown in the block diagram Fig. 9. These are multipled over several positions when required.

4.7 2VF equipment at magneto exchanges without auto transit switching, is in enclosed cabinets with removable front and rear covers. Fig. 10 shows a typical 5 line 2VF trunk line unit for a magneto exchange. Battery supply is not required as a "Transrector" mains unit provides -ve 50V D.C. supplies, smoothed and unsmoothed, and 26V A.C. for the valve filaments. Each trunk line has one relay set and a 2VF receiver. The 600 c/s and 750 c/s oscillators, and relay set interrupter are common to all lines.



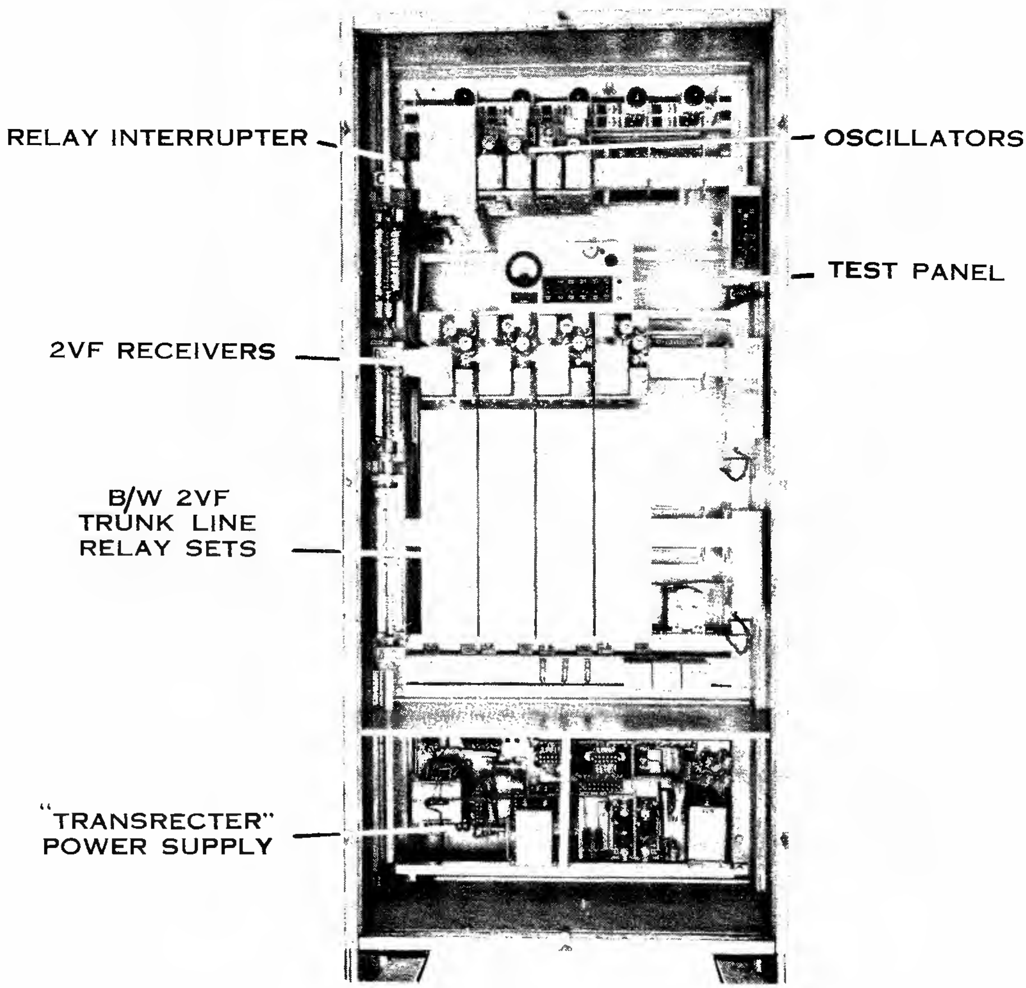
TYPICAL 2VF TRUNK LINE RELAY SETS.

FIG. 8.



BLOCK LAYOUT OF MANUAL END.

FIG. 9.



FIVE LINE MAGNETO 2VF UNIT.

FIG. 10.

4.8 In addition to transmitting and responding to the above 2VF signals, the relay sets have several other functions. Briefly the more important ones are :-

Splitting. When a signal tone operates the X or Y relays in the 2VF receiver a splitting relay (SP) divides the circuit after a short delay and prevents further tone from passing through to the telephonist or subscriber. This also prevents an further signal or signals from being mutilated by speech. (Any signal which could possibly be mutilated is made to recur, such as Answer signal and Clear Back, or is of considerable length such as Clear Forward so that it will be effective in the first break in speech, NU or busy tones.) Fig. 11 shows where the splitting occurs. A signal from A is effective at the 2VF receiver at B and causes splitting between the receiver and switchboard in the trunk line relay set.

Tone Sending. The 2VF receiver is connected to the circuit via relay contacts which open only when tone is transmitted from the local relay set. That is, signals from A to B do not operate the receiver at A (Fig. 11).

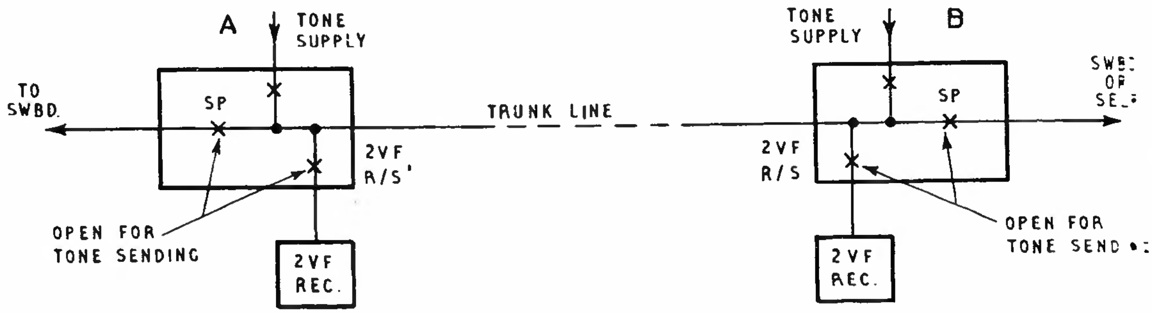


FIG. 11.

Tandem Switching, Automatic (Transit Switching). Where two 2VF trunks are switched together via a trunk selector, each relay set at the intermediate station is sw... into a condition which allows all subsequent 2VF signals (except Clear Forward) to pass straight through without performing any function. See Fig. 12.

During the transmission of signals between A and C the tones are received by the ... receivers at B_a and B_c but have no effect in the associated 2VF relay sets.

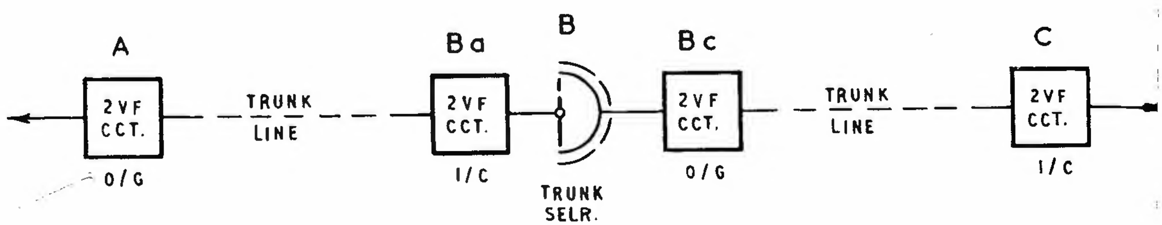


FIG. 12. TANDEM SWITCHING, AUTOMATIC.

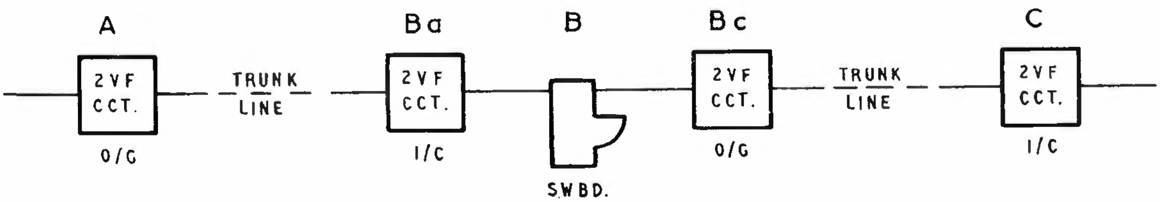
...e trunk is dropped, the Clear Forward signal from A, is effective at inc... ...ts B_a and C because it is a long pulse of 2 seconds duration. At the ... ...se of Clear Forward, B_a and C should release and return the Release sig... ...B_c respectively, completing their release.

ass...

If for any reason (such as NU tone interference) the 2 seconds of Clear Forward signal is not effective at either B_a or C, say C, it will not return the Release signal; B_c will wait about half a second and then send 6 seconds of Y tone which should cause C to release and return Release signal. However, B_c will then release irrespective of whether the Release signal comes from C or not. The 2VF relay set at A does likewise if no Release signal is received from B_a.

Tandem Switching, Manual. Where 2VF signalling trunks are switched together via a manual exchange, the 2VF signals do not pass from end to end but where necessary are relayed through the cord or connecting circuit on a D.C. basis and repeated on the far side independently. See Fig. 13.

The cord circuits of sleeve control trunk switchboards and the connect circuits of the cordless positions at auto trunk exchanges will pass Answer, Clear Back and Ring Forward signals between trunk line circuits as a D.C. condition.



TANDEM SWITCHING MANUAL.

FIG. 13.

In a call from A to C, the subscriber at C answers and an Answer signal is returned from the 2VF relay set at C. This is received at B_c and a D.C. signal (batt. on ring) is relayed to B_a which in turn transmits an Answer signal to A.

Answer Acknowledge signals are returned independently from A to B_a and from B_c to C (without DC repetition) and the connection is ready for conversation between subscribers.

At the end of the call, Clear Back is sent from C to B_c, relayed as a D.C. signal to B_a and Clear Back sent from B_a to A. The Clear Back signals continue until stopped by either :-

A Ring Forward (or Recall) from A which is repeated as D.C. from B_a to B_c and re-sent from B_c to C where the cord circuit supervisory lamp flashes, or the call lamp lights if the plug has been withdrawn. The circuits revert to the preanswered condition.

or

Clear Forward signals from A and B_c when the respective trunks are taken down. Separate Release signals are returned from B_a and C.

Full supervision on the call and answer side of the cord or connect circuits is thus given at A and B and at C also if it is a CB exchange. When C is a magneto exchange the Answer signal is returned to B_c when the telephonist answers, and Clear Back is returned when the plug is withdrawn.

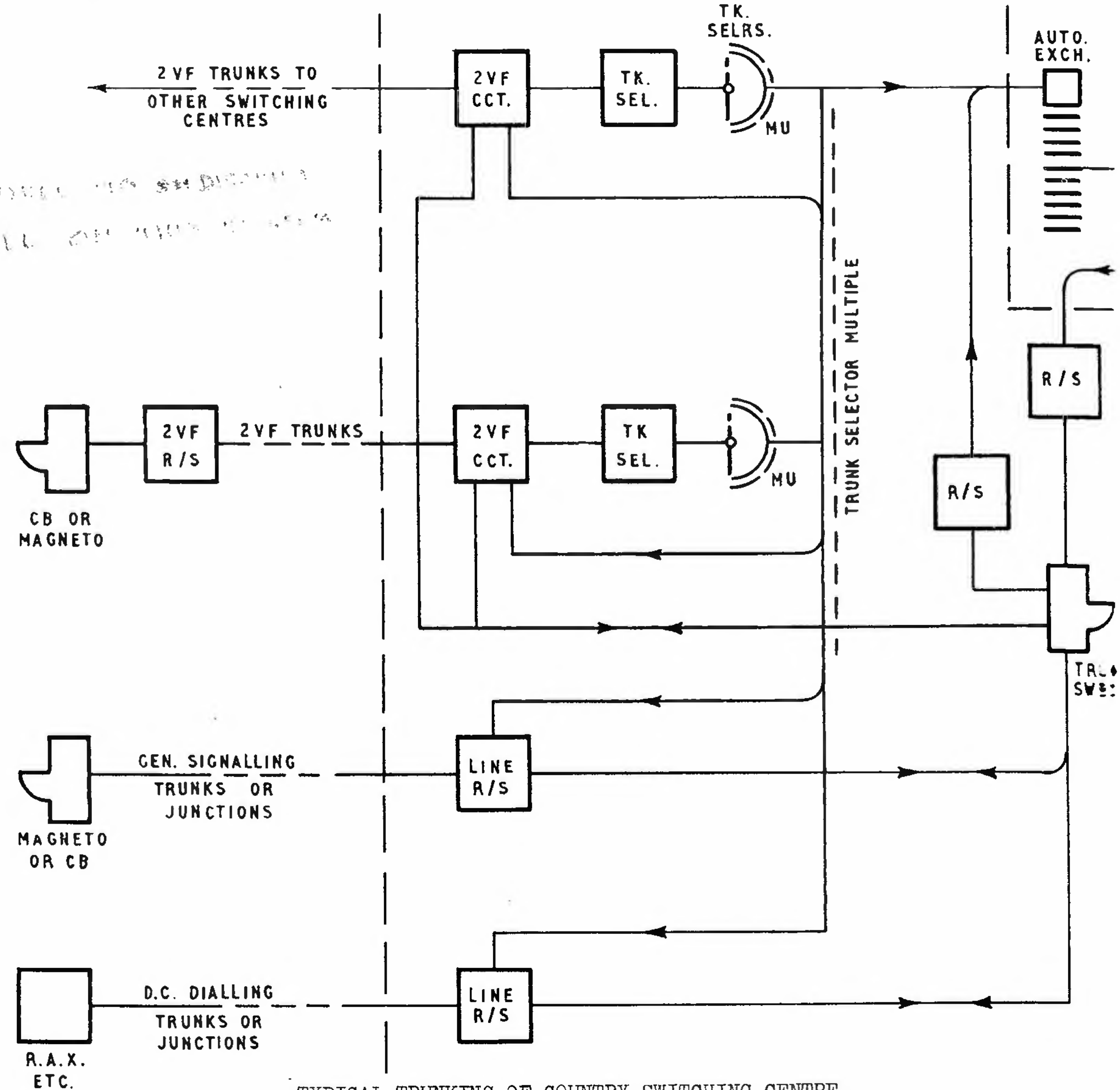
Appendix 3, Page 40, shows circuit elements of the more important functions of 2VF trunk line relay sets.

5. 2VF TRANSIT SWITCHING.

5.1 Transit switching means automatic switching of through calls via the trunk selectors at any switching centre, main, primary or secondary. Where 2VF trunk lines are equipped with trunk selectors, calls are set up by means of dial pulses including calls for local subscribers.

5.2 Transit Switching at Country Exchanges - Fig. 14 shows in block form trunking arrangements of a typical country switching centre with a local automatic exchange. For clarity, the 2VF receivers and tone supply are omitted. Bothway 2VF trunk line circuits are shown in Fig. 14 but incoming and outgoing circuits are also used, mainly on large trunk groups (together with some bothway circuits). Outgoing relay sets are not associated with trunk selectors. The 2VF relay sets are mounted on 10 or 20 line racks as shown in Fig. 8.

The trunk selectors are mounted on racks of 20 or 40 circuits as shown in Fig. 15.



TYPICAL TRUNKING OF COUNTRY SWITCHING CENTRE.

FIG. 14.

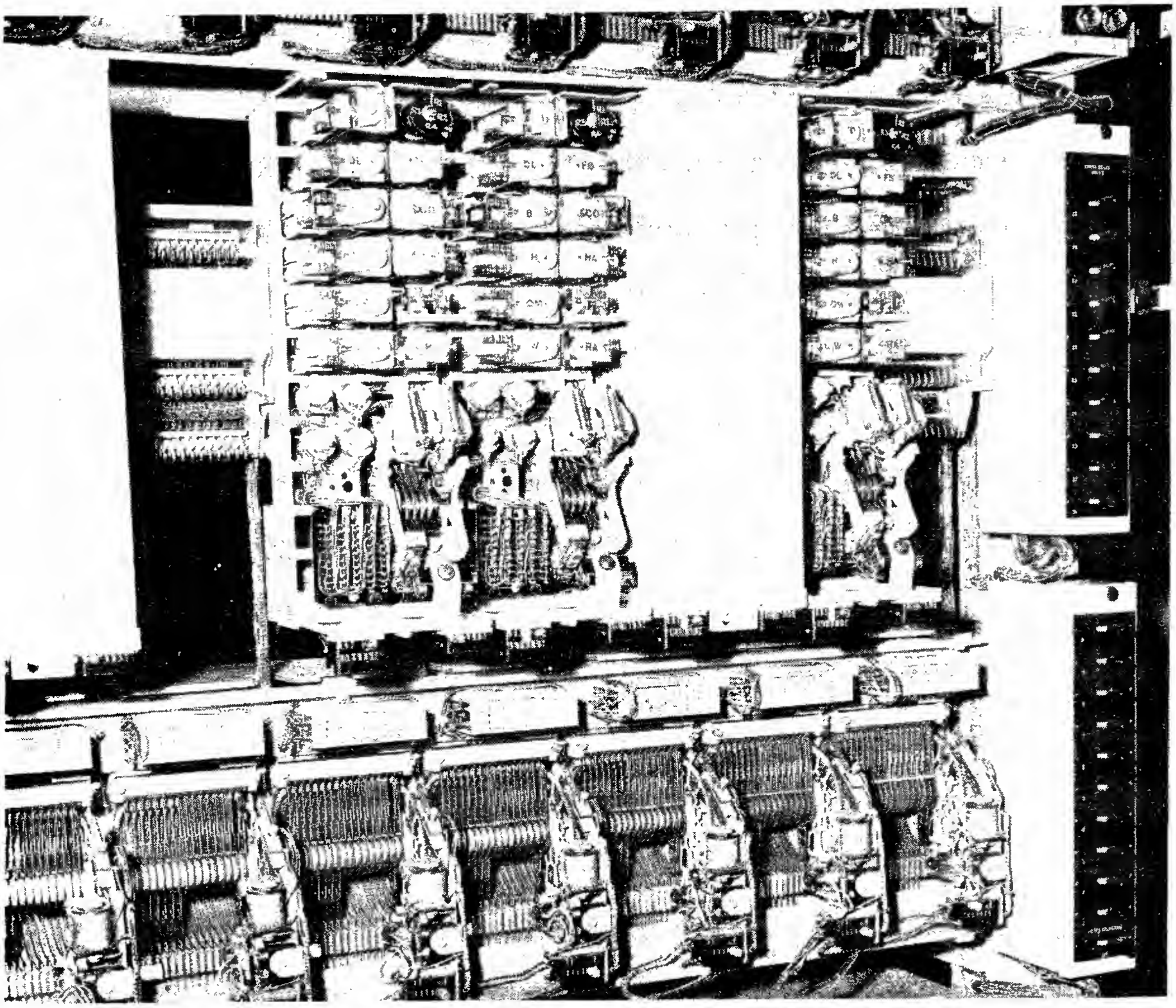


FIG. 15. TRUNK SELECTORS.

The trunk selector relay set includes a 25 outlet ratchet uniselector on which dialled pulses are received, as the MU does not respond directly to dialled pulses. For details of the use of the MU as a group selector see the paper "The Motor Uniselector and High Speed Relay".

The 2VF trunk lines have accessto :

- Local subscribers via trunk selectors and incoming 1st local selectors.
- Other 2VF trunk lines via the trunk selectors and the 2VF trunk line relay sets (O/G and B/W).
- Any generator signalling and D.C. dialling trunk lines or junctions whose relay sets are wired to the trunk selector multiple.
- All trunk lines via the trunk switchboard.

Generator signalling and D.C. dialling trunk lines gain access to the local subscribers and all other trunk lines via the trunk switchboard.

5.3 As explained in the paper "C.B. and Sleeve Control Exchanges" each trunk line or junction terminates on a relay set which converts the functions of sleeve control cord and position circuits to the signalling and terminating requirements for that line, (including the 2VF trunk line relay sets).

Where the local exchange is C.B. manual instead of automatic, trunk calls to and from the subscribers are completed via Terminating trunk positions having access to both the subscribers' and trunk multiple jack fields. Through calls are handled by Through trunk positions unless switched via the trunk selectors. Alternatively, both through and terminating traffic are handled by Composite trunk positions. With an auto exchange, only Through positions are necessary.

At some exchanges with C.B. local and sleeve control trunk positions a few final selectors have been provided with access from the trunk selector and with the final selector multiple tied to the subscriber's switchboard multiple. This allows incoming trunk calls to local subscribers to be completed by the originating operator.

Fig. 14 however, also applies to country exchanges using Magneto transit 2VF trunk line circuits. These are used where the trunk switchboards are not of the modern sleeve control type. The local exchange may be automatic as in Fig. 14, or early type C.B. or magneto switchboards, in which case terminating trunk traffic would be handled on "B" positions.

The sequence of operations for the several types of call at a country transit switching centre are outlined in the following paragraphs.

5.4 Through Trunk Line Call 2VF to 2VF (Figs. 14 and 16) - The pick up X pulse seizes the incoming line circuit when the distant operator plugs in, or the trunk is seized via a trunk selector at the distant end. Dialling pulses of X tone are converted to D.C. pulses in the 2VF receiver and are used to step the marking uniselector (or digit switch) in the trunk selector relay set. This marks the required group on the trunk selector multiple; the motor uniselector drives and seizes the first free outlet to a 2VF trunk line circuit in that group. This in turn sends pick up X tone to line to seize the distant trunk line circuit.

Further dialling pulses from the originating end pass straight through the transit station as X tone without being repeated. As explained in paragraph 4.8 this applies also to all the supervisory tones, Answer, Answer Acknowledge, etc. After the call is set up the only tone to perform a positive function at the intermediate station (or stations) is the Clear Forward Y tone which, in persisting for at least 1.5 secs. initiates the release at all stations.

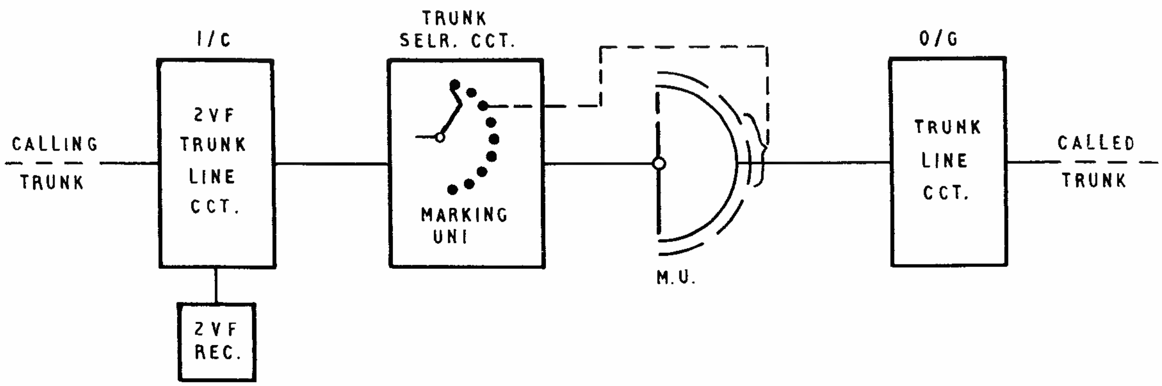


FIG. 16.

5.5 Other types of call originated on the 2VF lines are outlined below and Fig. 17 shows the trunking with more detail than Fig. 14. Each outlet shown on the MU represents the first free line in the group marked by the digit switch as described in para. 5.4.

Through Trunk Line Call, 2VF to Auto Dialling. When the auto trunk line relay set is seized from the trunk selector, the switchboard side of the circuit is disconnected and the engaged lamp lights on the board. Subsequent digits dialled are sent as loop pulses direct from the 2VF relay set to position the selectors at the distant exchange. The pulses are not repeated in the auto trunk relay set.

Incoming Call, 2VF Trunk Line to Local Subscriber. The trunk selector seizes a free incoming first selector in the auto exchange and loop pulses from the 2VF relay set control this and subsequent switches.

Through Trunk Call, 2VF to Generator Signalling Trunk. The trunk selector seizes a free trunk in the group. The calling telephonist then rings forward, (the calling code information for generator signalling trunks shows the number followed by R to advise the telephonist to ring forward - for example .... 25 R). In the incoming 2VF relay set the X tone pulse is converted to a DC signal which, passed forward to the generator signalling trunk line relay set operates a relay to connect ringing current direct to the trunk line. An answer condition is relayed back to the 2VF relay set which then returns the Answer Y tone to the calling end. This is necessary at this stage as there is no change in circuit conditions over the line, when a call on a generator signalling trunk line is answered; correct supervisory lamp signals are therefore given at the calling end during subsequent conversation.

Incoming Call, 2VF Trunk Line to Switchboard. The calling telephonist dials the single digit code allotted for the manual board; the trunk selector digit switch steps. At the end of the digit the trunk selector drives but no group is marked, and it continues driving to the last contact where it causes a relay to operate in the 2VF relay set and make connection direct from the calling line to the manual board. The calling lamp lights for that particular line. (See Appendix 3, Page 40.) With this arrangement the switchboard incoming lines do not appear as a group on the trunk selector multiple. This allows lines to have individual incoming or bothway appearances on the board and the answering telephonist knows which line is calling. However, at some country centres, mainly in New South Wales, the switchboard incoming lines are taken from a group of outlets on the trunk selector. (Group shown dotted Fig. 17.) In this case there are no individual incoming appearances; when required, calling telephonists announce the name of the originating station.

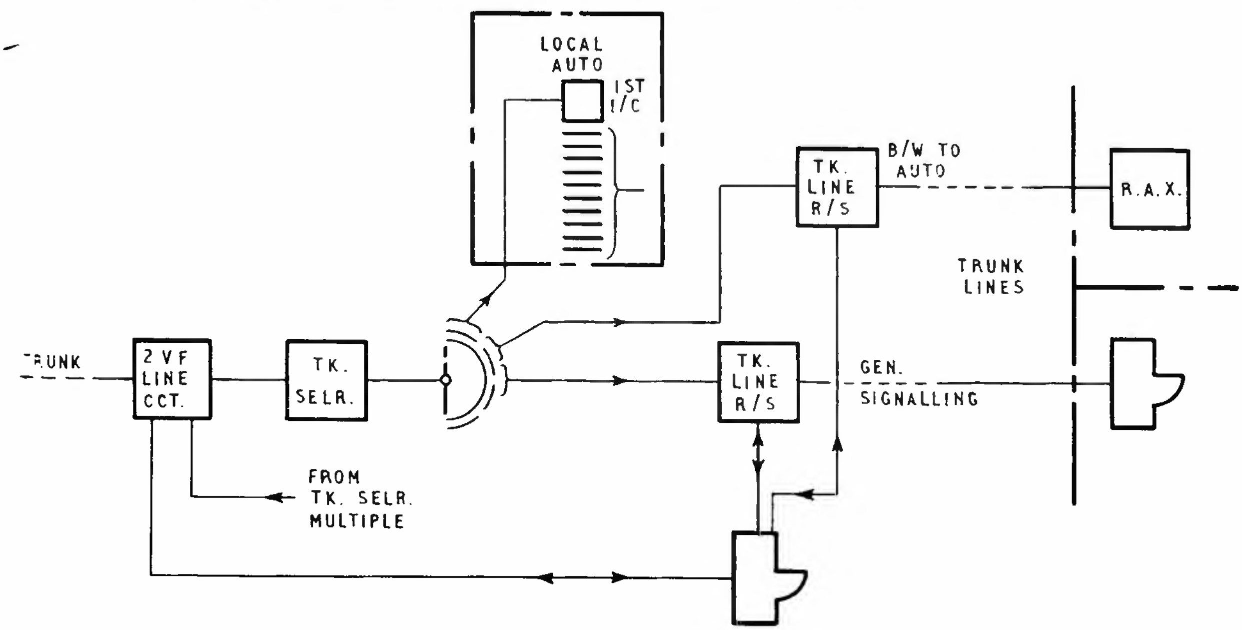


FIG. 17.

5.6 Outgoing calls on 2VF trunk lines may originate either by a telephonist plugging in from the board, or by a trunk selector of another calling 2VF trunk line seizing the circuit. The pick up and release conditions are as described for the called line in para. 5.4.

5.7 More than 9 Trunk Groups - Country switching centres may have a large number of groups of trunks but with only a few trunks in each group or route. The 100 outlets of a motor uniselector are ample, but if there are more than 9 groups some two-digit dialling codes are required; one of the 10 digits (generally 0), is required for the manual board code even though it may not appear as a group on the selector multiple.

To avoid having to provide second selectors in such cases, which would be wasteful when there are spare outlets on the first selectors, the trunk selector marking circuit is altered by changing straps, so that when 2 is the first digit received, the marking uniselector steps 2, does not mark a group but self drives to contact 1' where it "homes" temporarily. A second digit (1 to 0) steps the switch on to the appropriate marking contact. This enables the one switch to mark up to 18 separate groups with a combination of single digit and two digit codes thus - 1, 21 to 20, 3, 4, 5, 6, 7, 8 and 9.

Like any other homing selector, the multiple for large groups of trunks may be graded to conserve outlets and still provide sufficient trunks for the traffic offered. For example, 18 trunks may be graded into 12 outlets; in most cases however grading is not necessary and full availability is given.

5.8 2VF Transit Switching at Main Trunk Centres - The large numbers of trunks terminating at Main trunk centres require facilities somewhat different to those just described. to cater for the large volume of through and terminating traffic. Also the manual positions may be cordless positions of auto trunk exchanges, or corded trunk positions of an earlier type than the sleeve control switchboards used at country switching centres.

Two or three ranks of trunk selectors are provided - a single digit of the routing code positions a selector in each rank. The first trunk selectors(transit) are a part of the incoming and bothway 2VF trunk line circuits, and are on the same rack as the 2VF relay sets and receivers. D.C. dialling trunks may also terminate on trunk selectors via a conversion relay set.

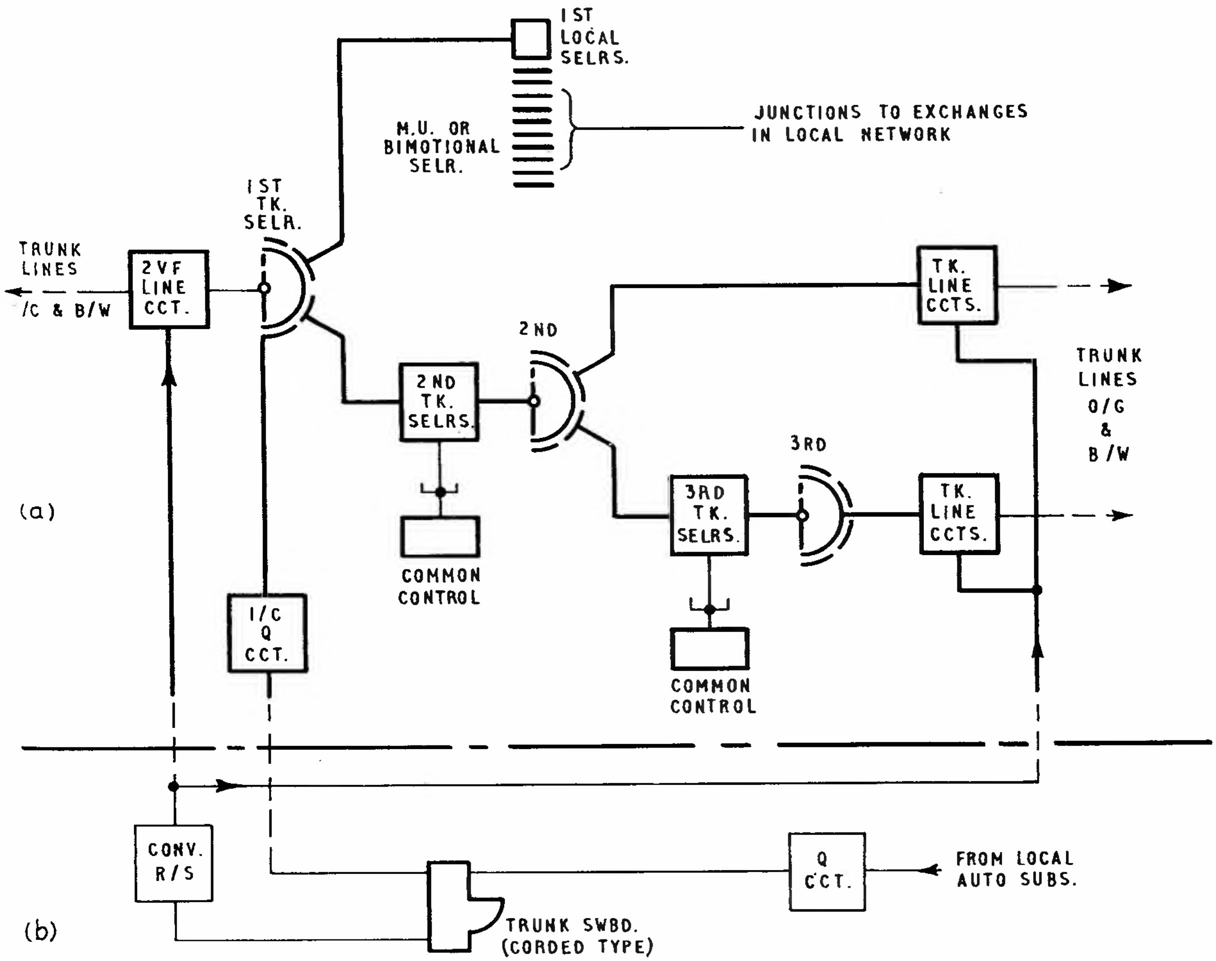
The first trunk selector multiple is divided into a maximum of 10 groups trunked to :

- Incoming first local selectors for access to the city network.
- The Through trunk positions for calls on which the calling telephonist requires assistance, or for access to trunks not available via the trunk selectors.
- Second trunk selectors.

In a few cases the more important trunk groups are trunked direct from the first selector outlets, and only a few groups of second selectors are trunked from the remaining outlets.

The basic trunking arrangements for main end transit switching (Main trunk centres are in Fig. 18a. Fig. 18b, is of minor importance only, and shows how early type corded trunk switchboards are associated with a 2VF transit exchange. As these 2VF relay sets are designed to work with the cordless switchboard circuits, conversion relay sets are necessary, but for incoming calls these may be part of the queueing circuit. The arrangements at cordless trunk exchanges are covered in Section 6.

Each group of second trunk selectors gives access to up to 10 groups, comprising trunk lines, and third selectors when required.



MAIN END TRANSIT EXCHANGE.

FIG. 18.

The third trunk selectors, when provided, give access generally to trunk lines of minor importance which may be 2VF, D.C. dialling, or generator signalling.

Calls into the city network and transit calls to other trunk lines are set up as described for country switching centres.

5.9 At main trunk centres, incoming lines to the manual position appear as a group on the first trunk selector multiple. The trunk selectors test into the available trunks after the pulses are received to mark the required group. A queueing circuit may be provided between the selector outlets and the trunk positions, to ensure calls are answered in order of arrival.

5.10 Second and third trunk selectors generally have individual equipment of three relays per circuit and one common control circuit for each 6 or 8 selectors. This saves space and equipment as the common control is freed for use by other selectors as soon as the selector tests in. Refer to the paper "The Motor Uniselector and High Speed Relay".

5.11 Four Wire Switching. (Fig. 19.) Trunk lines which are carrier channels or physical lines with terminal amplifiers, may be switched "four wire" to similar types of trunks by connecting the hybrid coil networks together using the familiar "tail eating" arrangement. This reduces the loss at the through station and improves stability. With transit switching via trunk selectors this is automatic (provided the hybrid N+ and N− wires are extended to the relay sets. Generator signalling trunks with terminal amplifiers may also be provided with four wire relay sets).

Each motor uniselector has an eight wiper circuit (2 sets of 8 single ended wipers covering 16 arcs to give over 100 outlets). In addition to the normal +, − and P, there are two network wires N+ and N−, a TT wire and a Marking (M) wiper. The eighth wire is S (supervisory) in main end trunk line circuits and FW (four wire at country switching centres. All circuits however, have an FW relay which is operated when two four wire circuits are interconnected via the trunk selector. The N+ and N− wires are switched through by the FW contacts in each line circuit. When a four wire trunk is switched to a two wire trunk the FW does not operate and the network of the four wire trunk remains terminated in the line circuit. (The TT wire is used on 2VF to 2VF transit switched calls to prepare both line relay sets for end to end 2VF signalling.) See Appendix 3, and Fig. 35 in Appendix 5.

Sometimes the network wires are also extended to a network jack on the manual board and two trunks may be interconnected four wire using special network cord circuits. However, these are not generally provided at later exchanges as it was found that they were rarely used by telephonists.

True four wire switching as distinct from "tail eating" connection will be used more in the future particularly with crossbar type trunk exchanges. See Appendix 4, Page _.

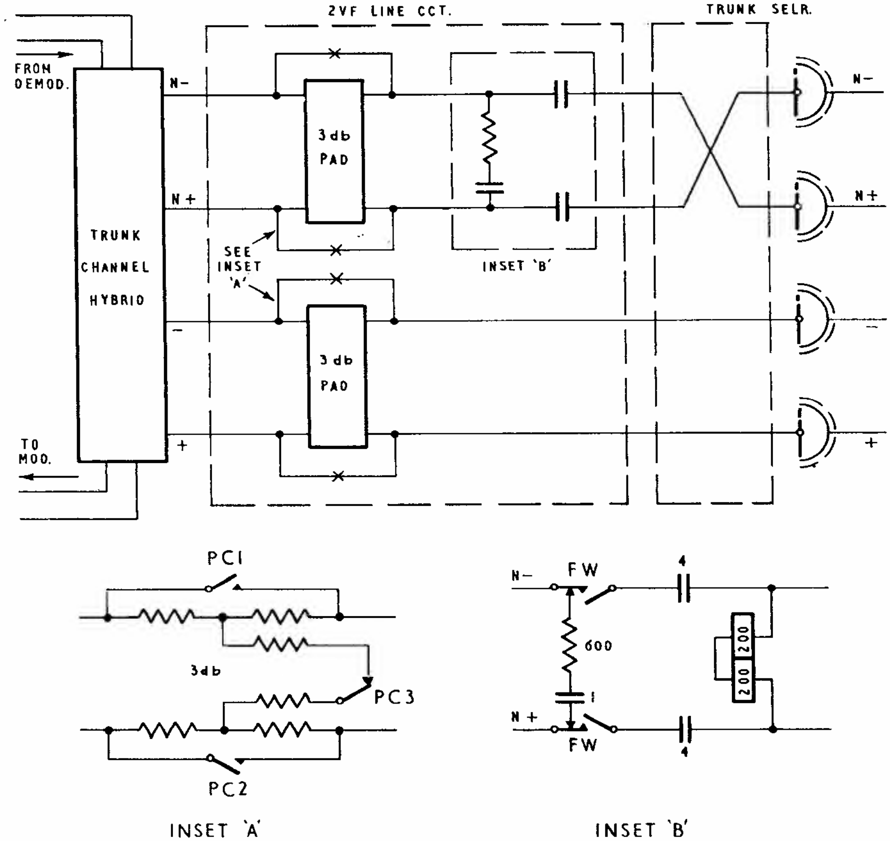
5.12 Pad Switching - To maintain overall transmission equivalents within satisfactory limits on through calls, pad switching is sometimes used. Ideally, pad switching should enable the overall subscriber to subscriber equivalents to be a minimum of -6 db and a maximum of -15 db. This is less difficult to arrange for fully auto switched calls than those switched by cord circuits at one or more centres. As network cords for 4W switching are rarely used, methods of pad control over a single cord circuit are being investigated.

All 2VF trunk line circuits are provided with either a single 3 db attenuation pad or two pads of 1 + 2 db. 3 db pads are also provided in 4W generator signalling trunk line relay sets. 2VF trunk lines however, are two wire circuits when not associated with a carrier channel, or when the hybrid network wires are not extended into the relay set. The pads are in this case switched out of circuit during all calls. As shown in Fig. 19, the pads are removed by the operation of a PC relay. Other two wire trunk line circuits do not have pads.

Strapping on individual relay sets is adjusted so that the PC is either operated or remains normal as required for the particular connection.

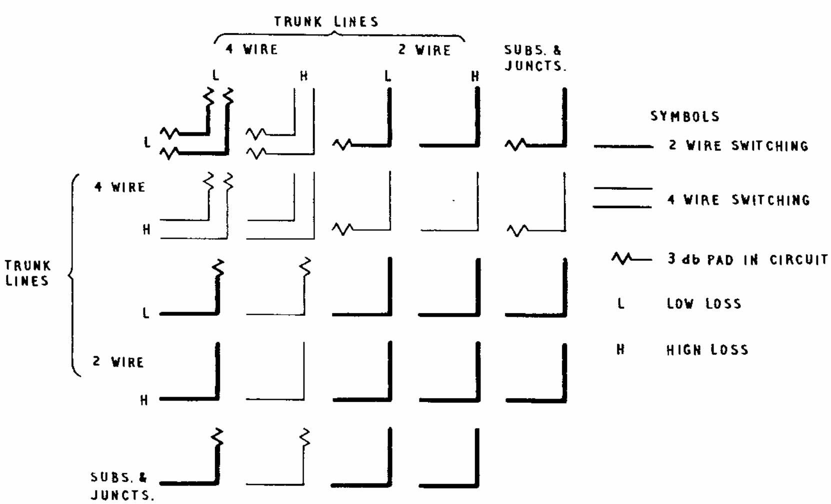
Trunks at a switching centre are classed as either "high loss" or "low loss". The dividing line depends generally on the line equivalent; the actual figure varies. For example, greater than a -6 db equivalent may be classed as a high loss circuit. Generally speaking, therefore, lines which are capable of being switched four wire (carrier channels and those with terminal amplifiers) are also low loss trunks. Two wire trunks are usually high loss trunks.

Fig. 20 shows possible 2VF relay set pad switching combinations in diagrammatic form. Assuming the vertical lines in the diagram represent calling lines as listed above the diagram and the horizontals represent called lines as classified on the left, the symbols used in the right angles joining the various vertical and horizontal columns show when two wire or four wire switching may be used and whether the 3 db pads are switched out or left in circuit; heavy lines indicate those in general use. Fig. 20 shows possibilities rather than uniformly established practices, as the extent to which pad switching can be used at present depends on local conditions and other factors beyond the scope of this paper. Circuit elements of 2VF relay set pad control principles are in Appendix 5, Page 42.



PRINCIPLE OF 4 WIRE SWITCHING AND PAD CONTROL.

FIG. 19.



TYPICAL ATTENUATION AND PAD CONTROL ARRANGEMENTS.

FIG. 20.

6. AUTO TRUNK EXCHANGES.

6.1 In automatic (or semi-automatic) trunk exchanges the calls are routed and switched via automatic selectors.

Calls originating from local subscribers are answered on cordless trunk positions and whenever possible completed on demand, the telephonist directing the call through the auto equipment by means of keys. When required, the auto equipment performs discriminating functions such as alternative routing or temporary storage of calls during short periods of congestion. These operating aids greatly facilitate demand working by 'tiding over' short periods of trunk congestion; delay working is resorted to only when waiting time would be excessive.

Auto trunk exchanges provide for incoming (terminating) and through calls to be completed automatically in the same way as described for other transit switching centres. (Fig. 18.)

The basic principles of call switching in an auto trunk exchange are not particularly involved. The auxiliary facilities however - queueing of incoming calls, link positions, call storage, alternative routing, delay control and supervision, common selector controls and pneumatic tube docket distribution, - make possible the success of the scheme but do result in complexity of the exchange as a whole. The fundamental principles given in the next section should be understood thoroughly before proceeding.

Cordless trunk exchanges are operating at Melbourne, Adelaide, Canberra, Sydney and Lismore. Differing local conditions and a time span of nearly twenty years between the first and last installations have resulted in differences in detail, but principles are the same.

6.2 A basic trunking diagram of a typical auto trunk exchange is in Fig. 21.

Generally, different calling numbers are allotted for various types of trunk call; that is, subscribers dial separate numbers for intrastate, interstate, and calls from public telephones. In this way callers are directed to positions catering for that class of call.

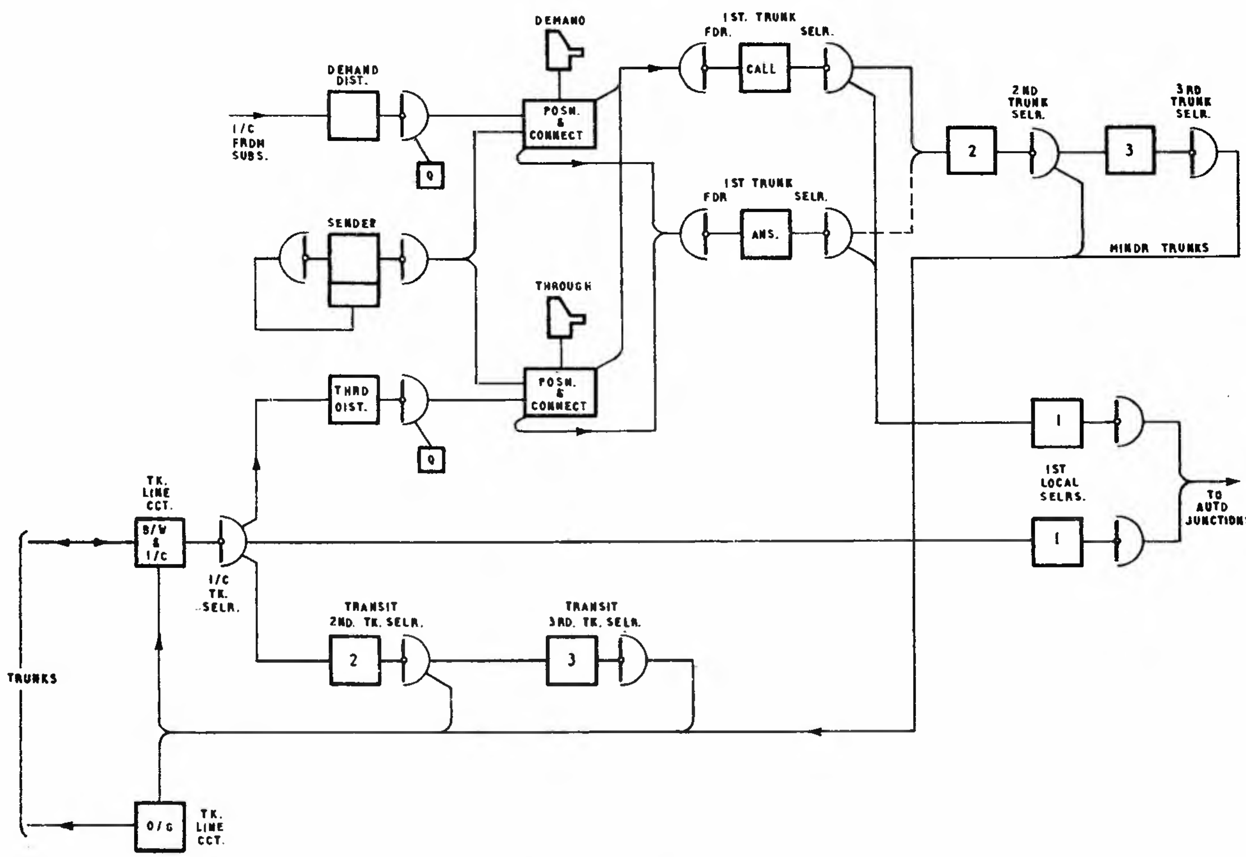
Successive incoming calls each seize a vacant demand distributor and arrange themselves in order of arrival (queue up); ringing tone is returned to the caller. Calls are answered on any position which has access to the particular distribution or queue - the call at the head of the queue is extended to a connect circuit when any telephonist answers the call lamp (one per position). The connect circuits are the equivalent of the cord circuits on corded boards.

About thirty positions, each having six connect circuits, have access to any one queue which holds ten or more calls before busy tone is returned to callers. The high calling rate demand numbers may be trunked to several separate demand distributions (queues).

The telephonist prepares a docket of the call details, then via the Call side of the same connect circuit, seizes a 1st trunk selector (generally via an associated finder).

On each position a digit key strip is provided instead of a dial. This is used to seize a spare "sender" circuit and the appropriate routing code is "keyed up" on the digit keys, followed by any further digits necessary to position trunk and/or local selectors at the distant centre or at transit stations en route. The sender stores this information and retransmits code signals to position the local 1st and 2nd trunk selectors (and 3rd local trunk selectors when required), followed by dialling pulses for the remaining digits stored. The sender then releases.

Note that dialling pulses are not used to position the local trunk selectors but special code signals over four wires (described later). The sender automatically determines how many and what digits to send as code and how many as pulse trains.



AUTO TRUNK EXCHANGE - TYPICAL TRUNKING.

FIG. 21.

When a conversation commences the telephonist starts the timing clock associated with the particular connect circuit. The clock stops automatically when the caller clears.

Incoming and bothway trunk lines terminate on trunk line relay sets and associated incoming trunk selectors which give access to -

The Through positions via the through distributors and queue circuit.

The city network via local 1st selectors.

The outgoing and bothway trunk line circuits for transit calls via 2nd and 3rd trunk transit selectors.

The 1st incoming and 2nd and 3rd trunk transit selectors are controlled by pulse trains from the distant (calling) end. For this reason these ranks are separate to the corresponding code positioned local trunk selectors, though they may test into the same trunks on the multiple side. (In Melbourne the incoming 1st trunk selectors are called 2VF Distributors.)

Through trunk calls may also be completed via the Through positions and are answered and extended to the required trunk line (or subscriber) via the connect circuits. The sender is used as described above.

As well as connection to the demand distributors outlets, each connect circuit has access to a first selector on the Ans side, so that a call set up on the Call side may be reverted to a subscriber, as for example, when the required group is in delay, or for checking purposes. On Through positions, calls are reverted to trunk lines via the Ans 1st trunk selectors. These may have access to the local network only, or to the trunk multiple as well, depending on requirements of the particular positions they serve.

6.3 Cordless Operating Positions - The following types of position are provided :

- Demand Positions accept calls from only one demand queue distribution (sub-divided into ordinary and pay telephone or P.T. demand positions).

- Through Positions accept calls from only one through queue distribution.

- Link Positions accept calls from two queue distributions. They answer and connect calls from one queue or the other to equalise the load between distributions and also to concentrate traffic during light load periods. For example, at night three link positions may handle all the traffic from six queues. Link positions may be further sub-divided into Like and Unlike Link positions; unlike positions accept calls from two types of distribution, for example, demand and P.T. demand, or demand and through. Switching between queues is generally automatic but in some cases Unlike Link positions have key switching between queues.

- Suspense Positions deal with all calls not completed for reasons other than the required trunk group being in delay, such as particular person not available, number not answering, etc. Enquiry calls from subscribers who have not been recalled for connection after the notified delay time has elapsed, are also routed to the Suspense positions from the Trunk Enquiry positions via a rank of miscellaneous services selectors.

- Trunk Enquiry Positions answer calls from the trunk enquiry queue and route them to other positions such as Pricing, Suspense, or to the traffic officer.

Fig. 22 shows typical cordless trunk positions and Fig. 23 the arrangement of a typical key shelf. The earlier positions are made of fibre and polished wood, and on a hinged keyshelf, have standard lamps, lever keys, plunger keys, designations, order wire type press keys and B.P.O. No. 44 timing clocks.

A later type of position as installed in Sydney trunk exchange is shown in Fig. 1. These boards have shaped metal panels, a P.V.C. surface on the wiring shelf, a special type of plunger key, modified timing clock, and standard lever keys. The lamps are mounted behind designation openings engraved on the inclined surface above the timing clocks; the lamp signals show up as illuminated lettering, for example, CALL WAITING and SENDER TAKEN. The keyshelf opens from the back and hinges forward allowing easy access for maintenance. The timing clocks, digit key strip and other plunger keys have plug and socket connections to allow easy removal to a test bench for maintenance. (Jacked in timing clocks are now also used in corded switchboards and other auto trunk exchanges). See Appendix 6, Page 44.

Except for minor differences the two designs have the same or similar designations and are operated in the same way. In any one exchange the various types of position listed above are practically identical. The covered openings on the writing shelves in both Fig. 22 and 23 are the entrances to the pneumatic tubes; the telephonists press the hinged lid and insert dockets for return to the receiving post.

CORDLESS TRUNK POSITIONS.

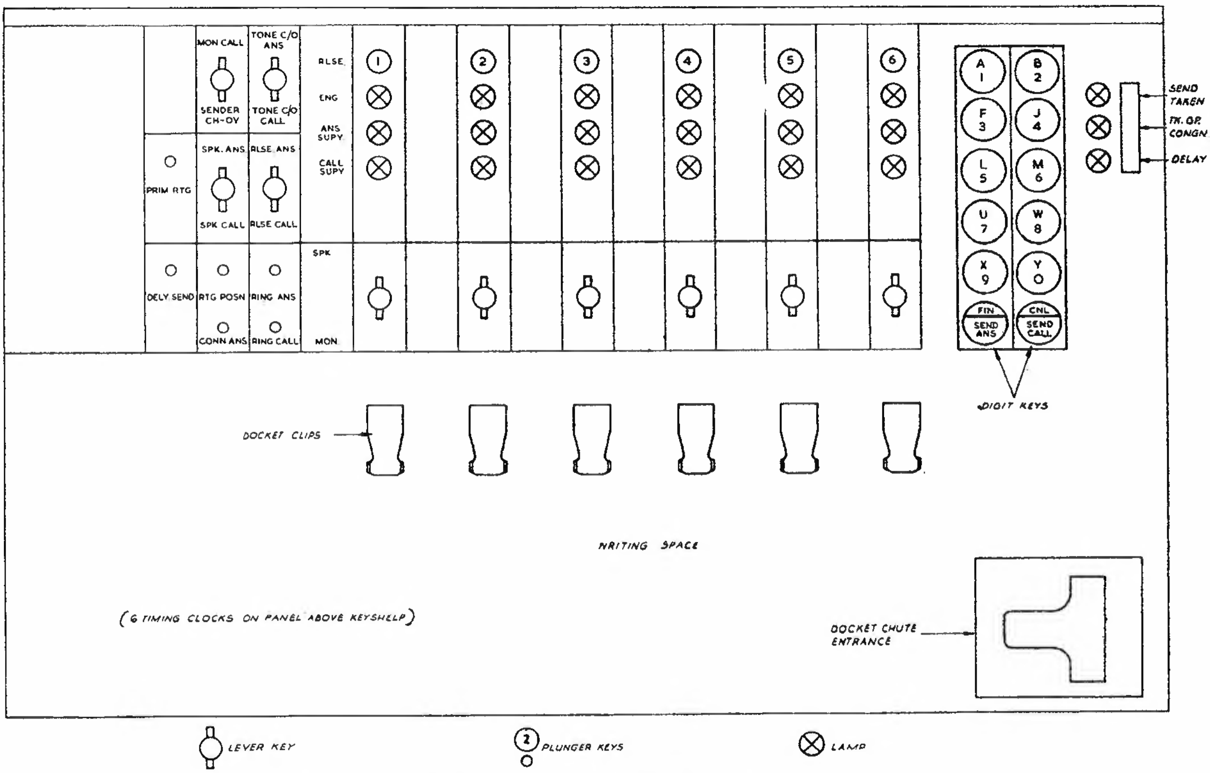
FIG. 22.

The positions have six connect circuits, each comprising one lever key SPK and MON (Speak and Monitor), four supervisory lamps, a press type RLSE (Release) key and a timing clock, which in most cases is in a sloping panel above the key shelf and is not shown in Fig. 23.

To the left of the connect circuits are several lever and press type keys which are the position circuit keys. These have common functions and are effective in whichever connect circuit the SPK key is thrown. On the right of each position are the 14 (or 12) keys and three lamp signals associated with the sender.

When calls are waiting in a queue distribution, a lamp lights on all positions which have access to that particular queue. If the waiting time of a caller in a queue exceeds a pre-determined figure, a second lamp glows or flickers to indicate an urgent condition.

Relay sets for the connect and position circuits are rack mounted in the equipment room.



TYPICAL KEYSHELF - CORDLESS TRUNK POSITION.

FIG. 23.

6.4 Connect Circuits. The SPK key is for speaking to connected parties and for answering and connecting functions in conjunction with the various position circuit keys. In the MON position of the key the telephonist listens via a high impedance monitoring circuit. The Eng supervisory lamp glows continually while the connect circuit is in use.

The Ans and Call supervisory lamps indicate the conditions on each side of the connect circuit with steady glow, flashing or flickering signals. The time check supervisory lamp associated with the clock (not shown) glows for 12 seconds immediately prior to the end of the three, six and nine minute periods. At the end of the three and six minute periods the lamp goes out, but at the end of nine minutes the lamp flickers to notify the telephonist that the clock must be re-started and the fact recorded on the docket.

The clock stops when the caller clears. For P.T. positions the clock circuit may be arranged to flash the lamp at the end of each 3 minute period. For a fuller description of clock operation see the paper "CB and Sleeve Control Exchanges".

With the call in progress, only the Eng lamp remains alight. A steady glow on either the Ans or Call supervisory lamp indicates the party on that side of the circuit has cleared or has not answered (the answer side may be used for calling as well as answering). A flashing Ans lamp on Through positions indicates a recall signal from the calling trunk line.

The RLSE (Release) key clears both sides of the circuit.

6.5 The Position Circuit - With a SPK key thrown, the several lever and press keys have the following functions. (Key designations are shown in Capitals) :-

- CONN ANS (Connect Answer). Pressed to cause the connect circuit to accept a call from the incoming queue, or, (when no calls are waiting) to preset the circuit to accept a call without it having to enter a queue.
- SPK ANS - SPK CALL. A three position locking lever key giving dividing facilities to a connect circuit via the SPK key.
- RLSE ANS and RLSE CALL. A three position non-locking lever key enabling either the answer or call side of a connect circuit to be released.
- TONE C/O ANS and TONE C/O CALL (Tone Cut Off). These keys have no effect on ordinary service tones such as busy or N.U., but are used to cut off various supervisory tones used to assist telephonists - storage tones etc.
- RING ANS and RING CALL. These two press keys are used on outgoing trunk connections set up from either the answer or call side of a connecting circuit to ring forward to or recall the distant manual exchange. The trunk line relay set converts to the required type of signalling (for example, X tone for 2VF lines). Ringing on the answer side may be necessary for reverted calls on the Through positions.
- SEND CH-OV (Sender Change Over). Gives access to another sender.

A press key - RTG POSN (Routing Position) - gives the telephonist direct access to the routing position for information on routing codes etc., for towns not included in the visible index file on the position (independent of SPK key).

6.6 The Key Sender and Associated Lamps and Keys. The ten digit keys are designated with the usual dial markings A1, B2, F3, etc. The other functions - SEND ANS, SEND CALL, FIN and CNL (Finish and Cancel) are combined on two keys. The keys, PRIM RTG and DEL SEND (Primary Routing and Delay Send) are part of the sender circuits. Three lamp signals, Sender Taken, Delay and Trunk Group Congestion are near the digit keys.

A sender is coupled to a connect circuit when the SPK key is thrown and the SEND ANS or SEND CALL key pressed, depending on which side of the connect circuit the call is being set up. The Sender Taken lamp glows when a sender circuit is seized. The routing code and number are then keyed followed by the FIN key. Operating the CNL key at any stage releases the sender (for mistakes made in keying).

Normally the sender releases automatically after it has sent all the codes and pulses; the Sender Taken lamp goes out. However, when the required trunk group has been placed in delay and therefore not available to demand telephonists, the Sender Taken lamp remains alight and the Delay lamp :-

Flickers when the delay is up to 15 minutes.
Flashes when the delay is up to 30 minutes.
Glows steadily when the delay is 45 minutes or more.

In the later exchanges a recorded voice also announces delay times to the telephonist. The sender is then cancelled.

6.7 Delay Working. The delay supervisor's position or desk provides lamp indication of the state of each trunk group, that is, whether it is congested and if so the number of calls in storage. Delay working replaces demand working when the supervisor operates keys to close the group to demand telephonists and return the lamp signals etc. of delay times as described above. Alternatively in some exchanges the introduction of delay working is either manual or automatic as determined by another key on the delay supervisor's desk. When automatic, the delay working is commenced for a group when the number of calls in storage reaches a predetermined figure.

Groups in delay are operated from normal demand positions which are given access to groups in delay by operation of a key on the delay supervisor's desk in Melbourne and on monitors' posts at later exchanges. These telephonists then gain access to the group using the DEL SEND key before keying the other digits.

6.8 The Sender. A number of senders is shared by up to 100 positions. Depending on the traffic, they are provided generally at the rate of about one for three or four positions. Each sender has about 140 relays and four or five motor uniselectors. Five senders occupy a full rack together with a set of terminal blocks called a translation field common to the five senders.

The capacity of the sender is 10 digits at one coupling. Fig. 24 shows in block form how the sender is associated with the translation field, and the other sources of the 'information' it requires to perform its many functions.

When a SEND ANS or SEND CALL key is pressed together with a SPK key thrown, the bank of either the A or B switch is marked, and a start signal is received on the appropriate start lead. The couple switch A or B seizes the marked outlet, connecting the sender to the 1st trunk selector via the position and connect circuits. The couple switches each have 16 arcs.

The 10 digit keys transmit their signals to the sender over four wires, W, X, Y and Z. (See Fig. 25.) The code receiving relays consist of ten groups of four relays; the relays are operated by earths on the code leads in one of ten combinations depending on the digit key pressed. The code receiving relays lock when operated and in this way store the digits received.

The number of digits keyed is counted by another group of relays which also switch the incoming leads from the key strip to four others code relays after the receipt of each digit. The first number is received and stored by AW, AX, AY and AZ, the second by BW to BZ and so on up to KW, KX, KY and KZ for the tenth number. The FIN key is pressed to notify the sender all digits are keyed, which in most cases is less than ten.

The first part of the number is the routing or "exit" code and controls the selectors within the trunk exchange. These digits are sent out again to the trunk selectors as four wire codes and are carried between ranks of selectors on the −, +, N− and N+ wires.

After the exit code any subsequent digits are sent as "dialling" pulse trains with a measured inter digital pause which -

(i) position trunk selectors and/or local exchange selectors at the distant centre and any intermediate switching centres, or

(ii) position selectors in the local city network.

In (i) the sender generates and transmits X tone pulses. Simultaneous battery pulses on the N− are also transmitted when carrier systems using this form of incoming dialling are in use. The 2VF trunk line circuit or carrier channel terminal equipment accepts the type of pulses applicable.

In (ii) loop pulses are sent.

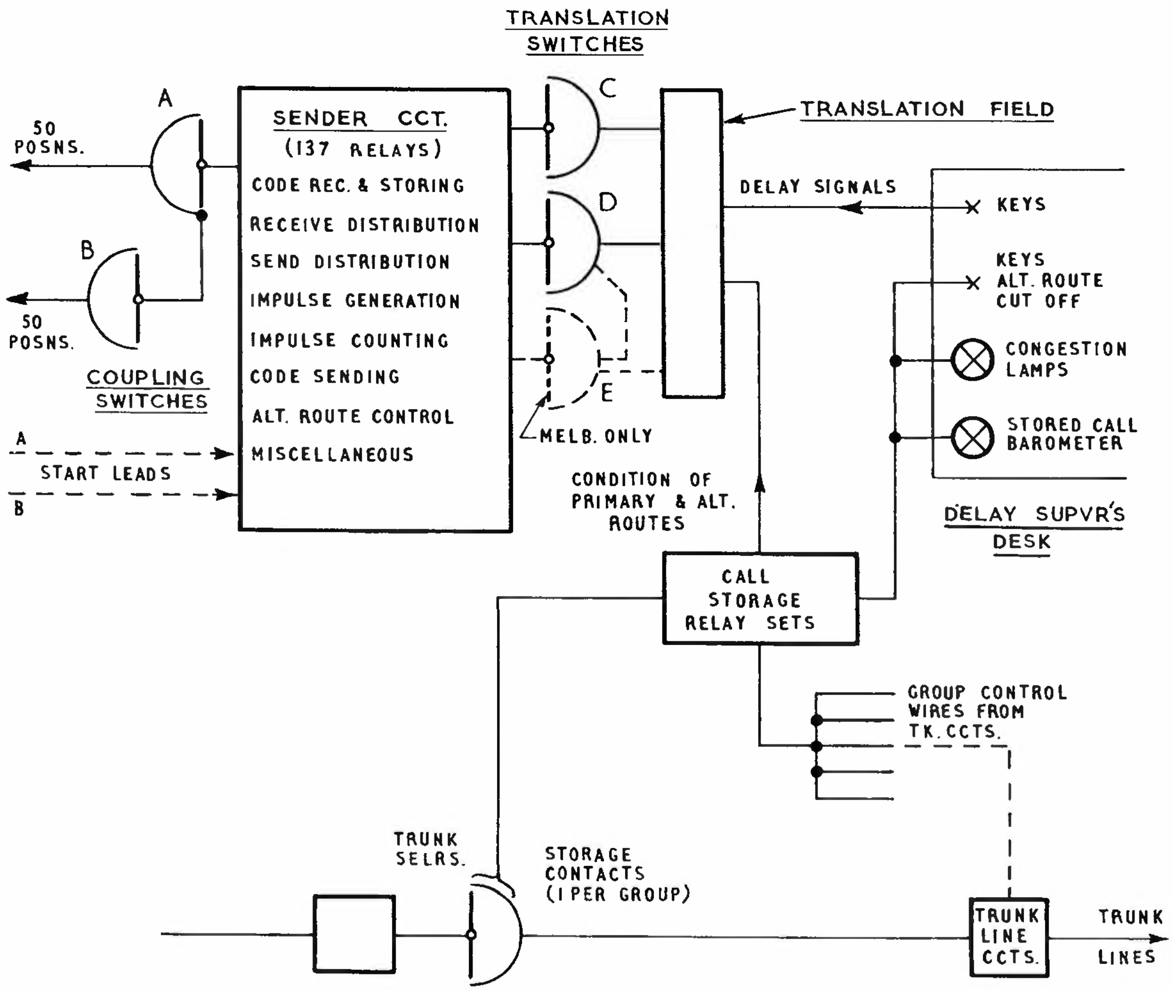
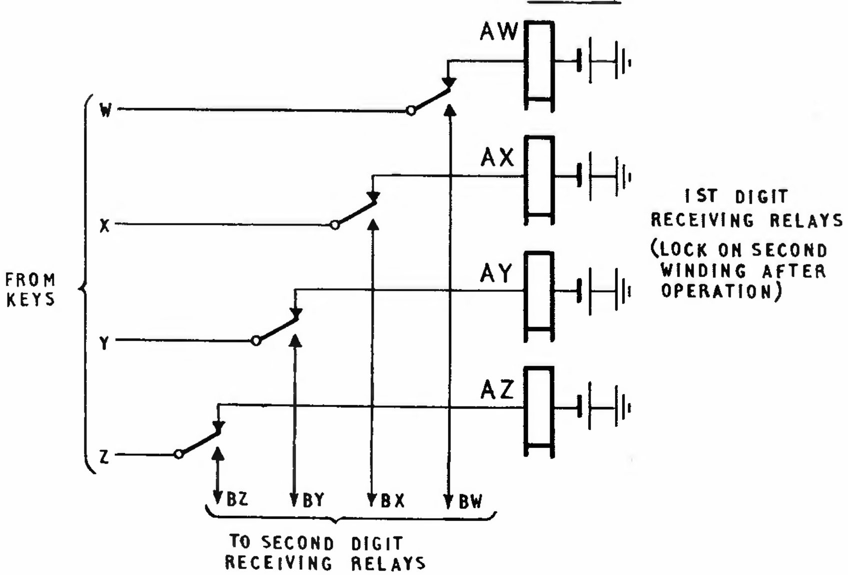


FIG. 24.



DIGIT	CODE WIRES EARTHED
1	W
2	X
3	Y
4	Z
5	W Z
6	X Z
7	Y Z
8	W Y
9	X Y
10	W X

FIG. 25.

When the first part of the code is received the translation switch (or switches) drives to a marked outlet and makes connection to various circuits via the translation field blocks.

The sender circuit then does the following -

(i) Determines the condition of the required trunk group, that is whether -

a free trunk is available, or

the group is congested, or

the group is in delay.

(ii) Determines whether the digits will be sent as four wire code or as pulses, and whether the pulses are to be loop, or VF and battery. (Assuming a free trunk is available in the primary route.)

(iii) Sends the exit code digits (translated if necessary), followed by the pulses in succession; determines when each exit code digit has been effective, (a signal is sent back from the selector control) disconnects it and sends the next digit; applies an interdigital pause between pulse trains.

(iv) Releases itself after the last train of pulses is sent.

(v) When the primary route is congested, and there is an alternative route with a free trunk, a translation switch drives on to another marked contact and there obtains the new exit code and other information necessary to establish the call over the alternate route.

(vi) Repeats steps (ii), (iii), and (iv) above for the alternate route but if necessary inserts extra pulse trains for automatic transit switching at intermediate stations. When the call has to be through switched at a manual exchange on the alternate route the Sender Taken lamp on the position is flashed to warn the telephonist of this fact. The sender is then cancelled before speaking.

(vii) When the primary route is congested and there is no alternate route, or when both primary and alternate routes are congested, sends the code for the primary route and then releases. If the route is still congested when the last trunk selector is testing over the wanted group, the call either goes into storage via that selector bank, or trunk congestion and/or busy tone signals are returned to the operator.

(viii) When the group is in delay, extends the signals from the delay supervisor's desk to the Delay lamp on the position, and also the recorded announcement if provided.

(ix) Releases itself after a 30 - 60 second delay whenever it is being held unnecessarily by an incomplete set up, or other operating irregularity.

NOTE: The condition of both primary and alternate routes of all trunk groups is being continually presented to the sender via the storage relay sets, by means of a group control wire for each group. The sender tests the condition of both primary and alternate routes simultaneously as soon as the exit code is received and the translation switches positioned on the primary route contacts. If not congested the primary route takes preference. (See Fig. 24.)

6.9 Alternate routing. This is outlined in the sender description in the previous paragraphs. An alternate route is generally via one intermediate switching station as shown in Fig. 26. A-B is the primary route and A-C-B the alternate route.

When the route A-B is congested the sender at A will route the call via A-C if a trunk in that group is free.

If transit selectors at C find the route C-B congested, the 2VF relay set returns a re-route signal (X tone). This causes the sender to release the alternate route A-C and to send the primary route exit code. If A-B is still congested the call is stored for that route.

When C is a manual station the telephonist there advises A of congestion on route C-B, and the sender is cancelled. The call is then either reverted to the subscriber after a delay or re-established on the primary route A-B to go into storage. However, as the alternate routing is automatic, the telephonist in keying up the call a second time, forces the call into the primary route using the PRIM RTG key.

Also, the delay supervisor can cut off the automatic alternate routing when conditions make this desirable, as would be the case, if the route C-B in Fig. 26 was having long periods of congestion.

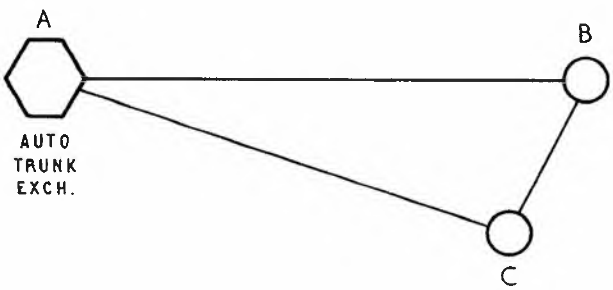


FIG. 26.

6.10 Call Storage. An outlet is reserved on the trunk selector multiple for each trunk group requiring storage facilities. The sender connects the code to position the selector or selectors as already described. If all the lines are busy in the marked group the motor uniselector drives over the group to the storage contact which is marked together with the group. (See Fig. 24.)

Each group has a storage relay set which counts the number of selectors resting on the storage outlet and lights successive lamps in a strip or 'barometer' on the delay supervisor's desk, to indicate the calls awaiting a line in that particular trunk group.

While a call is stored the telephonist may restore the SPK key. The connect circuit supervisory lamp (Ans or Call depending on which side of the circuit the call was set up) stays alight, but goes out momentarily every six seconds as a reminder. When a line becomes free the supervisory lamp flashes (or flickers in some exchanges) on all positions with calls stored for that group. Re-operation of the SPK key causes the selector to re-search the group. If a number of telephonists are waiting and only one line becomes free, the first selector to reach the outlet takes the call and the others return to the storage outlet.

To complete the setting up of a call on a line picked up from storage, the telephonist re-engages the sender and keys up only the digits required for selecting operations beyond the local centre; that is, the complete number less the exit code. The sender is aware of the condition and sends out pulses only.

6.11 Demand Distributors. When large numbers of incoming calls have to be handled, calls are queued, with the calling lamp signal appearing on a number of positions.

The demand distributors each have a relay set and a motor uniselector arranged by wiper switching to give 200 outlets. The first part of the M.U. bank is reserved for a queue of 10 to 20 callers; the connecting circuits of 27 positions or more occupy the remainder of the bank, the queue contacts and connecting contacts being multipled over all the M.Us. in a distribution. Fig. 27 represents the bank allocation assuming a queue of up to 20 calls.

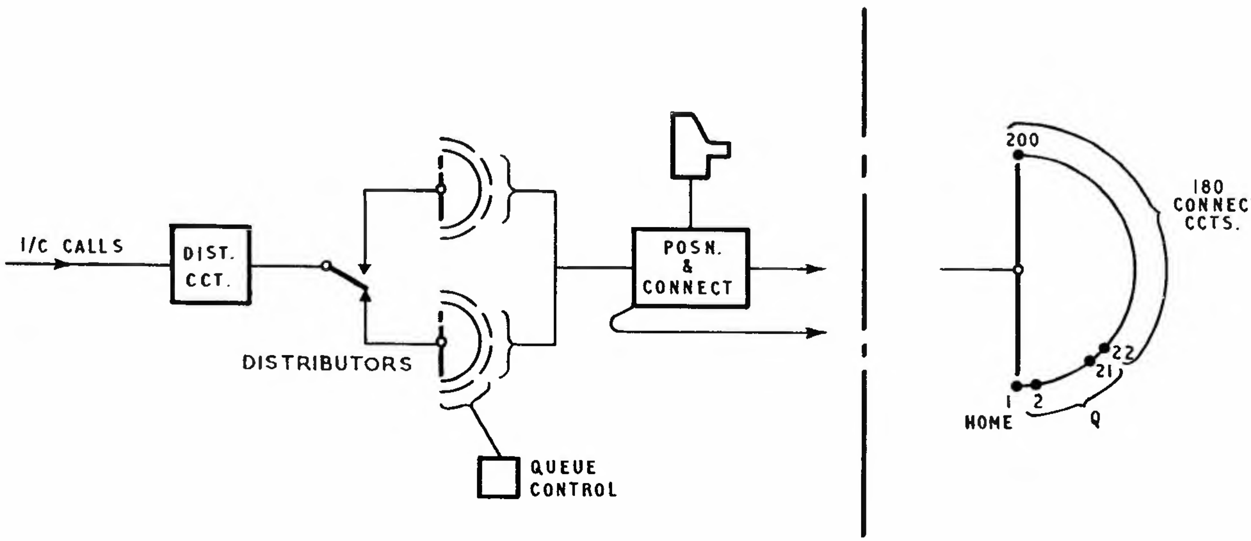


FIG. 27.

Contacts 2-21 are the queue positions; contact 21 is the first queue position, 20 the second, 19 the third and so on, contact 2 being the last. When the first caller seizes a demand distributor, the M.U. drives to contact 21, the next caller to 20 and so on. When the queue is full, following callers receive busy tone.

When any telephonist operates SPK and CONN ANS keys, the call occupying the first queue position drives off contact 21 to the contact marked by the connect circuit. All the other calls in the queue move up one contact.

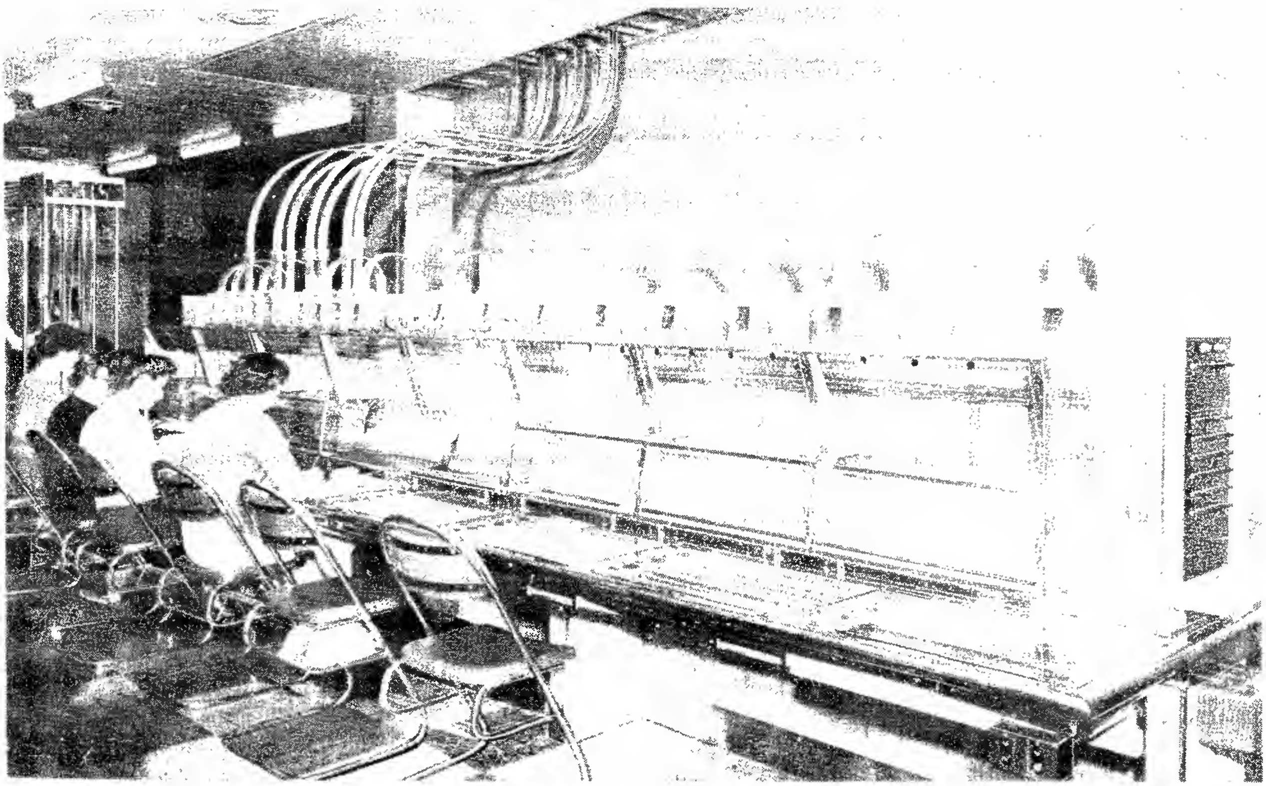
During periods of lighter traffic, a telephonist may preset a connect circuit to the answering condition, so that an incoming call drives straight to the marked connect circuit without entering the queue.

While the queue is limited in size to ensure waiting time is not too long, the number of calls in progress simultaneously is limited only by the number of incoming junctions and demand distributors; a hundred of these comprise a distribution in a typical case.

If the waiting time of a call in the queue exceeds a predetermined time (for example - 10 seconds), the telephonists receive a lamp signal indicating the urgent condition. To suit variations of traffic and positions staffed, keys are provided whereby a monitor or traffic officer can restrict the queue to less than its full size.

Some of the connecting circuits appearing on the distributor switch banks are those of link positions. The same connecting circuits appear on another distribution. As previously mentioned, the circuits are switched to one distributor or the other to take calls from whichever queue has the most calls or longest waiting time.

6.12 Pneumatic Tube Distribution. Completed dockets, and uncompleted dockets for calls to groups in delay, are placed by the telephonists in the receivers on each position and are taken by pneumatic tubes to a common receiving post where they are sorted and re-directed if necessary. Fig. 28 shows a typical receiving post.



PNEUMATIC TUBE RECEIVING POST.

FIG. 28.

6.13 Miscellaneous. In the equipment room of an automatic trunk exchange a number of automatic routiners are provided for routine testing the selector, junction and 2VF trunk line circuits. These are similar in many respects to those used in automatic exchanges, and described in the paper "Testing in Auto Exchanges".

The Speech Detector is a type of automatic routiner which can be set to 'listen' for a brief period on all the trunk lines in turn, to detect those which are busy without conversation. This is a simple way of keeping a check on the trunk lines to ensure that none are withheld from traffic owing to false operation by telephonists, failure to release, etc.

Another type of routine tester is the country end test set, which with a Technician at each station, is used for testing 2VF trunk line relay sets at country stations.

The routiners, country end tester and speech detector are also provided at some large switching centres, having corded trunk switchboards.

6.14 Other Features. The foregoing covers the main features of auto trunk exchanges. Further details such as automatic alternate routing on transit calls, local first selector arrangements, outgoing trunk preselectors etc., are in Appendix 6, Page 44.

7. MULTIMETERING.

7.1 Direct dialling by subscribers beyond the unit fee area requires that the subscriber's meter be pulsed for the duration of the call, at a rate determined by the distance to the called subscriber, or in practice, by the digits dialled to obtain the connection.

Subscriber dialling over trunk routes for very long distances introduces problems such as :

- Centres which are relatively close geographically, but because of trunk routing are served by different switching centres, must be given access to each other at appropriate charging rates. Exchanges are zoned wherever possible to avoid this problem; where it cannot be avoided the routing codes dialled must also operate discriminating equipment to adjust metering rates.
- Some subscribers may require advice with their account (or equivalent information) as to how much trunk calls have cost; that is, an accounting problem has to be solved by technical means.

Overseas, these problems are solved in a number of ways. Australia's great distances and relatively small population present some unique problems, which are at present in the process of being solved. See Appendix 7, Page 48.

Multimetering on trunk calls of up to a hundred miles or so is technically easier and is being used in several places.

7.2 Fig. 29 is a block diagram of the equipment used for multimetering on some "short haul" trunk calls. On junctions to exchanges outside the unit fee area the selector level is trunked to a variable rate repeater relay set instead of the normal R.S.R. Associated with each variable rate repeater set and on the same rack, is a code selector relay set.

Common basic pulse and night rate relay sets on the M.A.R. supply earth pulses to all repeaters at one rate for the day tariff and at a slower rate for the night tariff. The night rate is introduced automatically by a time clock. The basic pulse and night rate circuits are provided in duplicate and on failure of the duty sets, change over to the standby sets is automatic. Typical basic pulse rates are 9 seconds day rate, and 12 seconds night rate.

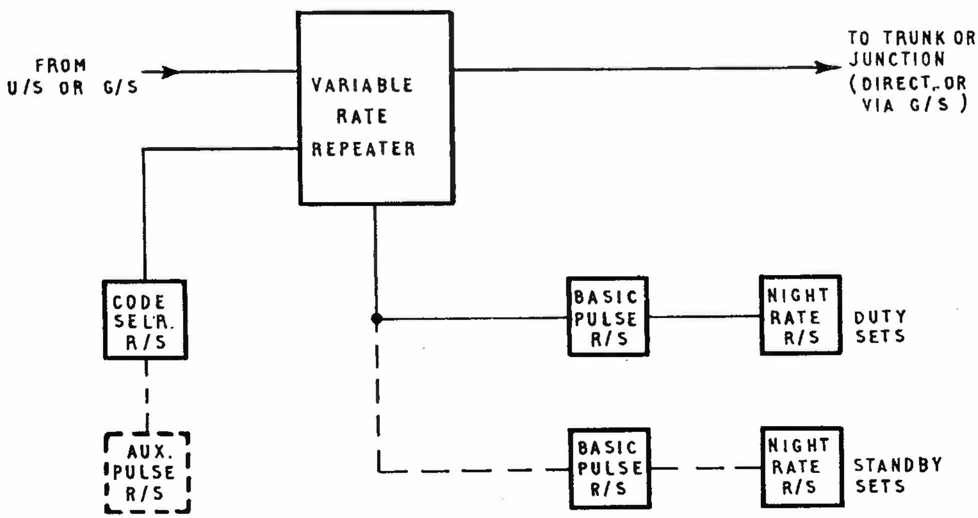


FIG. 29.

7.3 Basic Operation. Fig. 30 is a simplified circuit showing basic principles only.

Incoming dialling pulses are repeated over the junction to the distant selectors and also to a counting uniselector (CS) in the code selector. This circuit discriminates after counting one, two or three digits as necessary, and according to the destination of the call, tariff relays in the repeater set are operated via the CS banks and suitable strappings.

The variable rate repeater set contains a fee determining (FD) uniselector with bank strappings which are altered in their combinations by the contacts of the tariff relays. With the call in progress the FD uniselector is stepping under the control of earth pulses from the basic pulse circuit.

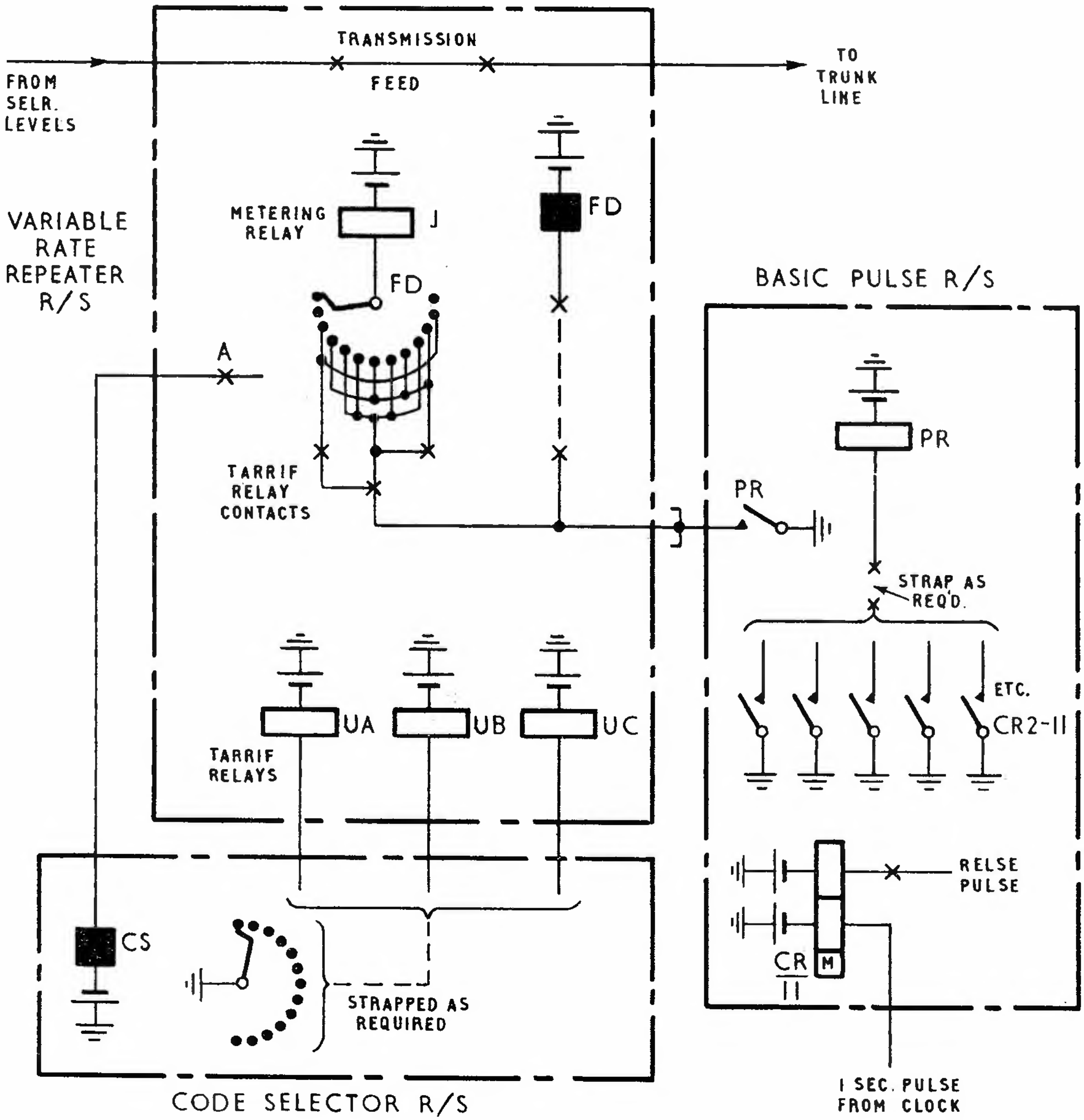


FIG. 30.

When the called subscriber answers, a unit fee is registered against the caller in the usual way for an auto-auto repeater. The FD uniselector commences to step and irrespective of the metering rate takes at least two steps before the metering relay (J) is again operated. This unmetered pause gives the caller time to clear in the case of a wrong number. The FD switch is stepped at the basic pulse rate and the J relay is re-operated at intervals determined by the FD bank strappings and the particular tariff relays operated; each operation of J connects a metering pulse to the incoming P wire.

Where high tariff rates apply, such that the metering rate is greater than the basic pulse rate, an auxiliary pulse relay set provides additional earth pulses to operate J several times between basic pulses. This facility is not yet used.

7.4 Additional facilities. Some important additional facilities provided by the variable rate repeater circuit are :

- Forced release of the junction 3 to 6 minutes after the commencement of one of the following conditions -

  Permanent loop, CSH, called subscriber not answering (including receipt of busy or NU tones), undue delay between digits.

- NU tone returned on barred levels.

- Certain subscribers may be barred access by modifying their line circuits; this is detected by the repeater which returns NU tone.

- Prevents false metering caused by premature answer signal from reversed junction or reversed internal trunk.

- If during a call a second caller comes across the connection on the calling side of the repeater (result of "stop on busy" switch), the call is forcibly released on the junction side and NU tone returned to both subscribers. This is necessary since, if the call continued, the stop on busy caller would be held and his meter operated at the same rate as the first caller's.

- The trunk may be either a D.C. loop signalling circuit or a carrier channel, in which case the repeater circuit is modified by alteration of shelf strappings to give the type of pulse repetition and answer signal response required by the carrier channel terminal equipment.

- Unit fee calls may also be routed via the repeater in which case an appropriate tariff relay prevents the FD switch from stepping.

A fixed rate repeater is available for exchanges where only one metering rate applies.

7.5 The basic pulses are produced by a magnetic counter which has ten small armatures and eleven contacts. When energised by one second earth pulses from the exchange clock it operates one armature for each pulse. The operation of armature 1 removes an auxiliary spring load from armature 2 which, at the end of the first pulse, allows armature 2 to prepare its magnetic circuit for operation on the following pulse. Operation of armature 2 prepares for the operation of armature 3, and so on. Once operated the armatures hold between pulses to the remanent core face. The operate pulses are fed to one coil; all operated armatures are released at any desired stage, by a release pulse in a second coil on the relay.

Each armature has a contact which may be strapped as needed to give the basic pulse at the desired rate. The counter occupies the space of two 3000 type relays.

8. REFERENCES.

A.P.O. E.Is. on Transmission Performance Standards including
PLANNING Transmission B 2050 and B 2080 etc.

The Telecommunication Journal of Australia.

Vol. 12 No.1 (1959) - The National Telephone Plan - Numbering) - R.W. Turnbull,
Vol. 11 No.5 (1958) - Nation-wide Dialling System for Australia) B.F. Marrows, W.J. Pollock.

Vol. 8 No.3 (1951) - The Design of an Automatic Switching Plan for Australia - C. Cruttenden.

Vol. 6 Nos. 3 and 4 (1947) - Expansion of Long Distance V.F. Dialling in Australia - F.P. O'Grady.

Vols. 3 No.5 and 4 No.2 (1942) - The Victorian 2VF Signalling System - A.E. Bayne.

Vols. 2 No.4, 2 No.5, 2 No.6, 3 No.4 and 3 No.5 (1939-41) - The New Melbourne Trunk Exchange - C. McHenry, L. Paddock, C.L. Hosking.

NOTE: When using early references allowance should be made for amendments and developments.

9. TEST QUESTIONS.

(1) List three features used to speed up the handling of trunk traffic.

(2) Describe how one of the features named in Question (1) improves trunk switching as compared to earlier methods.

(3) (i) How are trunk switching centres classified?
(ii) Briefly define each classification.

(4) With the aid of a diagram show the difference between Direct and Final Choice trunk routes.

(5) With the aid of a diagram show the basic requirements of a trunk line equipped for 2VF signalling.

(6) Describe the basic operation of a 2VF receiver.

(7) A trunk call is made on a 2VF line, from a country manual exchange to a subscriber in a city auto network. List the sequence of tones used in the setting up and release of the call, and describe their function.

(8) What do you understand by the term "splitting" as applied to 2VF trunk line relay sets?

(9) Describe the release of a 2VF trunk call transit switched via one intermediate station.

(10) Draw a basic trunking diagram of an auto transit switching centre at a country centre with a local auto exchange and sleeve control trunk positions.

(11) With reference to the diagram of Question 10, describe the setting up of a call from -

(i) a 2VF trunk line to a generator signalling trunk line,
(ii) a 2VF trunk line to the trunk switchboard,
(iii) an R.A.X. trunk line to a local auto subscriber.

(12) How are country transit selectors given access to more than 10 groups of trunk lines without the use of second trunk selectors?

(13) (i) Draw a block diagram to show how transit calls can be routed at a main trunk switching centre.
(ii) What is the main difference in the setting up of calls to the trunk switchboard when compared with country transit exchanges.

(14) What is meant by "four-wire switching" as applied to transit switching?

(15) With the aid of a simple trunking diagram, briefly describe the setting up of a call from a city auto subscriber to a distant town via an auto trunk exchange.

(16) Briefly describe what happens when a call, set up by the operator of a cordless trunk position, is alternatively routed by the sender.

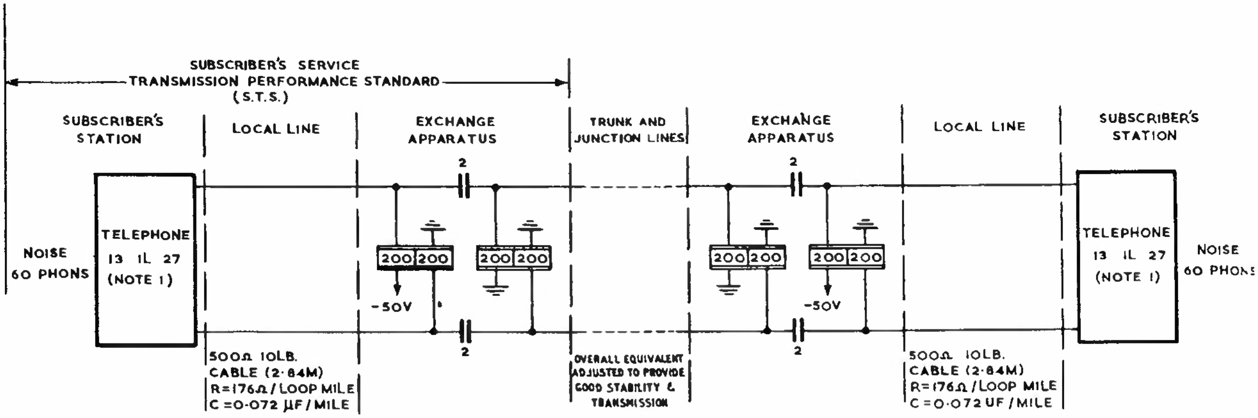
(17) Describe the principle of queueing for handling large numbers of callers.

(18) Explain the principles of call storage.

(19) What are the main functions of a delay supervisor's desk?

(20) With the aid of a digram, describe the basic principles used in multimetering on some short haul trunk calls.

APPENDIX 1.



NOTE 1.

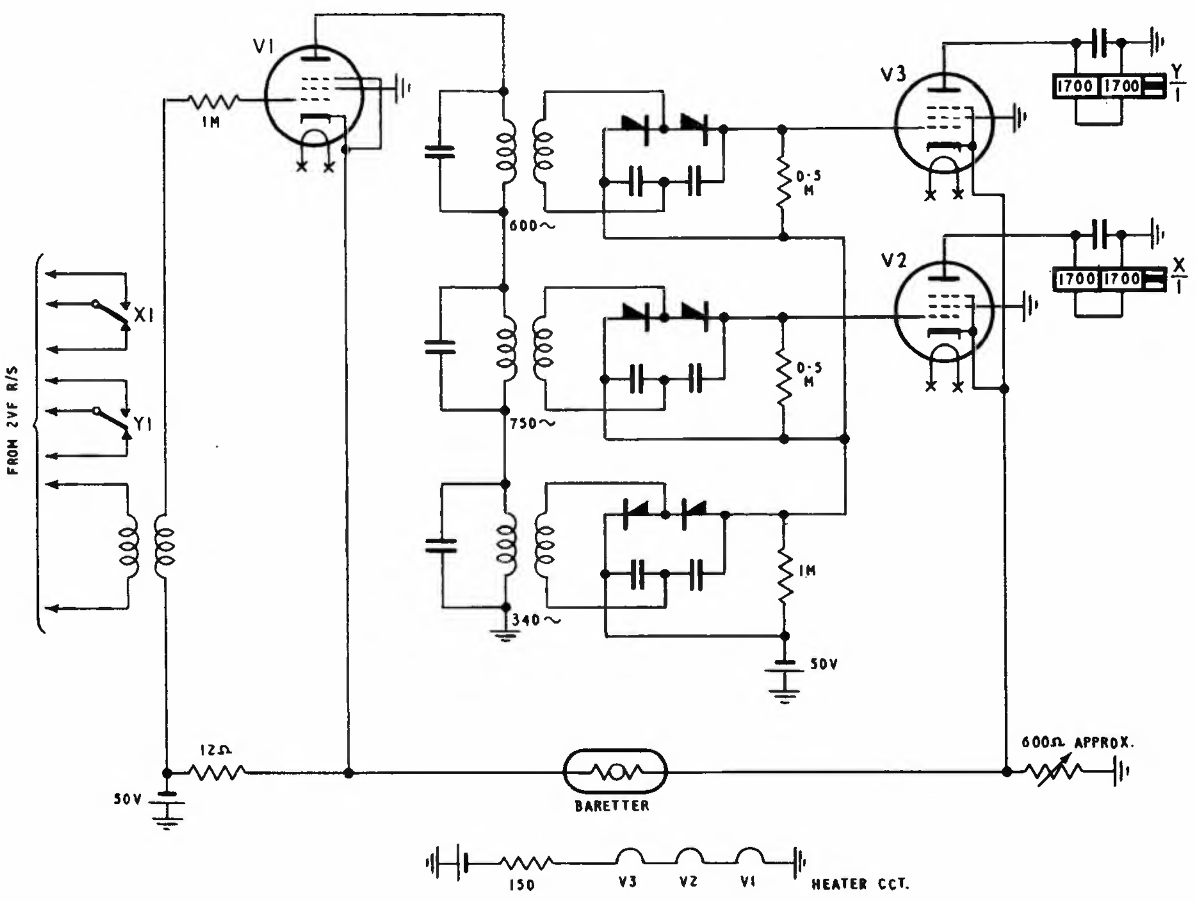
Telephone 13. 1L. 27 refers to handset type telephone having the following transmission components -

Transmitter Inset	No. 13
Receiver Type	1L
Anti-sidetone induction coil	No. 27

TRANSMISSION PERFORMANCE STANDARDS.

FIG. 31.

APPENDIX 2.



2 V.F. RECEIVER.

FIG. 32.

APPENDIX 3.

A3.1 2VF Trunk Line Circuit - Some of the more important circuit elements are simplified in Fig. 33. The Main end circuit with trunk selector directly associated, differs in some respects but for the main functions Fig. 33 can be regarded as typical.

A3.2 Incoming seizure and dialling. Pick up X tone from the distant end operates X in the 2VF receiver. B operates and locks at B4. At the end of the pulse, X1 releasing operates A, AX and AY via B3. Other relays not shown are operated by B (BR BA etc.) and the circuit is ready for dialling. A1 loops the trunk selector which prepares to receive D.C. loop pulses. Incoming dialling trains pulse X1 which operates C for the duration of each train and pulses A. Owing to the capacitor QA, AX and AY release slightly before A. This isolates the receiver from the selector during dialling at AX1 and AY1 to prevent D.C. surges from blocking the receiver. Loop pulses are repeated to the trunk selector and subsequent auto exchange switches via A1 and C3 which short circuits the "back bridge" circuit during the repetition.

(In Main end circuits the trunk selector marking uniselector is stepped directly by X1.)

A3.3 Tone Sending. The sending of X or Y tone is by the operation of either TX or TY, in series with one coil of SP. The line is split in every case at SP3 and SP5 and the local side terminated at SP6.

During transmission of X or Y tone, the 2VF receiver is isolated at TX4 and TX5 or TY4 and TY5.

On dialling out from the local trunk switchboard, AA relay (not shown) is pulsed and AA1 sends the X tone pulses to line via the TX and SP contacts operated.

A3.4 Split Guard Pause. Incoming Y tone (such as Answer and Clear back on O/G calls and Answer Acknowledge on I/C calls) operates Y. Y1 releases Z which, after 150-200mS lag, operates SP at Z2. This is the split guard pause and is a safeguard against momentary operation of Y during speech, causing false operation of the circuit.

Y1 also operates G; G6 opens the tone sending circuit to prevent the possibility of tone being sent from both ends at once. When Y tone ceases, no tone can be sent until G releases after a lag of 100-150mS as G6 is open. This is the guard pause and gives time for any line echo suppressors etc. to restore to normal.

A3.5 Answer Sequence. When the called subscriber answers on incoming calls, reversal on the outgoing + and − lines operates D. D3 operates SP and holds D. D6 connects $\frac{3}{4}$ second earth pulses to TY and a pulse of Answer tone is sent to line by TY1 and TY2. If Answer Acknowledge is received in the first interval, Y1 operates G, and G6 opens TY. However, Answer tone is sent until acknowledged. On acknowledgement, Y1 also operates AR via D2 and Z3. AR locks and opens SP at AR2. AR3 opens TY and prepares for Clear Back. After the Answer Acknowledge ceases, Y releases and Z re-operates, releasing SP at Z2.

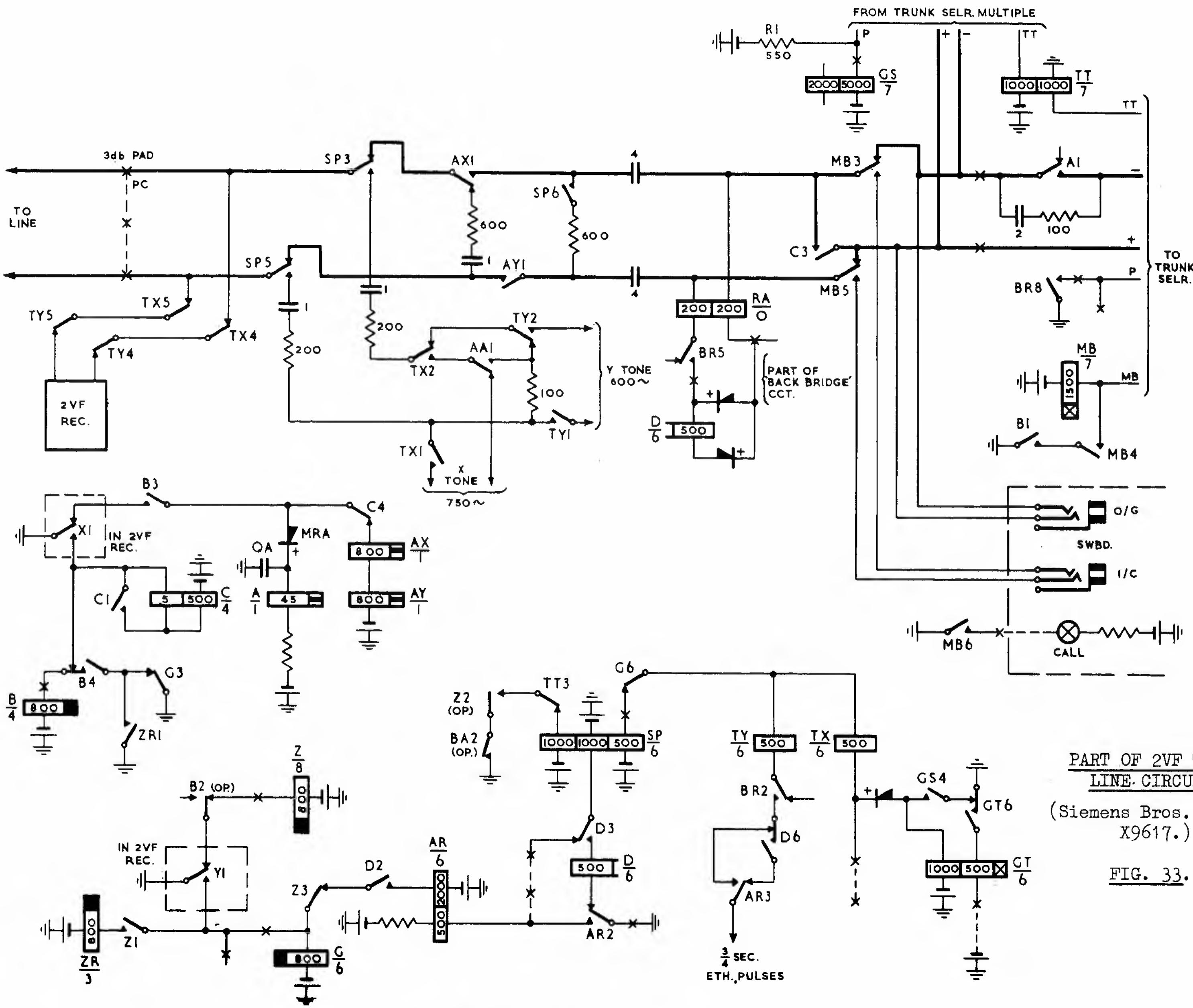
When the called party clears, D releases; SP operates via D3 and AR2. AR3 and D6 connect the earth pulses to TY and Clear Back is sent to line.

A3.6 2VF Transit Calls. When the trunk selector tests into another 2VF trunk, the TT relays in both line circuits operate in series over the TT wire. Any X and Y signals still operate X and Y in the receivers but the various contacts of TT hold the circuits in a condition where the signals pass right through without splitting. For example, Y signals release Z as before but TT3 prevents Z2 from operating SP.

Only Clear Forward tone operates Y for long enough to complete the following sequence at the I/C relay set - G operates, ZR operates, Z releases (150-200mS), ZR releases (80-100mS), B releases (300-400mS). The release of B initiates the release of the circuit and the sending of Release Y tone.

When seized from the trunk selectors of another 2VF line circuit TT operates as above and GS operates over the incoming P wire. (The trunk selector MU tests into the battery behind 550 ohm R1.) GS4 operates TX and SP to send the pick-up pulse. GT operates after a delay and ends the pulse by opening GT6.

A3.7 Incoming to the Manual Board. At the Main end and some country centres, access to the Through trunk positions is via the trunk selector outlets. At other country centres the trunk selector drives to the last contact (after receiving the code for the manual board) and operates MB in the trunk line circuit over the MB lead. MB3, MB5 and MB6 divert the line to the incoming jack and light the call lamp.



PART OF 2VF TRUNK LINE CIRCUIT.

(Siemens Bros. Drwg. X9617.)

FIG. 33.

APPENDIX 4.

A4.1 True four wire switching is the through connection of carrier channels with the elimination of the hybrids. This is normally done when channels of two systems are connected together permanently at an intermediate station. However when the channels are required for use at the intermediate stations, hybrids must be provided.

In true four wire switching via transit selectors, the trunk line relay set controls the hybrid termination and switches it out of circuit only on calls transit switched to similar trunks. Fig. 34 shows the principles and not necessarily the switching arrangement used.

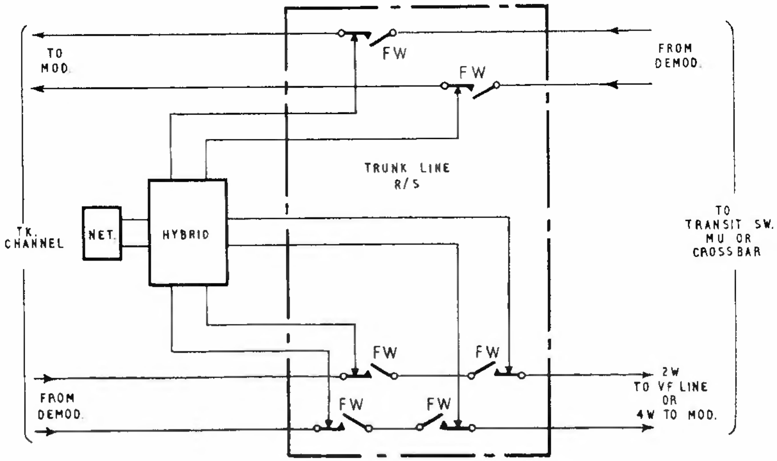


FIG. 34.

APPENDIX 5.

A5.1 Typical pad control circuit elements for 2VF trunk line circuits are in Fig. 35. Four wire circuits have the straps FW and 4W. A four wire high loss trunk would rarely occur but where one does, the strap 4WHL is also inserted.

Two wire trunks have the strap 2W and if they are also high loss trunks, the 2WHL strap is inserted. With these strappings, the various four wire, and pad switching combinations of Fig. 20 on Page 21 are achieved.

Briefly the principles are - with the line in use PC is operated under the following conditions :

- In any 2W circuit.
- When two 4WHL trunks are connected, via both RA retard coils in the trunk selector and N— wires to both PC relays via 4WHL straps. FS remains unoperated, being differential.
- In a 4W circuit connected to a 2W high loss circuit via 2WHL strap, — wire, R retards and 4W strap.

  (FS operates on one coil during four wire to two wire connections.)

However, the extent to which these facilities can be used in Australia is at present limited by local conditions at each centre, and by other factors outside the scope of this paper. There is, therefore, little uniformity even within a State. This Appendix shows principles and possibilities rather than established practices.

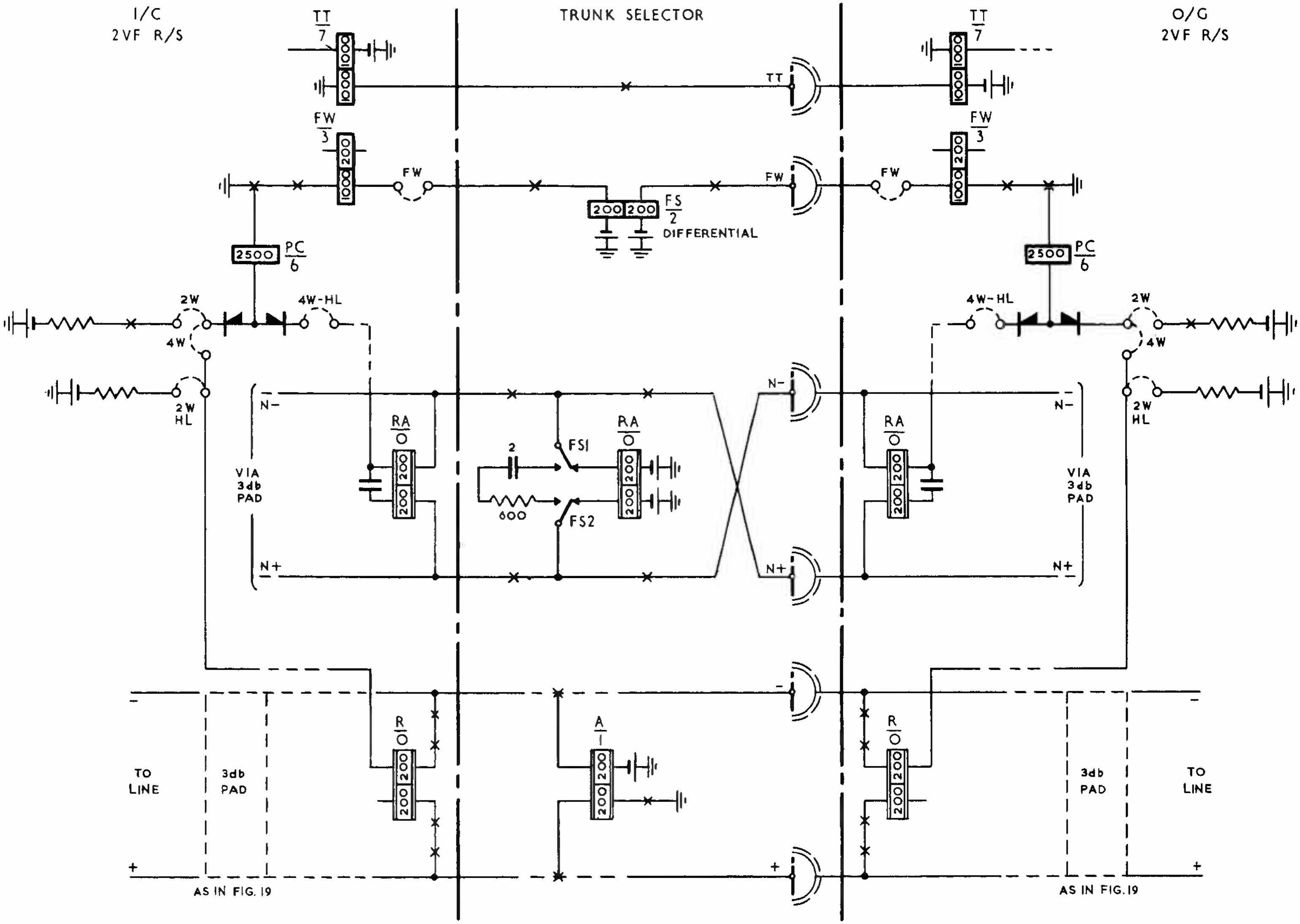
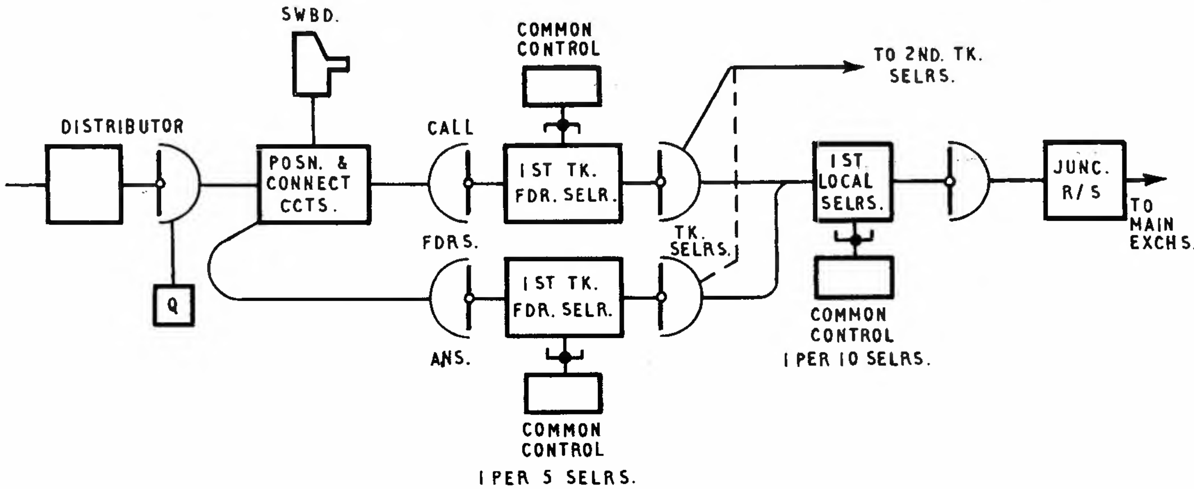

I/C
2VF R/S
TRUNK SELECTOR
O/G
2VF R/S
TT
7
1000
1000
FW
3
200
1000
PC
6
2500
2W
4W
4W-HL
2W
HL
FS
2
200
200
DIFFERENTIAL
N-
N+
VIA
3db
PAD
RA
O
200
200
FS1
FS2
2
600
R
O
A
I
TO
LINE
3db
PAD
AS IN FIG. 19

FIG. 35.

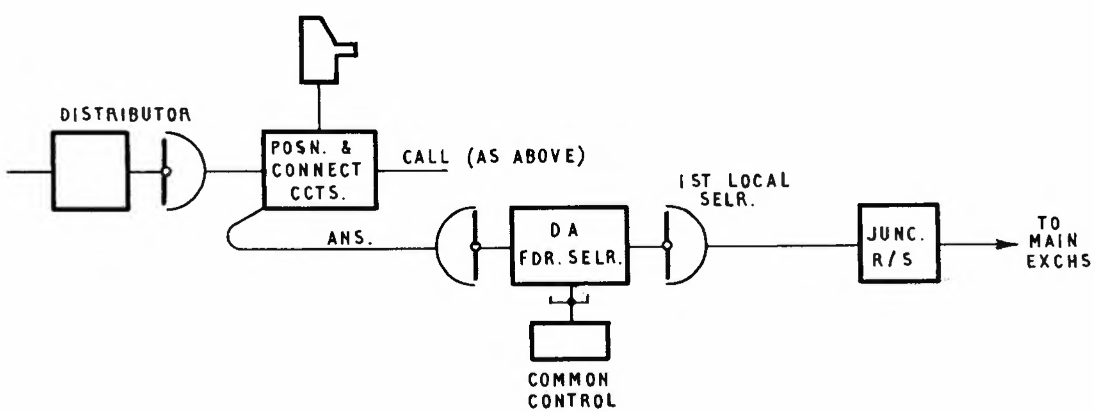
APPENDIX 6.

AUTO TRUNK EXCHANGES - ADDITIONAL FEATURES.

A6.1 Local First Selectors. Instead of providing junctions to one set of first incoming selectors in the nearest main exchange in the city network, it is usual to provide a rank of local first selectors in the trunk exchange and provide junctions to second incoming selectors in all main exchanges in the network. These first local selectors are motor uniselectors and like the trunk selectors, they have common controls and are positioned using the 4-wire code signalling from the sender. One or both of the following diagrams (Fig. 36) may be added to the basic trunking diagram in Fig. 21.



(a)



(b)

FIG. 36.

Not many positions require access to trunk selectors on the Ans side of the connect circuit, and to save unnecessary provision of first selectors, an alternative sometimes used is to associate first local selectors with a digit absorbing finder circuit as in Fig. 36(b). As the telephonist uses the same code to call a local subscriber from either side of the connect circuits, the DA finder selectors absorb the digit otherwise used to position the first trunk selector.

A6.2 Common Control is used extensively throughout Auto trunk exchanges. This is also shown in Fig. 36.

A6.3 Outgoing Trunk Preselectors. Large trunk groups are sometimes connected to the banks of outgoing preselectors (M.Us.) instead of being graded direct to the trunk selector banks (Fig. 37). In this way, it is possible to increase the availability without increasing the number of outlets from the trunk selector. The outgoing preselectors are non-homing and normally rest on a free trunk, so that when seized no hunting time is required. Group control is provided to close the group on the trunk selector banks when no outlets are available to the preselectors, and to prevent the preselectors driving while the condition lasts.

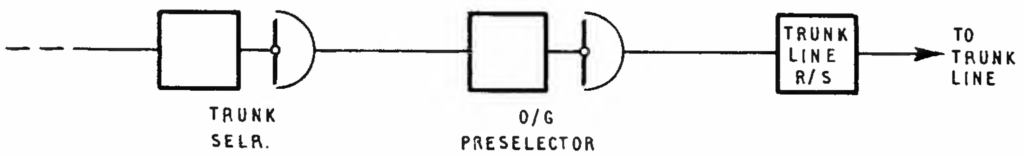


FIG. 37.

A6.4 Alternate Routing on Transit Calls.

The equipment required to re-route transit calls automatically is called a transit register. These are not provided in all auto trunk exchanges. (See Appendix 7, Page 48.)

If a through transit call encounters congestion in the required trunk group and an alternate route has been allotted, the selector control calls in a free transit register via a register hunter (a ten point ratchet uniselector associated with the control). Fig. 38.

Information on the previous digits dialled is transferred to the register from the selector common control. Subsequent digits dialled in are stored in the register. In a similar way to the sender, the register ascertains from the translation field the code necessary for alternate routing.

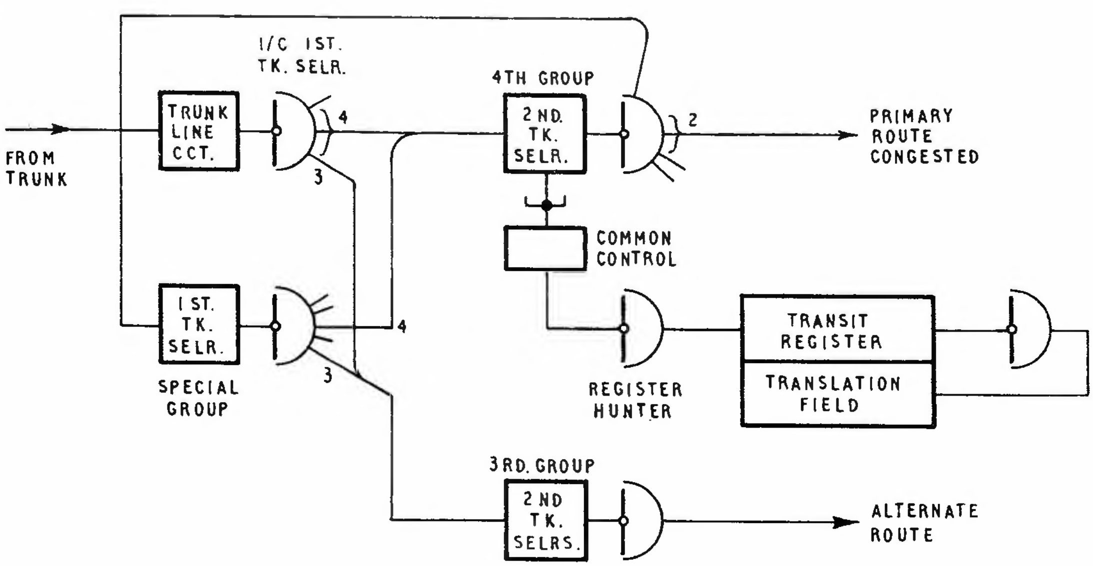


FIG. 38.

When the alternate route trunks appear as a group on the same rank of trunk selectors as the primary group, the selector tests into a trunk in the new group and the register sends any extra digits necessary, followed by the stored digits. The register then releases.

When the alternate route trunks appear on another group of selectors, the register causes the selector holding it to test back into a small group of transit first selectors provided for this purpose in the multiple of the second and third transit selectors. Digits then sent position the first and subsequent transit trunk selectors to the alternate route group. Any additional digits are sent followed by any stored digits. The register releases.

For example, suppose the primary group was reached by incoming digits 42, and digits 12501 followed and were stored in the register. Suppose also that the alternate route code is 37 and requires additional digits 23 for transit routing at another switching centre. The 4th group, second selector, will test back into a special first transit selector and the digits 372312501 will be sent from the register.

A6.5 Some of the features of the Sydney trunk exchange are in Figs. 39, 40 and 41. Fig. 39 shows the Delay Supervisor's Desk. Most prominent are the rotary switches which are turned to the appropriate delay time for the particular group. The lamps for congestion and stored calls are behind the engraved vertical panel. Fig. 40 is the keyshelf of an operating position and Fig. 41 a near view of a position with the back open showing the plug and socket connections for the timing clocks, digit keys and position keys.

FIG. 39.

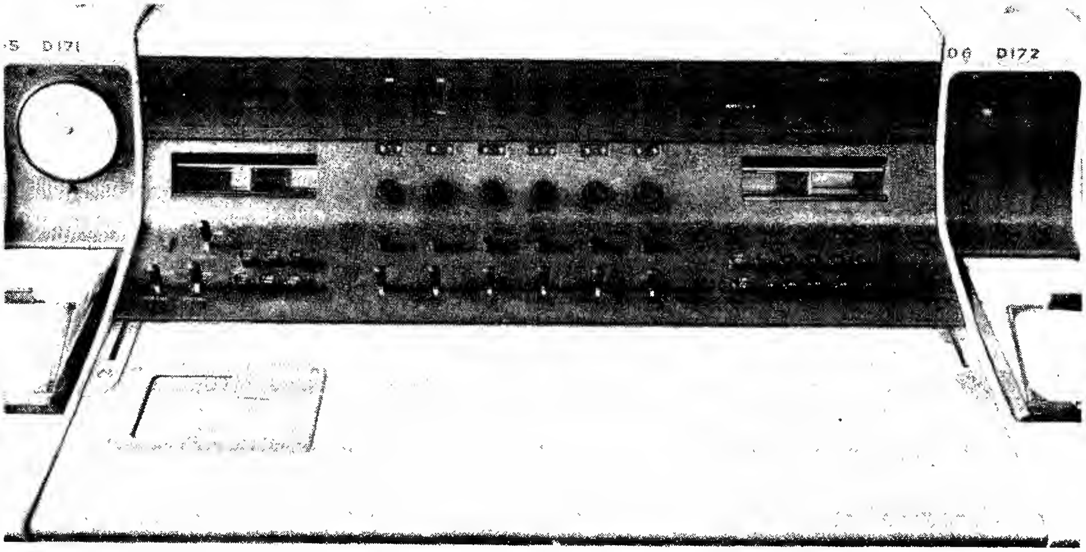


FIG. 40.

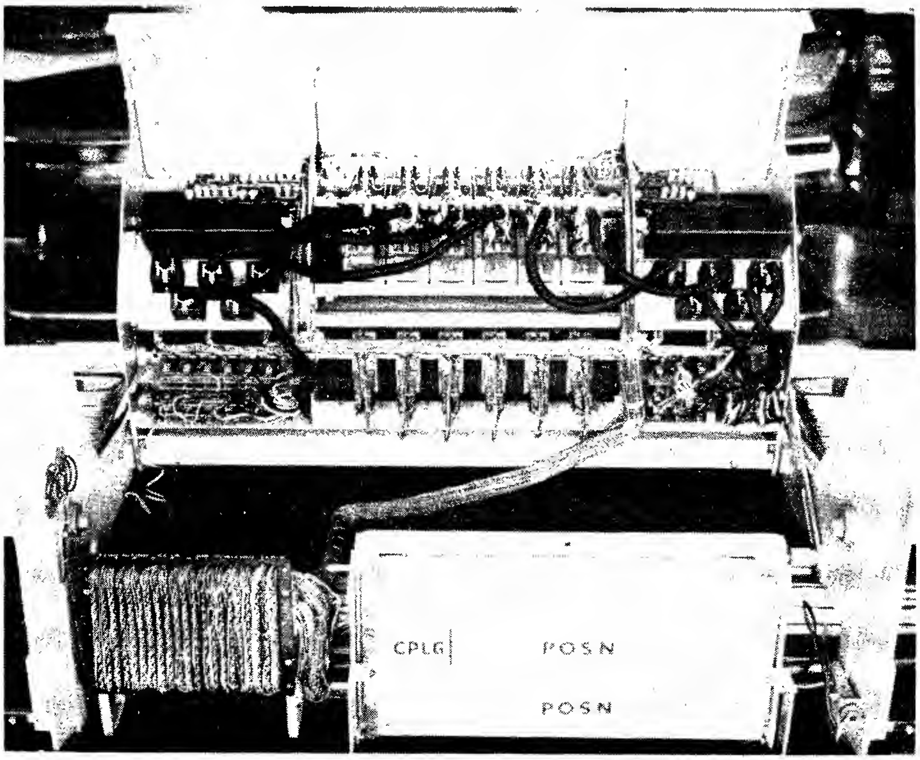


FIG. 41.

APPENDIX 7.

FUTURE TRENDS.

A7.1 Australia's rapid expansion in the last decade has created such a demand for communication services that a great deal of advance planning and investigation was undertaken to ensure that future needs are met in the best ways - technically, economically and socially.

In October, 1956, a committee was appointed and named the Automatic Networks and Switching Objectives committee (A.N.S.O.). One of the immediate problems was the impending growth of the Sydney and Melbourne automatic networks beyond their present numbering capacity. This was viewed as part of the larger problem of the national switching network, which to benefit fully from modern technical advances and also to be in keeping with overseas trends will be mechanised (automated) to the fullest possible extent.

In August, 1959, a full report was issued outlining the plan, the main features of which are -

Ultimate nation-wide subscriber dialling.

National "closed" numbering scheme, with a maximum of 9 digits.

Numbering Plan Areas to serve subscribers' main communities of interest.

Grouping of exchanges for call charging.

Extended local service areas.

Multimetering on trunk calls.

Register-controlled; high-speed switching system using automatic alternate routing.

Switching centres classified as Main, Primary, Secondary, Minor and Terminal.

Maximum of 9 links in tandem.

Standard service codes.

A7.2 Because of the far reaching technical implications of the plan, all types of switching systems were investigated. As a result, the A.P.O. has adopted the crossbar system for extending telephone automation.

A7.3 A closed numbering scheme gives every subscriber in Australia a unique number, the dialling of which gives access to that subscriber from any other in Australia, except from subscribers in the same numbering plan area when a shorter number will suffice.

Each subscriber's national number will consist of an area code followed by the directory number making a total of up to 9 digits. For example, a Sydney subscriber's national number may be 02 - 537 6426, and an R.A.X. subscriber's national number may be 073254 - 24[illegible]. The area codes are the digits before the dash and the directory numbers for calls within the numbering plan area are after the dash.

A7.4 On trunk calls the digits will be received and stored in registers at the switching centres en route, which from the area code information will re-transmit the necessary signals to establish the call over the most direct available route. The registers will generally differ from that described in Appendix 6, although the fundamental principles apply.

High-speed multi-frequency V.F. signalling will be used; this will ensure very short waiting times after dialling.

END OF PAPER.

THE AUSTRALIAN POST OFFICE

COURSE OF TECHNICAL INSTRUCTION

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

PRIVATE AUTOMATIC BRANCH EXCHANGES P.A.B.Xs.

GENERAL DESCRIPTION

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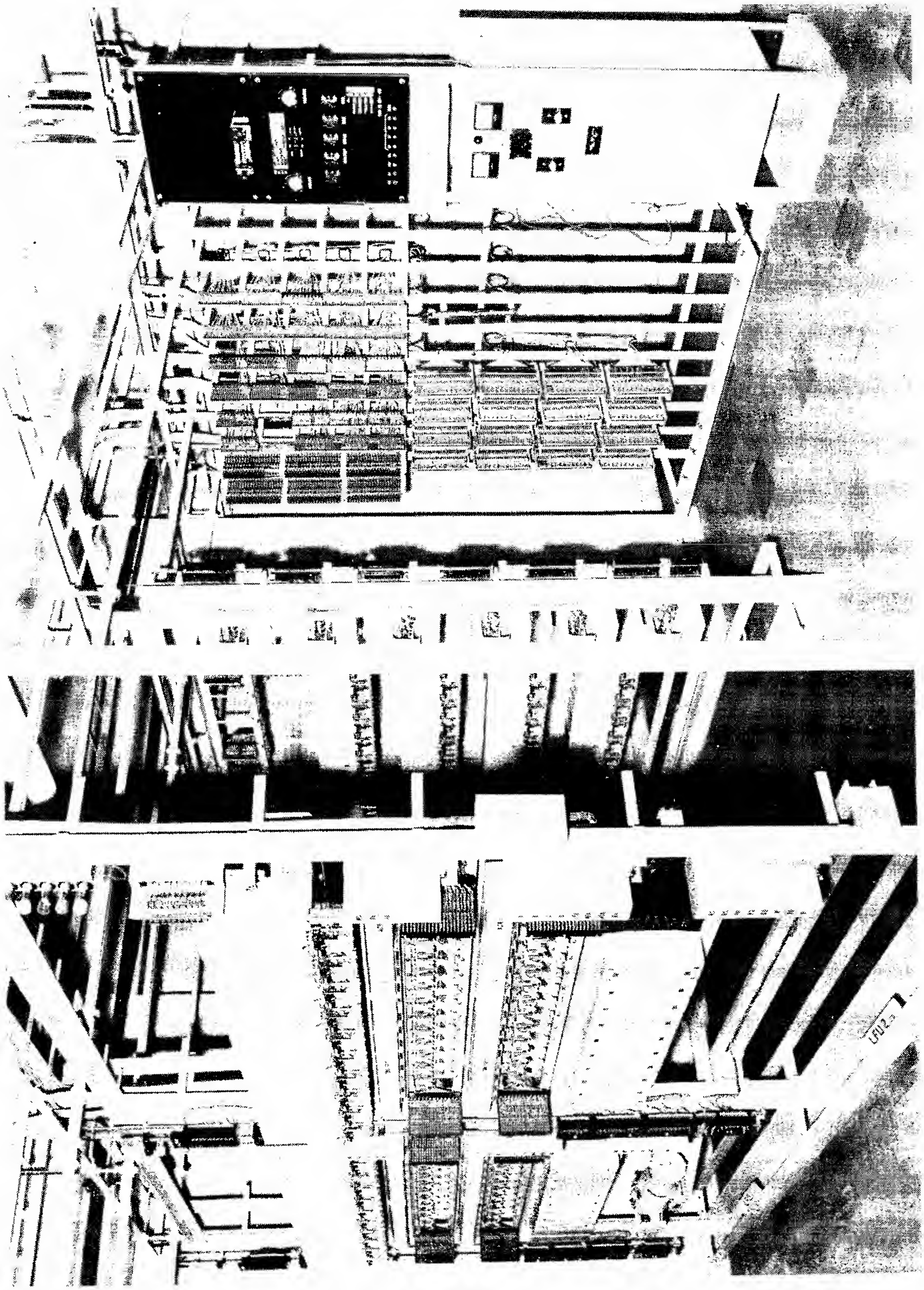
1. INTRODUCTION.

1.1 For large organisations having many extension telephones (hospitals, department stores, etc.), the P.M.B.X (P.B.X.) is now less often used than the P.A.B.X. to give the required switching service. Private Automatic Branch Exchanges provide a better service to the extensions, and the operating staff necessary is much less than that required to handle the same traffic on a P.B.X., where every call has to be switched by the operator. A P.A.B.X. enables extensions to make calls directly to other extensions, and to "outside" subscribers via the public exchange.

1.2 These facilities are very attractive for business subscribers, and the demand is such that P.A.B.Xs. are also serving a great many small organisations having less than 25 or 50 extensions. Small "units" may be used in these cases, and the necessary manual operations are so few that the operator may be engaged mostly on other duties.



TWO VIEWS OF 200 LINE P.A.B.X.

FIG. 1.

2. P.A.B.Xs. - GENERAL.

2.1 Many special facilities are provided by P.A.B.Xs. so their design, installation and maintenance problems differ from those of public automatic exchanges. Fig. 1 shows two views in the equipment room of a 200 line P.A.B.X.

2.2 A Manual Switchboard is always provided with a P.A.B.X. mainly to handle incoming calls. It is not practicable to eliminate all manual operation for these reasons:

- It is generally desirable to have incoming calls answered at a common point and directed to the required extension, as many callers are not familiar with the organisation.
- If the desired extension is busy, the telephonist may connect another suitable extension, or, if the call is important, ask the extension to clear. This reduces the holding time of all the equipment and may save the caller several ineffective calls.
- The manual board removes the necessity to list all the extensions in the public directory.
- An information centre for the P.A.B.X. is necessary and the manual board supplies this need.
- The telephonist may also orginate exchange calls for extensions desiring such service or for those not having direct exchange access.
- The P.A.B.X. may be connected to a manual public exchange where it is not usually possible to dial out on subscribers' lines.
- Direct in-dialling to P.A.B.X. extensions is a special facility now given to many government and semi-government departments, but as a universal practice the long numbers of up to nine digits would increase the possibility of dialling errors.

2.3 Types of P.A.B.X. The various P.A.B.Xs. in use are divided into two main classes - 'Unit types' and 'other than unit types'.

Other than unit types use rack mounted equipment and require the subscriber to provide a suitable room. The various arrangements are -

(i) Uniselector P.A.B.X. - so called because the trunking uses the conventional arrangement of one uniselector per line. This type is only used for larger installations where several hundred extensions are required and the average calling rate per extension is high.

(ii) Line Finder P.A.B.Xs. - so called because uniselectors are used as line finders.

2 Digit	50 extensions, 16 exchange lines (approx.), usually in separate incoming and outgoing groups. Often called Type E.
	89 extensions, 30 exchange lines (approx.), usually in separate incoming and outgoing groups. Often called Type F and is an extension of Type E.
3 Digit	Over 100 extensions, exchange lines according to requirements of subscriber. Sometimes known also as Extended Type F.

Line Finder P.A.B.Xs. are not suitable for high extension calling rates.

Unit types are so called because all the switching apparatus is mounted in a dustproof, sound absorbing cabinet. This 'unit' is compact and quiet enough to be installed in an ordinary room or office, if more suitable space is not available. The various units are:-

(i) Type C - 4 bothway exchange lines, 25 extensions

(ii) Type CA - 8 bothway exchange lines, 50 extensions (Made by adding another unit (A unit) to Type C.)

Siemens and Halske Type C - 5 bothway exchange lines, 29 extensions (Made in Germany); only a few of these units have been installed and none in recent years.

2.4 All types of P.A.B.X. have undergone considerable development since first introduced and the process is still going on.

Unit types C and CA have always used 2000 type equipment and the general appearance has changed little. However, many circuit changes and improvements have been made since the first units were installed in 1938.

Other P.A.B.Xs., both Line Finder and Uniselector, have been installed using a wide variety of equipment types, layouts, assemblies and circuit arrangements. Installing practices followed in each State vary also, these having been determined largely by availability of equipment, and the very large demand for P.A.B.Xs. after the 1939/45 war. A typical service area in any capital city could contain equipment of these designs - pre-2000, 2000 type, SE.50, Siemens 16, and perhaps Siemens and Halske, often with two or more types in the one exchange. The descriptions in this paper will therefore deal with general operational principles of the commonly met types.

In 1957, the Department made arrangements for P.A.B.Xs. to be installed by the telephone equipment makers and a greater measure of standardisation is being aimed at.

2.5 Line Finder and Uniselector P.A.B.Xs. have many common or similar features. The same type of equipment and circuit arrangements may be used for the manual boards, most of the selectors and relay sets, the M.D.F., and common services such as ring, tone and alarm circuits, and power supply. These similarities are dealt with in detail later (Pages 10 and 11).

The manual switchboards generally have a maximum of 16 cord circuits per position. The number of positions is determined by the total number of incoming jack ended circuits, or the subscribers' requirements. Fig. 2 shows a typical manual switchboard layout.

The M.D.F. is usually single sided with the required number of verticals of fuse strips and terminal blocks. Arrester strips may be provided in some cases. See Fig. 1.

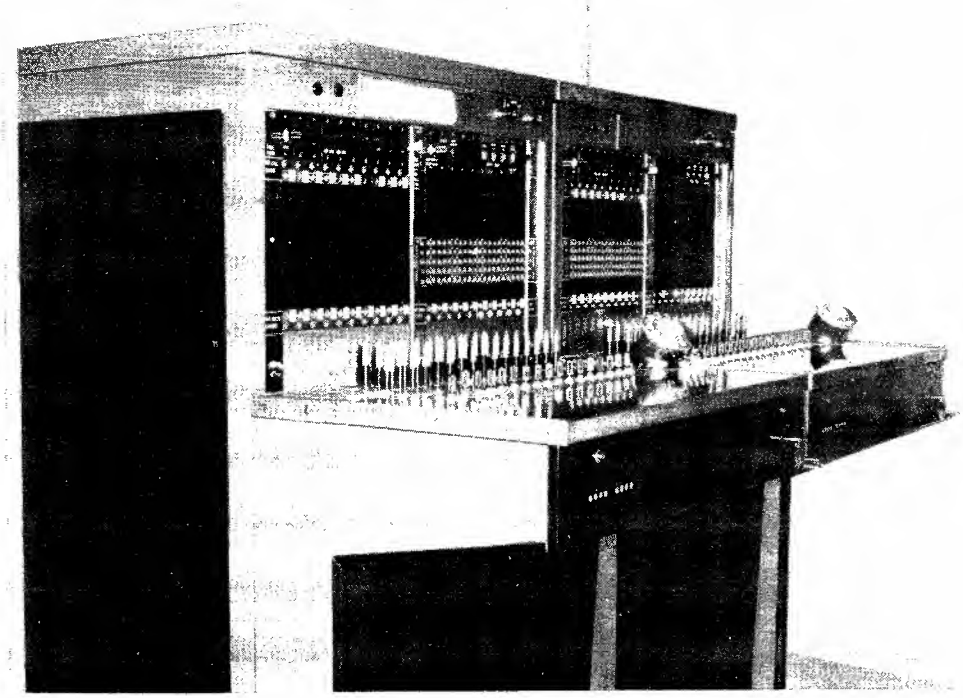


FIG. 2. TYPICAL MANUAL SWITCHBOARD FOR A P.A.B.X.

3. P.A.B.Xs. - FACILITIES AVAILABLE.

3.1 The connections possible, and other facilities available with all P.A.B.Xs. are listed and briefly described thus:-

- Extension Calls to other extensions dialled direct.
- Extension Calls to public exchange subscribers dialled direct (prefixed by "0").
- Extension Calls to operator by dialling 9 (or 91 in some cases).
- Barred Access. Selected extensions may be denied direct exchange access.
- Reverted Calls. Set up by the operator to an 'outside' subscriber and then reverted to an extension.
- Incoming Calls. Answered at the manual board and routed by the operator to the required extension.
- Night Service. Incoming exchange calls may be routed to selected extensions after hours.
- Call Back. Selected extensions may hold incoming exchange calls and call another extension or the operator.
- Trunk Offering. Enables the operator to advise an extension making a call that an incoming call is waiting. A warning tone is provided if required.
- Tie Lines. To other P.B.Xs. or P.A.B.Xs. Available to the operator from the manual board and from the extensions dialled direct.

Additional Facilities Available with Other Than Unit Types:

- Executive Lines. Direct C.B. lamp signalling lines from important extensions to the manual board.
- Group Hunting. Final selectors in 3 digit systems may be arranged to select the first free line in a group of extensions if the first line dialled is busy.
- Code Calling. Visual or audible code signals for key persons may be set up by the operator (seldom provided).

Conference facilities were available but the facility is now rarely, if ever, used.

Additional Facilities Available with Unit Types:

- Camp on Busy. Calls incoming to a busy extension from the public exchange or operator, 'camp on' until the extension clears; the extension is then automatically re-rung and switched to the caller.
- Through Clearing. Exchange calls switched through to an extension by the operator, clear automatically when the parties clear. The exchange line, however, is not 'freed' at the unit until clear at the exchange.
- Auto. Transfer. Selected extensions may transfer exchange calls (incoming or outgoing) to other extensions without the aid of the operator. This functions in conjunction with the call-back facility, which with unit types may be used on outgoing as well as incoming exchange calls.

4. UNISELECTOR P.A.B.Xs.

4.1 The number of Uniselector types in use is relatively few compared with the number of Line Finder and Unit types. The provision of one uniselector per extension line is necessary only when the extension calling rate is fairly high (averaging above 0.12 T.U. per extension).

A Uniselector P.A.B.X. usually consists of separate racks of uniselectors, final selectors, group selectors and relay sets. Composite uniselector/final selector racks are now being used.

25 outlet uniselectors are generally used, mostly homing, although some early P.A.B.Xs. used non-homing line switches. Others have two 10 point uniselectors in tandem (Siemens 16 system).

4.2 Typical trunking of a Uniselector P.A.B.X. is shown in Fig. 3.

Outline of Operation. The group selector performs the normal functions of a 1st group selector. When seized by a calling extension uniselector it returns dial tone, steps vertically when pulses are received, then automatically selects the first free outlet on the level dialled.

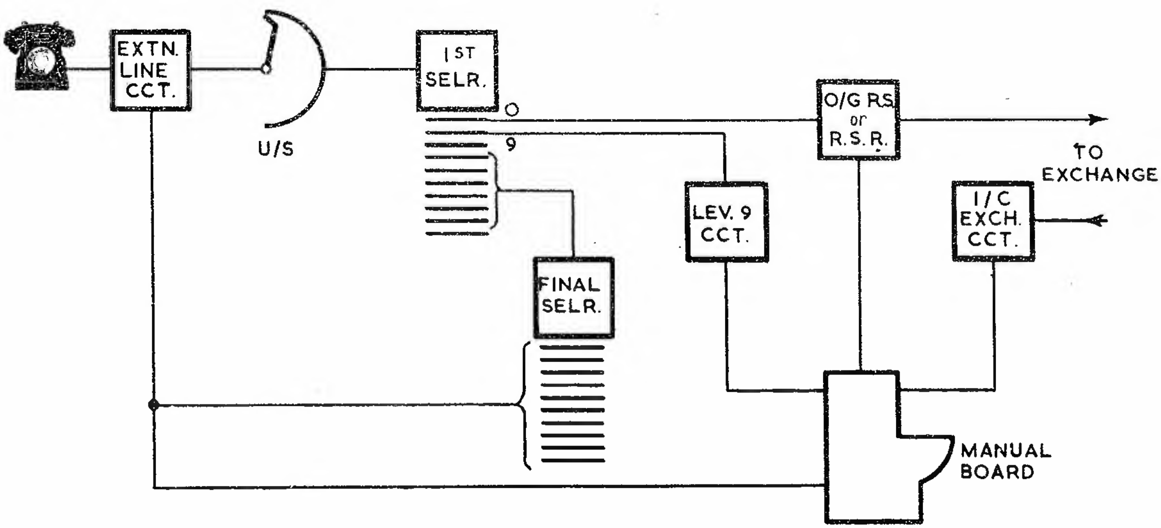
Levels 2 to 8 are trunked to the required number of hundreds groups of final selectors; if required tie lines may be connected to spare levels.

Level 9 is trunked to the information relay sets (or level 9 circuits) and thence to jacks on the manual board.

Level 0 is trunked to the O/G exchange lines via either: (i) relay set repeaters which perform the usual R.S.R. functions except metering, and serve also as revertive call relay sets for the manual board, or (ii) a set of two relays per line with supervisory and P wire guarding functions (4 ccts. per base). In the latter case the pulses are not repeated and transmission feed is from the parent exchange; separate revertive call relay sets are required between the switchboard and the O/G lines as in Fig. 4.

Group selector repeaters may be used instead of normal selectors in which case the trunking of the levels and the selector operation is as described for Fig. 4.

The final selectors respond to the last two digits on local extension calls, functioning in the normal way except that metering is not provided. Uniselector P.A.B.Xs. operate for the remaining facilities as described in Paragraph 5.3 (General Operation Circuits Common to U/S and L/F P.A.B.Xs.).



TYPICAL TRUNKING UNISELECTOR P.A.B.X.

FIG. 3.

5. LINE FINDER P.A.B.Xs.

5.1 Three Digit Line Finder P.A.B.Xs. (Extended Type F). These are similar to Uniselector P.A.B.Xs. except for the trunking to the first selector. It is not usual to extend a line finder type beyond about 400 extensions; most 3 digit line finder P.A.B.Xs. have between 100 and 300 extensions. Fig. 4 is the trunking diagram of a typical 3 digit line finder P.A.B.X.

50 outlet uniselectors (A.P.O. or B.P.O. non-homing) are used as line finders. A group of up to 12 line finders and one allotter serves 50 extensions. Two L/F groups, 10 final selectors and the L and K relays of 100 extension line circuits are mounted on the one rack called a line unit (L.U.) or line finder unit (L.F.U.). These racks were designed for the 2 digit line finder P.A.B.Xs. Types E and F; hence the term 'Extended Type F' refers to the 3 digit types. Compare the line units in Fig. 1 (extended F) with the Type F rack in Fig. 5.

General Operation. Extension Calling. A start signal from the extension line circuit is extended via the allotter to the control relays of a free line finder (pre-selected by the allotter). The line circuit also marks the calling extension on the line finder multiple (P wire).

The line finder drives and tests into the marked outlet, thus connecting the calling line to a group selector repeater.

The allotter steps on and pre-selects the next free line finder for the following call in that 50 line group.

The group selector repeater is a special type of 100 pt. 1st selector which:

- Returns dial tone (starting the ringing machine or dial tone relay when supplied).
- Provides a transmission bridge.
- Steps to the level dialled and seizes the first free outlet on that level.
- Repeats subsequent pulses to -

(a) the final selector (on levels 2, 3, etc., as required)
or (b) the public exchange (on level 0)
or (c) any tie lines to other P.A.B.Xs. (for example, on levels 8 or 7).

- When stepped to level 0 by an extension which is barred exchange access, drives to the 11th step and returns busy tone.

On level 9 an information circuit is seized which causes a lamp to glow on the manual board.

For local extension calls, the final selectors respond to the last 2 digits, functioning in the normal way except that metering is not provided.

Some 3 digit line finder P.A.B.Xs. use normal group selectors and not group selector repeaters, in which case this part of the trunking is as described for Fig. 3. The remaining operations common to L/F and U/S P.A.B.Xs. are described in paragraph 5.3 (P.10).

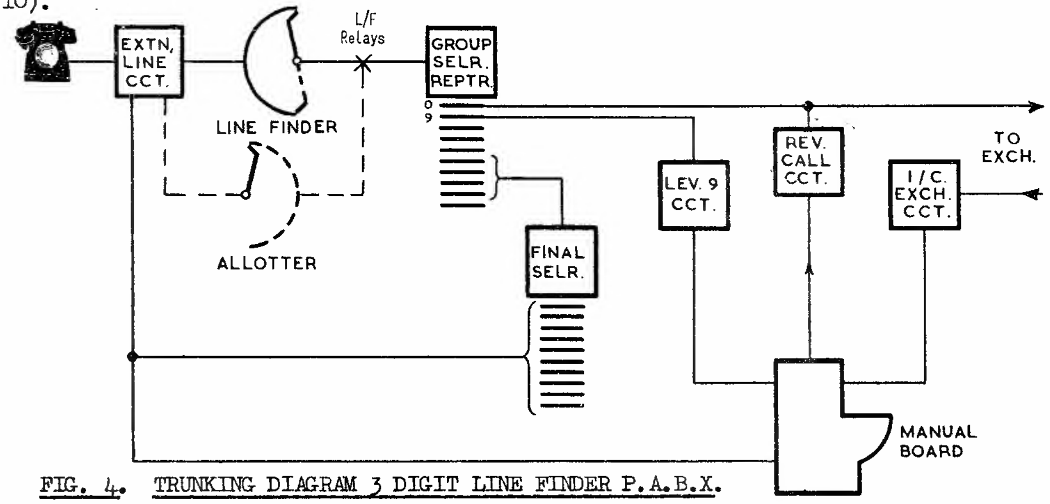


FIG. 4. TRUNKING DIAGRAM 3 DIGIT LINE FINDER P.A.B.X.

5.2 Two Digit Line Finder P.A.B.Xs. - Types E and F. These types are very similar, Type F being an extension of Type E. The equipment rack for a Type F is shown in Fig. 5.

Type E serves up to 50 extensions using 12 line finders connected directly to 12 final selector repeaters (F.S.R.) and one allotter. The numbering scheme is - extensions 10-59 (5 levels of F.S.R.) and '9' for information.

Type F serves up to 89 extensions, an additional 39 using a second group of 1 allotter and up to 8 line finders wired directly to 8 final selector repeaters. This makes a total of 2 allotters, 20 line finders and 20 final selector repeaters when the traffic warrants a fully equipped rack. The numbering scheme is - extensions 10-99 (except 91), and '91' for information.

The whole 20 F.S.Rs., 20 line finders and 2 allotters are mounted on the one rack (L.U. or L.F.U.). The ringing machine, if provided, and auxiliary relays and apparatus are also mounted on the L.F.U.; sometimes also the exchange line and level 9 relay sets.

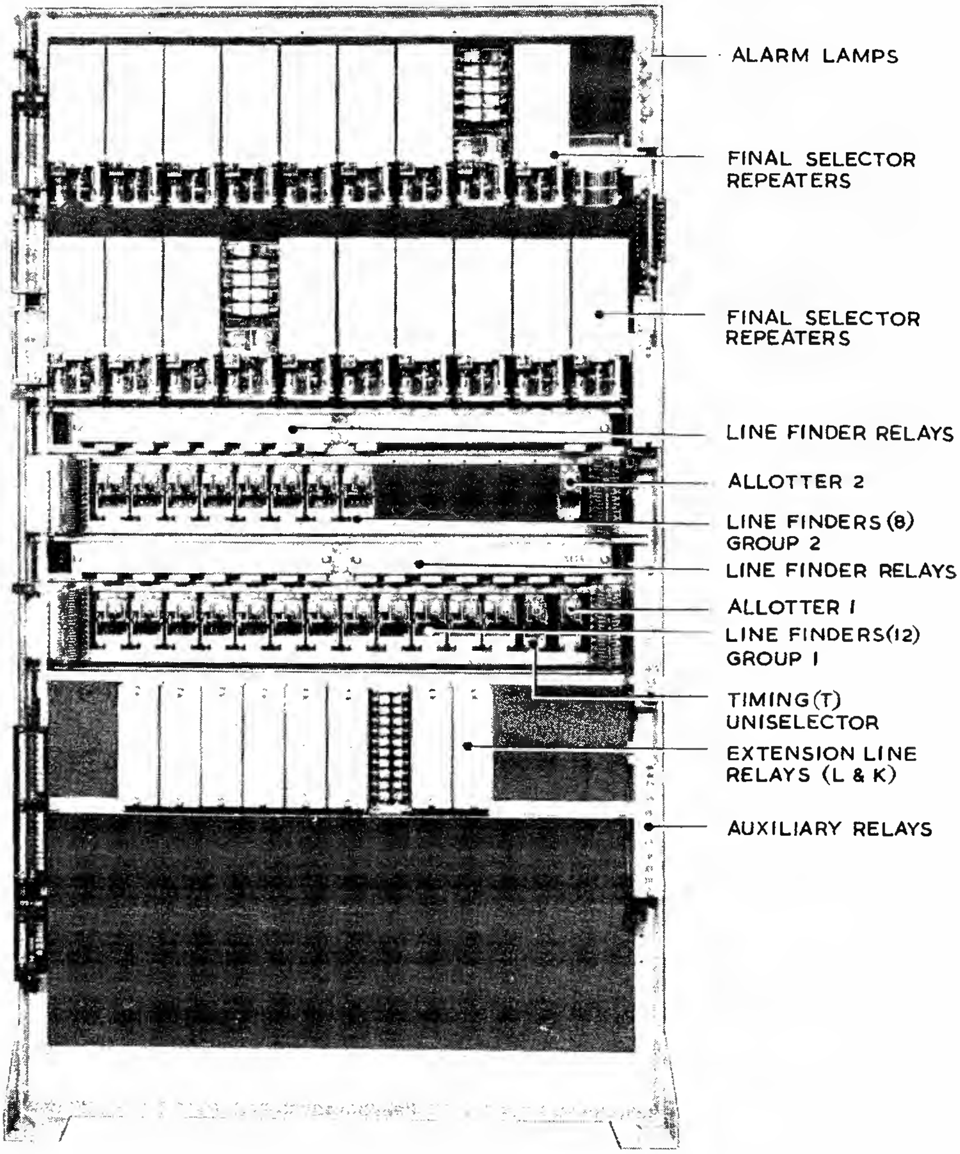


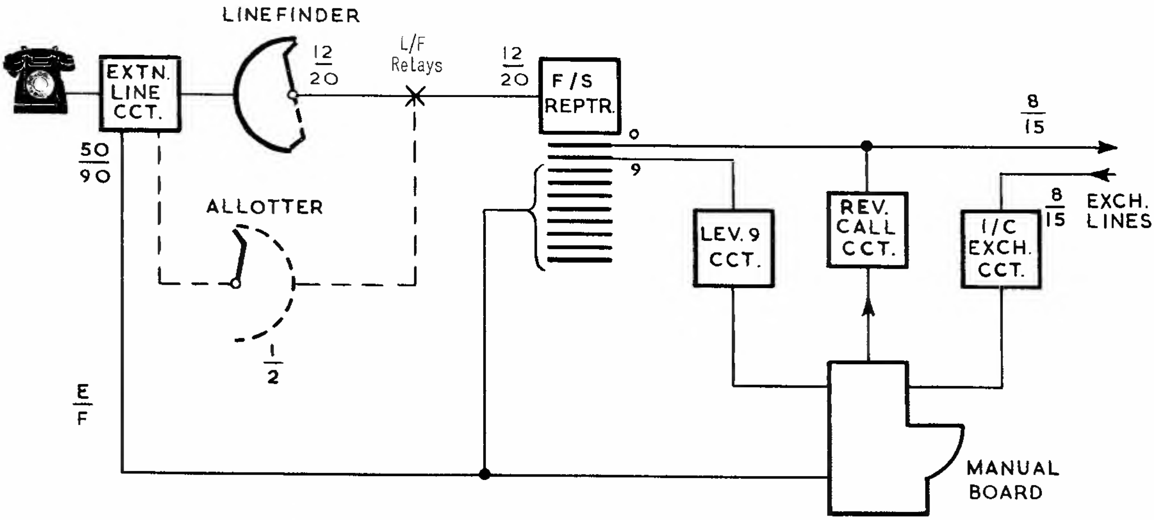
FIG. 5. LINE FINDER RACK FOR 2 DIGIT P.A.B.X.

Fig. 6 is the trunking diagram of a 2 digit line finder P.A.B.X. The figures indicate the number of circuits normally provided for the Type E and Type F - for example $\frac{12}{20}$ means the circuits for $\frac{E}{F}$ respectively.

General Operation. Extension Calling. The line finder and allotter function as described for the 3 digit types (paragraph 5.1) and extend the calling line to a final selector repeater which :

- Returns dial tone (starting the ringing machine or tone producing circuit, if necessary).
- Provides a transmission bridge.
- Functions as a final selector on levels giving access to extensions - Type E levels 1 to 5, Type F levels 1 to 9.
- Functions as a selector repeater on level 0, repeating subsequent pulses over the exchange line, and for E Types only, on level 9 also as a selector (no subsequent digits).
- When stepped to level 0 by an extension barred exchange access, drives to the 11th step and returns busy tone.

With Type F exchanges the final selector repeater must act as a final selector on level 9 since this level is used to provide the maximum extension capacity. This prevents access to the information lines by the dialling of '9' only as in all other P.A.B.Xs. Outlet 91 is usually reserved for information but as one line would be insufficient, the F.S.R. multiple is divided (for 91 only) into the required number of lines. If, for example, 4 information circuits are required the multiple is divided between every five switches (giving one information circuit for every five F.S.Rs.) If however, an installation has more than 50 extensions but considerably less than 80, single digit selection of information lines may be used as for Type E (F.S.R. self drives on level 9). This, however, is not always favoured as a gradual growth to more than 80 extensions would mean a change for the users of a long-familiar operating procedure.



TRUNKING DIAGRAM 2 DIGIT LINE FINDER P.A.B.X.

FIG. 6.

5.3 General Operation Common to all Line Finder and Uniselector P.A.B.Xs.

Incoming Calls are answered and extended to the required extension by the telephonist.

The facilities provided by the cord circuit include -

Lamp supervision for both answering (EXCH.) and calling (EXTN.) cords,
Engaged test for extensions,
Automatic (keyless) ringing on the calling cord.
Ringing tone to caller (in most cases).

Reverted Calls. The telephonist dials out on one of the jack ended outgoing lines provided. If desired the call may then be reverted to an extension on the other cord. This facility is often used by extensions who have exchange access, but who may save time by dialling the telephonist on level 9 and 'booking' the call with her. Barred access extensions may also make outgoing exchange calls in this way.

Call Back. Extensions requiring call-back facilities were originally provided with a second extension line and a 'call-back box' (consisting of a bell set and 2 lever keys). By means of the keys the extension could hold a call on one line while making a call on the other. Sometimes one extension line circuit was divided between the incoming and outgoing sides (final selector and switchboard multiple divided from L/F multiple or uniselector) and separate pairs cabled to the call back box.

In the more recent installations the extension is provided with a button on the telephone which when pressed, earths one side of the line. The cord circuit has been redesigned so that an extension engaged on an incoming call may -

Press the button to isolate and hold the call; be connected automatically to his normal line circuit; receive dial tone.
Call another extension.
Hang up and be re-rung from the cord circuit (automatically).
Answer, and speak to the original caller.

Night Service was originally provided by means of keys on the manual board, which when operated connected selected extensions to particular incoming exchange lines (one key per line) and disconnected the extension line circuits. The night service key is now added to the cord circuits and any extension may be night serviced, or if desired, given temporary exclusive use of an exchange line.

Trunk Offering is provided by means of a special cord circuit on the manual board. This enables the operator to offer trunk, or other important incoming calls to extensions who are engaged via the automatic equipment. Generally a low level tone is provided to warn extensions that the operator has come across the connection.

5.4 Miscellaneous Features of Uniselector and Line Finder P.A.B.Xs.

Layouts. Some installations have a separate relay set rack which has mounted on it the relay sets for incoming exchange lines, revertive call lines, information circuits, cord circuits, relay set repeaters (if used), and other miscellaneous relay sets such as for tie lines, etc. Other installations have no relay set rack and cord circuit sets are in the back of the manual board, while the other relay sets mentioned above are mounted below the extension line relays on the line finder rack or racks (L.F.U.).

Final selector repeaters have mechanically operated level springs (NP) which are adjusted to give selector functions (self drive) on the desired levels. Also one NP contact operates only on level 0, so that an earth received from 'barred access' line circuits via an auxiliary wire, can prevent the switch testing in. This contact is provided also for this same reason on selector repeaters and group selectors.

The allotters are 25 pt. uniselectors and to reduce the amount of stepping required, each of the line finders in a group (8 or 12) appears twice on the allotter banks. (With 3 digit types, 12 line finders are provided per 50 line group but in most cases only 10 are used).

Ring, Tone and Alarm circuits. The main methods for the supply of ring and tones are:

- Ringing current and tones supplied from the parent exchange.
- Ringing current, busy tone and N.U. tone from the exchange; dial tone produced locally by means of a vibrating reed relay.
- Interrupted ringing current from the exchange; all tones produced locally using valve oscillators, the ringing current, and relay interrupting circuits.
- A small ring and tone machine which starts and stops automatically as required. In some cases a ringing machine is provided as a standby in conjunction with any of the above schemes and arranged to start automatically should the ringing current supply fail. (This is usually warranted only with essential services - hospitals etc.).

The alarms provided are -

Fuse alarm (F.A.).
Release alarm (R.A.) - delay approx. 9 or 20 seconds (depending on delay circuit).
Line finder alarm (L.F.A.) - Line finder types only; delay approx. 9 or 20 seconds.
Ring fail (R.F.) - delay approx. 9 or 20 seconds.
P.G. alarm (also C.S.H.) - delay 2-3½ minutes, or no delay latest circuits.
Charge fail, Supply fail, or AC fail (not always provided).
Capacitor alarm - failure of uniselector spark quench capacitor (uniselector types only - not always provided)
Low voltage (only sometimes provided)

With the P.A.B.Xs. installed by the equipment makers after 1957 the following additional alarms may be provided. -

Total ring fail	- failure of ring from parent exchange and from local ringing machine standby (if provided).
Busy fail	- failure of busy tone supply.
Capacitor alarm	- failure of line finder spark quench capacitor.

The line finder alarm occurs when a line finder fails to find the calling line within a short time. The delays for L.F.A., R.A. and R.F. are obtained either by using thermal relays, or in later circuits, relays in conjunction with large capacitors. The P.G. alarm delay is timed by a stepping uniselector (timing switch T) but with later circuits there is no delay and the P.G. alarm circuit may be switched off when no Technician is in attendance.

Uniselector and line finder P.A.B.Xs. which use 2000 type equipment often have the release earth for each selector wired via an open circuit type heat coil. Continued current in the rotary magnet owing to a faulty release action will operate the heat coil. This protects the magnet and also causes the release alarm to be given.

Extension of Alarms to the parent exchange is generally provided. There are many variations of the facility but in a typical case all alarms except P.G. light an alarm lamp (one for each P.A.B.X.) on the exchange test desk. By operating a key associated with the lamp the testing officer notes whether the alarm is prompt or deferred as indicated by two further lamps. This also places the circuit in the 'receiving attention' condition to disconnect the alarm from the exchange alarm scheme. Usually all the alarms are prompt except Charge fail (Supply fail) and when a standby ringing machine is provided Ring fail and Busy fail are deferred also. Sometimes a lamp display is provided for the alarms on the manual board so that the testing officer may call the operator and ascertain which alarm is present.

Outgoing Exchange Lines. When more than 10 of these are required (3 digit P.A.B.Xs.) they are graded into the 0 level between the several shelves of selector repeaters or group selectors. The outgoing lines which appear also on the manual board as revertive call lines, are always the late choices of the 0 level outlets. Occasionally one or two revertive call lines are provided which are not shared by the 0 level. To let the operator know which are in use from the 0 level, busy lamps are provided adjacent to the revertive call jacks.

6. TYPES C AND CA UNIT P.A.B.Xs.

6.1 While designed to work into a 2000 type automatic public exchange, the C and CA P.A.B.Xs. operate satisfactorily in conjunction with magneto or C.B. manual exchanges; an auxiliary relay set is provided at the exchange to convert the various signals.

6.2 The auto. equipment is housed in a steel cabinet which is 2' wide 1'8" deep and when installed stands nearly 7' high. The C and A units are both this size, identical in external appearance, and when used together, the C unit is on the left viewed from the front. The units have removable covers on the front and rear. An opening is provided in the sides of the units for cabling between units, but is covered when only a C unit is required.

Fig. 7 shows the front and rear of a type C unit with the covers and cover rails removed.

6.3 Description of C unit. The extension line L and K relays are plate mounted at the top of the unit and alongside are several auxiliary relays for start circuits, attendant's circuit, etc., also plate mounted.

Below these are four 25 point non-homing uniselectors which serve as the link line finders (also known as extension line finders). To the right on the same brackets is a fifth 25 point uniselector which is the time pulse (T.P.) switch (see Section 6.6).

The next row of five uniselectors are 50 point non-homing finders; the four to the left are exchange line finders (often called junction finders, J.F.) and the fifth is the level 9 line finder (also called information finder or operator finder). To the left of the two rows of finders are the busbars and fuse mountings. A wooden panel below the finders has attached the maker's label, a battery jack and a mounting for open circuit type heat coils. (These are for protection in the link selector release circuit.) On early units they are mounted at the rear of this panel, but are omitted from the latest units having SE.50 link selectors.

The four link selectors (2000 type or SE.50) and associated link circuit relays are jacked into cradles above a two section bank.

At the bottom of the unit, four exchange line relay sets may be jacked in as required.

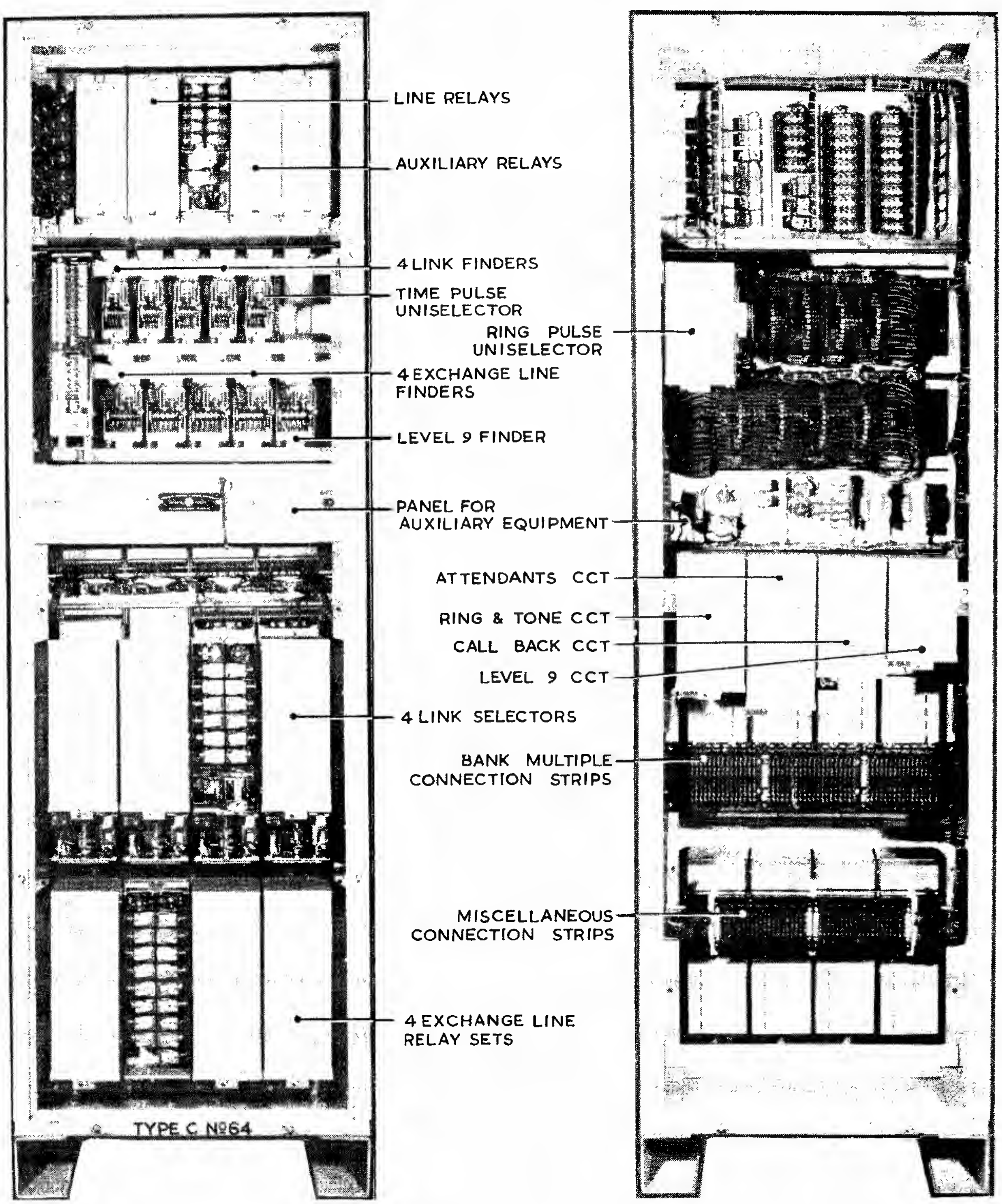
NOTE: A link circuit is a link selector and relays associated with a link finder. An exchange line circuit is an exchange line relay set associated with an exchange line finder.

At the rear of the C unit, the various mountings from top to bottom contain -

- A Ring Pulse relay set which includes a 25 point uniselector for interrupting the ring and tones.
- The wooden panel to which is screwed auxiliary apparatus for the Ring, Tone and Alarms circuit.
- Four jack-in relay sets for ring and tone circuit, attendant's circuit, Call-back circuit, Level 9 circuit.
- Bank multiple connection strips (these could be regarded as the I.D.F. but are not generally referred to as such).
- Miscellaneous connection strips.

The A unit viewed from the front is nearly identical to the C unit except for the omission of the level 9 finder, the T.P. uniselector, and one base of relays at the top (4 instead of 5). At the rear of the A unit are bank multiple and miscellaneous connection strips only (the attendants, level 9, call-back, ring, tone, alarm & pulse, and other auxiliary circuits provided in the C unit, also serve the A unit.)

The Attendant's Cabinet as the manual board is called, is a cordless table console which occupies less than 1 square foot of table space. The circuit design has reduced the manual operations to a minimum. Nine lever keys, 10 lamps, 2 press buttons, a dial and a 'key sender' consisting of 10 press type digit keys, give the attendant all the necessary control, access, and supervision for the full 8 exchange lines and 50 extensions. The same cabinet is used for both C and CA installations.



(a) Front View.

(b) Rear View.

FIG. 7. TYPE C P.A.B.X. UNIT.

Fig. 8 shows the details of the attendants cabinet. The functions of the various keys and lamps are dealt with in detail in the following pages but are described here briefly as an introduction to the operation, which in many ways departs from the conventional switching methods of most other automatic exchanges.

The first four lever keys are for the eight exchange lines, and the associated lamps are both calling and supervisory lamps, one for each line.

The fifth lever key is for the level 9 (information) circuit together with the calling and supervisory lamp below it. This is a bothway circuit - extension to operator or operator to extension. The "Waiting Call" lamp lights when a second extension dials 9 and the circuit is already engaged.

The "Non-urgent" and "Urgent" lamps give notice of certain fault alarm conditions in the unit.

The three lever keys on the right have auxiliary functions as indicated and are dealt with later. Another lever key "Test Extn." is often added in the space next to the "Night Extn." key.

The "Junction Test" key when pressed causes the lamps of busy exchange lines to glow, to allow the attendant to choose a free line to call out - using the dial. The "Release" key is used to release any such calls not reverted to extensions.

The 10 press keys of the sender are used by the operator for extending incoming (or reverted) exchange calls to the required extension or for calling extensions via the level 9 circuit.

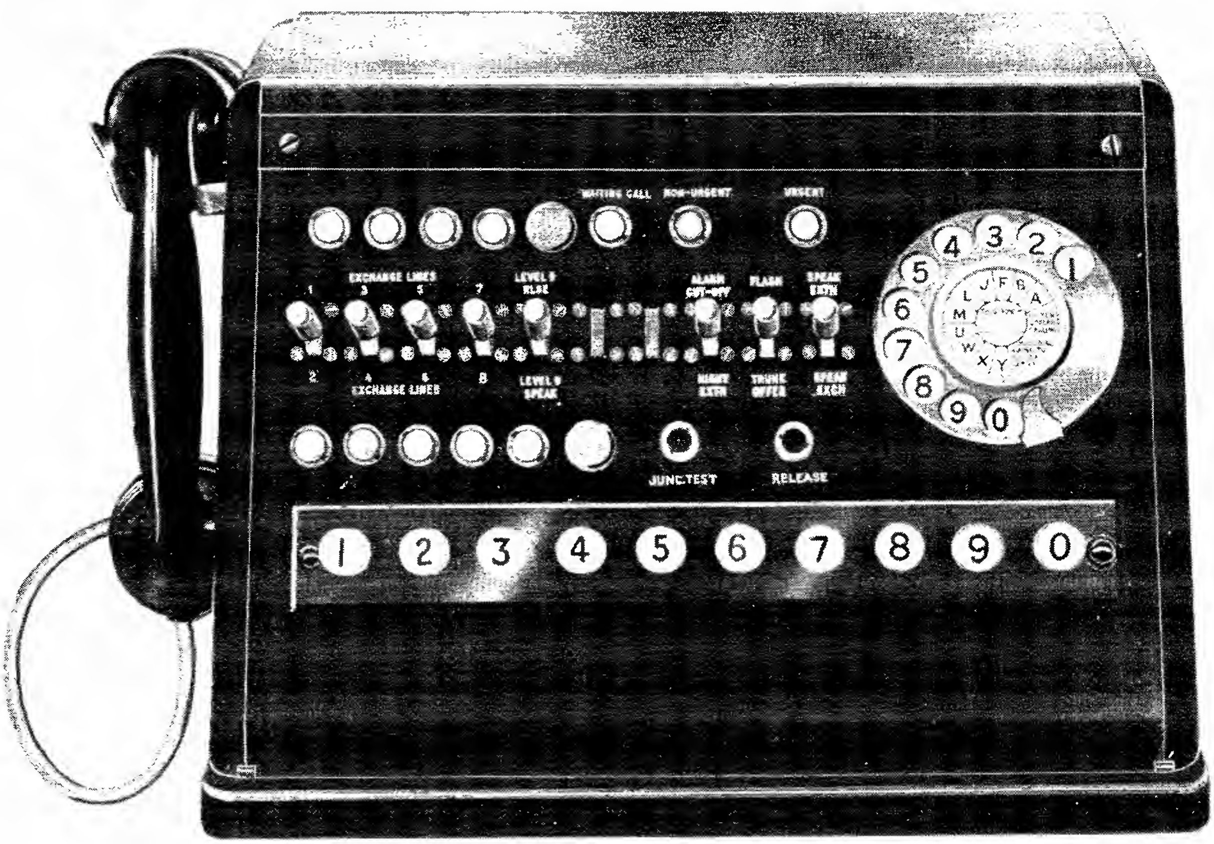


FIG. 8. ATTENDANT'S CABINET TYPES C AND CA P.A.B.X.

6.4 Numbering Scheme. Each unit will cater for up to 25 extensions which are numbered -

C unit 20-44
A unit 45-69

Fig. 9 is the trunking diagram of Types C and CA unit P.A.B.Xs. The number of the various circuits provided is indicated, for example, $\frac{4}{8}$ - these being the circuits for $\frac{C}{CA}$ respectively. The auxiliary trunking for the call back and auto transfer facility is omitted for greater clarity. (See page 18.).

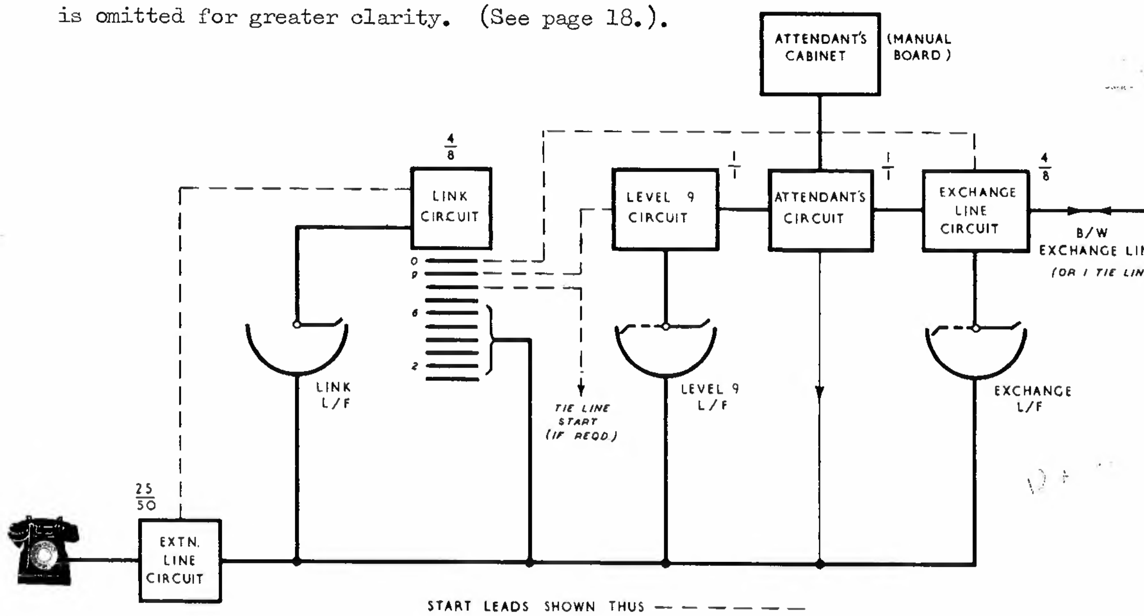


FIG. 9. TRUNKING TYPES C AND CA UNIT P.A.B.Xs.

Note:- Owing to the unusual trunking of these units several extra wires are used for testing and marking purposes instead of the conventional P wire.

For the benefit of more advanced students these are mentioned at times in the general description, for example (HF wire), but are explained in Para. 6.6 (Page 19).

6.5 General Operation. Extension Calling. The line circuit of the calling extension marks the outlet on the banks of the 4 link line finders (H.F. wire) and causes a start signal to be sent to all free link circuits in the unit. The link line finders which are controlled by relays in the associated link selector relay sets now drive, and the first to reach the marked outlet extends the caller to its particular link selector. The other finders stop searching.

The link selector:

- Returns dial tone (after starting the ring and tone circuit when necessary).
- Acts as a final selector on extension to extension calls (levels 2, 3 and 4 Type C; levels 2 to 6 Type CA).
- On outgoing exchange, information and tie line calls (extension dialling '0' or '9' or '8' respectively) steps to the level dialled and cuts in to the first contact, but starts setting up functions only, releasing after the call is taken over by the appropriate finder.
- When stepped to level 0 by an extension barred exchange access, returns N.U. tone.

Outgoing Exchange Calls. The extension dials '0' and the link selector causes a start signal to be extended to all free exchange line circuits (in both units for CA Type). Also from the link circuit a path is completed via the link line finder to mark the calling extension on the banks of the exchange line (or junction) finders (J wire). Controlled by relays in the exchange line circuit, the free junction finders search and the first to reach the marked outlet extends the caller to the associated exchange line. The link circuit is freed, the selector restores to normal and is available for further calls. Fig. 10 shows the circuits in use with the call in progress (heavy lines) and the circuits used in setting up (light lines).

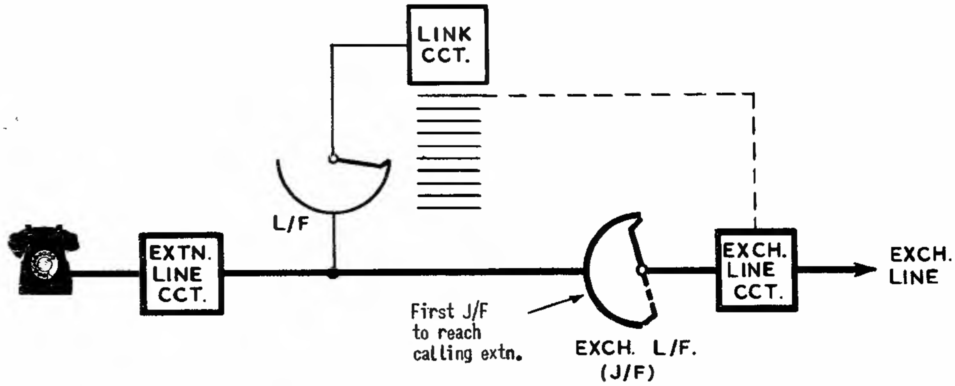


FIG. 10. OUTGOING EXCHANGE CALL - TYPE C P.A.B.X.

The subsequent digits pass through to the exchange to select the desired number; the exchange line circuit does not act as a repeater.

If all exchange lines are in use, busy tone is then heard when an extension dials 0; the tone being received via the first outlet on level 0 of the link selector.

Incoming Call. The exchange line lamp on the attendant's cabinet flickers, (0.2 sec on 0.2 sec off) and the buzzer operates. The attendant operates the associated exchange line key and speaks to the caller. The lamp goes out. To call the required extension the two appropriate digit keys are pressed in turn. This causes the required extension to be marked on the banks of the junction finders (M wire). The finder associated with the exchange line searches for the marked outlet and connects the required extension line to the exchange line circuit which then -

(i) Tests the called line and if it is free, rings the extension, at the same time lighting the exchange line lamp (steady glow). The attendant may restore the exchange line key at this stage.

(ii) Trips the ring when the extension answers and connects the extension to the exchange line. The lamp goes out; the parties may converse (see Fig. 11).

(iii) If the required extension is busy causes the lamp to flash slowly (0.8 sec. on 0.8 sec. off). (The caller is advised and may wait. The key is restored.)

(iv) Continues to test the called extension line at frequent intervals and when the line clears, automatically rings the extension as in (i) and (ii) above. (Camp on busy.)

(v) When both parties clear, releases automatically (through clearing). If the caller does not clear immediately holds the circuit until the line is free, so that it cannot be seized by extensions making outgoing calls.

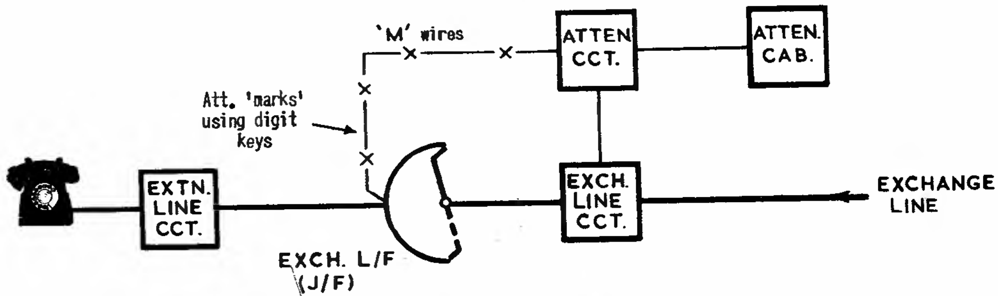


FIG. 11. INCOMING EXCHANGE CALL - TYPE C P.A.B.X.

NOTE:- Although the C and A units are each 25 line units, the exchange line finders are 50 point uniselectors so that all Type CA extensions will be accessible from exchange lines connecting to either unit, and vice-versa.

Trunk Offering. If an incoming call is 'keyed' to an extension and a busy flash is received, the attendant may if the call is urgent (for example, a trunk call) 'offer' the call to the busy extension, interrupting by means of the "Trunk Offer" key. A warning tone or clicks are heard by the interrupted parties to indicate that the attendant is 'across the line'. Meanwhile the incoming call 'camps on' and to take the call the wanted extension hangs up and is re-rung as described above.

Another facility is provided for use on incoming calls by means of the key "Speak Extn." -"Speak Exch." which allows the attendant to 'divide' a call switched through from an exchange line to an extension and speak to either party without the other overhearing. It is operated together with the particular exchange line key.

Attendant Calling the Exchange. The attendant may dial out on any free exchange line by operating the exchange line key and using the dial on the cabinet. So that the attendant may know which exchange lines are free and which busy, a press key "Junction Test" is provided, and this, when operated, causes the line lamps of busy exchange lines to glow. To clear, the "Release" press key is operated before the exchange line key is restored. (Through clearing is not effective for this class of call.)

Reverted Call. An outgoing call made from the attendant's cabinet may be reverted to an extension by use of the digit keys; the exchange line finder and circuit then function as described for an incoming call switched through. (See Fig. 11.)

Level 9 (Information) Calls. To call the attendant, an extension dials '9' thus raising a link selector to level 9. A start signal is extended from the selector to the level 9 circuit and the calling extension is marked on the multiple to the information (and exch.) line finders (J wire). The level 9 finder drives and extends the caller to the Level 9 circuit. The link circuit releases. The Level 9 call lamp flashes, and is answered by the attendant operating the "Level 9 Speak" key. (See Fig. 12.)

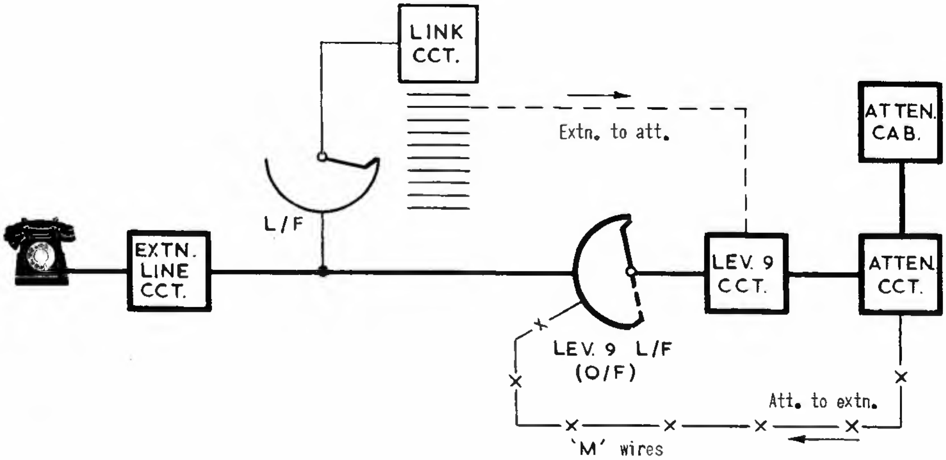


FIG. 12. LEVEL 9 CALL - TYPE C P.A.B.X.

The level 9 circuit is used also for attendant to extension calls. The "Level 9 Speak" key is operated and the required extension keyed on the key sender. The Level 9 finder drives to the marked extension (M multiple), and the extension is rung from the Level 9 circuit. If the called extension is busy, the camp on facility operates as for the exchange line circuits.

For both in and out level 9 calls, the circuit is released by momentary operation of the key from "Level 9 Speak" to the opposite position "Level 9 Release" (non-locking).

When an extension dials "9" and the level 9 circuit is busy, the link selector cutting in one step causes a "Waiting Call" lamp to glow on the cabinet.

Immediately the operator releases the first call, the level 9 finder drives to connect the other extension. The link selector then releases as before.

Call Back and Auto. Transfer. The exchange line circuit and the Call Back circuit operate in conjunction to provide these facilities. While engaged on an exchange call, extensions with an earthing button may:

- Press the button to isolate and hold the exchange line; be connected automatically to a link selector via a normal (spare) extension line circuit; receive dial tone.

- Call another extension by dialling, then :

  either (a) Press the button again to release the called extension and return to the exchange call.

  or (b) Hang up to transfer the call automatically to the second extension (see Fig. 13).

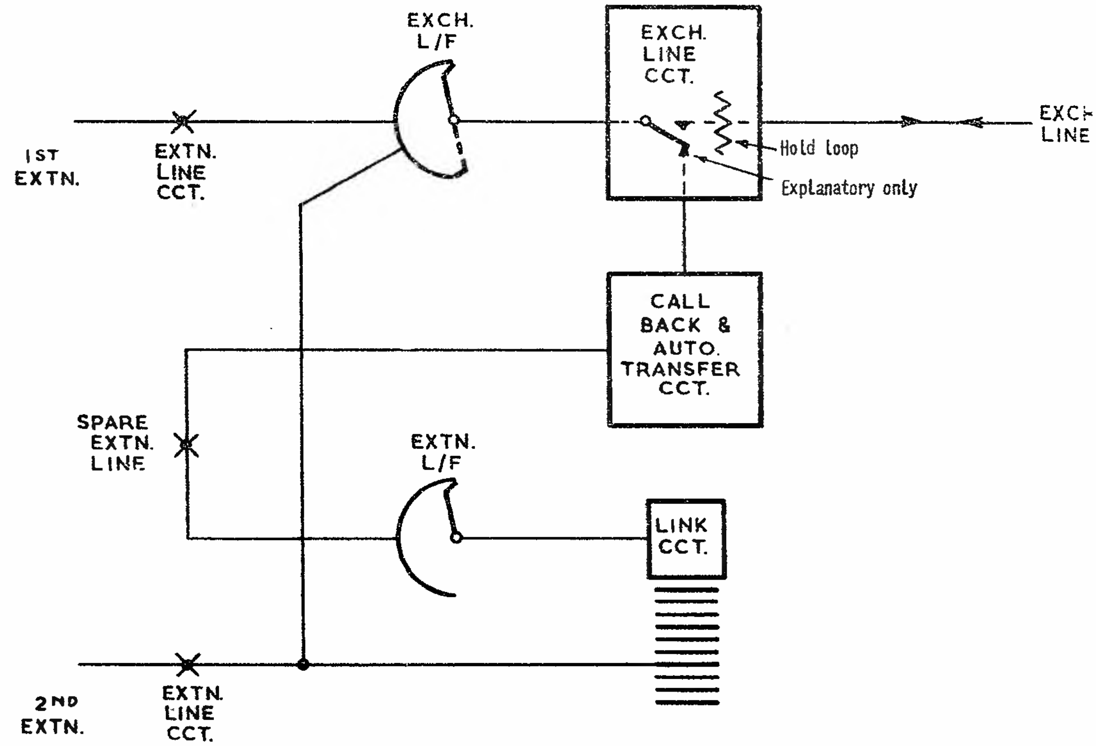


FIG. 13. TRUNKING - CALL BACK AND AUTO. TRANSFER TYPE C P.A.B.X.

The transfer is achieved by the exchange L/F driving from the first extension outlet to that for the second extension. The second extension is marked on the exchange L/F banks (J wire) via the link selector. After the transfer the link and spare line circuits return to normal.

A third facility is provided by the call back circuit. By pressing of the button twice (without dialling) the attendant is called across the line; the exchange line lamp flashes as for an incoming call.

Only one extension can use these facilities at a time, as only one call back circuit is provided.

Night Service. Selected extensions may be arranged to receive the incoming calls when the manual cabinet is not attended; one extension per incoming exchange line.

On the cabinet a single "Night Extn." key is operated. When an incoming call seizes the exchange line circuit the associated L/F drives to the selected extension which is then rung as for a normal incoming call.

All the extensions, including those selected to receive incoming calls may still use the exchange lines for outgoing calls in the normal way (by dialling "0").

Tie Lines. The exchange line and link circuits have recently been modified so that if desired they can be used for tie lines to other P.A.B.Xs. or P.B.Xs. Level 8 of the link selector is used for the tie line start lead. General operation is then as described for outgoing and incoming exchange calls.

6.6 Miscellaneous Features Type C and CA P.A.B.Xs.

Marking and Testing. As mentioned the conventional P wire is not used. The 'multiple' which is shown in Fig. 9 to connect the extension line circuits to the banks of all the finders and link selectors consists of the wires : + - H BD J M which connect from the multiple connection strips at the rear to the various circuits as follows:-

Extension Line circuit	+ - H	Extns. 20-44 in C unit and Extns. 45-69 in A unit
Link finder banks	+ - J BD	
Link selector banks	+ - H J	Extns. 20-69 in both C and A units.
Exchange L/F banks	+ - H J M	
Level 9 finder banks	+ - H J M	

One additional wire - HF - connects between the extension line circuits and the link finder banks.

Briefly the function of the auxiliary wires is as follows :-

H - Testing and busying for extensions, to all switches except link finder.

HF - Testing, marking and busying from line circuit of calling extensions to link circuit via link finder.

J - Marking of calling extension on exchange and level 9 finder banks. Marking of called extension for night service calls. (except early units).

M - Marking of called extensions on exchange and level 9 finder banks under control of digit key sender on attendant's cabinet.

BD - For extensions barred exchange access this terminal is strapped to the adjacent H tag on the terminal block. The link circuit then returns N.U. tone if the extension dials "0". The BD wire is used also for marking, during transfer of exchange calls between extensions (in conjunction with J wire).

An interesting feature of the M multiple from the digit key sender in the attendant's circuit, is that the full 50 extensions are served by only 14 marking (M) wires, and that the exchange and level 9 finders search for the called extension in most cases with two separate searching motions. If, for example, the attendant keys 47: after the 7 key is released the appropriate finder drives to the contact for extension 40, tests in momentarily, then drives on to 47. The tens and units are marked and tested separately, that is, 20, 30, 40, 50 and 60 are the tens, while the units 1 - 9 are each multipled over the five tens groups, that is 21, 31, 41, 51, 61; 22-62; 29-69 etc. So when 36 is keyed the finder drives to 30 before all the units 6 are marked, at 26, 36, 46, 56 and 66. It then drives to the next marked outlet - 36.

Night Service. The circuit arrangement for this facility has been completely changed since the first units were installed. Originally a two wire jumper was provided between the exchange line circuit and the selected extension 'M' multiple. With the later units a simpler circuit is used - a single jumper being required for each night serviced line, and marking of the selected extension is via the J wire.

This is done on the multiple blocks at the rear. Each exchange line has an NS terminal which is jumpered to the J terminal of the selected extension.

Start and Busy Chain circuits. The start leads do not actually connect straight to the circuits concerned, as shown in Fig. 9, but to auxiliary relays which are plate mounted at the top of the C unit. This circuit includes safeguards for the Level 8, 9 and 10 start leads, against the possibility of wrong connections should more than one of these levels be dialled together, and also against unwanted interference between circuits during auto. transfer and night switching operations.

When all exchange lines, are in use a series chain of contacts (one from each circuit) operates an auxiliary relay which causes busy tone to be heard from the link selector, (0 level first rotary step.)

Each link selector has a special vertical marking bank and wiper which alters the circuit conditions for the various levels as follows:- on levels 2-6 type CA, and 2-4 type C, the switches function as final selectors for local calls; on levels 9, and 0 the start leads connect from the vertical marking bank (also level 8 if a tie line is required).

Unused levels are strapped together on the vertical marking bank and connected to NU tone.

Ringing, Tone, Pulse and Alarm Circuits. Provision is made for :-

Continuous ringing current.

Interrupted ringing current 0.4 sec. on, 0.2 sec. off, 0.4 sec. on, 1.4 sec. off.

Interrupted ringing current 0.8 sec. on, 0.8 sec. off.
(used only for I/C exchange calls to extensions).

Busy tone, NU tone, Dial tone.

Warning tone (a series of clicks - for trunk offering).

Interrupted earth pulses of several kinds, namely:-

Busy Flash 0.8 sec. on, 0.8 sec. off - supervisory purposes.

Flicker earth 0.2 sec. on, 0.2 sec. off (off period is 1000 ohms earth) - lamp signal incoming call.

Auxiliary Flicker 0.2 on, 0.2 off - extension testing from exchange and level 9 circuits.

Tests Pulses - fed in sequence at 2.4 sec. intervals to exchange and level 9 circuits for testing during camp on busy.

'A' and 'Z' pulses - fed to the link circuits for forced release of selectors held by P.G. or C.S.H. conditions. 'A' and 'Z' pulses to any one selector are approximately 1 minute apart.

Ringing current is obtained from the secondary of a transformer, the primary winding being energised by pulses of D.C. from a special type of vibrating reed relay. (See Fig. 14). Dial tone is obtained after suitable decoupling from the primary side of this circuit. In early units ringing and NU tones were obtained from 'buzzing' relays which could be adjusted to the required frequency. Later units retained this arrangement for the ring tone whilst NU tone was produced by a valve oscillator. In the most recent circuit the ring tone is obtained direct from the ringing current via small coupling capacitors.

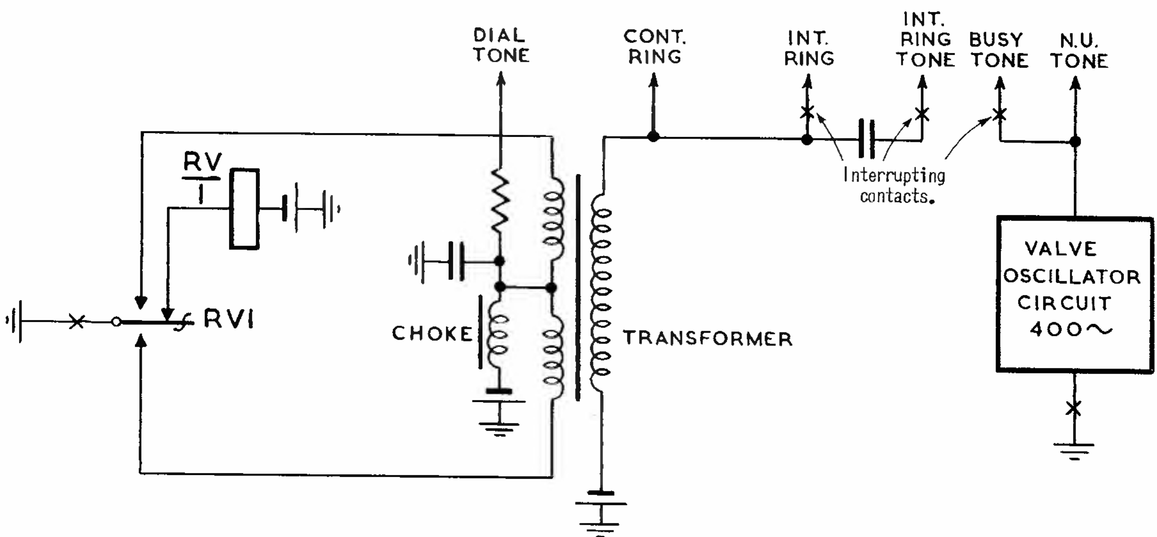


FIG. 14. ELEMENTS OF RING AND TONE SUPPLY - TYPE C P.A.B.X.

Two 25 point uniselectors stepping over suitably strapped banks are used to obtain the required interruptions of ring, tones and pulses. The ring pulse uniselector (R.P.) is stepped at 5 steps per second under the control of interacting relays. The time pulse uniselector (T.P.) steps once each full cycle of the RP switch (approximately 5 seconds), and its main function is to produce separate 'A' and 'Z' pulses for each link circuit.

The ring and tone equipment is started and stopped automatically as required by the various circuits supplied.

The Alarms are:- Fuse Alarm (F.A.), Release Alarm (R.A.) and P.G. Alarm. A Charge Fail alarm is sometimes provided, or in some cases an A.C. Fail or Supply Fail is preferred instead (which is much the same thing). Two alarm lamps on the attendant's cabinet, Urgent (red) and Non-urgent (green), are used to indicate the presence of a fault condition.

The method of classifying the various alarms, varies somewhat with different units and with local alarm extending arrangements:-

The F.A, is always urgent and the red lamp is accompanied by the buzzer. The 'Alarm Cut-off' key is used to stop the buzzer once the fault is noted by the attendant.

The R.A. is caused when a heat coil in the release circuit of the link selectors operates (prolonged current in the magnet owing to faulty release action). This is indicated by either the urgent red lamp and no buzzer or the non-urgent green lamp and buzzer.

The P.G. is always non-urgent - green lamp, no buzzer. After forced release of the link selector by the 'A' and 'Z' pulses (1-2 minutes approximately depending on the position of the TP switch) the P.G. or C.S.H. extension is locked back into its own line circuit K relay and the P.G. alarm given after a further delay of about 15 seconds.

NOTE: During a call both the L and K relays remain operated. The L releases to lock out a P.G. (L.S. relay in latest circuits).

Sometimes alarms are extended to the controlling exchange from Type C and CA P.A.B.Xs. Fuse alarm and Charge fail (or A.C. fail) only may be extended as prompt; or Release alarm and P.G. also as deferred alarms.

Clearing A.C. The through clearing facility on the exchange line circuits requires an A.C. for its operation and this is usually obtained from an auxiliary step down transformer connected to the supply mains, and having an output of 75-80V. If the supply should fail the local continuous ringing current is automatically connected to the clearing circuit. The principle of operation of the A.C. clearing is very interesting in that it enables the exchange line circuit to detect whether the line is 'held' or clear at the exchange, in spite of identical D.C. polarities in either condition.

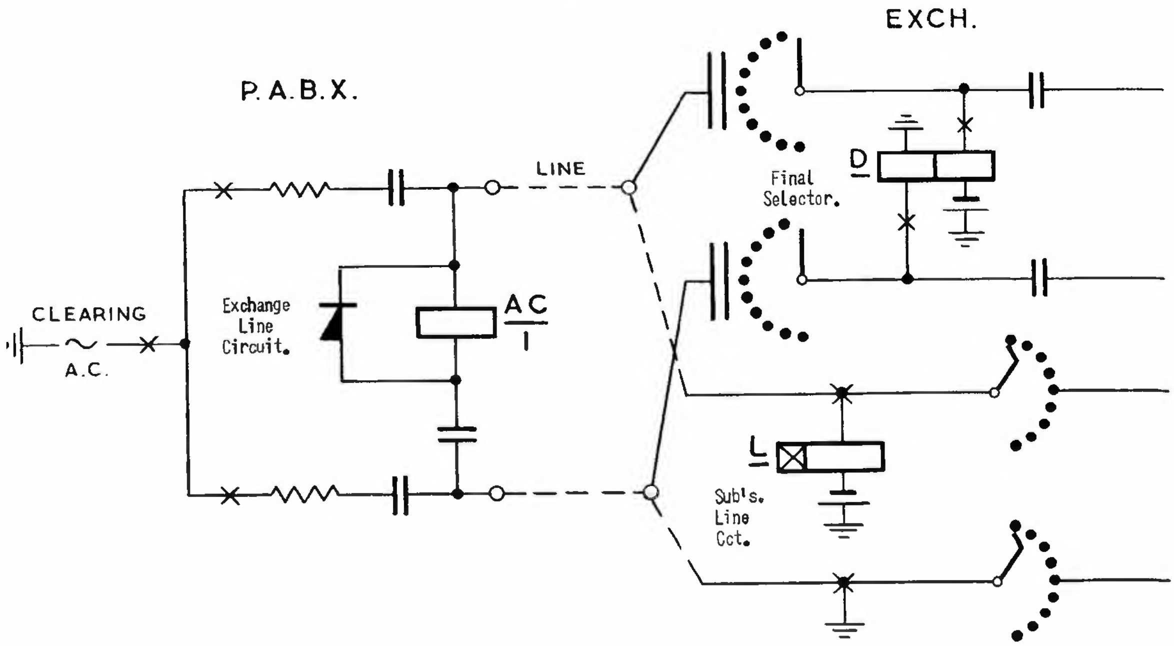


FIG. 15. ELEMENTS OF A.C. CLEARING CIRCUIT.

The extension clears at the end of a incoming call and the exchange line circuit partly restores to the condition shown basically in Fig. 15. The clearing A.C. is applied but the A.C. relay must then operate before the circuit is cleared for further calls. Can you detect the Wheatstone bridge in the above circuit?

The "Flash" key on the attendants cabinet may be used to attract the operators attention when the exchange lines connect to a manual exchange. It is a non-locking key which simply opens the line loop when operated (the exchange line key and the handset hook switch cannot be used for this purpose).

The "Test Extn." key when provided, is wired into either the last or the first exchange line circuit. It is operated when an extension is to be tested from the exchange test desk. The extension is connected to the exchange line by keying in the normal way. The extension answers but may hang up; the exchange line stays in the through condition for the test. The last exchange line circuit is now the standard one for this facility.

'Busying' of exchange line or link circuits must be done correctly or the service may be seriously affected. Opening the start lead (removing the 'flags' from test jack springs 1 and 2) is sufficient for a link circuit but with an exchange line circuit the busy chain must also be completed for that relay set, by placing the flag in springs 5 and 6. The exchange line must also be busied at the public exchange M.D.F.

7. POWER SUPPLY, TESTING.

7.1 The power supply depends on the size of the P.A.B.X. and the maximum load demand. The batteries are now always of enclosed cells, usually of the radio or home lighting type and enclosed in a special cupboard. The capacities range from 90 A.H. to 200 A.H. On the few occasions in the past where open cells in glass containers were used, these were generally installed in another room.

A static rectifier of suitable output is connected permanently across the discharge leads so that the 'floating' battery is kept permanently charged. Automatic voltage regulation is included in all the rectifiers now used so that the output 'follows the load' to avoid undercharging or overcharging of the battery.

Rectifiers for P.A.B.Xs. range in output from 1.5A to 30A and the correct floating voltage is 51.6V to 55.2V, full load to no load. A typical rectifier as used for the larger P.A.B.Xs. can be seen in Fig. 1 on Page 2. Modern rectifiers of 10A and over have provision for either manual or automatic regulation, and a fine control of the floating voltage while on "automatic" is usually provided.

With some of the Type C and CA unit installations now being carried out by the manufacturers, the supply may be direct from a rectifier serving as a battery eliminator. Rectifiers with sensitive automatic control are not suitable in this case.

7.2 Extension testing facilities are not installed at P.A.B.Xs., but a circuit is usually provided to enable any extension to be tested from the parent exchange test desk.

At Uniselector and Line Finder Type P.A.B.Xs. a test cord circuit is provided at the manual board. The testing officer gains access to an extension in one of the following ways (the method used depending on local practice in each state):

- After calling on one of the normal incoming lines (usually the last - least busy) the P.A.B.X. telephonist is requested to connect the pair of test cords between this line jack and the jack of the extension to be tested. A two position key is sometimes provided on the test desk - to allow the testing officer to test the extension line circuit into the automatic equipment by releasing the K relay, and to give a clearing signal on the test cord circuit supervisory lamps when the test is completed. Generally this key is common to the alarm extension circuit for the P.A.B.X. When a key is not provided the testing officer must call on another line to have the test cords taken down.
- A 4 wire test junction is accessible to the test selector (test distributor) and is wired via a relay set at the P.A.B.X. to a single test cord on the manual board with associated call & clear lamp and speak key. This enables extensions to be fully tested without additional keys on the test desk.

At C and CA Type P.A.B.Xs. having a "Test Extn." key provided on the attendants cabinet, extensions are tested as described in Section 6, page 22. In some areas (notably in N.S.W.) it is the general practice to provide all P.A.B.Xs. with a special test circuit accessible from the test selector as described above, and this includes Types C and CA also. In this case there are no test cords, the last or least busy exchange line circuit is used, but the actual relay set is by-passed by the test circuit, after the exchange line finder is positioned by keying in the normal way. Where neither of these arrangements are provided the Technician must make suitable temporary cross connections at the P.A.B.X.

7.3 Testing the selectors of Line Finder and Uniselector P.A.B.Xs. is done by means of the test set No. 1 (or 1A). This portable test set (on wheels) enables all the important functions of group selector repeaters, final selector repeaters, group selectors and final selectors to be tested. Control of the tests is by means of keys, and supervision by means of lamps and a head receiver.

The line finders and allotters may be checked by means of a buttinski and using a spare line circuit in each group. The Technician's telephone is sometimes wired via a key to serve this purpose.

7.4 Facilities of Types C and CA units may be checked for correct operation using a telephone or buttinski and with the co-operation of the operator. As there is no allotter, care should be taken to ensure that each of the finders is brought into use during the test, and that each link circuit is tested on all working levels, and for a call to both a free and a busy extension line. The test set No. 21 (Drawing No. CE.11039) is intended for testing the facilities of Types C, CA and Siemens-Halske units. This simplifies testing and also allows long line and short line/low insulation impulsing tests on the link selectors.

8. FUTURE TRENDS.

8.1 It is likely that a ring and tone circuit will be introduced which will be suitable for R.A.Xs. and P.A.B.Xs. and thus standardise this facility which at present is provided in many different ways. A completely static device would be most suitable as pulsing relays and stepping uniselectors in this type of circuit have a fault liability rather too high for unattended exchanges. Advances in the application of transistors may make this practicable.

8.2 Standard methods of providing night service facilities do not suit the needs of all subscribers. A number of alternative arrangements may be developed.

8.3 The Crossbar system offers a number of advantages for P.A.B.Xs., including small size inherent reliability and low energy consumption. Crossbar P.A.B.Xs. will be used in the future.

9. TEST QUESTIONS.

1. Why is a manual board necessary with a P.A.B.X.?
2. List the types and sizes of P.A.B.X. available.
3. Under what conditions would it be advisable to install a Type E P.A.B.X. rather than a Type CA.?
4. List the facilities available with a 3 digit Line Finder P.A.B.X.
5. List the main equipment items you would expect to find on visiting a Line Finder P.A.B.X. serving 170 extensions.
6. What type of P.A.B.X. is most suitable when the extension calling rate is unusually high? Give reasons for your answer.
7. What special facilities are given only by the Unit type P.A.B.Xs.?
8. Draw the trunking diagram of a Type F P.A.B.X. and describe the action of the equipment for an extension making an outgoing exchange call.
9. At some P.A.B.Xs. relay set repeaters are provided; while at similar P.A.B.Xs. they are not. Why is this?
10. (i) What type or types of P.A.B.X. use group selector repeaters and (ii) list the principal functions of this switch.
11. Describe briefly the action of an allotter in a Type E P.A.B.X.
12. How are several information lines obtained from one two digit number in a Type E P.A.B.X.?
13. Describe the principles of operation of one type of call back facility provided with any type of P.A.B.X.
14. List the main functions of link selectors in Type C and CA P.A.B.Xs.
15. Draw a trunking diagram of a Type C P.A.B.X. and describe the action of the equipment when (i) an extension calls the operator and (ii) another extension dials 9 while this first call is in progress.
16. With the aid of a block diagram describe what happens in the unit when a Type C extension transfers a call to another extension.
17. How are ringing current and tones supplied for a Type CA P.A.B.X.?
18. Describe one method by which P.A.B.X. extensions are tested from the parent exchange.

END OF PAPER.

RURAL AUTOMATIC EXCHANGES (R.A.Xs.)

GENERAL DESCRIPTION ONLY.

1. INTRODUCTION.

1.1 The telephone requirements of subscribers in country areas are much the same as those of suburban subscribers, but because homes are more scattered, it is difficult to satisfy at reasonable cost the desire of country dwellers for a comparable service.

Small magneto manual switchboards are generally used to provide a service, these small exchanges being connected to the larger centres by trunk or junction lines. Most of these exchanges have less than 50 lines connected.

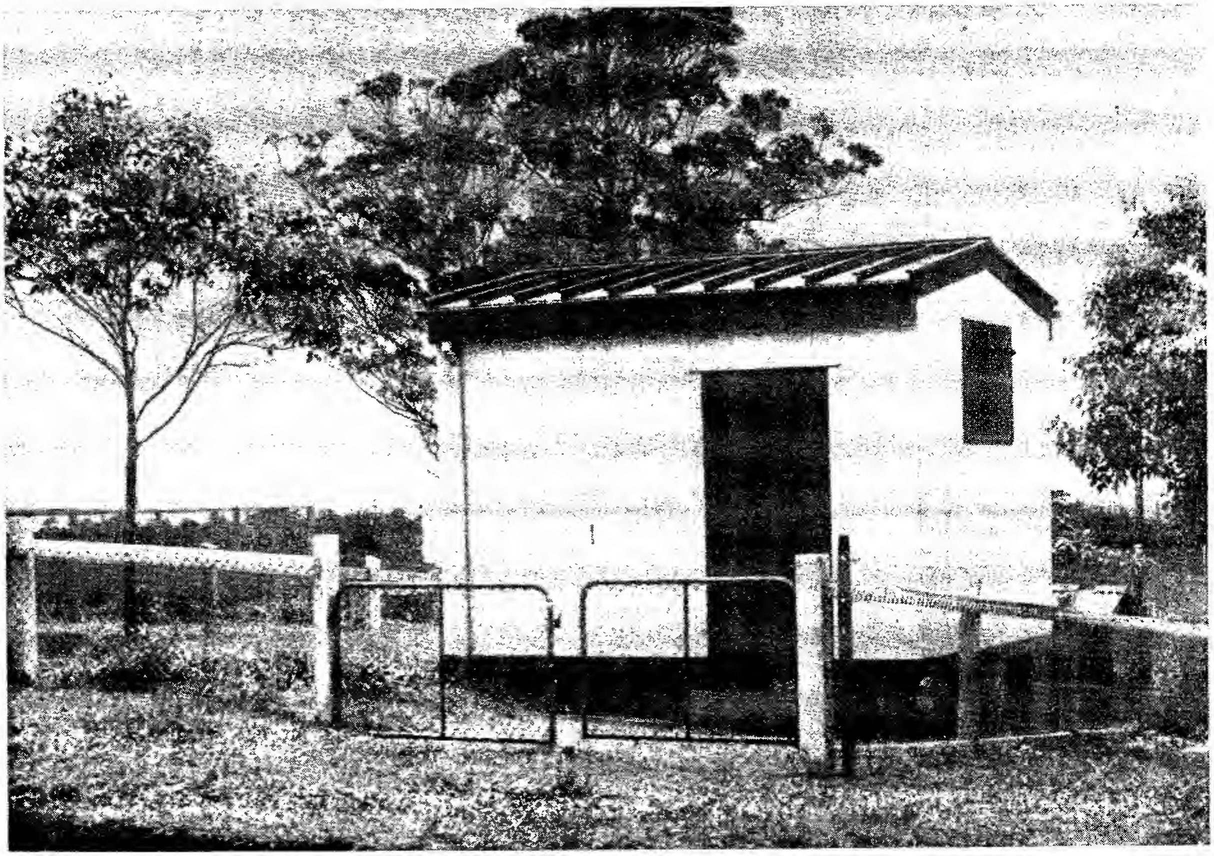
1.2 This arrangement has serious disadvantages. Usually, the exchanges are in the home of a subscriber who acts as telephonist (and often Post Office Keeper also), service being restricted to about 12 hours a day. An opening fee is then charged if service is required outside these hours. This is unsatisfactory for the subscriber who wants to use his service in his leisure hours, and especially in times of emergency.

Also the location of the exchange is determined by whoever is willing to accept the responsibility, and this rarely allows the most suitable layout of subscriber's lines. Any site away from the 'copper centre' means higher line construction costs.

As the number of subscribers connected increases, the hours of attendance may have to be extended, and this increases staffing difficulties.

Removals of country exchanges to other premises are frequent, involving heavy costs and possible interruptions to the service.

1.3 To overcome these difficulties, Rural Automatic Exchanges were developed. There are now over 1,000 R.A.Xs. in Australia, giving a continuous automatic service to more than 50,000 subscribers, and these figures are being increased rapidly. In many cases an R.A.X. replaces several manual switchboards. A typical R.A.X. is shown in Fig. 1.



TYPICAL R.A.X.

FIG. 1.

2. RURAL AUTOMATIC EXCHANGE (R.A.X.).

2.1 R.A.X. subscribers obtain connection to other parts of the telephone network, via trunk lines to a distant manual exchange known as the Parent Exchange. Direct access may be provided to adjacent manual exchanges, or other R.A.Xs. within the unit fee area. Fig. 2 shows the possible trunk line access for an R.A.X.; a large proportion of R.A.Xs. however, have access to the parent exchange only.

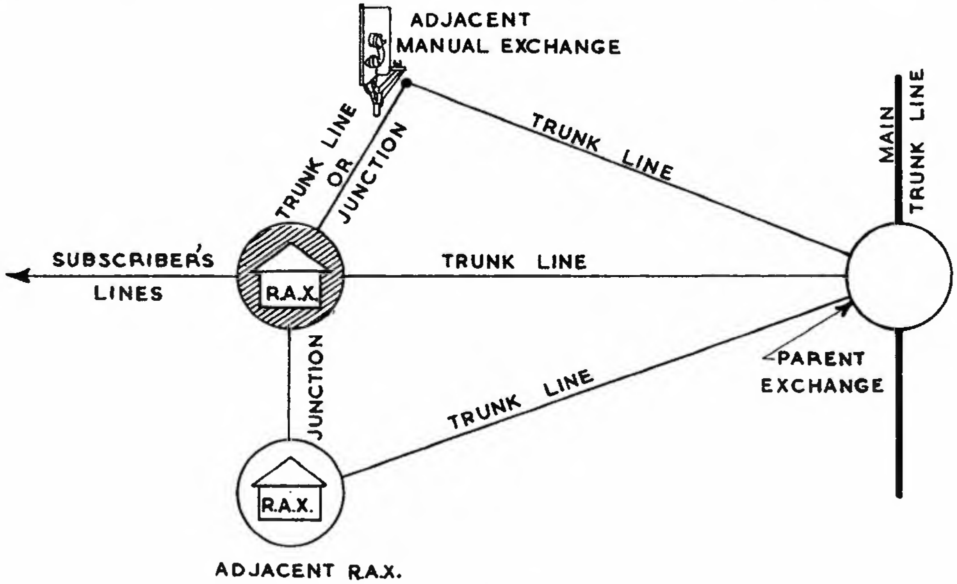


FIG. 2. TRUNK LINE ACCESS FOR AN R.A.X.

With the extension of multi-metering, direct access to subscribers outside the unit fee area will also be possible.

Reliability of operation is essential, as except for occasional maintenance visits, R.A.Xs. are unattended.

2.2 The R.A.X. is a complete exchange of up to 200 lines (or slightly over in a few cases) and includes batteries, charging plant, alarms, and in many cases testing facilities also. The equipment is housed in a small building having wooden or steel framing, with asbestos cement or galvanised iron sheeting externally, and asbestos cement or hardboard lining. In many cases, buildings are transported to the site fully assembled, and with most of the equipment installed.

2.3 Types of R.A.X. The first R.A.Xs. to be installed were designed in Great Britain. From experience gained with these units the Australian Post Office designed a unit more suited to our rural conditions. These were made by the British contractors, the first unit being installed in 1949 (Types C & D). A smaller unit was then designed in the A.P.O., the first of these being installed in 1951 (Type B).

The units are generally designated according to size and type -

Type B, for units with a capacity of up to 50 lines, but which cannot be extended beyond this number.
Type C, for units with a capacity of 50 lines, which may be extended to 200 lines (by adding type D units).
Type D, for 50 line units used for extending type C installations.

NOTE: The units designed by the equipment makers were sometimes referred to by the above designations, but more frequently by the name of the maker, for example - S.T.C. 50/200 line, or G.E.C. 50 line. Thus, the terms 'Type B', or 'Type C', have generally come to be regarded as referring to the standard A.P.O. units.

The Type B unit was made distinct from Type C, as a more compact and less costly unit can be made when the equipment is restricted to the needs of 50 subscribers. Actually the A.P.O. type B caters for a maximum of 40 subscribers plus 5 trunk lines.

Since 1954 branches of the British firms have been manufacturing the A.P.O. units in Australia, some of the common equipment of the C unit having been modified to avoid importing ring and tone machines.

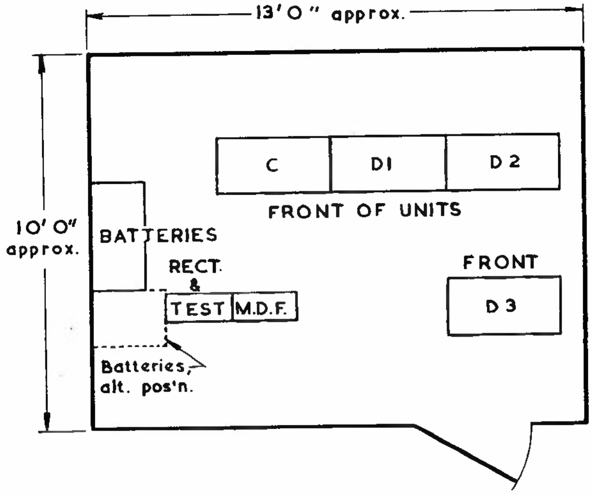
2.4 R.A.X. equipment is supplied in units which are housed in dustproof cabinets of sheet steel. The front and rear covers are removable. Some early cabinets were of wood.

Equipment layouts vary considerably with local practices in each State. Figs. 3a and 3b show two typical layouts.

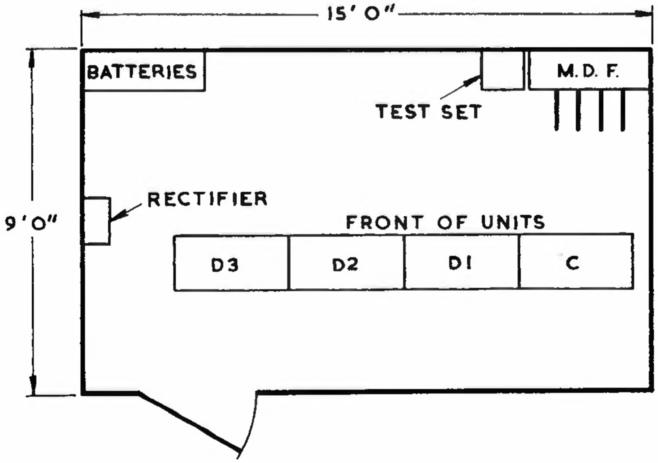
The Type B exchanges were originally installed in huts of 9' x 9' but the larger huts are now used as many Type B units, (50 lines), are eventually replaced with Type C units, (50-200 lines). No separate M.D.F. is required with the Type B, as this is mounted within the unit itself.

Fig. 4 shows the interior of an R.A.X. which contains a C unit and two D units, the C unit being adjacent to the end wall.

2.5 Use of Line Finders. Line finders are suitable for R.A.Xs. because the subscriber calling rate is generally low. In most cases less than 200 lines are connected, and therefore the standard 200 point line finder is unnecessarily large. A 50 point uniselector is generally used as a line finder, although the 100 point bimotional switch was used in some units of earlier design. Wherever possible the uniselector is used because of its reliability and comparative cheapness.



(a)



(b)

TYPICAL EQUIPMENT LAYOUTS
50/200 LINE R.A.X.

FIG. 3.

Test Set. M.D.F. C Unit. D1 Unit. Part of D2 Unit.

TYPE 'C' R.A.X.

FIG. 4.

3. R.A.X. - FACILITIES AVAILABLE.

3.1 The facilities available to R.A.X. subscribers are similar to those provided in a metropolitan automatic exchange area. The service, therefore, is continuous, secret, uses standard tones, and provides as required -

Service on the Following Types of Lines -

Subscriber's metallic circuit (2 wire lines).

Party lines (2 party, 3 party and 4-10 party).

Bothway trunk lines to the Parent Exchange.

Public Telephones (including multi-coin attachment for trunk line calls).

Bothway trunk lines to adjacent automatic and manual exchanges.

Single wire lines.

Multi-office trunk lines (Omnibus Trunks). These trunk lines appear in more than one manual exchange; code ringing is used to signal the required exchange.

Selective Metering of Calls by Party Line Subscribers. Calls made by party line subscribers are individually recorded, a separate meter being provided for each party.

Revertive Calls on Party Lines. Calls may be made between any 2 parties of the one party line. The caller dials "1" to eliminate dial tone, and without replacing the receiver, rings the called party's code with the hand generator. This is termed a revertive call. (With some units "01" is dialled on lines having more than 3 parties.)

Automatic Lockout of Lines Permanently Looped. The number of switching circuits in an R.A.X. is limited (5 or 6 per 50 lines), and these must be available for service as much as possible. Should a line become permanently looped (P.G.) it is temporarily locked out of service after a short delay - usually less than one minute. Normal service is restored to the line automatically as soon as the loop or fault condition is removed.

Non-metering on Calls to the Parent Exchange. Subscribers are not charged a 'booking' fee on trunk calls and the trunk circuits to the parent exchange are modified to make them 'non-metering'. Public telephones are of the multi-coin type. Since 1958 the new post payment type has been provided. The earlier type required prepayment for local calls but was fitted with a special dial enabling the caller to raise the parent exchange without first using pennies.

Detection of Fault Alarms from the Parent Exchange. This is provided in one of several ways, such as -

(a) The extension of alarms by means of a 'call' to the Parent Exchange,

and/or,

(b) The dialling of a test number at regular intervals, the various alarm (or all clear) conditions being distinguished by tones (See Section 5).

Battery Charging Over the Trunk Line to the Parent Exchange. Where no commercial power is available at the R.A.X. this alternative may be used. Several circuit arrangements are in use and these are discussed in Section 7.

Testing Facilities. Types C and D units are equipped with a test set which permits subscriber's line testing and also routine tests of selectors. Some early units provided for testing of subscribers' lines from the parent exchange (See Section 9.2). Type B units are provided with a simple test set in some States but not in others.

4. STANDARD A.P.O. TYPE R.A.Xs.

4.1 The two standard Types B and C have many features in common. They each use the same subscriber's line circuit, 2 party 2/3 party and 4/10 party relay sets, public telephone, and charge-over-trunk relay sets. The fully imported C Types use the same ringing code interrupter as the B Types. The B Type differs in that no bimotional switches are used. In each case all uniselectors are A.P.O. or the similar B.P.O. Type.

4.2 Elimination of Allotters. Experience with earlier units has shown that common equipment is a source of serious trouble, as its failure may put the R.A.X. "off the air". As R.A.Xs. are normally unattended, considerable time may elapse before the Technician arrives to restore service.
For this reason allotters have been eliminated from the line finder circuits of these standard R.A.Xs. The multiple search system is used; that is, all free line finders hunt in unison for a calling line, the first switch to reach the line is accepted, and the others release to be available for other calls.

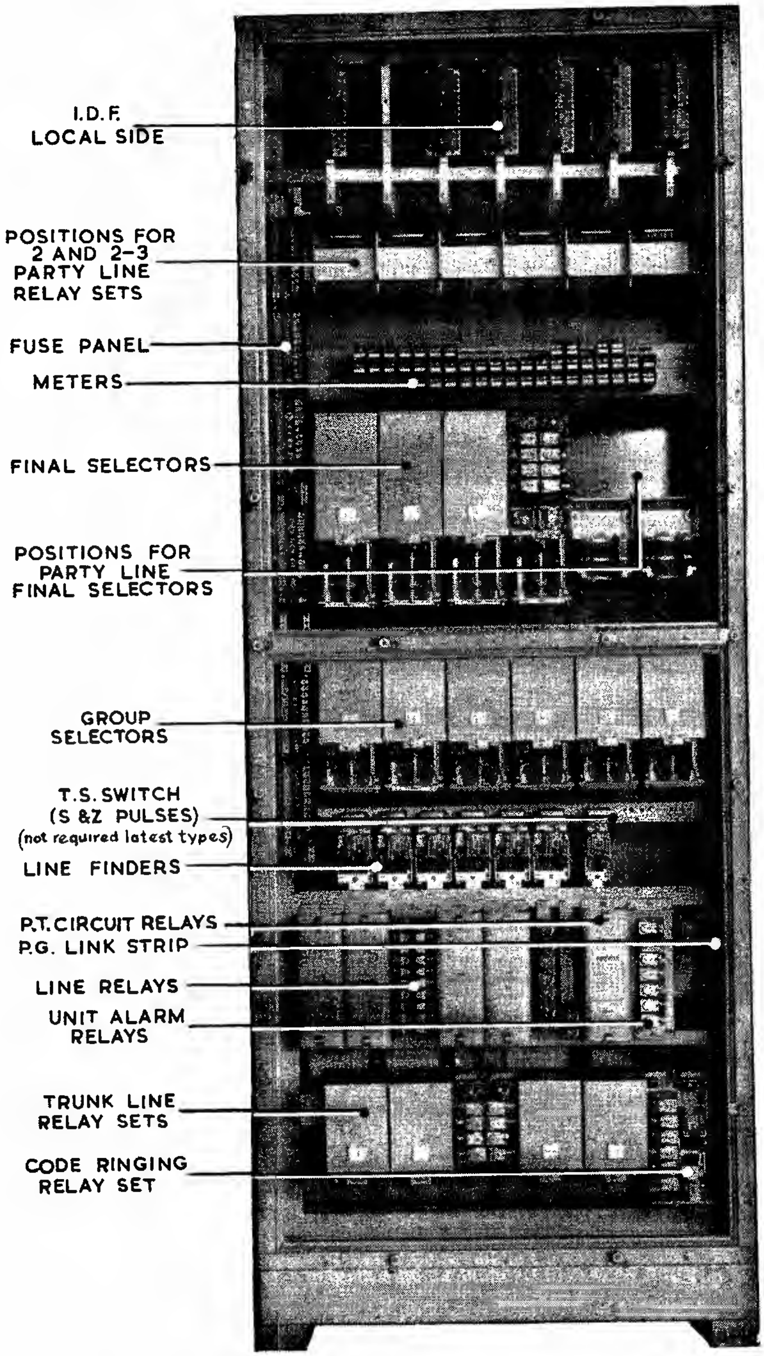
4.3 Since 1954, C and D units have been made in Australia. These are identical to the British units except for changes to the ring, tone, pulse, and alarm circuits, which use relay sets instead of the inductor tone type ringing machine and plate mounted auxiliary relays.

Approximately 500 B units are in service and it is expected that more than this number will not be required, as the B units replaced by C units are being re-installed where suitable.

5. A.P.O. 50/200 LINE R.A.X. (TYPE C-D).

5.1 The 50/200 line R.A.X. is built up using 50 line units to an ultimate capacity of 200 lines. The first 50 line unit (C unit) is in itself a complete telephone exchange of that capacity. The second and subsequent units (D units) are similar, with the exception that they get their ringing, tones and supervisory pulses from the C unit. These units use 2000 type equipment; the group and final selectors are 2000 type or SE.50 bimotional switches, with the circuits designed to perform the slightly different functions required for rural conditions.

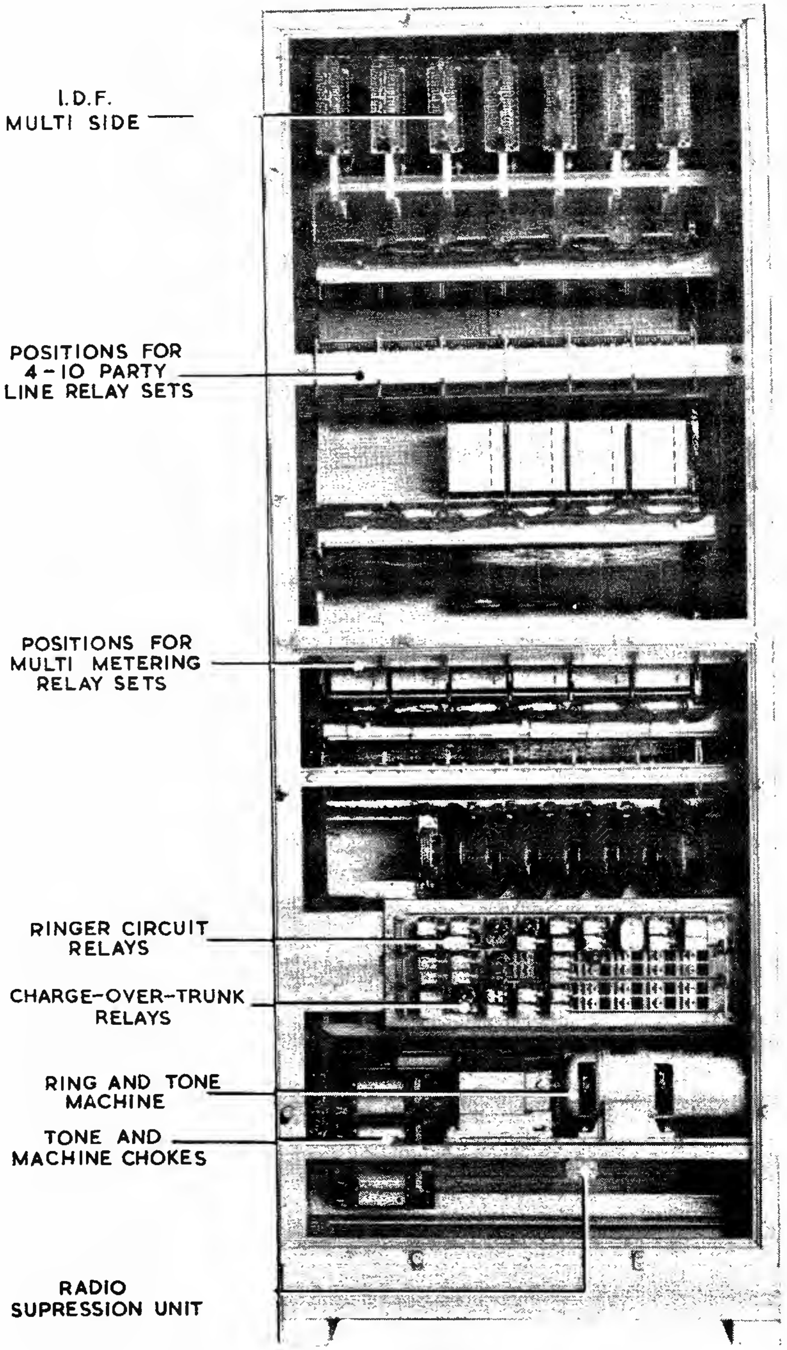
5.2 Description of the Type C and D Units. Each unit is in a dustproof steel cabinet measuring 8'3" high, 3' wide and 1'8" deep. The layout of the equipment facilitates maintenance, in that the bulk of the switching apparatus is mounted on the front of the unit, and can be handled by the Technician without the aid of stools or ladders.
Fig. 5 shows the front of the unit, whilst Figs. 6a and 6b show the rear of the two different C units now in use.
The local I.D.F. is mounted at the top of the unit. The terminal blocks at the rear form the 'multiple' side of the I.D.F., and serve as the terminating point for the incoming lines from the M.D.F., the group and final selector bank multiples, and the multiple cabling from other units. The terminal blocks at the front are the 'local' side and on them terminate the inlets to the subscriber's line circuits, trunk line relay sets, final selectors, and other auxiliary relay sets.
By means of jumpers, therefore, it is possible to connect any auxiliary apparatus to any line and line relay circuit. Also, as necessary, full availability connections, or grading, can be provided between the group selector bank multiples and the final selectors.
Plates can be removed from the sides of the units at the height of the I.D.F. to facilitate cabling between units.
The rear of the unit accommodates six 4-10 party line relay sets, if required; also cradles are provided for multi-metering relay sets. The ringing machine, when provided is mounted at the bottom of the rear side; the associated relays plus the charge-over-trunk circuit components, are plate mounted above the machine. Where ring & tone and pulse relay sets are used instead of the ringing machine, these are located in approximately the same position.
Type D units have a similar layout to the C units, except for the omission of the ring and tone equipment and associated common services.



A.P.O. TYPE 'C' R.A.X. UNIT FRONT VIEW.
(BRITISH MADE).

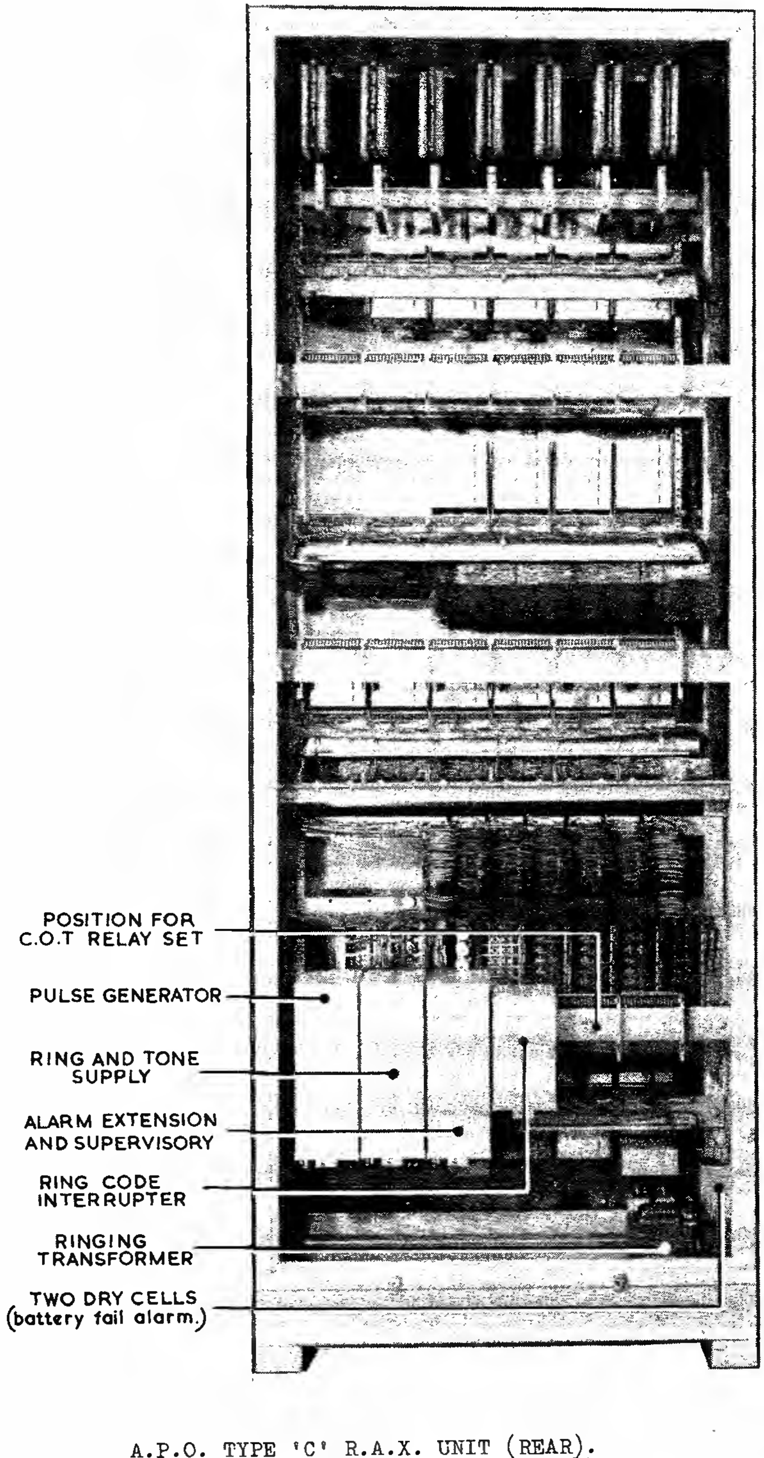
FIG. 5.

The extent to which equipment provision and location have been altered in the later unit, may be seen from a comparison of Figs. 6a and 6b.



A.P.O. TYPE 'C' R.A.X. UNIT (REAR).
(BRITISH MADE).

FIG. 6a.



A.P.O. TYPE 'C' R.A.X. UNIT (REAR).
(AUSTRALIAN MADE).

FIG. 6b.

5.3 Equipment Provision. Each C unit is equipped fully with group selectors and regular final selectors, but trunk line relay sets, auxiliary relay sets, and party line equipment are added as required. Type D units are supplied with 3 group selectors and 3 regular final selectors. Each fully equipped unit would contain the following equipment -

(i) British and Australian C or D units -

45 Subscribers' line circuits (plate mounted).
5 Bothway trunk line relay sets (auto-manual or auto-auto).
6 Line Finders) comprising 6 link circuits.
6 Group Selectors)
4 Regular final selectors (12 maximum for 200 line R.A.X. with 3 D units).

2 Party line final selectors.
6 2 or 2-3 party line relay sets.
6 4-10 party line relay sets.
1 Public telephone auxiliary line circuit (plate mounted).
1 Set of unit alarm relays (plate mounted).

(ii) Common and auxiliary equipment, C units only -

British	Australian
1 charge over trunk circuit (plate mounted).	1 charge over trunk relay set.
1 code ringing relay set.	1 ring code interrupter relay set.
1 ring and tone machine with associated ring, tone and alarm circuit (plate mounted).	1 pulse generating relay set.
	1 ring and tone supply relay set.
	1 alarm extension and supervisory relay set.

When relay sets are used ring current and dial tone are produced by vibrating relays; N.U., busy and ring tone by valve oscillators; ring and tones are interrupted by pulsing relays. (See Section 9.1.).

The charge over trunk facility (when used) and the extension of alarms, are associated (by means of jumpers) with the first and second trunk lines of the C unit only.

5.4 Numbering Scheme. Fig. 7 is the trunking diagram of an A.P.O. Type 'C' R.A.X.

A 3 figure numbering scheme is used, levels 2, 3 and 4 of the 100 outlet group selectors being used for subscribers' services.

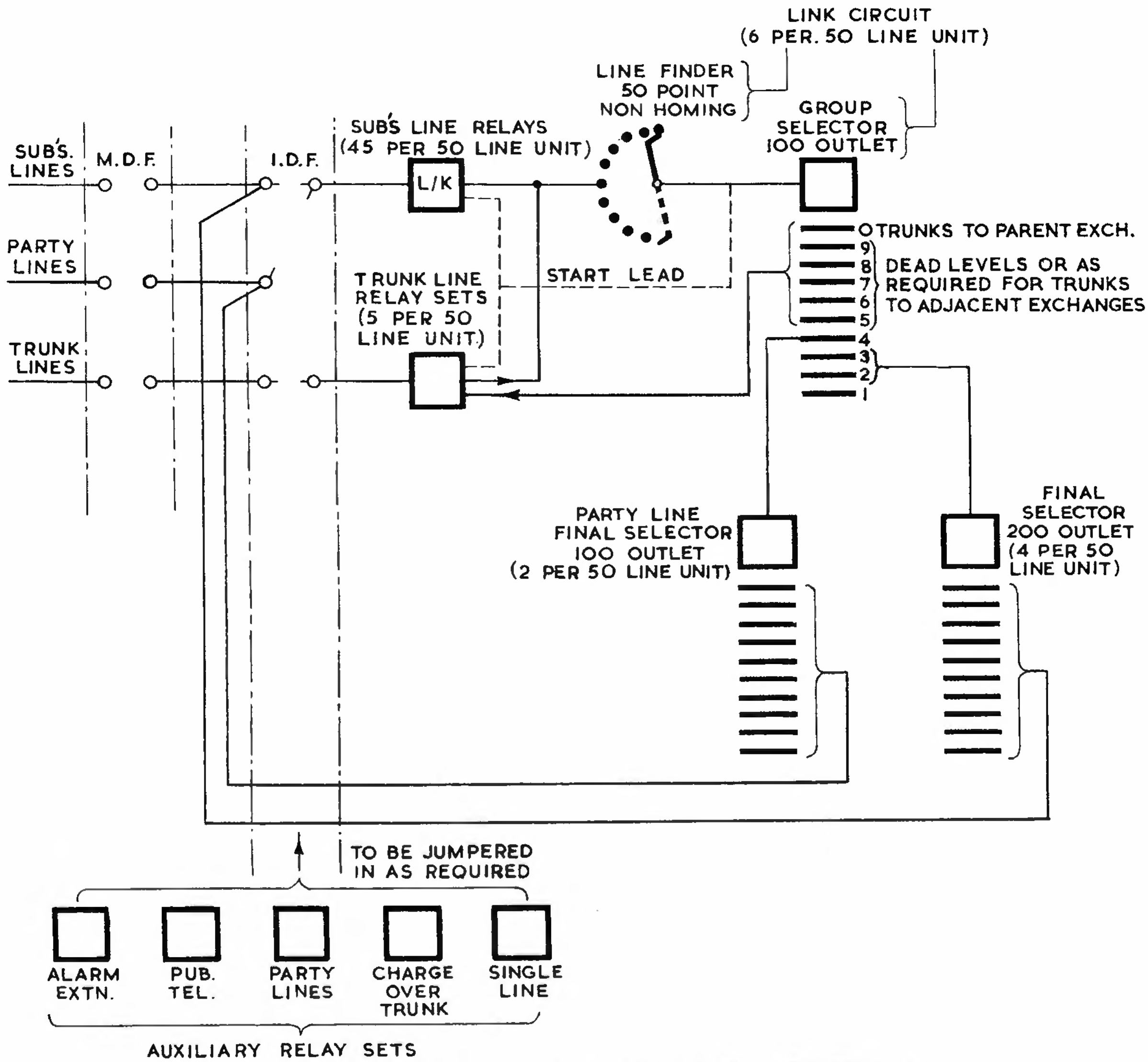
Exclusive subscribers, including public telephone and 2 party lines, are in the series 200-399, being served by the 200 line regular final selectors trunked from levels 2 and 3.

2-3 and 4-10 party lines are generally included in the 400-499 series, being served by the party line final selectors trunked from level 4, except when more than 200 lines are connected, in which case another level is used.

The parent exchange is trunked from level 0 of the group selector, whilst levels 5-9 can be used for adjacent R.A.Xs. and manual exchanges.

Level 1 of the group selectors is used for releasing the link circuit on revertive party line calls.

5.5 General Operation - Local Calls. The caller lifts the handset, the line circuit marks the calling line on the line finder banks and applies a start signal to all free line finders in the unit. The first line finder to reach the line extends it to the associated group selector. The remaining line finders come to rest and are available for further calls. Dial tone is returned to the caller from the group selector.



TRUNKING DIAGRAM 50/200 LINE A.P.O. TYPE 'C' R.A.X.

FIG. 7.

The caller dials three digits in the series 200-499. The first digit steps the carriage of the group selector to the level dialled and the wipers hunt automatically for a free outlet to a regular final selector (initial digit 2 or 3), or to a party line final selector (initial digit 4). The first free outlet is seized and the connection is extended to the final selector.

The last 2 digits are dialled - the final selector (regular or party line) functions in the usual manner except that the party line selector causes the appropriate code ring to be connected to the line, instead of the normal auto-ring.

At the end of the call, the connection is released by the calling subscriber replacing the handset. If the caller fails to clear after the called subscriber has done so, a "Called Subscriber Held" alarm is given after a short delay.

Permanent loops are forcibly released from the link circuits and a P.G. alarm given.

Trunk or Junction Calls.

Outgoing calls to the parent exchange use level 0 on the group selectors, and calls to adjacent exchanges use levels 5 to 9, the outlets being trunked via bothway repeater relay sets (auto-manual or auto-auto). Overflow meters are connected to all working levels of the group selectors.

Incoming calls from the parent or adjacent exchanges loop the line relay circuit in these same trunk or junction line relay sets, and cause the free line finders to search for the calling line in the manner described for a local call.

Party Line Calls. A special telephone with a hand generator is used for party line subscribers.

2 Party Line. Selective ringing is provided from the regular final selector via an auxiliary line circuit. The ring is earth circuit return on either the A or B leg. On outgoing calls a separate meter is selected by the auxiliary circuit, depending on the party calling. Calls between parties are made by the caller dialling "1" and then using the hand generator. The group selector steps to the first level, drives to the eleventh step and then releases. This causes the line circuit to revert to the P.G. condition; the line finder and group selector are thus freed.

2-3 Party Line. The auxiliary relay set selects the required meter on outgoing calls. On incoming calls the appropriate code ring is connected by the party line final selector. Inter-party calls are made in the same way as for the 2 party line.

4-10 Party Line. A more elaborate auxiliary circuit is necessary for this class of line and the telephones are fitted with a special dial. Outgoing calls are always prefixed by the digit "0". The dialling circuit of the telephone transmits impulses (earth circuit return) over both legs of the line, the dial being arranged so that one impulse of the train is 'masked' from the A leg. (A different impulse for each party.) Two uniselectors in the auxiliary relay set respond to this initial train of impulses (one to the A leg pulses and one to the B), and ensure respectively that - (a) the calling party's meter is switched into circuit, and (b) no call can proceed unless prefixed by "0". Code ring is connected to the line by the party line final selector.

Inter-party calls are made as is done on the 2 and 2-3 party circuits, except that with the early units the caller must dial "01".

5.6 Special Circuit Features A.P.O. Type C-D R.A.X.

In general, the switching circuits follow conventional 2000 type practice. Several extra features have been included to suit the special requirements of R.A.Xs.

Metering. No positive battery is provided; metering is by a negative battery pulse over a fourth wire (M) in each trunk between the line circuit and final selector (via the line finder and group selector).

Outlet Testing, Group Selectors. The free trunk condition for which the group selector searches is battery on the P wire. As the group selector cannot test into a P wire which is open circuit or at earth potential, "stop on busy" troubles are virtually eliminated.

Forced Release, Group Selectors. If a group selector is looped and dialling is not started within a short time, two pulses known as the S and Z pulses cause the group selector to open the incoming P wire. This causes the release of the L relay in the line circuit and the setting up of the P.G. fault condition. The K relay holds to the line loop (or fault). (It is worth noting here that the subscriber's line circuit is so designed that during a normal call, both L and K relays are held operated.)

P.G. Links. To simplify the location of P.G. lines, the line circuits can be isolated from the P.G. alarm relay by means of removable links. One link is provided for each 10 subscribers' lines, and one for the five trunk line relay sets. In the C unit, additional links are provided to isolate each D unit.

Pulse Release. The release circuit of the group and final selectors is such, that overheating of the rotary magnet cannot occur if a switch fails to restore owing to a mechanical defect. When release conditions are applied, the release alarm earth circuit is completed for a short period only (the combined release lags of three slow acting relays). If the switch fails to restore fully in this period a high resistance relay is introduced into the circuit to reduce the current in the rotary magnet to a safe value, and to also complete the release alarm circuit.

Line Finders. No allotters are provided and the simultaneous search of all free finders in a unit ensures a minimum finding time. The circuit is so arranged that the testing relays of two finders cannot operate in parallel to seize the same calling line. The line finders have no separate relay set but are controlled by relays mounted in the group selector relay set.

Spare Levels. Level 1, which is used for party line revertive calls, is arranged so that on the eleventh step the usual circuit to hold the A relay is omitted. When level 1 is dialled, therefore, the A relay cannot hold to the eleventh step and the switch is released. On other spare levels use is made of level springs (N.P.A. and N.P.B.). When spare levels are dialled these springs are operated by an auxiliary cam on the carriage head of the switch, and when the 11th step is reached, supply N.U. tone to the caller instead of busy tone.

The Party Line Final Selectors, which are 100 line, are provided with a fourth bank ("R") whereby the ten different code earth pulses from the code interrupter equipment, are fed to the final selector ringing circuit. This bank ("R") is multipled vertically over the ten levels as well as between switches. This means that the same code is sent to the parties on contact 1 of each level, that is 411, 421, 431 ..... 401. Likewise contact 2 of all levels would share the same code, and so on. In this way, the same 10 codes appear on each level. Thus a 4-10 party line with 10 parties would occupy one complete level (for example, 431, 432 ...... 430 for level 3). The +ve and -ve wires are commoned to form one line, either on the final selector bank or the I.D.F. blocks.

The code ringing circuit is so arranged that the ring is sent to line only at the beginning of a code cycle, and when the party answers, the ring is not tripped until the end of a code cycle. This is an attempt to avoid the calling of wrong parties owing to incomplete code rings. The ten different sequences of earth pulses are produced by a stepping uniselector in the British units, and by pulsing relays in the Australian units.

The public telephone auxiliary line circuit is designed so that when the parent exchange is called, the operator receives 12-15 seconds of ring tone on answering the call, to indicate that the call is from a public telephone.

Fault Alarms. The alarms provided, and the methods used to signal the parent exchange and to identify the type of fault, have undergone some alteration since the first A.P.O. 'C' units were installed. The fault alarms provided may be summarised as follows -

	URGENT.	NON-URGENT.
Early units	Fuse alarm Release alarm C.S.H. alarm	P.G.
Additional alarms later units (Australian manufacture).	Ring and tone fail Power fail Battery fail	N.U. alarm (ceased and unallotted lines).

Provision is made for noting and identifying alarms in one of the following ways -

(i) Urgent alarms are so arranged that the parent exchange is 'called' on a trunk line. The telephonist on answering hears a tone which serves to identify the type of alarm. The trunk line circuit restores to normal when the plug is withdrawn.

Non-urgent and urgent alarms may be detected from the parent exchange by dialling a special test number (for example, 399), the presence or absence of any alarm being notified by a distinguishing tone.

Typical tones used are -

Condition	Early units (using ringing machine).	Later units (using ring & tone relay sets).	
All Clear	Inverted ring tone	— — — — —	
Fuse Alarm	Busy tone	— — ——	
Release Alarm	Dial tone	— —— —	
C.S.H. Alarm	Continuous 400 c/s tone	— ——	Ring tone pulses
P.G. Alarm	N.U. tone	— — —	
N.U. Alarm	....	— —	
Power fail Alarm	....	—— —	
Battery Fail (or low voltage)	....	Buzzertone. (From self interrupted relay).	
Ring and Tone Fail	....	No tone.	

(ii) A modification of the above arrangement is often used on both types of C unit, as the telephonists at the parent exchange may dismiss the service tone as unimportant, particularly as the line is found clear if unplugged and answered a second time.

Any urgent alarm is extended as before, but the tone heard in every case is a single distinctive tone (6 or 5 pips of 400 c/s tone, repeated). The Technician is advised, and on dialling the test number hears the identifying tone as listed above under 'Early units'.

The test number may be dialled at any time and a routine check is perhaps the most reliable method of all.

Congestion meters are provided, and one is pulse operated at regular intervals if all link circuits in a unit become busy together. The approximate duration of congestion is thus recorded.

6. A.P.O. 40 LINE R.A.X. (TYPE B).

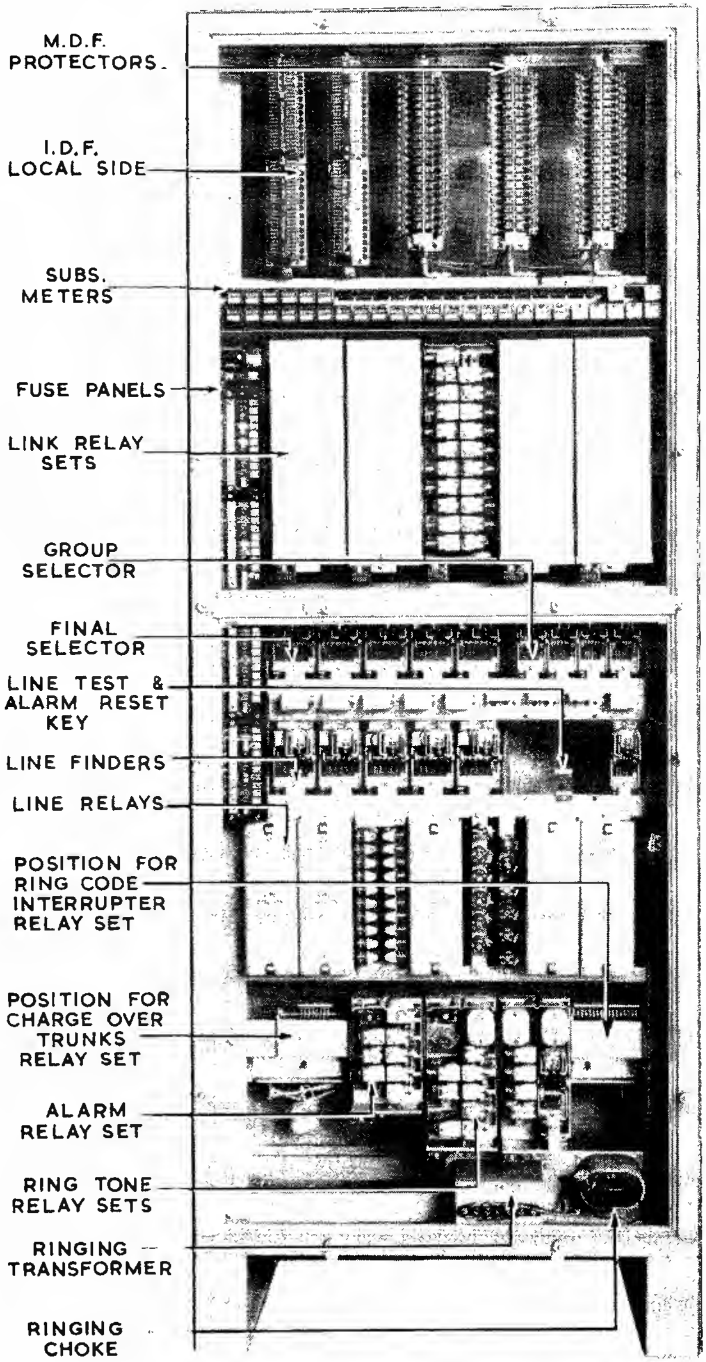
6.1 The type 'B' R.A.X. is a small non-extendable exchange designed to cater for a maximum of 40 subscribers and five trunk lines. The facilities provided are practically the same as for the Type C units, in fact as listed in Section 4.1, many of the auxiliary circuits and relay sets are identical.

The use of uniselectors simplifies the unit and reduces maintenance; the possibility of release faults in particular.

6.2 Description of the B Type Unit. The unit is contained in a dustproof steel cabinet 7' high, 2'7" wide and 1'8" deep. Fig. 8 shows the front view of the equipment.

Layout of Equipment. As will be seen, most of the equipment is fitted on the front of the unit, the rear being used for party line relay sets. Space is also provided at the rear for the addition of multi-metering relay sets.

Main Distributing Frame. At the top of the unit is the M.D.F. which has an ultimate capacity of 75 fuses (3 blocks), mounted on the rear, and 60 protectors (3 strips) mounted on the front. These M.D.F. components are not provided in the unit initially but are fitted in the required quantity when the unit is installed.



A.P.O. TYPE 'B' R.A.X. UNIT (FRONT).

FIG. 8.

Local I.D.F. The local I.D.F. is also at the top of the unit. Two terminal blocks at the rear form the 'multiple' side and serve as the terminating point for the final selector multiple, the M.D.F. cabling and the group selector multiple. Four terminal blocks on the front form the 'local' side and on them terminate the inlets to the trunk and subscribers' line circuits, and the cabling from the auxiliary circuits - party line, public telephone, charge-over-trunk, and fault test number. The I.D.F., therefore, provides flexibility of connections so that the R.A.X. may be varied, by means of I.D.F. jumpers, to accommodate as many exclusive lines, trunk lines and auxiliary circuits as required.

6.3 Equipment Provision. When installed, the unit is equipped with only sufficient relay sets to provide the required service. Fully equipped, the unit contains the following apparatus -

40 Subscriber's line circuits.
5 Party line relay sets (maximum 4/10 circuits is two).
5 Link circuits. (Each circuit consists of - a line finder, group selector, final selector, and link relay set.)
5 Trunk line circuits (plate mounted).
1 Public telephone auxiliary circuit.
1 Charge over trunk relay set.
1 Alarm relay set.
1 Code ring interrupter relay set.
1 Ring, tone and pulse circuit. (2 relay sets using vibratory relays for ring, ring tone and dial tone; valve oscillator for busy and N.U. tones; stepping uniselector to interrupt ring and tones.)

NOTE: Ten is the maximum number of parties on 2/3 and/or 4/10 party lines.

6.4 Numbering Scheme. Two digit numbering is used, the subscribers being numbered from 20-59. Exclusive services and 2-party lines normally occupy the 20-49 group while 2-3 and 4/10 party lines are placed in the the 50-59 group (exclusive services may use this group when not required for party lines).

The maximum of 5 trunk lines may be in one, two, or three groups, but trunks to any one exchange (parent or adjacent) would very rarely exceed 2. The parent exchange is raised by dialling "01", any further lines in this group being numbered 02, 03 and so on as required. Automatic hunting over all the busy trunks in the group is provided.

Adjacent manual or automatic exchanges may be included in the switching scheme, and adjacent automatic exchanges are usually in group 9 and raised by dialling "91". A second trunk in the group (92) would be selected by automatic search if 91 were busy.

An adjacent manual exchange would normally be selected by dialling "04".

As will be seen from the above the trunk switching possibilities are quite flexible up to the total of 5 trunks or junctions.

6.5 General Operation. Fig. 9 is the trunking diagram of the A.P.O. type 'B' R.A.X.

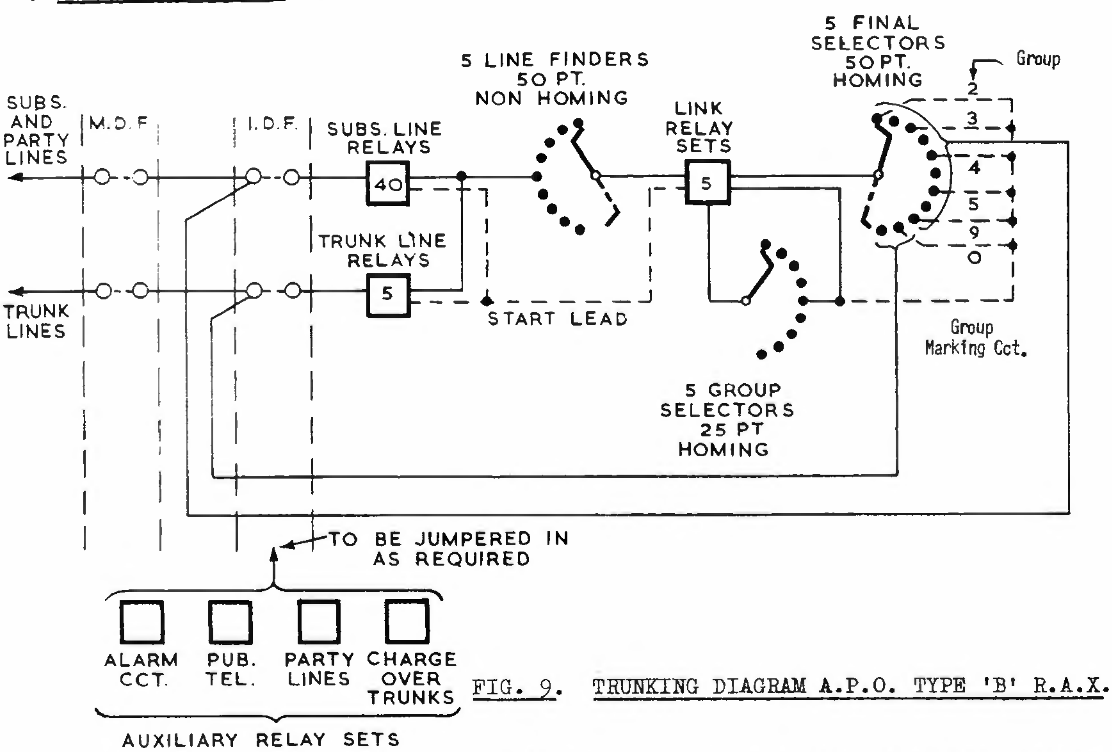


FIG. 9. TRUNKING DIAGRAM A.P.O. TYPE 'B' R.A.X.

Each link circuit includes a line finder, a group selector and a final selector.

The group selector is unlike the usual group selector in that, it has no +, - and P wipers and the speaking circuit by-passes it altogether. Its principal function is group marking of the final selector bank.

Local Call. The calling subscriber is switched to the link circuit by the first free line finder to test into the calling line. Dial tone is returned to the caller. The first digit (2, 3, 4 or 5) is dialled, and the group selector steps under the control of the impulses received. This results in one of the final selector banks being 'marked' one contact before the beginning of the group dialled; the final selector then self drives to this marked contact. The second digit is dialled and the final selector steps to the wanted line under the control of these impulses. At this stage the link circuit performs the normal final selector functions (testing, ringing, metering, etc.).

Trunk or junction calls are set up in a similar manner; when '0' or '9' is the first digit dialled, the link circuit is changed to function as an auto-manual, or auto-auto repeater, as required.

This operation will be more readily understood by reference to Fig. 10 which shows the allocation of the final selector outlets, and the relation of the group marking contacts to the separate 'tens' groups.

F/S OUTLET	ALLOCATION
1	HOME OR 20 GP. MARK
2	SUB. 21
3	22
4	23
5	24
6	25
7	26
8	27
9	28
10	29
11	SUB. 20 OR 30 GP. MARK
12	SUB. 31
13	32
14	33
15	34
16	35
17	36
18	37
19	38
20	39
21	SUB. 30 OR 40 GP. MARK
22	SUB. 41
23	42
24	43
25	44

F/S OUTLET	ALLOCATION	
26		SUB. 45
27		46
28		47
29		48
30		49
31		SUB. 40 OR 50 GP. MARK
32		SUB. 51
33		52
34		53
35		54
36		55
37		56
38		57
39		58
40		59
41		50
42	FLEXIBLE. STRAPPED AS REQUIRED	9 GP. MARK
43		TK. 91
44		TK. 92
45		O/F METER.
46		"O" GROUP MARK
47		TK. 01
48		TK. 02
49		O/F METER
50		TK. 04

Examples: (i) Call to sub. 25. '2' dialled; F/S does not drive. '5' dialled; F/S steps to outlet 6 (sub. 25).

(ii) Call to sub. 40. '4' dialled; F/S self drives to outlet 21. '0' dialled; F/S steps to outlet 31.

(iii) Call to parent exchange. '0' dialled; F/S drives to 46. '1' dialled; F/S steps to outlet 47. If 1st line busy F/S self drives to outlet 48 (02). If 2nd line also busy F/S drives to outlet 49 - overflow meter operated.

FIG. 10.

Calls to Party Lines. For parties 51-50 the ten code earth pulses are fed to the link circuit via an auxiliary bank of the final selector, the ringing circuit being altered to transmit the code ring determined by the last digit dialled.

Auxiliary circuits for party line, public telephone, charge-over-trunk, ring code interrupter, lockout of P.G. lines, P.G. isolating links, and fault test number function in a similar way to those in the C units. Provision is not normally made for extension of alarms to the parent exchange, but a circuit to enable this is sometimes added.

7. POWER SUPPLY FOR R.A.Xs.

7.1 While the equipment will operate satisfactorily between potentials of 46 and 60 volts, it should for preference be kept within fairly narrow limits.

Continuity of electrical power is essential and the methods of maintaining the supply vary according to local conditions. In all cases at least one battery is provided and in areas where commercial power is either unreliable or unavailable, 2 batteries may be installed. The consumption of a B type unit is approximately 6 ampere hours per day, and for a fully equipped C plus D installation, it may be 20 ampere hours per day.

7.2 When the local power is A.C., one enclosed type battery is used; generally eight 6 volt batteries of approximately 100 ampere hours. A constant potential rectifier having automatic voltage regulation ("Transrector" or similar) is connected to the unit with the battery floating. This unit increases its output to a maximum for heavy load periods and reduces the output to a trickle charge during periods of no load. Under ideal conditions the battery is maintained between 51.6 and 55.2 V, and refresher charges are not necessary. Many of the rectifiers may be switched to manual control or "gassing", if an overcharge becomes necessary following a prolonged failure of the commercial supply.

If the A.C. power mains are some distance away, the rectifier is sometimes mounted on a pole and a 2 wire D.C. charge lead to the R.A.X. provided on an aerial route. The charge lead may in certain cases be provided between the R.A.X. and the parent exchange. This is distinct from charging over the trunk line, although the charge lead may be readily used as an additional trunk line when commercial power becomes available at the R.A.X.

7.3 When the local power is D.C., two batteries are provided, one being charged while the other supplies the load. The charge is limited to the correct value by means of series resistances. This method is now very rarely used.

7.4 When local power is not available the alternatives which may be used are -

Charging over trunk lines.

A wind driven generator.

A petrol or diesel electric generator set.

Transporting charged batteries from a station having a commercial power supply.

Each method has its disadvantages so that the method adopted in a particular case depends on the existing conditions. In some cases, 2 sets of batteries are provided (or a larger capacity battery).

Charging Over a Trunk Line. With this method, a rectifier is provided at the parent exchange, and with the 'charge' key operated, charging current is automatically connected when the line is not in use, and automatically disconnected if it is seized from either end.

The voltage drop in the line is appreciable, so the output voltage of the rectifier is determined by the charging current required, and the line resistance. Voltages up to 150 V are used. Usually the charge is connected earth return with the two line wires in parallel. Serious electrolysis of underground cables can occur if a sufficiently low resistance earth is not obtained. For this reason a metallic circuit charge over the trunk is sometimes used. With a busy R.A.X. the charging time on the trunk may be insufficient to maintain the battery in a charged state. To overcome this, a modification of the scheme is sometimes used (mainly in N.S.W.) whereby the charge is not interrupted by calls on the trunk. A cailho circuit carries the charging current, while dialling into the R.A.X. is done by means of low frequenty A.C. impulses (100 c/s).

Wind Driven Generator. A three bladed variable pitch propellor geared to a D.C. generator, is mounted on a steel mast adjacent to the R.A.X. (see Fig. 11.) Many of these are in use where wind conditions are suitable (particularly in S.A. and Victoria).

The generator must produce a suitable charging current under varying wind conditions; therefore to avoid excessive output, its speed of rotation must be controlled during high winds. This control is by a governor attached to the shaft, which, according to the wind velocity, varies the angle (pitch) that the blades offer to the wind. The variation is such that no increase of propellor speeds (or output) occurs with winds over 20 m.p.h. The output of the generator can be varied by changing the position of the tail in relation to the blades; a hand lever allows this to be done and also can be used to stop the propellor.

A rectifier in series with the charge lead prevents a reverse current when the generator voltage falls below that of the battery. Originally a cut-out relay was used for this purpose.

Two batteries are connected in parallel to give a greater reserve during periods of little or no wind.

Motor Generator Sets. Development of reliable methods of automatic or remote control, has now made this method preferable in many cases, to charging over the trunk or the use of wind driven generators.

TYPICAL WIND DRIVEN GENERATOR INSTALLATION.

FIG. 11.

The petrol or diesel electric set is mounted on a concrete base a short distance from the R.A.X. building and protected by a well ventilated but weatherproof housing. A 2-3 H.P. four stroke engine, water cooled by means of a tank and with fuel capacity sufficient for a total running time of about 24 hours is generally used. The engine may be started and stopped from a control panel in the R.A.X., or by dialling a special number from the parent exchange and then operating "start" or "stop" keys in the control circuit. In the latter case supervision is by means of tones to determine whether the motor has started (or stopped), and the generator is charging.

Automatic start and stop, under control of the battery voltage or ampere-hour discharge, has been successfully tried. The remote control method, however, is more widely used.

The generator has an additional field winding (series) and is used as a motor operating from the battery in order to start the engine. Cranking ceases if the engine does not run in a reasonable time.

Transporting charged batteries from a station having a commercial power supply is a costly and cumbersome method, and is now rarely used except perhaps as a temporary expedient.

8. EARLY TYPES OF R.A.X.

8.1 The R.A.Xs. installed in Australia before the introduction of the standard A.P.O. units were supplied by the following -

Automatic Electric Co. (A.E.C.)

British General Electric Co. (G.E.C.)

Messrs. Siemens Bros. and Co.

Standard Telephones and Cables Pty. Ltd. (S.T.C.)

The methods used by these firms, to provide the various R.A.X. facilities, differed from each other in many respects, including the circuit arrangements and the items of equipment used to perform the various functions. No further purchases of these types will be made.

8.2 A.E.C. Type R.A.X. The trunking of the A.E.C. Unit is in Fig. 12. Uniselectors (50 point) are used as line finders. In B types, 100 point final selectors are used, but in C and D types (to avoid the use of group selectors) 200 point final selectors are used. The allotter is called the assigner in these types. The number of connecting circuits is usually 5 or 6 per 50 lines.

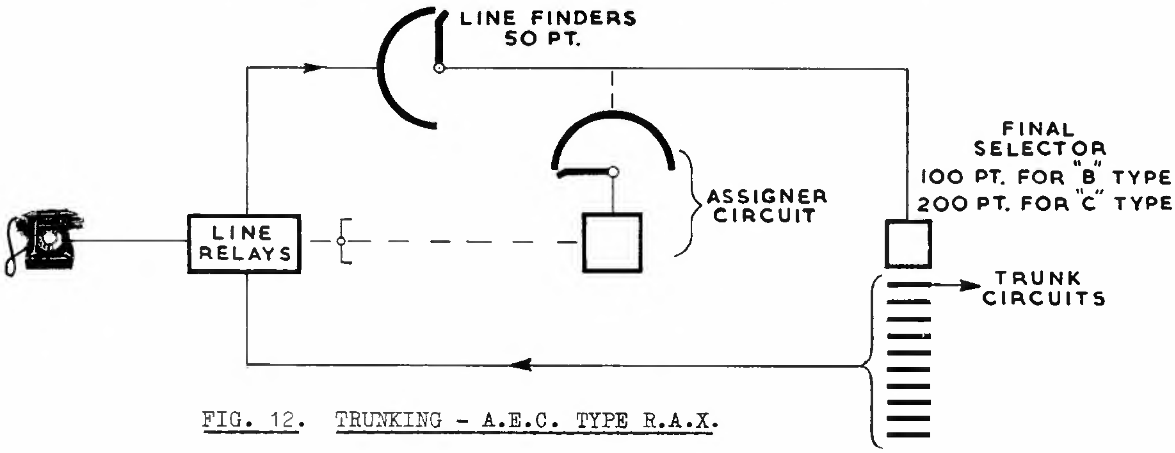


FIG. 12. TRUNKING - A.E.C. TYPE R.A.X.

8.3 G.E.C. Type R.A.X. The G.E.C. Unit employs similar trunking to the A.E.C. Unit, except that on the C and D types both group and final selectors are used. These switches are both 100 point. The use of group selectors allows the trunk circuits and special circuits to be additional to the 200 subscribers' lines and also allows extension beyond 200 lines. The trunking diagram of the G.E.C. Unit is shown in Fig. 13.

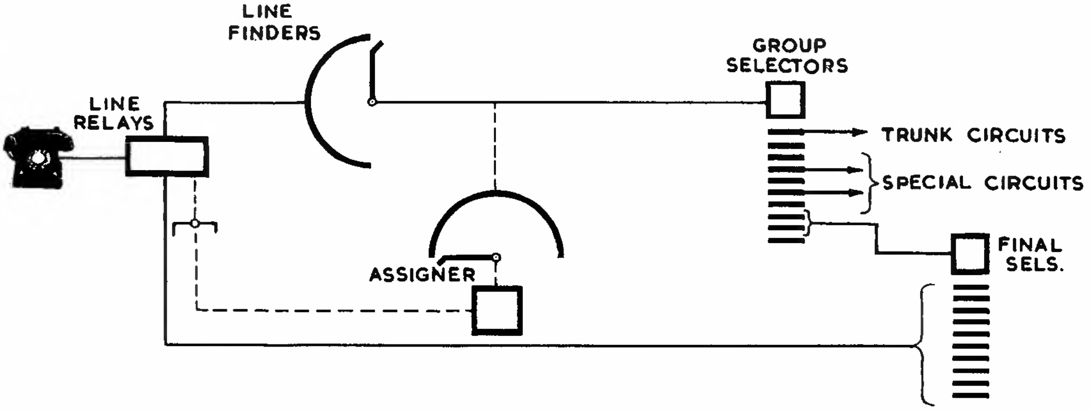
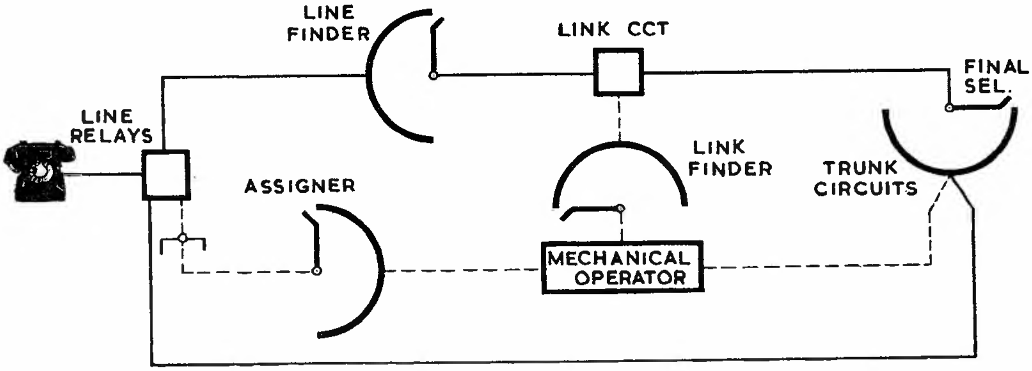


FIG. 13. TRUNKING - G.E.C. TYPE R.A.X.

8.4 Siemens and S.T.C. R.A.Xs. (B Type). These systems differ in that use is made of apparatus called a "Mechanical Operator" or "Controller". This is an assembly of uniselectors and relays, which receives particulars of the call and establishes the connection. The operator or controller then frees itself to undertake similar functions for the next call. Only 2 or 3 of these units are included in an installation, the number being determined by the amount of switching to be performed. The trunking diagram of this system is in Fig. 14.

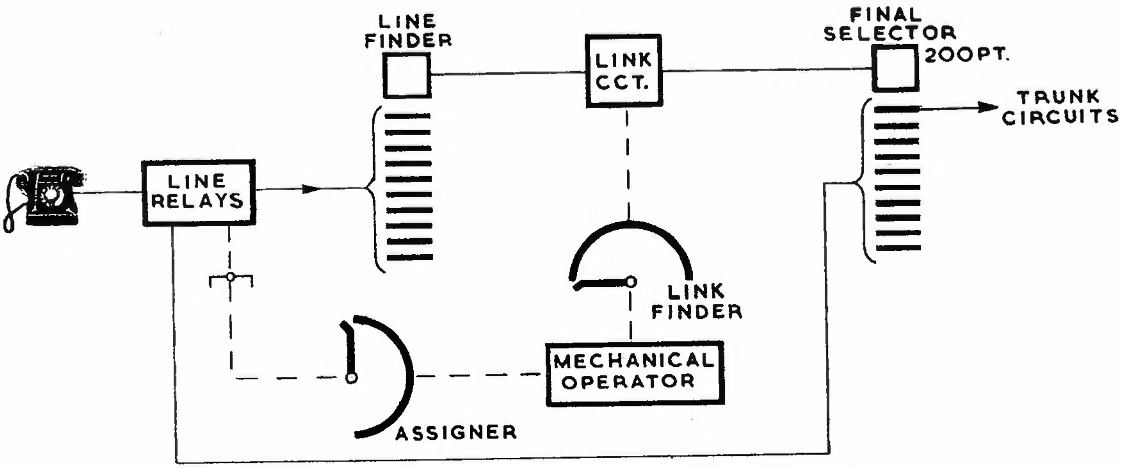


TRUNKING - SIEMENS AND S.T.C. UNIT R.A.X. (TYPE B).

FIG. 14.

An incoming call operates the relative line relays causing the assigner to seize a preselected mechanical operator. The mechanical operator, in turn, starts an associated link finder searching for a free link circuit, each of which connects a line finder to a final selector. The line finder finds the calling line and dial tone is given from the mechanical operator, the assigner circuit being disconnected. The dialling impulses are received in the mechanical operator and set uniselectors which mark a contact in the bank of the final selector (which is a uniselector). The final selector operates to find the marked contact, and thus connects the calling line to the called line.

8.5 Siemens and S.T.C. R.A.Xs. (C and D Types). In the C and D types of these R.A.Xs. the line finder and final selectors are bimotional switches as in Fig. 15.



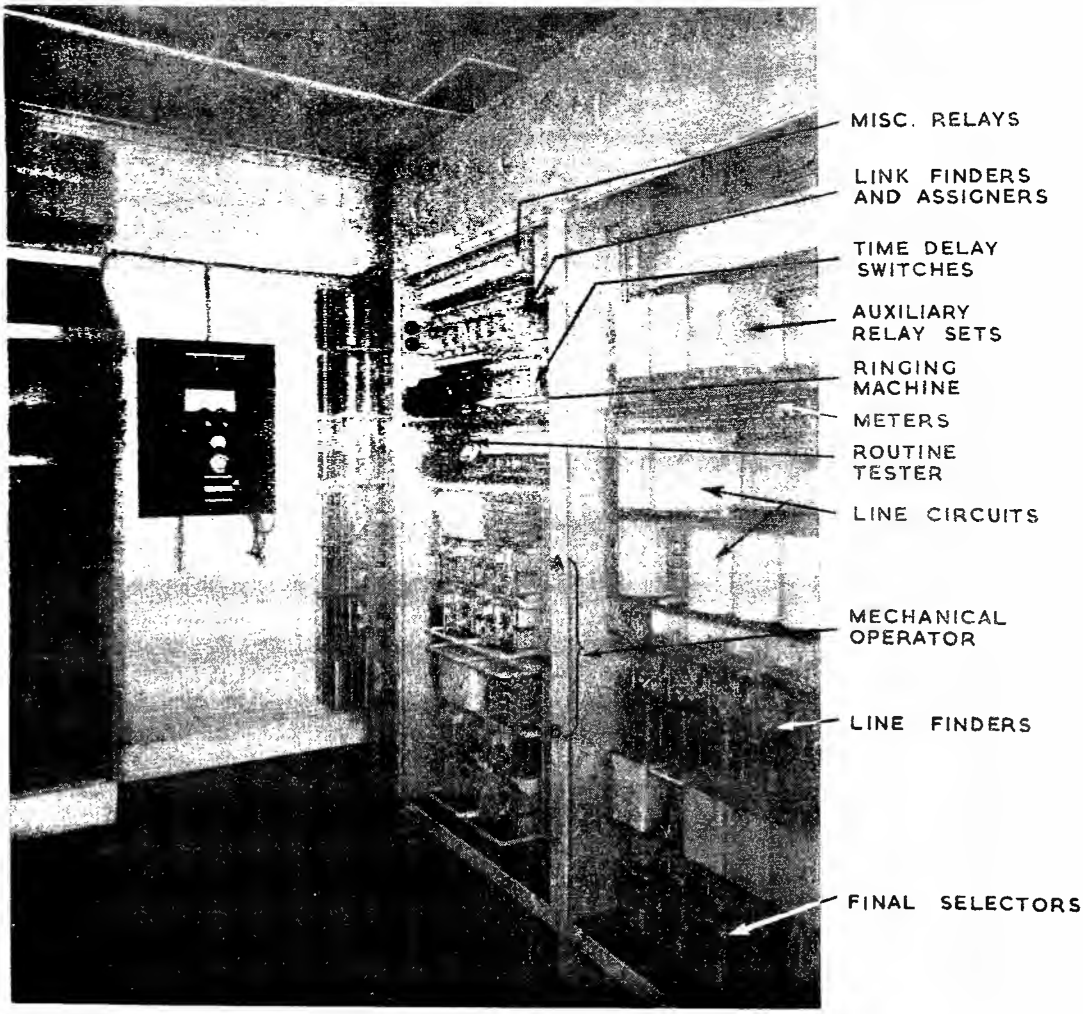
TRUNKING - SIEMENS AND S.T.C. UNIT R.A.X. (C AND D TYPES).

FIG. 15.

A call from a subscriber connected to this type of unit takes a route similar to that followed by a call through a B Type unit, except that the incoming pulses direct the 200 point final selector to the called line. At the same time, however, switches are set in the mechanical operator for discriminating on trunk circuits, public telephones, party lines, multi-office circuits, battery control, etc. Fig. 16 shows an R.A.X. of this type which includes two mechanical operators.

The mechanical operator also transmits ringing and tones, code calling on party lines or multi-office trunk circuits and supplies the metering pulse when the called subscriber answers. It then releases, to be available for further use, and the connection is maintained via the simple link circuit.

The system has the advantage of confining several switching functions to the common group of mechanical operators, but their disadvantage is that being common equipment, their failure results in the failure of the connecting circuits.



SIEMENS TYPE R.A.X.

FIG. 16.

9. FUTURE TRENDS.

9.1 Crossbar R.A.Xs. have been used in Australia and found successful. The inherent reliability and small space requirements of a crossbar system make it very suitable for R.A.Xs. More crossbar R.A.Xs. will be used in the future.

9.2 Remote testing and busying, are from past experience deemed to be desirable facilities. Where provided on occasions, remote testing of subscribers' lines has saved the Technicians and Linemen a considerable amount of travelling. A relatively simple remote test set will shortly be standardised for A.P.O. units, and provide facilities for testing subscribers' and trunk lines from the parent exchange. The same circuit may also include facilities to enable remote busying of trunk or junction lines, and 1st choice final selectors.

9.3 Multi-metering facilities will be provided in due course to enable the R.A.X. subscriber to be automatically switched beyond the unit fee boundaries. The standard A.P.O. Type B and C units have been designed with this end in view, and as can be seen in Fig. 7b, relay set cradles are provided and wired for the multi-metering relay sets. However, the type of multi-metering originally proposed is not likely to be used and some alteration will therefore become necessary to existing R.A.Xs. to suit nation-wide switching developments.

10. TEST QUESTIONS.

1. Name the types of services which are catered for by special R.A.X. line circuits.

2. How are special line circuits associated with both the line and switching equipment in A.P.O. R.A.Xs?

3. State the chief difference between the ordinary subscribers' line circuits of an R.A.X. and a metropolitan automatic exchange.

4. What is the usual numbering scheme for a type 'C' R.A.X?

5. Draw a trunking diagram of an A.P.O. Type 'C' R.A.X. and briefly describe the action of the equipment for a call from a subscriber to the parent exchange.

6. List the main items of equipment you would expect to see at an A.P.O. R.A.X. serving 130 subscribers.

7. What is the result of eliminating allotters from R.A.Xs?

8. Draw the trunking diagram of an A.P.O. Type 'B' R.A.X. and describe the action of the equipment for a local call.

9. Describe how a subscriber on an R.A.X. party line calls another party on the same line. Include the action of the exchange equipment.

10. How are permanent loop faults prevented from holding R.A.X. switching equipment?

11. Describe briefly two methods used to supply ring and tones for R.A.Xs.

12. What determines the ring code sent to a subscriber on an R.A.X. party line having three parties?

13. How is the parent exchange telephonist made aware that a call is from a public telephone?

14. Describe one of the methods used to bring alarm fault conditions at an R.A.X. to the notice of the Technician.

15. Describe one method of maintaining the power supply at an R.A.X. which is remote from any source of commercial power.

END OF PAPER.