Buyer

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CONTENTS

THE POSTAL ELECTRICAL SOCIETY OF VICTORIA

INFORMATION SECTION

SWITCHBOARD LAMPS, NO. 2

Small incandescent lamps were used overseas for signalling purposes in telephone switchboards installed as early as 1894. During the following years, several different designs of lamps were developed with various methods of mounting, but gradually all but the No. 2 type, as illustrated in Fig. 1, were abandoned. Although there are a number of lamps available for use with various voltages they all are of the same shape and size, and have the same external design.

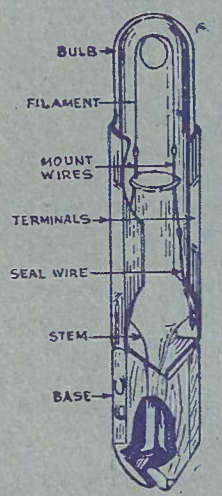

Fig. 1.
Switchboard lamp, No. 2, U.S.A. design.

It is important that the users of switchboard lamps should realise the exact requirements of circuits associated with switchboard lamps so that the correct type of lamp is selected for each particular use. For example, in a switchboard, other apparatus may be associated with the lamp and consequently the characteristics of the lamp affect the operation of this other apparatus.

The chief requirements to be met in the design of switchboard lamps are:—

(a) The lamp should give a satisfactory signal, i.e., glow perceptibly, at low voltage.
(b) The lamp should not produce objectionable glare at higher voltages.
(c) The current consumption should be low.
(d) The external dimensions should be as small as practicable.
(e) The lamp should have long life and should be sufficiently sturdy in construction to withstand normal packing and transport conditions.
(f) In certain designs the lamp must function on a current within certain limits so that any associated apparatus will function correctly.

All switchboard lamps of early design had carbon filaments, but latterly there has been a trend to replace the carbon filament by a tungsten filament. Switchboard lamps of both types are used extensively in the Australian telephone network. For certain telephone purposes the characteristics of a carbon filament are required, while for others the use of tungsten is desirable. During the past years the use of tungsten switchboard lamps has been increasing and for some purposes carbon lamps are being superseded.

The filament of a carbon lamp is attached at the ends of two straight mount wires which are supported by the inner glass structure of the lamp. These mount wires, in turn, are welded at the other end, to two seal wires which extend through the glass bulb and are either soldered or welded to the inside surface of the terminals. There are four different filaments or shapes of filament used for carbon lamps, viz., the loop or U, the single, double or triple loops. The type used depends on the length and diameter of the filament required for the particular characteristics desired, but in all cases the filament is stiff enough to require support only at the ends where it is fastened to the mount wires.

The specific resistance of tungsten is much lower than that of carbon so that for lamps of the same current and voltage rating, a filament both smaller in diameter and greater in length is necessary when the tungsten is used. To get a length of filament in the lamp sufficient to give the required resistance it has been found necessary to wind the filament in a form of a helix. Even then it is difficult at times to get a sufficient length into the bulb. The helix is formed by winding fine tungsten wire on a steel mandrel with a diameter of from .0025" to .014", depending upon the type of lamp. Following this the mandrel is cut into lengths that will give the desired number of turns in the helix and is placed in acid which dissolves the steel and leaves the helix of tungsten wire. The filament is wound on the mandrel at high speed and the delicacy of the operation can be appreciated only when it is observed through a microscope. After the removal of the mandrel the filament is clamped or welded to the ends of the mount wire. In some rated lamps the filament is short enough not to require additional supports, but for higher voltages one or two anchor wires are required to support the greater length of helix.

For switchboard signalling purposes the only part of the light from the lamp that is useful is that which falls on the rear surface of the glass cap ordinarily placed in front of the bulb. This is termed "end illumination" of the lamp and is the average illumination in foot candles on a plane surface 0.28" in diameter touching the end of the bulb and perpendicular to the axis of the lamp. For convenience the term "end illumination in foot candles" is contracted to "end foot candles."

Since carbon has a negative temperature-resistance co-efficient while that of tungsten is positive, the characteristics of the two types of lamps are quite different. A tungsten lamp of the same voltage and current rating as a carbon lamp usually gives a satisfactory signal at a lower voltage, and withstands over-voltage better. Also the resistance of the tungsten lamp when cold is only a fraction of that of a carbon lamp of the same voltage and current rating. When voltage is first applied, therefore, a momentary surge of current flows in a tungsten lamp which causes it to reach normal brilliance quicker than would a carbon lamp under the same conditions. The quicker response of the tungsten lamp gives a better "flashing" characteristic than the carbon lamp so that its use is more desirable under certain circuit conditions.

Under other conditions where the lamp is shunted with a resistance, the positive temperature coefficient of tungsten is a disadvantage, because its resistance falls with decrease in temperature. The glow of a tungsten filament will not decrease sufficiently when placed in a circuit designed for a similarly rated carbon lamp, for example, in a C.B. cord circuit the lamp is shunted at a certain stage of operation by a $83\frac{1}{3}$ ohm resistance. In this connection a carbon filament lamp is better than a tungsten filament lamp. Also the effect of the initial surge of current in a tungsten lamp may be more severe on the contacts of the control relays.

The necessity to use tungsten filament lamps on P.B.X. switchboards arose because under certain conditions of power supply it is possible that the lamp will not receive sufficient voltage to give satisfactory signals. It was found practicable to develop a tungsten lamp which will meet both minimum and maximum voltage conditions satisfactorily. As a result, the tungsten lamp will replace the carbon lamp to a large extent for this type of service.

(Continued on Cover iii.)

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THE ERECTION OF LONG POLES

J. A. Kyne

The erection of poles varying in length from 50 ft. to 110 ft. for service installations has introduced the telephone engineer to methods of erection of which previously he has had little experience. In some instances poles were erected on channel iron footings, with or without pivot pins, but in more urgent cases the poles were erected direct in ground. In this article methods used are described, and illustrated with photographs of the actual work.

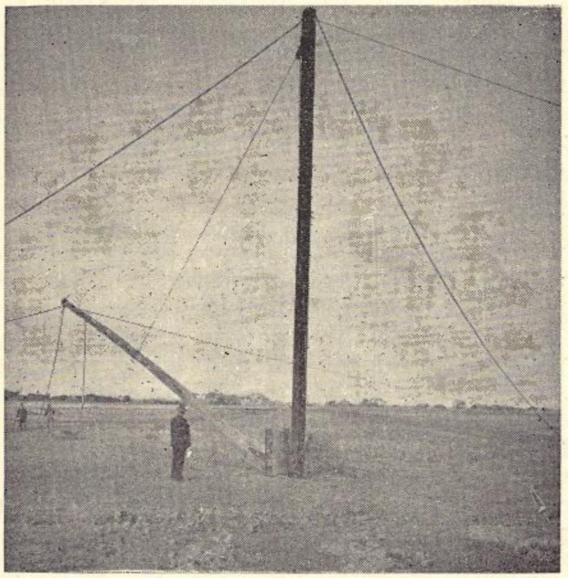


Fig. 1.—Standing Jury.

Standing Jury.—An oregon beam 10 ins. x 10 ins. and 40 ft. in length is erected using a truck fitted with derrick and winch, in a hole approximately 1 ft. 6 ins. in depth, at the rear of the main hole or footing, and held in position with three guys. One guy of $\frac{3}{4}$ in. wire rope is directly behind the jury to withstand the lifting strain; the other two of 4 in. manilla rope are spaced at approximately 120 degrees to hold the jury in position prior to lifting and to prevent side movement of the jury during lifting. A $\frac{3}{4}$ in. diameter wire rope from the winch truck is then taken through 6 in. snatch blocks at the foot and head of the jury and attached to the main pole. It is not necessary to use the snatch block at the foot of the pole if a direct pull along the line of the main pole is possible. Where channel iron footings are used, the point of attachment of the winch rope to the main pole is approximately 40 ft. from the butt of the pole, but if the pole is to be erected in the ground the distance has to be increased by the depth of the hole. On the main pole, side, fore and aft guys are fitted, the side guys with luff tackles being kept taut, and adjusted when necessary during erection, to keep the pole in a vertical plane.

Fig. 2 shows the setting up of a channel iron footing preparatory to pouring the concrete. A pivoting pin is not used in this instance and a shaped plate formed from $\frac{1}{4}$ in. boiler plate is used to hold the butt of the pole in position. This plate is attached to the footing by four $\frac{3}{4}$ in.

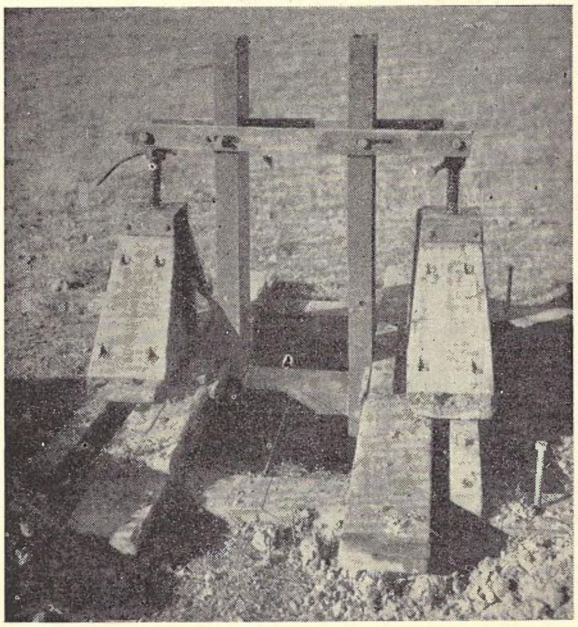


Fig. 2.—Channel Iron Footing for Poles.

bolts. The spacing between the centre of the footing and the plate can be varied by means of these bolts so that centre of the butt of the pole when erected corresponds with centre of the footing. The footing is anchored against the pull to prevent any tendency to move. The lower snatch block is held to the jury by means of a $\frac{5}{8}$ in. link pole chain, and the upper block by a wire rope strop. The use of strops rather than chains is recommended. Eye splices on the ends of winch ropes and wire rope strops, together with D shackles, enable attachments to poles to be made quickly and easily. In practice, two turns of rope are taken round the pole before fitting the shackle. Where rope guys are comparatively short, single timber hitches or bowline knots are used for attaching guys to poles. If the ropes in use are in one length and are sufficiently long to provide two guys, the rope can be given one clove hitch near its mid-point and these hitches then placed over the top of the pole and tightened. The snatch blocks in use have steel cheeks which are shrouded to protect the wire rope and prevent it from jamming.

Falling Mast.—A quadrant shaped hole is required in this instance. A small round pole is

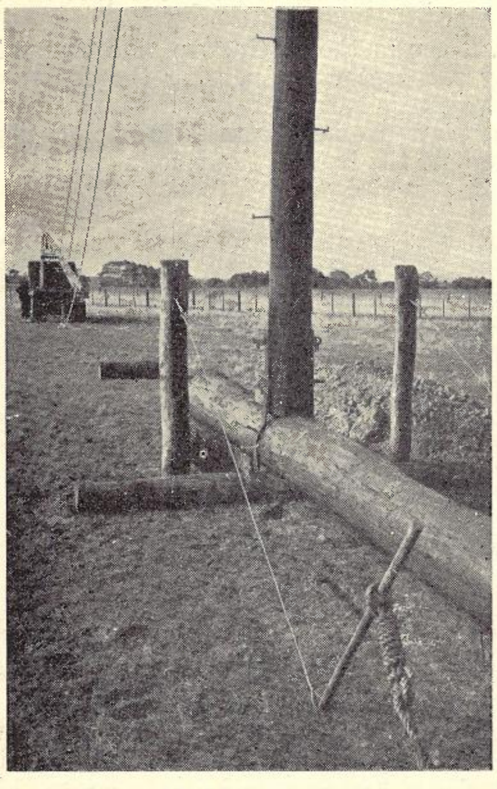


Fig. 3.—Fitting of Poles for Falling Mast Method of Erection.

set across the rear of the hole, generally upon two strips of boiler plate, and the main pole is then placed in position across the hole and at right angles to the smaller or pivot pole. Using a derrick truck, a 35 ft. round pole, fitted with pole steps, is then placed upright on top of the main pole at the point at which it rests on the pivot pole, and is clamped to the latter pole. The two clamps are from 4 in. x $\frac{3}{4}$ in. mild steel bar, and are bolted with 1 in. bolts to the falling mast and pivot pole. Fox wedges are inserted at base to take up any slackness in the fittings.

This upright pole, or falling mast, is set back in the head slightly and then attached to one or more points on the main pole with wire rope. The ropes are then strained up tightly with tramway clips and after two turns round the main pole are held with wire rope clips. This slight set back in the head of the falling mast is given to ensure that when the head of the mast ultimately approaches ground level the main pole will have arrived at the vertical position. On ground rising in the direction of pull, a greater set back will be necessary. Forward movement of the main pole is prevented by stayed stub poles in front of the pivot pole, and pole steps in the main pole just above the clamps.

The winch rope is taken from the chassis member of the winch truck through a 6 in. snatch block at the head of the falling mast to the drum of the winch. As the winch rope is wound up the falling mast is drawn down and the main pole lifted. When the main pole nears the vertical position the weight of the falling mast takes control of the lifting and men on aft guy ease out this guy until the vertical position is reached.

With the main pole in the vertical position, pole steps just above the clamps are removed and in some cases clamps slackened off until the pole drops to the bottom of the hole. It should never be necessary for this drop to exceed 6 inches. Rope guys are made off and while permanent stays are being fitted, the falling mast gear is dismantled and the hole filled.

Fig. 3 shows details of the clamping arrangement. Permanent terminations on 7/14 stay wires from the stub poles save time and the chock on which the falling mast is to rest, facilitates removal of the mast to the next job.

Fig. 4 shows in particular the side guys on the falling mast. These are terminated before lifting commences, with two turns around the bar, and half hitches and remain fixed. Luff tackles, 4 in. double and treble blocks, with 2 in. rope, are in use on the side guys to keep the butt of the main pole clear of the sides of the hole. One side guy rope from the main pole is being released slightly but locks on itself once the slack is given out by the luff tackle. This tackle is attached to the main side guys by plaited rope stoppers or selvage strops. The bars used are $1\frac{1}{8}$ in. steel 6 feet in length. On two of these bars rings are fitted to take one end of the luff tackle.

Poles can be erected on footings with this method by simply setting up the falling mast in a small hole abutting the concrete of the footing, and then proceeding as described above. Alternatively, a special fitting for attachment to

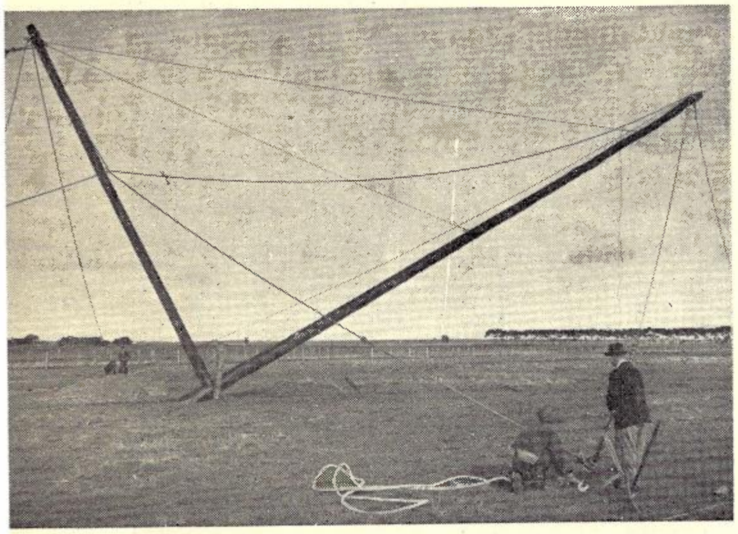


Fig. 4.—Falling Mast Method of Erection.

the channel irons and to a pivot pin through the foot of the falling mast can be assembled.

Two Trucks Method.—The fitting up of any type of jury pole takes considerably longer than the actual lifting of the main pole. With the advent of a second winch truck, a new method was evolved. The hoist from one truck is attached to the pole just above its point of balance and the pole at that point lifted to the height of the derrick, 25 feet in this case. The second winch truck pulling in the line of the pole takes up the slack on its winch rope, as the

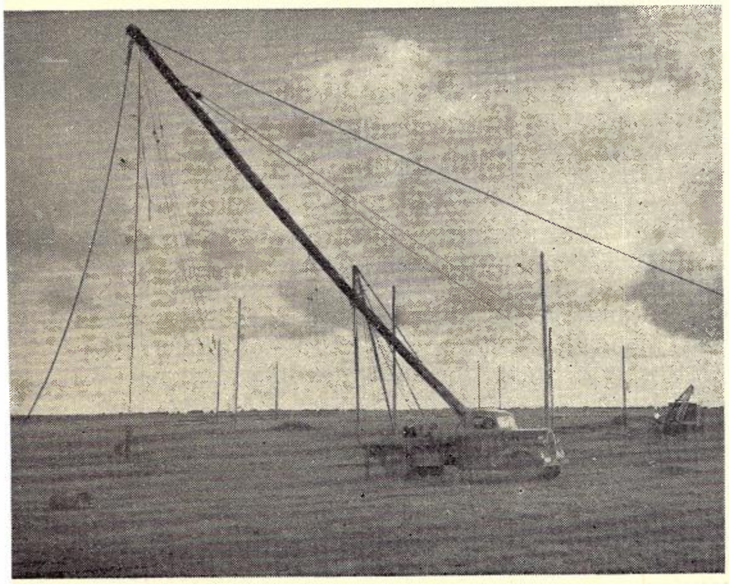


Fig. 5.—Two Trucks Method.

first truck lifts, then takes over and completes the lift.

To release the first truck, the hook of the hoist on the first truck is held down as the second winch truck takes over, allowing the wire rope strop to be lifted clear of the hook. Obviously this hook cannot be moused but as the lift is a direct one there is no danger involved. With this exception all hooks in all cases used are moused. The first truck is prevented from tipping upward by struts at the rear. Rope guys on the pole are similar to those previously described. Bagging at the head of the pole is used to prevent the ropes coming in contact with wet sap.

Fig. 6 shows a 70 ft. pole in position on the footing. Stays terminate in eye-bolts and lugs, and the butt of the pole is held with clamps formed from 2 in. x $\frac{1}{4}$ in. M.S. plate. The butt is also bound with 400 lb. G.I. wire to prevent

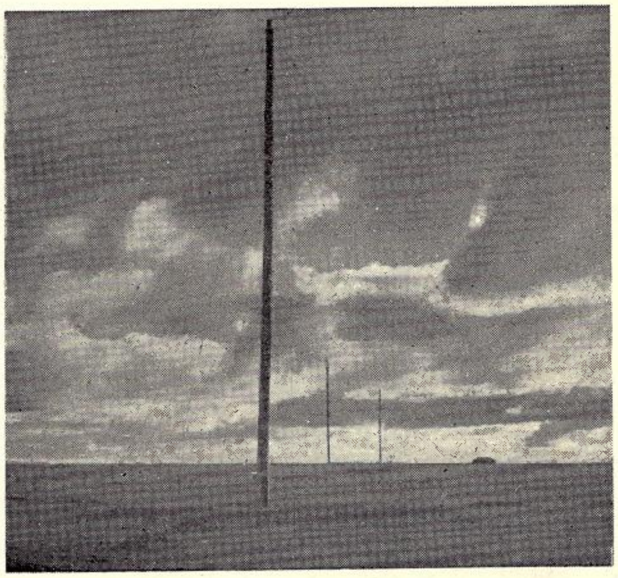


Fig. 6.—Permanent Staying of a Pole.

splitting, and the concrete of the footing is raised sufficiently to ensure that water does not lodge at the foot of the pole. A $\frac{1}{4}$ in. M.S. cap, as used by the State Electricity Commission of Victoria, is fitted to the top of the pole to prevent splitting and decay. Holes for pole steps are bored with a pneumatic wood drill.

Poles are mostly messmate (E. obliqua), white stringybark (E. eugenoides) or yellow stringybark (E. muelleriana), the biggest a 110 ft. messmate being 3 ft. in diameter at the base and 1 ft. at the top, and approximately 7 tons in weight.

Poles are completely creosoted if sufficient time is available between delivery and erection for the creosote to dry, climbing hazards being increased unless the creosote is dry. All butts are creosoted and the ground in holes well puddled with creosote.

In practice it was found to be more convenient to use bars frapped together with 2 in. rope for the temporary guys, the stay rods being free from encumbrance which facilitated the termination of the permanent stays.

The Use of Sheer Legs (Figs. 7 and 8).—This method is preferred by The State Electricity Commission of Victoria for lifting poles up to 70 feet in length. The sheer legs of 6 ins. x 4 ins. oregon are 20 feet in length and are joined together at an acute angle.

The legs are placed in position astride the pole with the feet approximatly one-third of the length of the pole from the hole. A short length of wire rope is terminated on the pole just above the point of balance, taken through a slot at the head of the V frame and connected by a D shackle to the main winch rope. Two metallic stoppers, or tramway clips, are fitted to the short rope and prevent it from pulling through the slot. Consequently, as the winch rope is tightened the sheers are lifted until the short length of rope becomes taut. The pole moves into the hole and then upward as the top of the sheers rises.

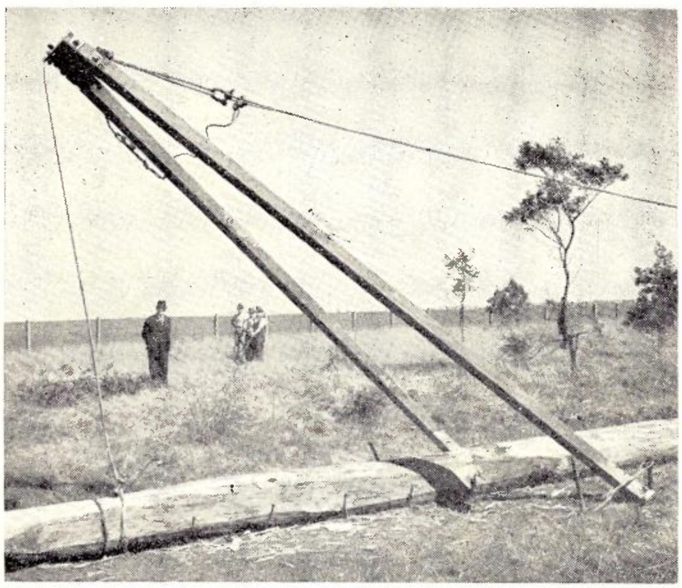


Fig. 7.—Sheer Legs Method—Preliminary Stage of Erection.

Fig. 7 illustrates the first stage in erection.

As the pole is lifted further, the sheers rise to the vertical and then commence to travel downward until a position is reached where the short rope and main winch rope are in one line. At this stage the sheers fall away and the winch truck completes the lift by a direct pull.

Fig. 8 shows the final stage of the lifting. To prevent damage to the sheers they are not allowed to fall directly to ground; a short length of wire rope and D shackle holds the frame to the winch rope. Side and rear guys are in use but as the winch truck remained in position in this case until the permanent stays are completed, no fore

Fig. 8.—Sheer Legs Method—Final Stage of Erection.

guy is in use. Donald strainers are generally used to tighten up the permanent stays prior to making terminations.

The winch truck on this job is anchored by means of the tractor coupled ahead. When the tractor or other heavy equipment is not available it is necessary, in all methods described, to securely anchor the winch truck with bars and guys ahead of the truck and chocks placed under the wheels.

Comparison of Methods.—The relative merits of the various methods are rather difficult to decide, as factors to be considered are length and type of pole and location in which pole is to be erected. Sites have varied from open paddocks to the rose garden of a suburban home. A market garden was a decidedly popular choice in some respects and a site for a future "bluestone" quarry not quite as well favoured. The most difficult sinking was at a foreshore site where close timbering and pumping were necessary. In restricted areas, the standing jury method is often the only possible choice. For poles up to 90 ft., the two truck method is quick and economical. With one truck only, sheer legs are probably most suitable, but for longer poles, especially if they are springy, or for fabricated masts the falling mast method is preferred. With two winch trucks and a double set of ropes available, four 110 ft. poles were erected in one day with the falling mast method, whilst the best effort for one day with the two truck method was seven 80-ft. poles. Actual lifting time with any method rarely exceeded 3 minutes. Considerable time is spent preparatory to the lifting in fitting up pole and gear and, within limits, any reduction in the amount of gear used will usually mean a reduction in the actual time taken to complete the task.

Good, firm direction of staff is essential otherwise there can be considerable wastage of effort. No unnecessary risks, such as standing or walking beneath a suspended pole should be permitted. Excluding men engaged on pole sinking the staff employed on the most extensive work consisted of approximately 10 ex-trainee linesmen and 20 older men. A few of the older men and all of the younger linemen worked with quiet confidence on the top of the poles. That all works were completed without accident is a tribute to the leadership of the foreman and the good sense and workmanship of the men concerned.

Details of main items of gear used in the various methods are given in Table 1.

TABLE 1.—Pole Erection—Main items of lifting gear required.

	Standing Jury.	Falling Mast.	Two Trucks.	Sheer Legs.
Highest pole lifted.	70 ft. on footings. 80 ft. in ground.	110 ft. in ground.	82 ft. on footings.	70 ft. in ground.
Lifting Aid.	40 ft. oregon beam, 10″ x 10″, fitted with pole steps. (¼″ m.s. backplate, 4-¾″ bolts–for footings).	35 ft. hardwood pole fitted with pole steps. (Plates from 4″ x ¾″ m.s. 4-1″ bolts, 1 pr. fox wedges — for poles in ground).	(¼″ m.s. backplate. 4-¾″ bolts–for footings.)	(¼″ m.s. backplate 4-¾″ bolts—for footings.)
Poles, pivot, 10 ft. approx.	—	1	—	—
Poles, stub, 10 ft. approx.	—	2	—	—
Boiler plates: ¾″ x 1′6″ x 3′.	—	2	—	—
Wire, s.s. galvd., 7/14.	30 ft. (anchoring footings—if required).	30 ft. (on stub poles).	30 ft. (anchoring footings—if required).	30 ft. (anchoring footings—if required).
Rope, G.P.S.W., ¾″ diam. (winch rope).	300 ft.	300 ft.	200 ft. Truck No. 1. 300 ft. Truck No. 2.	150 ft.
Rope, G.P.S.W., ¾″ diam.	100 ft. (back stay on jury).	200 ft. (bracing wires).	—	—
Rope, Manilla, 3½″ or 4″.	200 ft. (jury guys). 500 ft. (pole guys).	500 ft. (falling mast guys). 800 ft. (pole guys).	— 800 ft. pole guys.	3-60 ft. wire ropes and one additional luff tackle replaced Manilla rope.
Luff tackle (side guys).	2	2	2	2
Wire rope clips.	—	6	—	—
Bars, 1⅛″ x 6′.	7 jury guys. 8 pole guys. 4 footing.	4 stub pole guys. 8 pole guys.	8 pole guys. 4 footing guys.	6 pole guys. 4 sheer legs.
Rope, Manilla, 2″ (or short wire rope strops).	200 ft.	150 ft.	150 ft.	150 ft.
Wire rope strops (8 ft. with 2 eyes spliced or sling chain).	1 top jury. 1 foot jury, if required.	1 top mast.	1 top pole. 1 centre pole.	1-20 ft. length with 2 stoppers.
Snatch blocks, 6″.	1 or 2.	1	5	—
Luff tackle (each):				
Blocks, 4″ double.	2	2	2	2
Blocks, 4″ treble.	2	2	2	2
Manilla rope, 2″.	250 ft.	250 ft.	250 ft.	250 ft.
Sundries: Bars 6, Wire strops 4, Wheel chocks 4 (Anchoring winch truck). D shackles, 1″. Marline (for mousing hooks).	Common to all methods.			

CONDUITS — ALTERATION TO THE ALIGNMENT OF A BUTT-JOINTED DUCT ROUTE

W. B. Ridgeway

A road in Melbourne had to be lowered to permit the construction of an overhead railway bridge. In the footpath was a 6-way duct route made up from 4-way and 2-way butt-jointed concrete conduits, in the usual 2 ft. lengths, encased in 6 inches of concrete. The ducts were occupied by six trunk and junction cables, mostly containing balanced and selected pairs.

This system had to be moved 18 inches to a new alignment and lowered to meet the new levels. The maximum depth required was 7 feet, which occurred at a manhole on each side of which was 100 yds. of route to the next manholes.

Consideration was first given to the normal method of dealing with such cases, i.e., by laying a new duct route, drawing in new cables and cutting over to them and then withdrawing the old cables. The following factors ruled this out:—

(a) The road-work was of urgent military importance and time was the essence of the contract. It would not be possible to employ more than one jointer at each of the ends, and the cutting over, balancing and selecting would have taken some months.

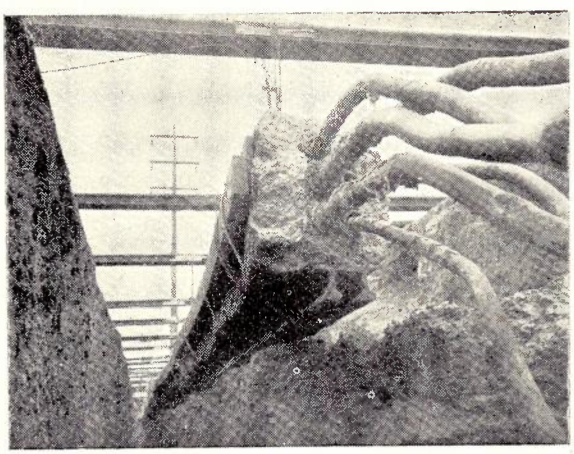


Fig. 1.—Method of Reinforcing Ducts.

(b) Suitable cable would have been difficult to obtain.

(c) The old duct system would have been a dead loss and there would have been a substantial loss on the old cable.

It was decided, therefore, to move the cables and ducts bodily. This entailed moving 200 yds. of the system 18 inches laterally and lowering to a new level so that the centre of the system would go down 7 ft. and the extreme ends one foot. The first operation was to make each 100 yds. a rigid rod, and to do so the ground was opened on one side of the ducts, and 6 in. x 1 in. timber runners fitted on that side and kept in position by toms. The ground was then further opened to permit the placing of rails under the ducts. These rails were coupled with fish-plates. The action was then repeated on the other side of the ducts. Bindings of 200 lb. G.I. wire were made round the system at 6 ft. intervals, wedges being used where necessary on the runners and rails. Fig. 1 illustrates the method, but with the toms removed.

The next step was to suspend the system so

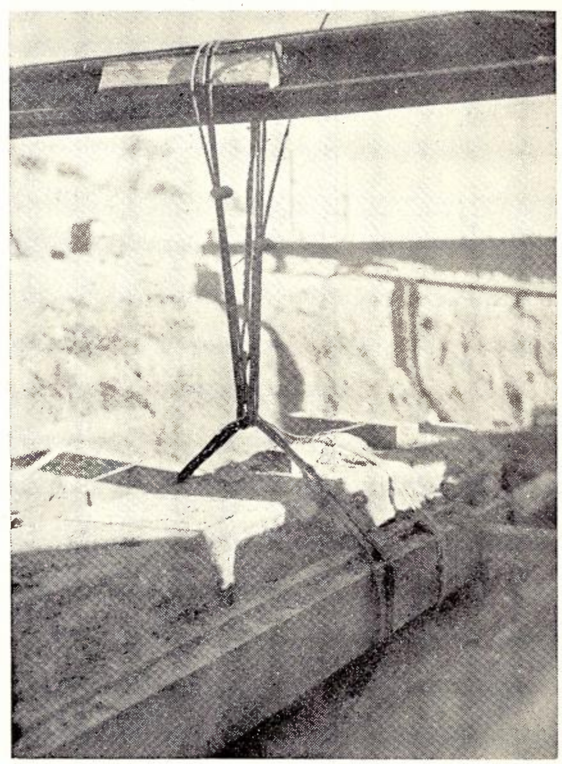


Fig. 2.—Halyard Support.

that men could work in safety below it. Beams formed of three 80 lb. rails interlocked, supported at each end on rollers, were used because the presence of power cables made a span of 13 ft. necessary, and bending had to be guarded against. The rollers were 2 ft. lengths of 3 in. G.I. pipe filled with concrete or wood. Loose strops made up of five turns of 25 strands of steel wire were formed round the conduits at the sixty-five points of suspension, and the ends were made off by binding with 60 lb. G.I. wire. It was at first intended that the suspension and lowering method should be by chain block and tackle, but difficulty was experienced in obtaining and retaining these for the time required. Halyards were, therefore, fashioned from stranded steel wire and consisted of three turns made up in a running loop. To ensure easy running of the halyard on the beam, rounded timber was driven into the space between the halyard and the web of the rails and the completed halyard was temporarily secured by "U" clamps as shown in Fig. 2.

Fig. 3.—Ready for Rolling.

The system was thus suspended whilst the excavation to the new depth was completed. It was necessary to remove the toms which, of course, were no longer required once the suspension was completed.

To provide sufficient play in the cables the ducts were broken away 3 ft. back from the original manhole walls. This was done at each end and at the centre.

Fig. 3 shows the system suspended, excavation finished and all in readiness for rolling. Sixty-

Fig. 4.—Ready for Lowering.

five men operated levers and were controlled from the central point by whistle and hand signals. Stop plates were tacked on the roller tracks to prevent the rollers over-running. The rolling took three minutes from the time the men took up the levers until the time the ducts were in the new alignment.

Fig. 4 shows the system ready for lowering. It will be noted that the clamps are still on the halyards and the men are clear of the cross-beams in case of side wall collapse. The clamps were then removed and the weight taken by the men on the falls of the halyards. The men at the centre lowered slightly faster than those in front of them. As the shallow ends grounded the halyards were slacked right off and the whole system was completely grounded and in its new position 33 minutes after the clamps were removed. Fig. 5 shows the finished job.

An essential feature of work of this nature is that the ground carrying the cross-beams must be sound. If there is the slightest chance of it

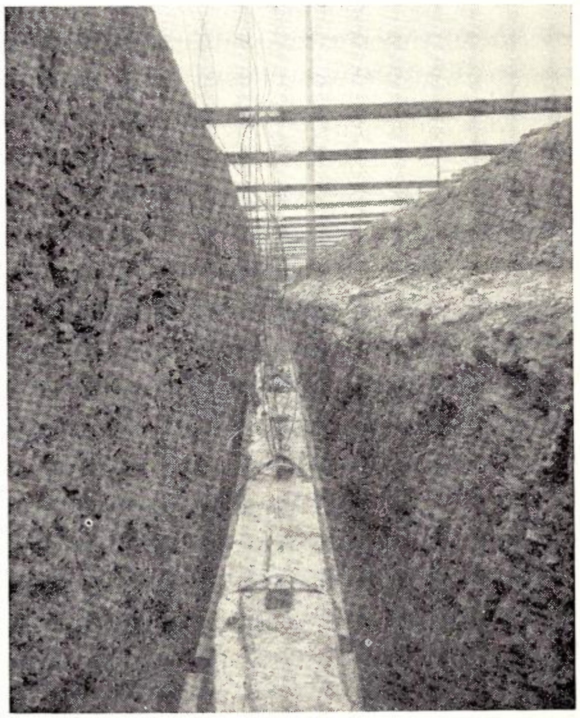


Fig. 5.—The Finished Job.

collapsing under the load it must be securely timbered.

An improvement could be effected in the lowering by having the strops fed through a 30° bend of iron pipe, as this would give the halyards freer movement. In the job described the system was suspended about ten days before being lowered, and in that time the halyards had bitten into the strops sufficiently to prevent free even movement.

RECRUITMENT AND TRAINING OF LINEMEN*

T. P. Wilks

Introduction. — Before dealing with present practice, it will be of interest to review briefly the recruitment of lines staff prior to the adoption of the present training scheme. Recruitment by examination was first adopted about 1906, when a call was made for men to work in Country Parties, the range of eligibility being 21-45 years. This was followed by a second examination in 1908, at which the writer was one of the 600 candidates. The first section of this examination comprised an educational examination in the subjects, spelling, writing and arithmetic. The candidate had to obtain at least half marks in each subject, before being eligible to compete in the practical test, which consisted of the following:—

- Sinking a 5′ hole.
- Fitting arm and bracket to pole.
- Climbing pole with spurs.
- Use of axe and adze.
- Regulating, jointing and tying wire on the ground.
- Knowledge of timbers, 6 samples.
- Knowledge of knots.
- Splicing ropes.
- Reeving tackle.

After recruitment, to gain experience four new men were usually included in a party, which contained at least two experienced men, and as they gained their experience, and proved their efficiency, they became the leading hands with other parties.

The above method continued until 1914, when as the result of the War all examinations lapsed, and a number of candidates, who had previously qualified, were not appointed until they returned from the War.

In 1923 examinations were resumed, but on this occasion, owing to the "preference" clause, entrance was restricted to returned soldiers. The subjects were similar to the 1908 requirements, except that spurs were replaced by stirrups. The 1923 examination was followed by a further examination in 1927 and all those who obtained pass marks received appointment; provided, of course, they were not beyond the age limit, satisfied the Commonwealth Medical Officer, and had given satisfaction in a temporary capacity.

In 1934 a number of young men from within the Service, mainly Telephonists, Messengers, etc., were given an opportunity to qualify as Linemen. The training method adopted was to employ them in a line party for approximately six months, then subject them to a practical test, generally similar to the 1908 test.

* Lecture delivered before The Postal Electrical Society of Victoria on 20/10/1941.

Within the last two years a number of returned soldiers who had been employed in a temporary capacity for a period of at least two years, and had satisfactorily performed the duties on which they had been employed, received permanent appointments.

In all the foregoing the successful candidates have been recruited directly to the Lines staff. However, in recent years there has been considerable development throughout the Commonwealth in the application of Carrier Systems to existing open wire routes, and, more recently, the provision of long-distance underground cables for carrier working. The use of the higher frequencies has required not only higher standards of construction, but a high standard of training of the personnel employed on the work.

To achieve this object, it became apparent that a course of training was essential. Such a course would need to include a basic training, in the fundamentals of mechanics and electricity, as well as practical tuition in the use, care, and appreciation of tools, as well as instruction in the modern methods. The results should then be linemen who could not only carry out all phases of line construction in an efficient manner, but at the same time could be relied upon to carry out any change of construction standards, and quickly appreciate technical developments which would occur during their official career.

The following notes outline the examination and training education associated with the Melbourne Linemen-in-Training School:—

Entrance Examination. — The first call for Linemen-in-Training was made in October, 1937, when particulars of a competitive examination were listed. Those eligible to compete were youths born not earlier than 11th June, 1918, and not later than 11th June, 1919. The subjects of the examination were:—

Educational:
- Handwriting.
- Spelling.
- Arithmetic.

Practical:

Exercises involving the use of one or more of the following:—

- Hand Saw.
- Wood Chisel.
- Brace and (Bits, Centre).
- Plane—(Jack).
  - (German Jack).
  - (Smoother).
- Blow Lamp.
- Metal Snips.
- Rule.
- Tri Square.
- Soldering Bit.

Rivetting Hammer.
File.
Hack Saw.
Stocks and Dies.
Hand Drill.
Ratchet Drill.
Diamond Pointed Chisel.
Scribers.
Dividers.
Callipers.

To qualify, a candidate had to obtain at least half marks in spelling and arithmetic. He then became eligible for the practical test, consisting of a series of 10 exercises from which the candidate had a choice of six.

Typical Exercises are:—

(a) Given piece of boiler plate 4″ x 3″ ⅜″ thick, rough edged, square with file, drill, 2 holes ⅜″ at a given distance from edges.

(b) Two pieces of timber, 6″, 4″ x 1″; check one piece through the other and fasten with 4½″ x ¼″ bolt.

(c) Given 18″ of 4″ x 1″. True up faces and ends and cut into four pieces of equal length.

(d) Make up to given dimensions Small Cup Shaped Container from two sections cut from sheet tin.

In addition to the tool exercises, candidates were required to reeve treble and double blocks, and tie knots such as reef knots, clove hitch, etc. Although the practical tests were completed early in 1938, it was not until the 12th September, 1938, that the first trainees entered the School at Fisherman's Bend, Melbourne. When mustered, the strength of the group and their previous occupations were:—

Motor Mechanics and Engineering	10
Farmers' Sons	3
Machinists	3
Blacksmiths' Assistants	2
Plumbers' Assistants	2
Cabinet Makers' Assistants	2
Factory Hands	2
Butcher's Assistant	1
Grocer's Assistant	1
Postal (Temp.) Assistant	1
Carpenter's Assistant	1
Dry Cleaner's Assistant	1
Timber Yard Assistant	1
Upholsterer's Assistant	1
Student	1
Salesman	1
Railway Employee	1
Total	34

Accommodation. — Preliminary arrangements had been made to complete the school organisation so far as the selection of the staff, preparing a tentative syllabus, obtaining plant and material, and securing a suitable location to carry out the project. Temporary accommodation was obtained at the Submarine Cable Depot at Fisherman's Bend. Whilst this building met requirements as far as floor space was concerned (2,620 sq. feet school and 360 sq. feet office and store), it lacked suitability for the reason that the two tanks contained therein, each 25 ft. in diameter, were approximately 6 ins. above the floor level. As it was necessary to set up tables and forms for the dual purpose of providing lecture and luncheon accommodation, the whole floor was restored to the level of the tank tops. This was done by concreting. In addition, the entrances in the shape of two ramps were reconstructed by the same method. These operations were carried out by the trainees and provided an opportunity for demonstrations of manual mix, machine mix (batch method) and penetration (using hand mixer for mortar method).

As the shed had rather a drab appearance it was decided to improve the appearance by an application of paint both inside and out, and with this completed the building looked less like a shed and more like a school. Plans have been prepared for a permanent school which, when completed, will accommodate 50 trainees, the estimated maximum number attending the school at any one period. It is designed so that classes can be segregated, and provision is made for separate accommodation for lectures and luncheon. The provision of this new building has been delayed by the War conditions.

TABLE 1.

Phase of Training	School Instruction	Practical Experience in Districts
Aerial Line Construction (Including preliminary training)	4 months	2 months
Cable Jointing	3 ,,	1 month
Conduits and Manhole Construction	1 month	1 ,,
Cable Laying	1 ,,	1 ,,
Telephone and Telegraph Equipment	2 weeks	2 weeks
Engineering Office	—	4 ,,
Engineering Store	—	2 ,,
Motor Vehicles and Course Revision	3 weeks	—
Total	10 months, 1 week	7 months

Syllabus of Training.—Details are shown in Table 1. The total time taken to complete the syllabus is approximately 18 months, but this varies according to the demands made on the school.

All trainees are expected to obtain the necessary qualifications. This is done progressively, and not by a final examination, for following the completion of each particular subject trainees are given the opportunity to display their efficiency and knowledge. Practical tests are held in Aerial Lines and Cable Jointing, which are also covered by Questionnaires. In Conduits, Cable Laying, Telephone Equipment and Motor Vehicles the test is by Questionnaires only.

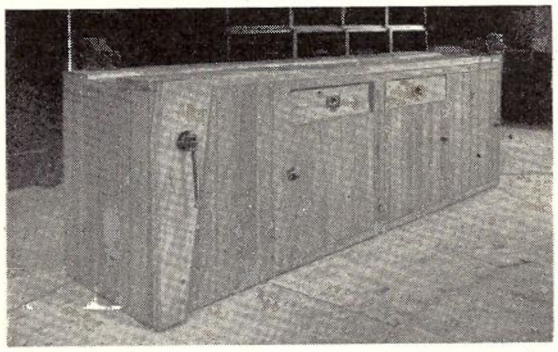


Fig. 1.—Two-Way Work Bench.

To qualify, trainees must obtain at least 60% in all tests, and should they fail to do so they are required to undergo further instruction and are then re-examined. Experience has shown that these examinations are not a true reflex of a trainee's efficiency, as quite a number develop "Examination Complex." This is influenced by the competitive nature of the tests, as the marks obtained in the sectional tests contribute towards a "Course Aggregate."

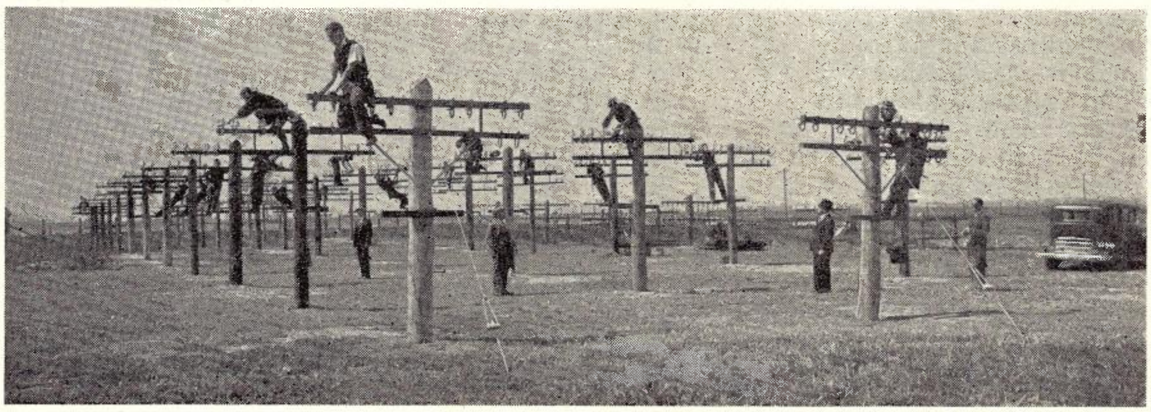


Fig. 2.—Trainees at Work on Practice Poles.

School Organization. — In normal times the school staff consists of five officers whose grades and functions are as follow:—

Supervisor—1—Exercises general supervision on all matters affecting the welfare of trainees and school. Arranges instruction, prepares and delivers lectures, supervises trainees' movements in districts; also the technical training at the Melbourne Technical School.

Instructors—2—Usually one is attached to the Aerial Lines Section and the other to the Cable Section. Prepare and deliver lectures. Check note books.

Demonstrators—2—Assist Instructors and carry out demonstrations as required (one allotted to each section). Keeps check on tools and material. Compile records from the Daily Working Reports.

Experience has proved that during practical instruction it is not desirable to load an Instructor or Demonstrator with a group of more than 12 Trainees. Progressive supervision can then be given over each allotted task.

Record Cards.—In order to provide a suitable record of a trainee's activities throughout the whole course, individual cards are kept. These include a full record of the time spent on each subject and particulars of conduct, attendance, diligence, efficiency, etc., from which a final report can be prepared at the completion of the course. At the inception of the course, trainees are informed of the existence and objects of these cards. They then know that they are responsible for the "story" written thereon.

Note Books.—So that trainees will have a written record of instruction imparted by lectures given during the course, they are asked to take notes and make diagrams of all essential subjects. In the first instance, they are recorded in rough books, but later they are transferred into a permanent book (usually a separate book is kept for each subject). This arrangement assists the trainees to memorise and understand the subject.

These note books are periodically examined by the School Staff, marks are allotted and recorded on the Record Card. This action is intended to encourage the trainees to keep note books clean and neat and to include diagrams and sketches. After the note books are checked they are returned to trainees to serve as a reference later on in their career.

Preliminary Training. — When trainees first enter the school following a formal welcome they are given a discourse on "School Discipline," the objects of the course, and Departmental procedure, and the functions of the Engineering Branch and its relation with other branches are described.

As a preliminary to the training course proper, the first instruction given deals with tools most used in Line Construction. This instruction covers approximately four weeks. Most of the timber used is obtained from case timber which previously housed units of telephone equipment. From this timber have been built tables, stools, nests of lockers, cupboards, bins, etc. It is intended that the use of this equipment will only apply to the temporary quarters as in the new school, such furniture will be provided as an integral part of the new building. However, one of several items of equipment made up by the trainees during "tool exercises" which will form a valuable part of the equipment of the new school is a 2-way work bench. This is shown in Fig. 1.

Aerial Line Construction.—In following "Tool Exercises" with "Aerial Line Construction" further opportunity is afforded the trainees to become proficient with tools, and appreciate the necessity to keep tools in first-class condition to obtain the best results.

The first exercise carried out is usually dressing and arming poles. Old poles are made available and trainees given practice in cutting slots, fitting arms, and the use of axe and adze. This exercise precedes the more important operation of "Fitting Poles," which is first applied to what is termed a "practice pole" on which a trainee performs most of his basic training. These poles are approximately 12 ft. in length and are designed to permit a trainee to carry out work on a pole, yet close to the ground. Working under these conditions, he develops confidence and overcomes the strangeness of working in a body belt. Another advantage is that only one trainee works on his allotted pole, and thus segregated it is not difficult to check the work of each individual. Fig. 2 shows trainees at work on practice poles.

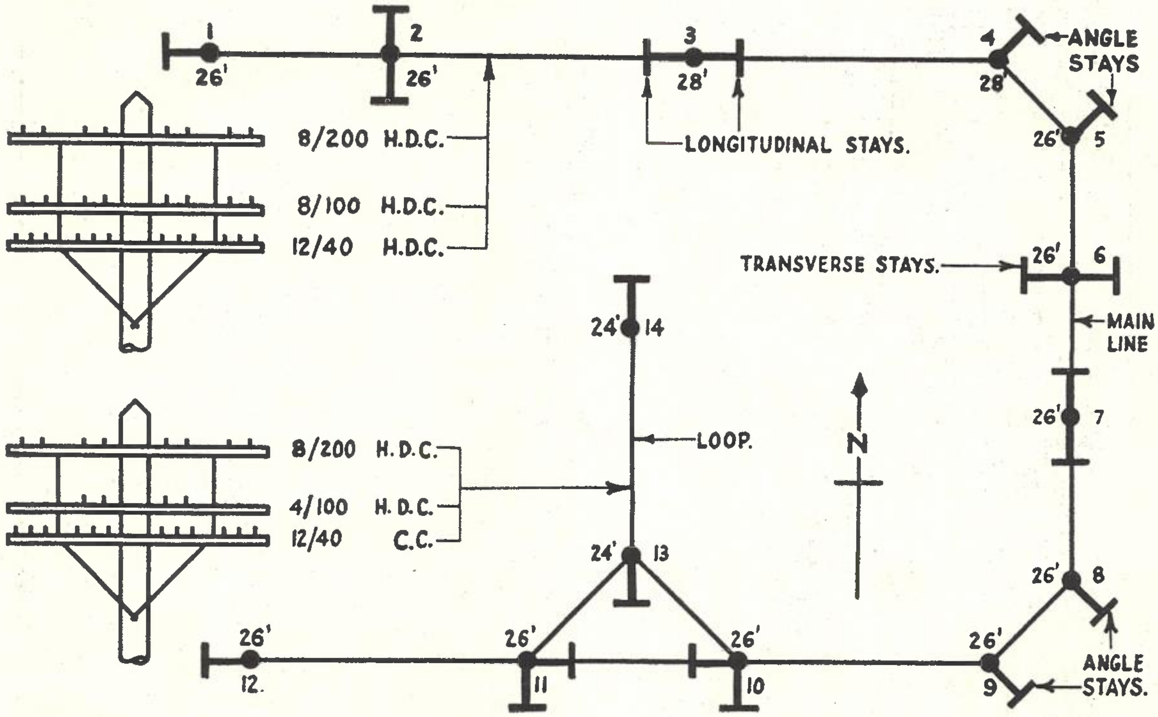


Fig. 3.—Layout of Trunk Route.

Prior to operations on the practice poles a plan is drawn up on which a number of poles are plotted. The number equals the trainees in the group, and the poles are spaced at sufficient distance to permit of wiring and staying exercises without congestion. Second-hand poles of various sizes are used, and in laying these at the pegmarks experience is gained in loading and unloading poles on and off pole trucks.

When the poles have been completed, i.e., 2/80-inch arms fitted satisfactorily, it is usual to give instruction and practice in sinking holes apart from the hole sunk in the erection of the poles. When poles are erected on the practice area, each trainee is responsible for the correct alignment of his own pole. The poles at the end of each run are Cable Terminals, and on these instruction is given in fitting and mounting Cable Boxes and running O.D.T. There are usually four trainees allotted to each terminal pole. After all poles on the "lay-out" have been erected, and terminal poles stayed, different classes of fitting are mounted in preparation for wiring exercises, using all classes of wire used in subscriber's line construction. This follows preliminary instruction given on the ground, in the work of jointing, tying, and terminating line wires, as well as stay terminations. Exercises involving all these operations are then carried out aloft, and, having completed these, the wires, fittings, and arms are dismantled, and replaced with plant used in trunk-line construction. See Fig. 3 for lay-out of trunk route.

As a preliminary alternative poles are fitted with transverse and longitudinal stays. Wires of various gauges are then erected, viz., 100 lb., 200 lb., H.D.C. and 400 G.I. The next exercise is designed to demonstrate "Pole Renewals." In this case trainees work in pairs. A recovered pole is erected alongside an existing pole, and all wires, etc., transferred from the old to the new pole. This includes the cutting over of physical and phantom transpositions, including the precautions necessary to avoid traffic interruptions.

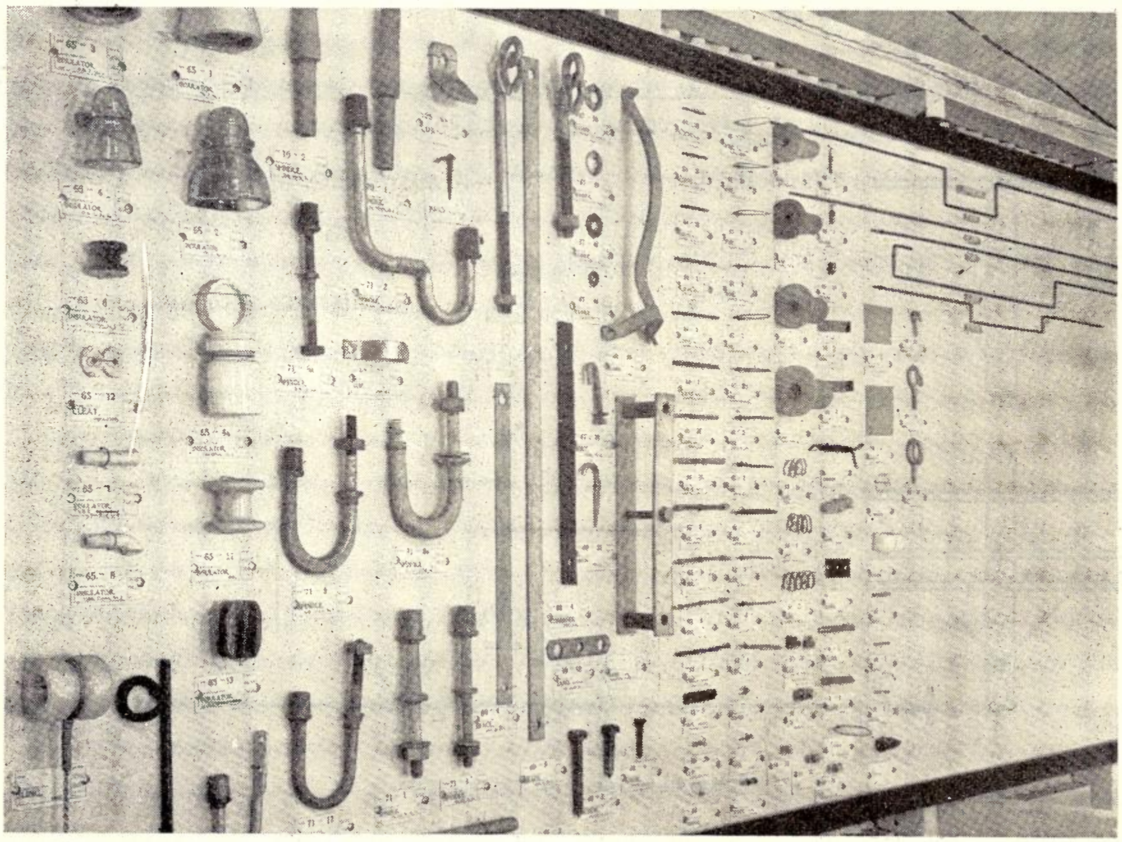


Fig. 4.—Identification Board for Line Equipment.

This completes most of the basic training in this class of construction. Throughout the period of practical instruction the trainees have been given a series of related lectures, 20 on Tools, 18 on other subjects. These lectures also include the identification of pole and arm timbers, climbing poles with stirrups, knots and tackle, maintenance of tools. Fig. 4 shows the "identification board" for line equipment used during these lectures. Included on this board is a sample of each item of material used in aerial line construction.

The next operation is the erection of a standard trunk route using poles 26 ft. or 28 ft. in height. The route is pegged out and is so designed to demonstrate the methods of construction adopted in grading, countering 90° angles, also looping or legging wires to intermediate stations by a "Y" loop.

The extent of this work is governed by the number of trainees comprising the group. The number of poles erected is on the basis of allotting two trainees to each pole, exclusive of the terminals. The poles used are erected by different methods, such as pikes, lifting jack, block and tackle, and also with and without the aid of a pole truck. After completion the route is left "in situ" so that the following group can have an appreciation of the ultimate objective of their training in Line Construction.

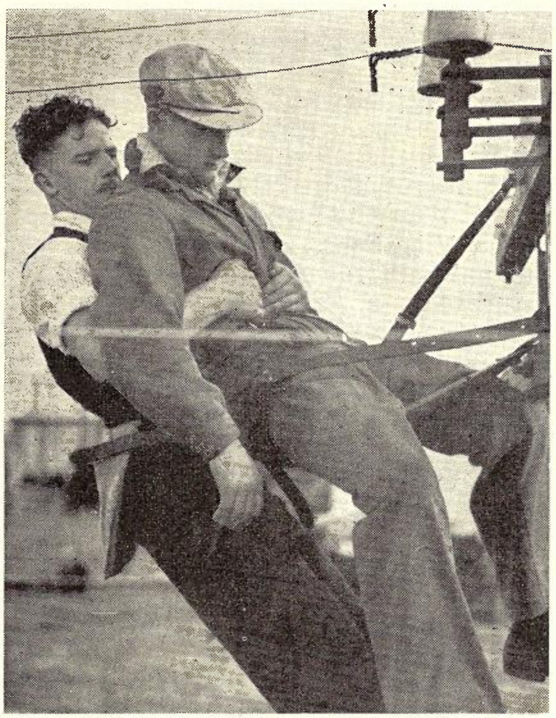


Fig. 5.—Application of Artificial Respiration.

In the final stages of this section training is given in methods of "Pole Top Resuscitation" following electric shock and, having resuscitated the victim, lowering him from the pole top to the ground. This instruction was developed from a report published by the Duquesne Light Co., of Pittsburg, Penn., which stated that there had been 16 applications of the "pole-top" method to date and of these 14 had been successful. This success is considered largely due, not only to the shortening of the period between shock and application of resuscitation, but to a procedure whereby artificial respiration was obtained by applying pressure to the front of the body in the abdominal region (see Fig. 5), thereby forcing the contents of the abdomen upwards and backwards under the diaphragm so as to reduce the chest cavity and expel the air from the lungs. Air is then drawn in by a quick release of the hands. Experiments with this method at the Training School have created widespread interest outside as well as within the Department, and a demonstration film was prepared of the procedure adopted.

(To be continued.)

AERIAL LINE CONSTRUCTION

A. S. Bundle

Part 6—Wiring Details

This section covers the following:—

- Importance of detail in wiring;
- Fatigue of line wires;
- Chafing of line wires;
- Tying-in;
- Joining wires;
- Terminating.

Importance of Detail in Wiring

The following notes are prefaced so that the value of correct methods of wiring may be fully appreciated.

In Australia, under the direct control of the Postmaster-General's Department, there are approximately 900,000 miles of aerial telephone wires which are attached to some 27,000,000 insulators. The average annual number of interruptions on these lines is of the order of 100,000. Repairs to faults causing these interruptions cost about £60,000 per annum. About 80% of the interruptions occur upon subscribers' lines, chiefly because lighter wires are used.

The number of interruptions due to joints, ties and terminations combined, exceeds the number due to falling trees and branches, which form the greatest single cause of interruptions to open-wire telephone circuits. The most serious form of interruption is that of wire breakage. This is because of the permanency of the interruption until proper repair is effected, and also because the cost of repairs is usually higher than for contacts and other miscellaneous faults. Moreover, broken wires often fall across other wires and thus cause further interruptions. With the increased use of carrier telephone and telegraph systems and of multi-channel machine telegraph systems, line wire faults have become a much more serious problem, as a single fault may interrupt a large number of channels. Therefore, modern line construction and maintenance demand great attention to the wiring details, both with respect to design and execution.

The design of joints, terminations and ties is most important and must take into account all working conditions in which they will be used. Any weakness of design in regard to certain working conditions will affect every tie termination or joint used in such conditions. Carelessness in the execution of joints, ties and terminations will result in a potential fault at each point where the carelessness occurs.

The importance of joints and ties can be gauged from the fact that about 1,000,000 joints and 1,650,000 ties are made annually in Australia on lines erected by the Postal Department. These figures are based on the annual consumption of jointing sleeves and copper tapes but the writer has no sound basis for determining the number of terminations made. From the figures quoted, it is important that the joints, ties and terminations should be reliable and, at the same time, made as speedily as possible. If, for instance, one minute could be saved in the making of each tie, joint and termination, an annual saving of the order of £10,000 could be effected.

The design of the joints, ties and terminations should be such as to require little skill in execution and to minimise as far as possible the effects of faulty or careless workmanship. Fortunately, most linemen appreciate the need for care in these matters and study in the greatest detail the various methods of tying, terminating and jointing.

Fatigue of Line Wires

Fatigue.—When a metal is subjected to repeated stresses such as frequent bending stresses or expansion and contraction due to alternate heating and cooling, it becomes fatigued and looses its strength. The individual metallic particles become less cohesive as if by rubbing together they had become polished, making it possible to part them more readily. Cracks often develop or else failure occurs upon the application of excessive stress. If the cracks develop, with normal stresses a condition is reached where there is insufficient material to withstand these stresses and failure occurs. The fatigue of metals is sometimes referred to as "intercrystalline fracture."

Corrosion and fatigue frequency combine to cause failures. When a metal is subject to corrosive influence the product of corrosion (usually an oxide) frequently forms a skin which acts as a protection against further corrosion. If, however, the metal is subjected to repeated cycles of stress the skin may be repeatedly broken and the corrosion will extend further and more rapidly. These "corrosion pits" tend to concentrate both the corrosion and the fatigue to a critical point as the stress is increased by the reduction of cross-sectional area. The combined effects of corrosion and fatigue is called "corrosion fatigue." This is probably the cause of many line wire failures because the critical fatigue point closely corresponds with a point where another wire or sleeve or tape makes contact with the line wire. At such points moisture does not evaporate as quickly and there is also possibility of some slight electrolytic action so that the tendency to corrode is greater.

Causes.—Fatigue of line wires may be caused by:—

(a) The swaying motion resulting from wind gusts;
(b) The tiny vertical vibrations which cause the characteristic humming sound of telephone wires. These are referred to as "aeolian vibrations."

Because of their continuity and greater frequency (and consequent total number) the aeolian vibrations are the principal cause of wire fatigue. This has been definitely proved by examination of a great number of broken wire-ends.

Aeolian Vibrations.—Any span of wire has a definite natural frequency at which it will vibrate if disturbed in a certain manner. This is the basis of the beat method of determining the tension of wires. The wire can be vibrated at other frequencies but these vibrations fade away rather quickly unless the frequency is a multiple of the natural frequency. The natural frequency of the span can be determined from the equation:—

$$f_v = \frac{1}{2L}\sqrt{\frac{Tg}{W}} \qquad (23)$$

Where:

f_v = frequency of vibrations in cycles per sec.
L = length of span, in feet.
T = tension of wire, in lbs.
g = acceleration due to gravity (= 32 ft. per sec. per sec.).
W = weight of wire, in lbs. per ft.

For example, in the case of a 200 lb. H.D.C. wire in a 55 yard span at a tension of 200 lb. the natural frequency f_v

$$= \frac{1}{2 \times 3 \times 55}\sqrt{200 \times 32 \div \frac{200}{5280}}$$

$$= \frac{1}{330}\sqrt{168960}$$

= 1.245 cycles per second.

Vibrations are set up in a telephone line wire by cross winds which, because of eddy formation on the leeward side of the wire, cause it to move alternatively upwards and downwards. It has been shown that the frequency (f_w) of these vibrations can be calculated from:—

$$f_w = \frac{3.252\, v_w}{d} \qquad (24)$$

where:

v_w = wind velocity in miles per hour.
d = diameter of wire in inches.

When the frequency (f_w) of the forced vibrations coincides with the natural frequency (f_v) of the suspended wire or some multiple of f_v, then a steady vibrating condition will be set up forming vertical waves in the wires and usually causing the familiar humming sound.

It is interesting to ascertain in the example previously taken, what the wind velocity would be when the forced vibrations f_w due to the wind would equal the natural frequency f_v of the wire in the span.

$f_v = 1.245$ and if this is to equal f_w we have, from (24):

$$1.245 = \frac{3.252\ V_w}{d}$$

$$\text{or } V_w = \frac{1.245 \times .1119}{3.252}$$

$$= .0428 \text{ miles per hour.}$$

At this velocity the wind energy would not develop perceptible vibrations. However, at, say, 8.56 m.p.h. the 200th harmonic of the natural frequency would be reached and probably sufficient energy would be imparted (if the wind were reasonably steady) to set up perceptible vibrations at a frequency of 200 × 1.245 = 249 cycles per second.

These vibrations are most likely to develop during transverse wind conditions between 6 m.p.h. and 25 m.p.h. as the wind velocity is reasonably steady. Beyond 25 m.p.h. the winds are usually gusty and steady vibrating conditions are not usually set up. The conditions for resonance with the forced vibrations are dependent upon span length, tension, and weight per unit length of conductor. It is generally agreed that wires vibrate more freely at higher tensions, although data on this aspect is not entirely conclusive.

Fracture.—The waves travel back and forth along the wire between insulators at each end or between heavy joints in the span and the insulators, these points having sufficient inertia to reflect back the waves. At these points of reflection considerable bending stresses occur in the wire, and at such points fatigue failures occur. The repeated bending causes intercrystalline fracture or corrosion fatigue at the point where the stress is greatest—this being generally at the top of the wire where it is already stressed by bending where the sag commences. This results in the wire cracking through at the critical point.

When this cracking has gradually reduced the section of sound wire to about one-third of the original section the wire then fails under tension. Fatigue failures are, therefore, characteristic, showing a vertical crack through about two-thirds of the section and then a drawn out section indicating the area of the tensile failure (see Fig. 44).

Remedial Measures.—The methods of alleviating fatigue failures in overhead wires may be divided into two broad groups:—

(a) The use of specially designed dampers in each span to damp out any vibration which may be imparted to the wire.

(b) The provision of properly designed reinforcement at the supports so that the flexing of the wire is spread over a greater length of wire, thereby reducing the degree of strain in any segment of the wire near the critical point. By thus minimising the establishment of a sharply defined reflecting point this method must also have a damping effect upon the forced vibrations.

Much work has been done on the design of dampers for High Tension power lines, and

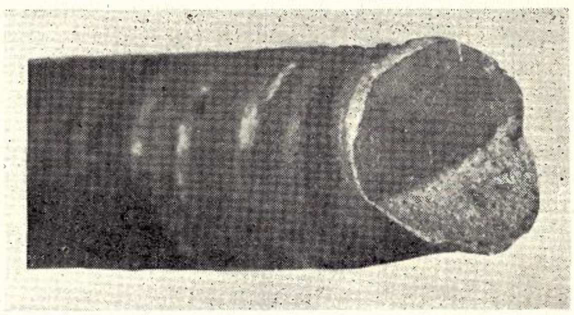


Fig. 44.—Typical Fatigue Failure.

several ingenious types have been developed. However, they are rather cumbersome and expensive, so that while this method may be feasible for power lines with comparatively few conductors and long spans, it does not appear to be economically practicable on telephone lines because of the multiplicity of spans of wires in an open-wire telephone route.

Reduced to terms of telephone line construction, method (b) suggests a method of "tying-in" or "binding-in" (the terms are synonymous) which will so reinforce the wire that it will not bend at the insulator and this reinforcement will decrease steadily on either side of the insulator without causing any abrupt change in the inertia of the wire. This appears to be the most practical method of dealing with the problem and further developments of this nature would not be unexpected.

Fatigue Resistance of Wires.—The resistance of metals to fatigue varies considerably, but the types of wire available for use as telephone conductors are limited by considerations of electrical resistance as well as mechanical strength. Cadmium copper has appreciably greater resistance to fatigue than pure H.D.C. However, for equal transmission loss cadmium copper wire is appreciably dearer than H.D.C. and its use would, therefore, be limited to those areas where fatigue failures occur frequently.

Chafing

Another cause of broken line wire is chafing. The wind causes the wires either to sway or vibrate and so move in relation to loose ties or to insulators, thereby causing the wire to wear away.

To overcome the chafing of hard-drawn and cadmium copper wires against insulators and tie wires, an annealed copper tape is wrapped over the wire before it is bound to the insulator. This tape must be of thin soft copper which can be wrapped firmly around the wire so that the wire cannot move independently of the tape and so chafe on it. If the tape is too thick in relation to the wire on which it has to be wrapped the acute bending which occurs when it is wrapped on the wire causes the copper to harden. This not only gives the tape a tendency to spring open slightly and thereby allow relative movement between the tape and wire, but being harder it wears away the line wire more quickly.

Fig. 44 also shows rings around the line wire, caused by chafing against the binding wire in a termination.

Tying-In

When line wires pass intermediate poles they have to be supported against the insulators. As the methods adopted for securing telephone wires to the insulators usually involve the binding of the wire to the insulator with another wire, the process is referred to by such titles as "tying," "tying-in," "binding" or "binding-in."

The requirements of an ideal "tie" are:—

(a) It must be capable of being made quickly and easily.

(b) The wire must be held securely against the insulator, even where there is a sharp upward or downward pull on the wire.

(c) The wire must not slide past the insulator in the event of a wire breaking in the span.

(d) The wire must not chafe against either the insulator or the tie.

(e) Reinforcement against bending must be provided, the degree of reinforcement being greatest at the insulator and tapering off steadily in each direction.

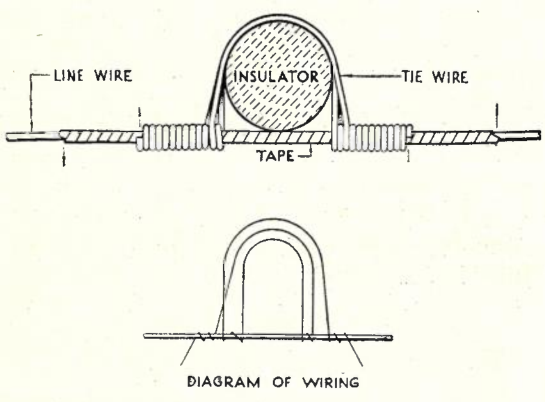


Fig. 45.—Australian Practice for Tying Wires.

There is no doubt that the ideal form of tie to meet all the above requirements under all conditions has not yet been designed. It is considered that there is opportunity for further development in this respect. The recognised types of ties used in Australia, Great Britain and the U.S.A. are outlined in the following paragraphs and associated diagrams:—

Australia.—The method used in Australia for H.D.C. and cadmium copper wires is illustrated in Fig. 45, and consists in first wrapping a tape made from annealed copper around the line wire and then making a special form of binding with an annealed copper wire of lighter gauge (50 lb. or 20 lb. per mile) than the line wire. A similar binding is used for G.I. wire except that the binding wire is also G.I. (60 lb. per mile) and no tape is used.

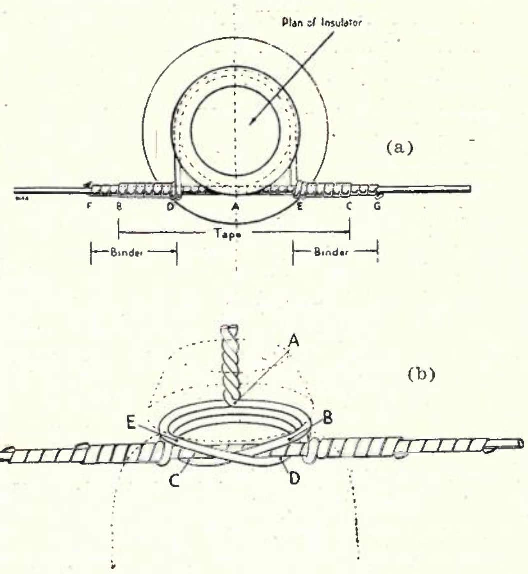


Fig. 46.—B.P.O. Methods of Binding Copper, Cadmium Copper and Bronze Wires.

Great Britain. — British Post Office standard methods are shown in Fig. 46. For copper, bronze and cadmium copper wires an annealed copper tape is first wrapped around the wire and the wire is then bound to the insulator with a special form of binder. This binder consists of a length of copper or cadmium copper wire with approximately one-third of its length flattened at each end, leaving the centre portion the original circular shape of the wire. The gauge of the wire used for the binder is approximately the same as the line wire and the material in the binder corresponds to that of the line wire but the binder is annealed. The method of wrapping is shown in Fig. 46a. Where additional strength is required this binding is reinforced with a double turn of binding wire around the insulator and crossing over the line wire. (Fig. 46b.) For G. I. wires the practice is the same as that used in Australia.

U.S.A.—The standard tie of the Bell System is illustrated in Fig. 47. When used with copper or copper-covered steel (Copperweld) wires, the same gauge of wire is used as in the line wire but the binding wire is thoroughly annealed. It will be noted that no tape is wrapped around the line wire before binding as in Australian and B.P.O. practice.

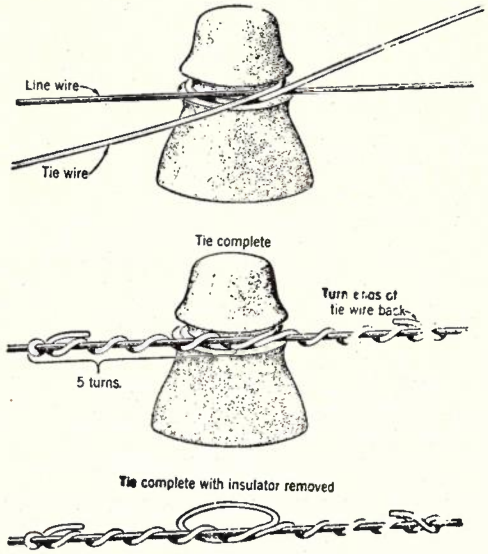


Fig. 47.—Bell System Standard Tie.

At poles where there is a sharp upward or downward angle a "modified horseshoe" tie is used, the method of binding being somewhat different and illustrated in Fig. 48.

On G.I. wires a very simple "horse-shoe" is used, consisting merely of passing a piece of binding wire behind the insulator and then making each end of it off with two or three turns around the line wire.

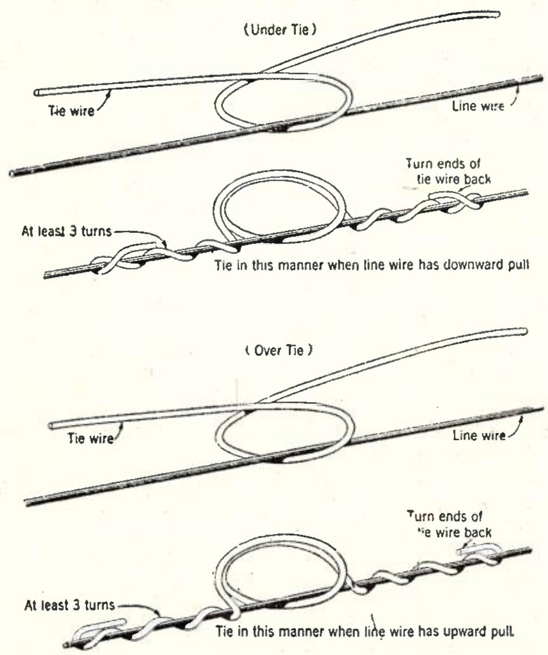


Fig. 48.—Bell System Modified Horseshoe Tie.

Spiral Ties. — A recent development in the U.S.A. for tying H.D.C. and copper-covered steel wires is to stiffen or reinforce the wires by using a splint. This splint consists of a piece of copper-covered steel wire about the same gauge as the line wire and pre-formed into a spiral to fit snugly over the line wire (see Fig. 49). The splint is lapped over the line wire after which a piece of binding wire is used to bind the line wire and splint to the insulator. The binding wire is of the same gauge as the line wire but is annealed. The internal diameter of the spiral pre-formed in the splint is smaller than the diameter of the line wire, and consequently when lapped round the line wire the splint grips it sufficiently to prevent any appreciable slipping.

In one form of splint, the ends are spiralled and the centre section is straight for about $\frac{3}{8}$ in. with a V formed at each end of this straight section. The shape of this splint and the form of the tie used with it are such that the line wire bears against the straight portion of the splint for the whole length of the straight section. The splint in turn bears against the insulator at two or three points. In this way the point contact between the line wire and the insulator is avoided.

The introduction of this spiral tie is considered a definite attempt to overcome the fatigue problem. It is possible that some form of tie involving a splint may be introduced in Australia in the future, but the matter requires careful consideration and some trials. It is necessary to be sure that the form of tie adopted will be suitable for use with Australian types of insulators and in Australian conditions generally. Moreover, care is required to see that such other disadvantages are not introduced, as:—

(i) Increased material and labour costs;
(ii) Greater liability to chafing;
(iii) The use of pliers is not called for in such conditions as would involve a liability to workmen nicking the line wire.

It is possible that the introduction of the splint into a tie would make it more expensive than the present standard and if this should prove to be the case its use would probably be limited to special circuits and in special circumstances where failures would otherwise be likely to occur.

Joining Wires

The requirements of an ideal joint are:—

(a) Speed and simplicity.
(b) Its insertion should not affect the resistance of the line, either by increasing or decreasing it, otherwise a series of joints in one leg would result in a resistance unbalance.
(c) It should not reduce the strength of the wire.
(d) It should not differ in mass from the wire itself, otherwise it is liable to form a re-

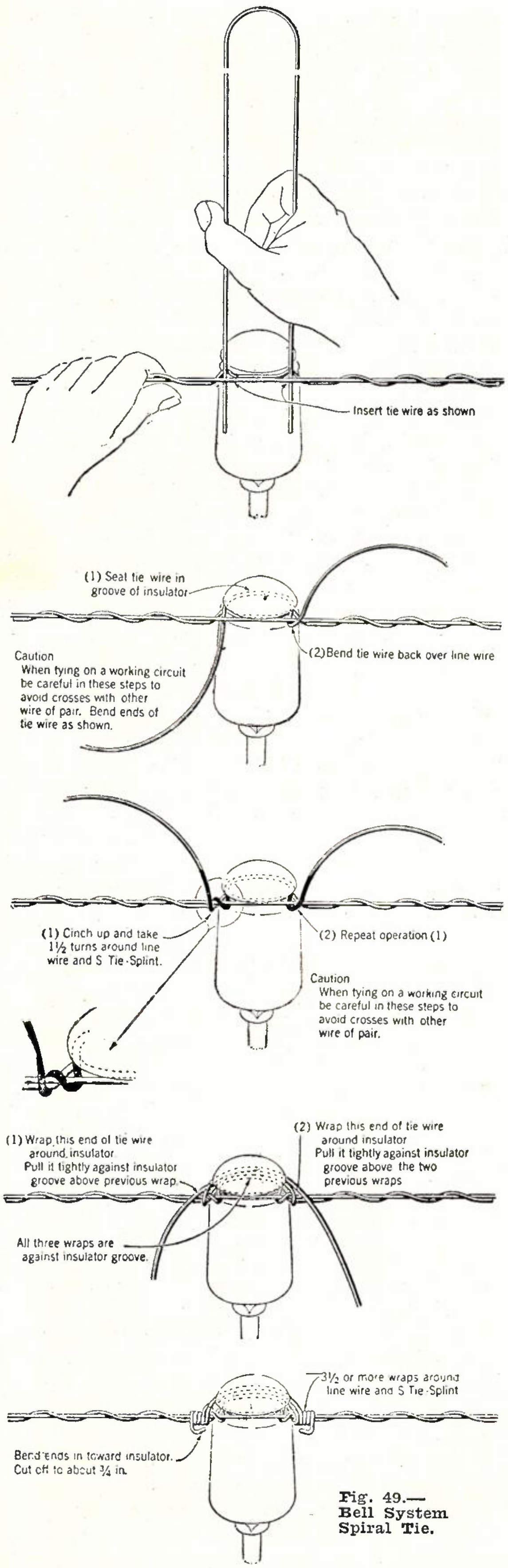


Fig. 49.—Bell System Spiral Tie.

flecting point for aeolian vibrations and fatigue conditions will set up resulting ultimately in a wire breakage.

Following is an outline of the various forms of joints used on telephone lines:—

(a) The twist joint (Fig. 50) as distinct from the twist sleeve joint, is not usually considered acceptable as a standard form but might be regarded as suitable for an emergency repair, to be replaced subsequently by a better form of joint. Electrical resistance will vary unless the joint is soldered, and if this is done with hard drawn copper wire, annealing is very liable to occur with resultant decrease in strength.

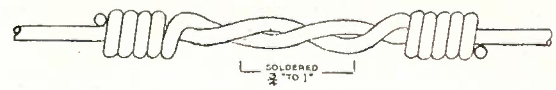


Fig. 50.—Twist Joint.

(b) The Britannia Joint (Fig. 51) is made by binding the overlapping ends of the wire with a lighter gauge wire and then soldering. The strength of the joint depends upon the shear strength of the solder. This joint is acceptable for G.I. wire, but because of the liability of annealing during soldering, is not regarded as suitable for H.D.C. wire. Its resistance is less than that of plain wire.

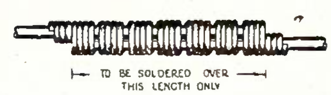


Fig. 51.—Britannia Joint.

(c) The twist sleeve joint (see Fig. 52) does not require soldering. The sleeve must be a neat fit to prevent corrosion occurring or the wire pulling through. The average strength of these joints is about 87% of the wire strength, tensile failures occurring usually within the sleeve at the point where the twist begins. These sleeves are also liable to develop fatigue failures, due to their comparatively heavy mass; in such cases the failure occurs at the end of the sleeve and is accelerated by the tendency to corrode at this point. Resistance varies with corrosion, but is usually less than that of plain wire.

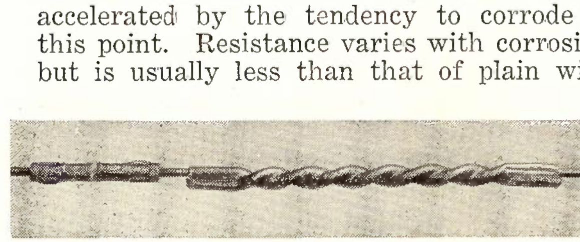


Fig. 52.—Pressed Sleeve and Twist Sleeve Joints.

(d) The rolled joints (Figs. 53 and 54) are in two forms. They are so called because after the two ends of wire have been butted inside the sleeve a rolling tool passes over it and compresses it by application of heavy pressure (approximating 2000 lb.). In the first type, the outside of the sleeve is spiralled, but after rolling this is rolled out and the wire has a wave formed into it. This wave, together with the friction between each wire and sleeve, prevents either of the wires pulling out.

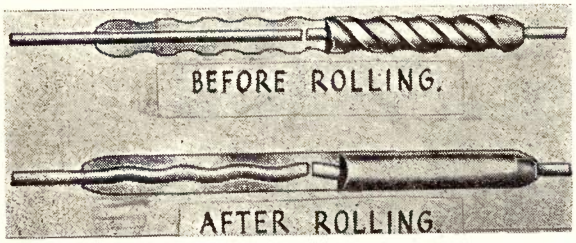


Fig. 53.—Rolled Joint with Grooved Sleeve.

The second form, which has been put into extensive use during recent years, depends upon tiny particles on the inside of the sleeve, causing sufficient friction after the sleeve has been rolled, to prevent the ends pulling out. In its earliest forms, tiny particles of emery powder were used, being held in position with lacquer. With the develop-

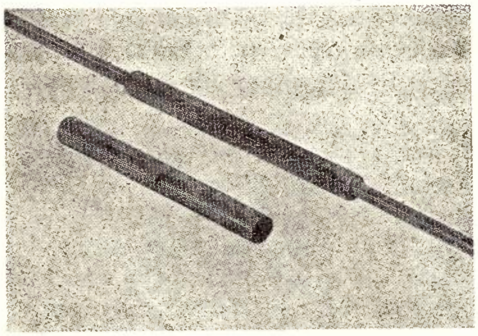


Fig. 54.—Rolled Joint with Sprayed Interior.

ment of metal spraying, non-ferrous metals (e.g., Nichrome, Monel Metal, Silicon Bronze, etc.) which are harder than H.D.C., have been sprayed into the inside of the sleeve, and this is the present form used. The tiny particles, blown from a special gun, key into the inside of the sleeve. When the sleeve is rolled they also key into the wire and effectively prevent slipping. Fig. 55 illustrates the type of rolling tool used.

(e) The pressed sleeve joint (see Fig. 52) is a variation of the rolled joint, the principal difference being that the sleeve is squeezed four or more times between two jaws of a special crimping tool (Fig. 56), instead of by a progressive rolling process. This method was developed in the U.S.A., where it is

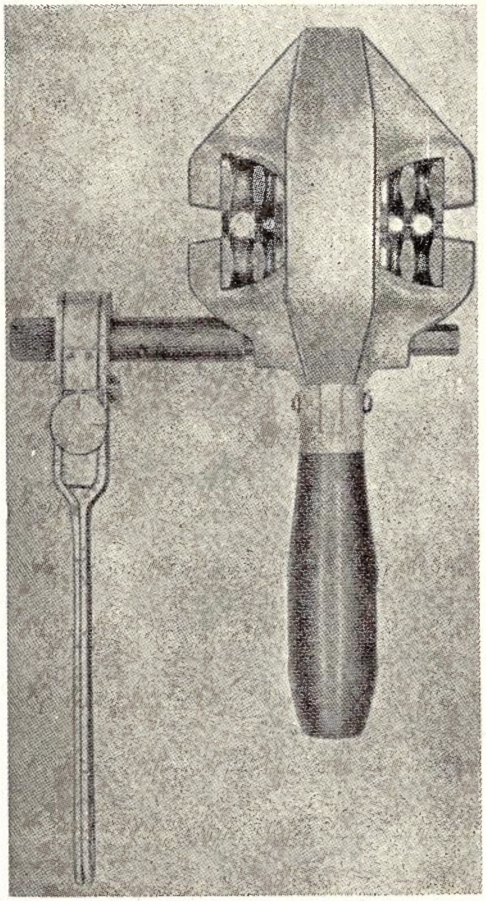


Fig. 55.—Sleeve Rolling Tool.

known under the trade name of "Nico-press." The tool is lighter and less expensive than the rolling tool.

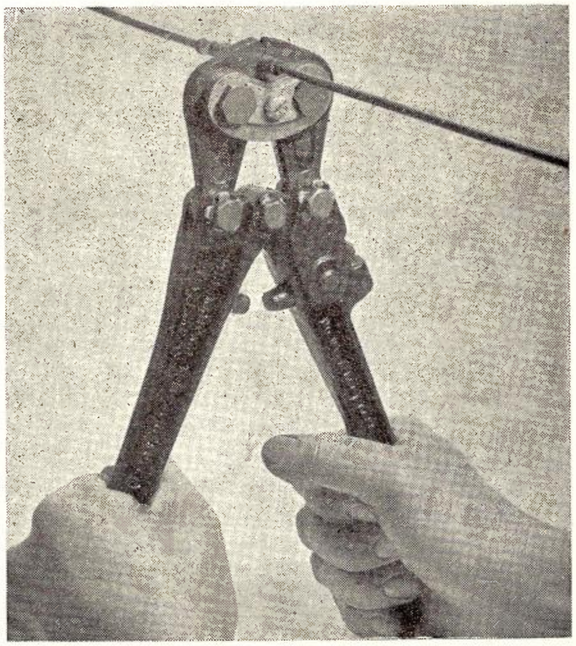


Fig. 56.—Pressed Sleeve (Nicopress) Crimping Tool.

The newer forms of joints (d) and (e) have the following advantages of the earlier forms:—

(i) Greater strength. Results of tests on twelve twist sleeve joints and eighteen pressed sleeve joints are listed in Table 9.

TABLE 9.

	Twist Sleeve	Pressed Sleeve
Max. strength of joint	100% wire strength	100% wire strength
Average ,, ,, ,,	87% ,, ,,	97.8% ,, ,,
Min. ,, ,, ,,	69% ,, ,,	95% ,, ,,

(ii) The mass is less. Fig. 52 shows a comparison in the mass of a twist sleeve joint and pressed sleeve joint on a 200 lb. H.D.C. wire. As a result of the reduction in mass there is much less likelihood of fatigue failures. Moreover, there is a saving in copper and consequent reduction in cost.

(iii) The electrical resistance is more constant and closely approaches the resistance of plain wire.

(iv) There is less possibility of corrosion, owing to the sleeve being squeezed tightly around the wire, thus preventing the ingress of moisture and air.

(v) The wire ends butt together, instead of overlapping. Hence in joining a broken wire it is not necessary to piece the line wire, with the result that only one joint is necessary as compared with two with sleeve joints.

Some of the pressed sleeves and the associated tools have recently been introduced in Australia. The sleeves are now being made locally but the tools are imported. This method has been received very well and experience gained to date has been favourable. There seems little doubt that its use will be extended.

Terminating

The termination of line wires is another phase of wiring detail which calls for careful attention to design and execution. Requirements of a satisfactory termination are speed, simplicity, adequate mechanical strength and freedom from fatigue failure. Space will permit only of attention being given to four forms of terminations.

Australian Standard.—Fig. 57 shows the Australian standard and is self-explanatory. In this latest version (only partly introduced at present) the binding wire is made off with ten turns along the line wire on either side of the 35 turns of binding over the double-wire portion. Previously the last ten turns were made off down the drip point, but tests have shown that by making them off along the wire there is less likelihood of fatigue failure developing at the point where the double-wire section begins.

Twist Sleeve Method. — The Bell System (U.S.A.) Practice is to use a short twist sleeve in lieu of binding wire, in the manner shown in Fig. 58. A similar method is used in the British Post Office for terminating 40 lb. and 70 lb. per mile cadmium copper wire.

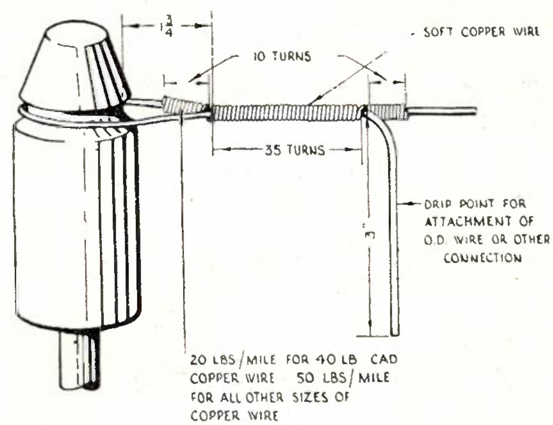


Fig. 57.—Australian Standard Type of Termination.

Rolled and Pressed Sleeve Terminators. — A method of terminating wires has been developed in which the rolled sleeve is used (see Fig. 59).

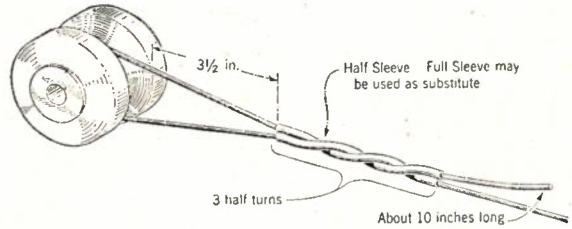


Fig. 58.—Twist Sleeve Termination.

A loop of hard-drawn cuprous alloy (e.g., bronze) is formed to slip over the insulator. The loop is semi-circular in cross-section and the two ends are brought together and slipped into one end of a sleeve and clamped. The line wire being terminated is then inserted in the other end and also clamped.

In place of a drip point for making connections the loop is provided with a special sleeve fixed on one leg of the loop into which the connecting wire is inserted and clamped. This method can be used with pressed sleeves as well as rolled sleeves.

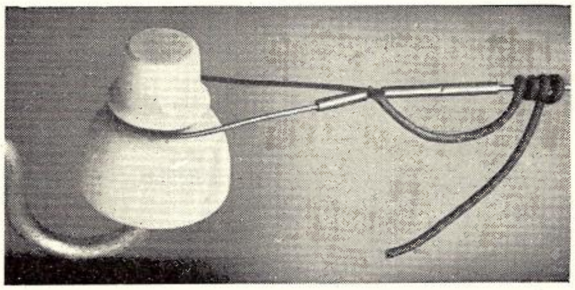


Fig. 59.—Rolled Sleeve Termination.

Another form of termination which has been developed for use with the pressed sleeve method is illustrated in Fig. 60. The special sleeve permits of a loop being formed in the line wire

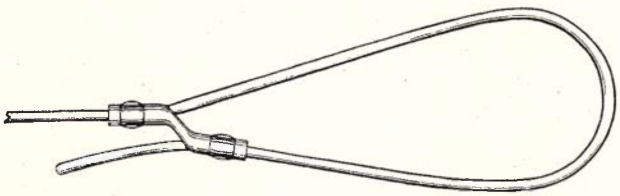


Fig. 60.—Pressed Sleeve Terminating Method.

which can pass round the insulator and also leave a projecting end for connection of the leading-off wire.

Bibliography

"The Vibration of Transmission Line Conductors," E. Bate, B.Sc., Wh.Sch. J.I.E. (Aust.), Vol. 2, No. 8, page 277, August, 1930.

"The Quantitative Determination of the Energy Involved in the Vibration of Cylinders in an Air Stream," E. Bate, B.Sc., Wh.Sch., and J. R. Callow, B.E.E. J.I.E. (Aust.), Vol. 6, No. 5, page 149, May, 1934.

"Vibration in Overhead Conductors," T. Varney, B.Sc. J.I.E.E., Vol. 77, No. 465, page 407, September, 1935.

"Vibration of Overhead Line Conductors," E. W. W. Double, B.Sc., and W. D. Tuck, B.Sc. J.I.E.E., Vol. 86, page 129, 1940.

Bell System Practices, G. 31.134. Issue 2, November, 1941.

Bell System Practices, G. 31.130. Issue 2, January, 1942.

"Rolling Joints," R. C. Moore, Bell Laboratories, record Vol. 10, No. 3, page 74, November, 1931.

"New Developments in Making Wire Joints," T. De Witt Talmage. Telephony, Vol. 104, No. 19, page 11.

Acknowledgment

The writer desires to acknowledge the use of diagrams from the following:—

(a) B.P.O. Engineering Instructions, "Line Overhead E. 3090," for Fig. 46.
(b) Telephony, Vol. 104, page 11, May 13, 1933, for Fig. 53.
(c) Bell Laboratories Record, Vol. 10, No. 3, pages 75 and 76, for Figs. 54 and 55.
(d) Bell System Practices, G.31.130 and G.31.134, for Figs. 47, 48, 49 and 58.

CHROMIUM PLATING

The technological papers to which reference was made at the end of the article on "Chromium Plating," Vol. 4, No. 1, page 25, are:—

"Metal Finishing," A Mankovich.

"Electroplating"—A survey of modern practice, S. Field and A. D. Weill.

"Throwing Power in Chromium Plating," H. L. Faber and W. Blum.

"Mechanism of Chromium Depositor" — An article from the Journal of Research of National Bureau of Standards (America).

"American Society of Testing Materials (A.S.T.M.) —Standards," 1940 Supplement, Part 1, Metals.

Metals Handbook, 1939 edition, American Society for Metals.

Society of Automotive Engineers (S.A.E.) Handbook, 1938, pages 438-440—"Chromium Plating."

An article compiled by the International Metal Co., Hartford, Conn., and the Pratt and Whitney Co., Hartford, Conn.

Practical Handbook on Electro Plating published by W. Canning and Co. Ltd., 1940 edition.—A.B.G.

THE MULTIVERSAL TEST SET

In the article on the Multiversal Test Set in Vol. 3, No. 6, page 347, the equation for the resistance to the fault when the ratio arms R_1 and R_2 were equal was given as:—

$$X = \frac{L - R_3}{1 - R_3/R_2}$$

This should have read:—

$$X = \frac{L - R_3}{1 + R_3/R_2}$$

—C.A.K.

CALL FEE INDICATORS—MELBOURNE TRUNK EXCHANGE

In Volume 4, No. 1, pages 10 and 11, type was transposed and the following corrections should be made:—

Page 10, column 2, first line.—After "Shown from two elevations in Fig. 1" delete the next sentence and substitute the following:—"The progressive duration of a call in minutes and tenths of minutes is indicated on the left and right hand numerals respectively. Operation of the time check commences when the start key is operated and the answering side of the connecting circuit is connected to a looped line, and stops when the calling subscriber restores the receiver."

Page 11.—Delete the first five lines under the diagram, Fig. 1.

Page 12.—The title of Fig. 3 should read "Pulse distribution including pulse alarm circuit."

A NOISE GENERATOR FOR TESTING SUBSCRIBERS' SERVICES

A. H. Little

The need for a method of testing the efficiency of subscribers' services overall from the mouthpiece of the subscriber's handset to the line terminals in the exchange, or from the line terminals in the exchange to the earpiece of the subscriber's receiver, has long been felt, and evidence can be found to show that the subscriber's transmitter circuit is frequently the cause of inefficiency, and can be classed as one of the most variable links in the transmission network. The object of this article is to describe a simple noise generator which was designed for the purpose of testing the trânsmission efficiency of subscriber's services to make reasonably sure that the "Standard Grade of Local Line Transmission" efficiency has been obtained. A drawing of the Generator is shown in Fig. 1. It consists essentially of a specially shaped brass container supported inside and near the top of a small wooden box and from which steel balls can be dropped and deflected against a suitable diaphragm to make a clattering noise by percussion as they fall.

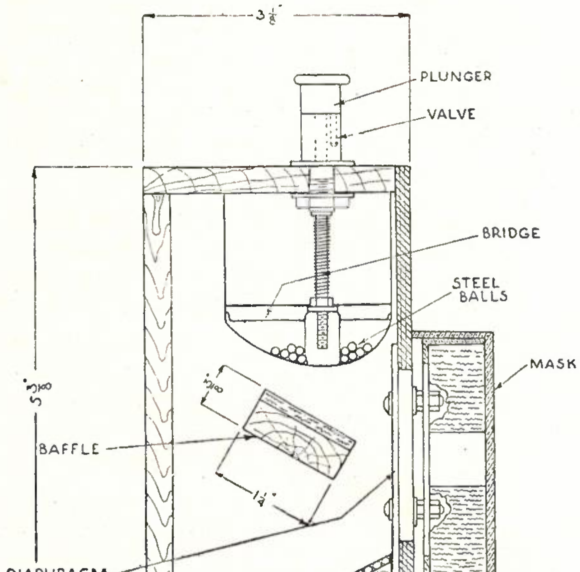


Fig. 1.—The Noise Generator.

The Brass Container.—The container is pressed from 20 gauge brass by a specially shaped die. The shape of this container is designed to give an even flow of balls during the noise generating period. A bridge is provided across the hole through which the balls pass to prevent congestion and sticking of the balls due to excess weight in the region of this hole. The size of the hole must be adjusted to give the best compromise between three factors:—

(1) The minimum number of balls required to give a suitable length of noise period;
(2) The maximum noise level allowable; and
(3) The constancy of flow of balls.

The Box.—The box in which the container is fitted is large enough to hold a baffle to deflect the balls, and a diaphragm, and to provide sufficient room at the bottom to hold all the balls free of the diaphragm when they have fallen. A passage is provided behind the brass container through which the balls can be rolled into the container when the box is turned upside down. A felt covering is provided in the bottom of the box to prevent an undue amount of noise being generated by the balls falling on the wooden bottom.

The Baffle.—The baffle is a wooden shelf covered with sheet rubber fitted inside the box in such a position, and inclined at such an angle to the horizontal, that the balls falling from the container bounce forward to strike the diaphragm and then fall into the bottom of the box. The rubber covering absorbs noise from the baffle and gives the balls a better trajectory. Adjustment of this angle within small limits gives a small measure of control of noise level.

The Diaphragm.—The diaphragm is an oblong piece of cloth base bakelite, clamped at four points to the front of the box: this material was specially selected and the method of attachment decided upon after a series of trials were made to obtain a suitable frequency response. The output of the generator has been analysed by means of a noise measuring set and wave analyser. The result of tests on four typical generators is shown in Fig. 2.

The Mask.—The mask consists of a sponge rubber disc in a brass container supported away from the front of the box to allow a free passage of air when a transmitter under test is placed against the front of the mask. There is a hole in the centre of the sponge rubber disc through which the noise passes to the transmitter. Discs with various sizes of holes are selected during final tests until one is found which allows the correct amount of noise to pass.

The Balls.—The balls are $\frac{1}{8}$ in. steel ball bearings, nickel plated to prevent rust. Approximately 16 gross of balls are required to give a noise period of 10 seconds. Twelve gross are generally found to give a noise period of sufficient duration for most purposes.

Noise Level. — When the noise generator is used with a standard telephone connected in a circuit equivalent to Drawing C.1054, the electrical power output level is approximately—3db referred to 6 mW or + 5 db referred to 1 mW.

Operation.—To operate the noise generator, the box is turned completely over in such a way that all the balls roll from the bottom of the box along the back of the box through the passage provided into the brass container. The box is then placed on a table or level support ready for use and the telephone transmitter to be tested is then held with its mouthpiece in gentle contact with the rubber mask. A valve in the top of the box is then opened, releasing the balls. The level of the electrical energy generated is measured in the exchange by arrangement with a mechanic or switchboard operator. A level of —5 db referred to 1 mW is considered to be a satisfactory level at this point, and reasonably assures that the "standard grade of local line transmission" efficiency is being obtained. A series of readings with the transmitter in reversed positions, i.e., rotated through an angle of 180° in the plane of the transmitter diaphragm, may be taken, and the mean calculated for more accurate results.

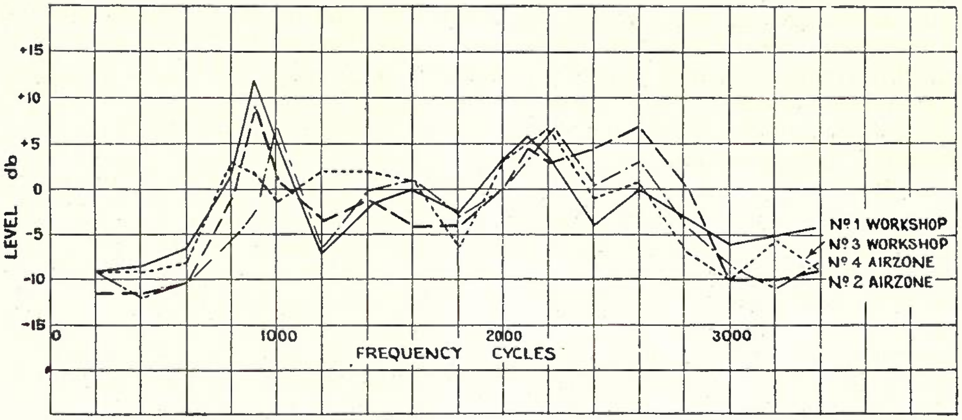


Fig. 2.—Comparison of Output Curves. The output levels shown are relative only.

Fig. 3.—The Noise Generator in Use.

To test receivers, a portable amplifier having a gain of 54 db is used. It is inserted in the line circuit of a telephone and by means of a key can be switched out of circuit while the exchange is being called preparatory to making a test. When the amplifier is switched into circuit, the battery supply is cut off from the telephone transmitter, ensuring that noise in the transmitter will not generate electrical energy, and the receiver is then held in front of the generator during a noise cycle. A special rubber mask with a very fine hole in it to give "Receiver on Ear" conditions is used for this test, and the gain of the amplifier is fixed at a figure which will give a reading of —5 db referred to 1 mW in the exchange when "Standard grade of local line transmission" efficiency is obtained.

The amplifier is fitted into a case about 9 ins. x 12 ins. x 4 ins. and although portable it is not recommended for use other than in the investigation of special complaints, due to its weight.

At small country offices the level is measured by the telephonist on a small portable rectifier meter provided for the purpose. The meter is left at the exchange by the mechanic prior to making the tests on the subscriber's telephone.

At larger exchanges a panel mounted type of level indicator may be used, or the test desk voltmeter adapted for A.C. testing by means of special copper oxide rectifiers.

A photograph of the noise generator in use is shown in Fig. 3.

References

A New Telephone Test Set—G. H. Domsch, and O. Bohm.

Siemens Reports on Advances in Communication Engineering, June, 1937.

C.C.I.F. 11th Plenary Meeting, Copenhagen, June, 1936. English Edition, pages 166 to 181.

THE VICTORIAN 2 V.F. SIGNALLING SYSTEM

A. E. Bayne (Siemens Bros. & Co. Ltd., London)

Continued from Vol. 2, No. 5, page 296.

General.—The initial operation of the Victorian 2VF signalling system has been confined to trunks between the capital city, Melbourne, and country exchanges at present operating on a magneto basis. Fig. 7 shows in outline the arrangements at each end of a 2VF trunk and it is proposed to detail the occurrence of the various VF signals in typical call set ups using this equipment. The routings of other types of call will also be described.

The majority of call routings at present handled by the system are one or the other of two types illustrated in Figs. 8 and 9. The first example represents somewhat more than 50% of the total traffic, and on calls to Melbourne automatic subscribers, reflect more than any other type of call the advantages gained by the introduction of 2VF dialling. For instance, a telephonist at Mildura (356 miles distance) originally dependent on magneto signalling to a Melbourne telephonist who set up the automatic connection, now directly controls the dialling of the Melbourne subscriber and obtains immediate lamp supervision of the call.

On long distance telephony in particular, the "one telephonist per call" is an achievement of considerable benefit to both the subscriber and the administration. Until all the various Victorian country exchanges are converted to automatic working, the call outgoing from Melbourne to the country subscriber must of necessity have two operator switchings. The absence of cords and plugs, the provision of Key sending and Call Storage equipment all constitute "operating aids"

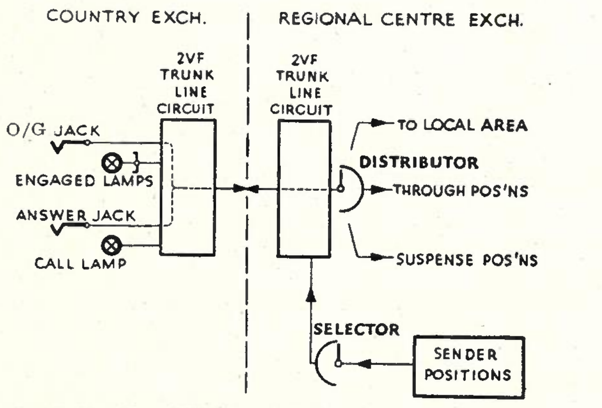


Fig. 7.—Both Way 2VF Trunk between Regional Centre and Country Magneto Exchange.

of a modern telecommunication system and, being available to the Melbourne Trunk exchange telephonist, compensate somewhat for the apparent advantage possessed by the country telephonist in making calls to Melbourne.

The Network Layout.—The Australian telephone system has been divided into regions which correspond approximately with the boundaries of the various States. The capital city of each State becomes a **Regional Centre**—in the case of Victoria this is Melbourne. Each region (or State) is divided into zones and the principal exchange in each zone will be a **Zone Centre** through which passes most of the traffic from other exchanges in the zone. Each exchange within a zone is classified either as a **Group Centre** (having branch trunks to other exchanges) or as a **Terminal Exchange.**

The grouping of these exchanges into a coordinated and comprehensive switching plan with trunks radiating from Regional Centre to Zone Centres and from a Zone Centre to Group Centres, and ultimately Group Centres to Terminal Exchanges, must depend to a large extent on traffic conditions as the scheme develops. The establishment of switching equipment at a country exchange chosen as a Zone Centre is intended to provide for a more economical use of trunks from the Regional Centre. This is because the cost of line plant is sufficiently high to justify additional signalling and switching plant even if only a small saving of line time can result. The grouping of trunks at a zone centre takes advantage of the fact that traffic peaks at the various exchanges seldom coincide, and in addition to the number of direct trunks from the Regional Centre, provision is made for a common pool of trunks to serve any one of the Group Centres experiencing peak traffic conditions.

Ultimately, each Zone Centre will have automatic switching equipment terminating a special group of Secondary trunks from the Regional Centre. This equipment must be capable of steering overflow traffic to exchanges within the zone, including also the zone centre exchange. Access to this secondary group of trunks as an alternative route from the Regional Centre is dependent on all primary (i.e., direct) trunks to a particular group centre being engaged. Under these conditions no special action on the part of the Regional Centre operator is required. The code of the Group Centre concerned would be keyed up in the normal manner, the sender automatically deciding when it is necessary to take the alternative route and adding the VF digit required to position the zone centre switching equipment.

During the first year's working, the alternative routing facility was introduced on a manual basis without the establishment of zone centres or common pool of overflow trunks. Each country exchange was allocated an alternative route via a branch trunk to an adjacent exchange and the sender gave a special signal to the Regional Centre telephonist signifying that an exchange other than the one called would answer.

Routings involving tandem working may always exist in a network of trunks covering an area such as Victoria. Automatic transit permits VF signals to pass from end to end of the connection but this is inadvisable with manual transit owing to possible interference of signals when the telephonist enters the connection. VF signals can, however, be relayed through a manual position on a DC basis in such a way as to prevent interference by the telephonist. Both methods are detailed in later paragraphs.

To facilitate the description of the various call routings the following abbreviations are used:—

RC. REGIONAL CENTRE (MELBOURNE).

ZC. Zone Centre (switching centre per Zone).

CE. COUNTRY EXCHANGE (Group centres or Terminal exchanges. Special reference to Auto. or magneto is applied where necessary.).

Call from CE (Magneto) to RC direct to local area.—Refer to Fig. 8. Insertion of the calling plug by the CE telephonist causes the engaged supervisory lamps to glow and the SEIZING signal to be sent. The application of this signal at the RC, prepares the circuit for impulsing and engages the trunk against seizing by an RC telephonist.

The CE telephonist dials the required number, the dialled impulses being converted into VF pulses. The first digit received causes the associated distributor switch to search a group of outlets leading to the local area. Further trains of impulses (if required) select the local area subscriber or manual exchange.

When the called subscriber answers, the VF ANSWER signal pulse is received and the CE supervisory lamp is extinguished. The sending of the ANSWER ACKNOWLEDGE follows immediately.

When the called subscriber hangs up, CLEAR BACK pulses are received and the CE supervisory lamp glows steadily. The CLEAR BACK persists until either the called subscriber removes the handset again or the connection is broken down by the CE.

When the CE telephonist withdraws the calling plug a CLEAR FORWARD signal is sent out, causing the loop to the automatic switches to be opened. When the CLEAR FORWARD signal ceases the RELEASE signal is sent back until the RC 2VF circuit completely reaches normal. Before starting to return the distributor switch to normal, the circuit measures off a period of 850 ms (minimum) from the opening of the loop, during which period the outgoing P wire remains earthed. The period is to cover the release of the selectors in the RC automatic exchanges and thus preclude the possibility of their being caught and held off normal by re-seizure by another distributor.

If Busy or NU tone is received, then on the CE telephonist breaking down the call, the CLEAR FORWARD signal takes effect during the first break in the tone.

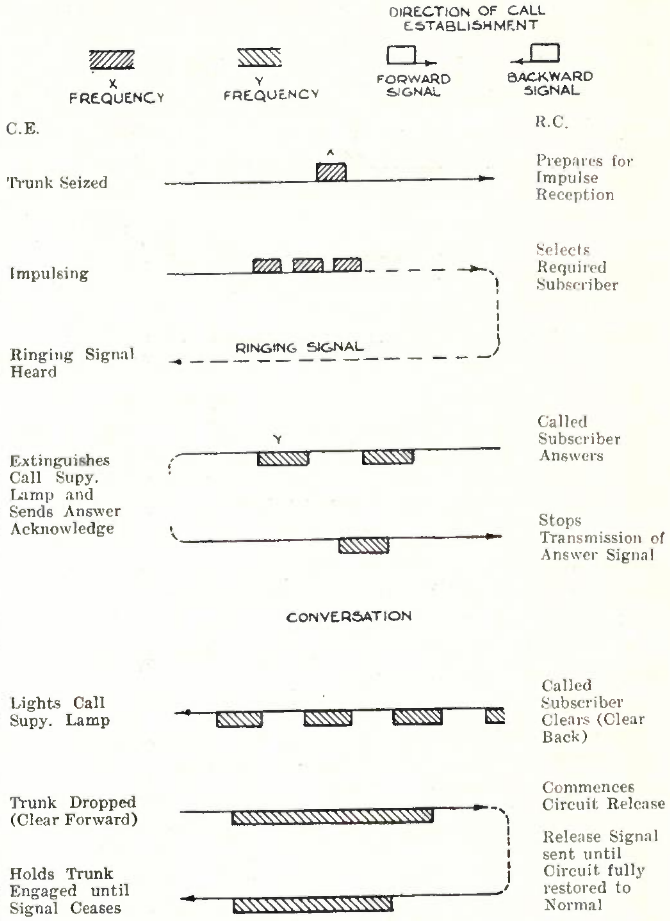


Fig. 8.—Call from CE (Magneto) Direct to Automatic Subscriber at RC.

Call from RC direct to CE (Magneto).—Refer to Fig. 9. The RC telephonist obtains access to a CE trunk via TRK Selectors under the control of a Sender. At the CE the call is initiated by the arrival of a SEIZING pulse which causes the engaged lamps to glow and the call/clear lamp to light. The telephonist answers by inserting the answer plug into the answer jack, thus extinguishing the call/clear lamp. The ANSWER signal is sent and acknowledged and the RC supervisory lamp is extinguished.

Should the called subscriber ring off, it will cause the CLEAR BACK signal to be sent and this results in lighting the RC supervisory lamp. The same occurs should the CE telephonist withdraw the answer plug. Re-insertion of the answer plug causes the CLEAR BACK signal to cease.

When the RC telephonist breaks down the connection, the CLEAR FORWARD signal arrives. When this ceases the CE reverts the RELEASE signal until circuit release is complete. Should the answer plug be in the jack as normally will be the case, the reception of the CLEAR FORWARD signal causes the call/clear lamp to flash. Withdrawal of the plug stops the lamp flashing.

The RC telephonist can RING FORWARD at any time. The call/clear lamp lights and the CE telephonist acknowledges the signal by withdrawing the answer plug and re-inserting it (or

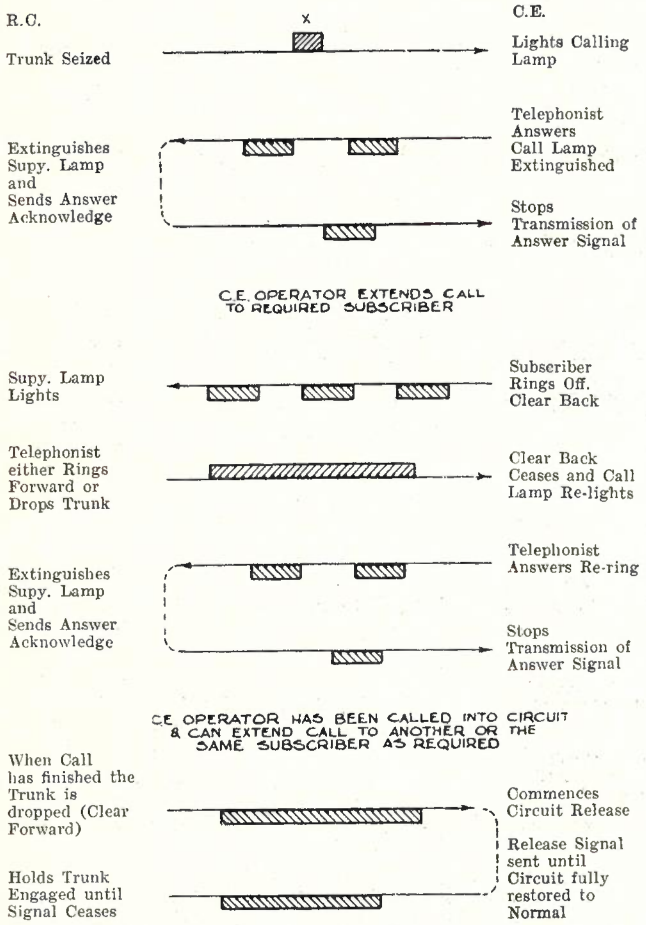


Fig. 9.—Call from RC Direct to CE (Magneto).

inserting it if already out). The ANSWER signal is then sent again and acknowledged by the RC.

Call from CE to RC routed to automatic area via Through or Suspense Positions.—The CE telephonist dials a single digit to obtain the RC trunk telephonist. The digit causes the distributor switch to select a free path of access to the trunk switchboard. When the RC telephonist answers, a VF signal is not sent but, circuit changes take place in the 2VF Trunk line circuit as follow:—

(a) A voice immunity guard is introduced on the X frequency receiving circuit, the function of which from that stage onwards being to record a RING FORWARD signal.

(b) The control of trunk release is made dependent on the RC telephonist.

(c) The back bridge conditions are changed to pass DC signals in either direction via the operating position.

When the call has been extended to the local subscriber, and is answered, a DC answer signal is received by the 2VF circuit from the local O/G to Auto. circuit; this actually is the Ordinary First Local Selector which is fitted with a transmission bridge and which has direct access to junctions leading to various local exchanges. The VF ANSWER signal is accordingly sent and acknowledged by the originating (CE) exchange. The calling supervisory lamps at both the CE and RC exchanges are extinguished by the subscriber's answer.

When the called subscriber hangs up, the calling supervisory at RC glows; the CLEAR BACK signal is also sent out to the CE where it causes the supervisory lamp to glow. If the RC telephonist is on the line, the reversion of the CLEAR BACK signal to the CE exchange is held up in order to allow conversation between telephonists to take place. Similarly the signal is temporarily suspended when the RC telephonist enters the connection.

The country telephonist can attract the RC telephonist's attention at any stage by sending a RING FORWARD signal. This will cause the RC answering supervisory lamp to flash until the telephonist answers, upon which the flash ceases. If the subscriber has answered, the circuits at both ends of the trunk return to the pre-answered condition. If the CLEAR BACK signal is being transmitted this will cease. The local connection established on the calling side of the RC position is not affected in any way.

When the CE telephonist breaks down the connection, the CLEAR FORWARD signal causes the RC answering supervisory lamp to glow steadily. When the signal ceases, the RC end applies the RELEASE signal to the trunk until the RC telephonist releases the connection and all apparatus has returned to normal. If the RC has already released, the RELEASE signal will persist until all apparatus is at normal.

Connection together of two VF Trunks via RC Tandem Manual Transit.—Calls may be set up by the RC as follows:—

(A) A call set up entirely by the RC to two VF signalling trunks. Both would be outgoing from the RC. Each trunk signals separately to and from the RC and no signal passes from end to end of the connection.

(B) Calls originating at a point outside the RC and connected via the RC to another trunk. The following signals are relayed through the RC on a DC basis in a forward direction; that is, in the direction in which the connection has been established.

(1) **Ring Forward.**—This signal causes the answering supervisory lamp at the RC to flash until the telephonist answers. The calling

supervisory lamp if not alight; glows when the RING FORWARD takes effect at the O/G side of the RC connection, and remains alight until a fresh ANSWER signal is received.

(2) **Clear Forward.**—This is relayed through the RC and causes the immediate application of 600 C.P.S. to the trunk on the outgoing side. This continues until the RC telephonist releases the connection, after which it continues for 2 seconds (the usual first pulse of the RC CLEAR FORWARD). The purpose of this prior and immediate application of CLEAR FORWARD is to obtain a quick clear down of the connection when the RC decides to release the circuits. When the signal has been relayed to the O/G side of the RC connection, both supervisory lamps glow.

The backward signals relayed through the RC are:—

(1) **Answer Signal** when received at the O/G side of the RC connection, this signal is relayed through the RC to the I/C side, where it is repeated to the originating trunk exchange.

(2) **Clear Back.**—When this is received on the O/G side, it removes the DC answered signal and causes the I/C side to send out CLEAR BACK pulses.

Call from RC direct to CE (Automatic).—The RC telephonist keys up the code associated with the automatic CE and when a free trunk is found the SEIZING signal is sent, preparing the CE circuit and associated selector for impulsing. At the same time the engaged condition is applied to the O/G circuit of the trunk in the local manual board. The sender is re-engaged and supplementary digits keyed up to route the call to the required subscriber.

When the subscriber answers, the DC reversal signal received in the CE trunk line circuit, causes the VF ANSWER signal to be sent to line which continues until the ANSWER ACKNOWLEDGE is received.

When the called subscriber hangs up the CE 2VF circuit sends out the CLEAR BACK signal. When the RC breaks down the connection a CLEAR FORWARD signal is sent which opens the loop to the automatic switches in the local area. When the CLEAR FORWARD ceases, the RELEASE signal is reverted until the circuit sending it reaches normal. Before releasing the trunk selector, the 2VF circuit measures off a period from the opening of the loop, long enough to guard the release of local switches.

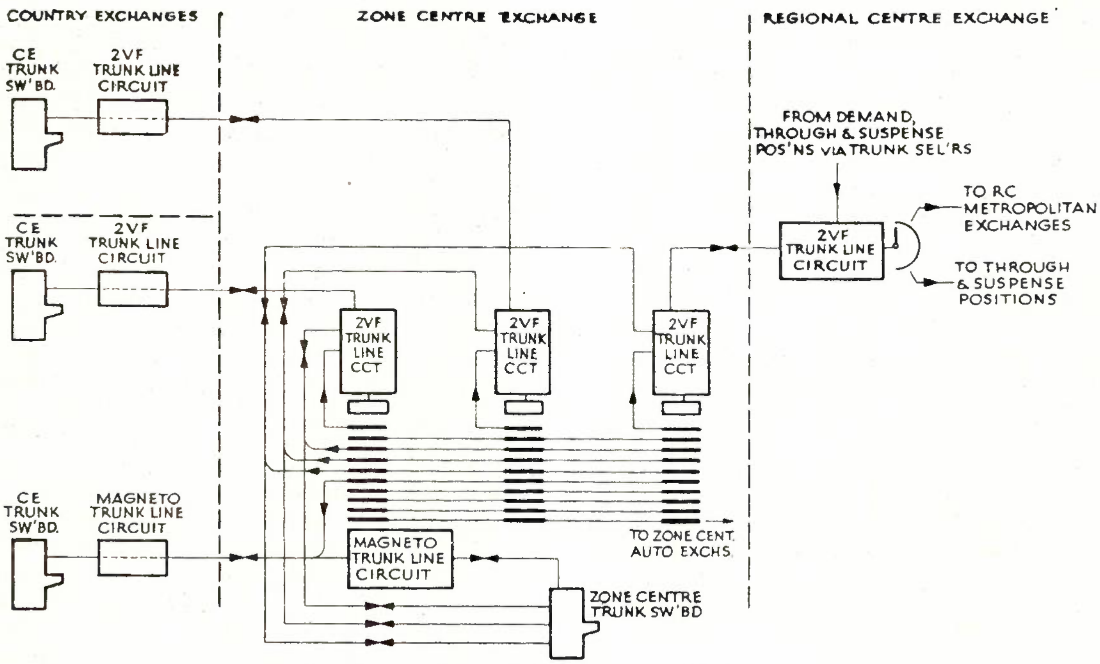


Fig. 10.—Typical Zone Centre Diagram.

The supervisory conditions at the RC are the same as for a call RC to CE (magneto) except that the automatic subscriber has direct control of the ANSWER and CLEAR BACK signals. A RING FORWARD signal from the RC is, of course, ineffective in the case of the foregoing automatic routing.

Access to the CE manual board can be obtained by the addition of a supplementary digit after the RC has keyed up the CE code. The trunk selector is positioned but released immediately after the associated calling lamp lights on the manual board. Being of the sleeve controlled type, the arrangements for translating signals to DC and passing them via the cord circuit are the same as previously described for the RC (manual transit), except that the CLEAR FORWARD is only effective on the answering side of the cord circuit.

When the telephonist inserts the answer plug, the calling lamp is extinguished, and on extension of the call the subscriber answering (or equivalent) controls the ANSWER SIGNAL, etc.

Zone Centre Routings. (Refer to Fig. 10.)

Call from RC direct to ZC local area.—If the local area is automatic, conditions apply as previously described for RC to CE (automatic).

If the local area is manual, all calls from RC will terminate on a sleeve controlled type of manual board and the calling lamp lights as soon as the SEIZING signal is received as a result of the RC telephonist sending ZC code. Manual transit conditions will apply as previously described.

Call from RC via ZC to branch trunk.—The RC telephonist sends a further digit to select the required route after having set up the connection to the ZC. The ZC trunk selector is positioned and searches for a free branch trunk. If the branch trunk is VF signalling or CB signalling, the signals are either relayed or translated through the ZC and the conditions remain the same as RC calls to CE.

If the branch trunk is magneto signalling it is necessary to ring and this can be done by the RC telephonist sending the RING FORWARD signal. This is converted into a DC signal which controls the application of 17 cycle ringing via the magneto branch trunk line circuit. The ring continues for as long as the RING FORWARD is sent out and when the ring ceases the magneto trunk line circuit returns an answered condition to the 2VF circuit.

If the called exchange (or magneto subscriber) rings back, either to attract attention or as a clear, the magneto trunk line circuit will remove the answered condition and the 2VF circuit sends out the CLEAR BACK signal to light the RC supervisory lamp. The RC telephonist can recall by again sending the CLEAR FORWARD.

When the RC breaks down the connection, the CLEAR FORWARD signal starts the release of the trunk selector and magneto trunk line circuit.

Call from CE to CE via ZC. Tandem working —Automatic transit.—The telephonist at the originating CE dials into the Zone centre where the 2VF pulses are converted to DC and the selector is positioned. As soon as the selector has searched and found a free trunk a SEIZING signal is sent to the called exchange and the two 2VF trunks are connected in such a way as to permit VF signals to pass right through. This would thus provide for the originating telephonist to directly dial a subscriber on the called exchange.

When the called subscriber answers, the ANSWER signal pulses pass direct to the originating exchange and subsequently the ANSWER ACKNOWLEDGE passes straight through the ZC. Certain other signals such as RING FORWARD or CLEAR BACK also have no effect at the ZC.

When the originating exchange breaks down the connection it sends the CLEAR FORWARD signal, which, by reason of its being a longer 600 C.P.S. signal than any other, is recorded at the ZC. When the CLEAR FORWARD signal ceases the zone centre selector releases and reverts a RELEASE signal to release the circuit at the originating exchange.

Should the CLEAR FORWARD which registered at the ZC fail to register at the called exchange, no RELEASE signal will be forthcoming from that exchange when the ZC selector is released. Under these circumstances, the ZC end waits for half a second and then itself applies a CLEAR FORWARD signal which should result in the RELEASE signal being reverted.

Call from RC via ZC secondary trunks to CE.—Should the RC telephonist key up the code of a CE the primary trunks of which are all engaged, the Sender does not attempt to establish the direct route but immediately searches for a free secondary trunk to the ZC. Having obtained connection to the trunk, the SEIZING signal is immediately followed by a train of VF impulses which route the call to the desired CE via the ZC secondary trunk terminating selector. Signalling then proceeds as for the normal RC to CE direct. Should the selector at the ZC find all branch trunks engaged, the RE-ROUTE signal is returned to the RC; the 2VF trunk line circuit translates the signal to DC and relays it to the Sender.

The Sender releases the alternative route, again attempts to establish the call on the direct route and, if unsuccessful, finally routes the call into the primary route storage. The fact that the Sender automatically selects a route via a special group of secondary trunks means also that the code selected is not one which comes within the normal trunk numbering scheme as applied to Country exchanges.

Call from ZC subscriber to RC.—This type of call is connected via the local sleeve control board and differs from the call originating from a magneto CE in that the supervision of the call is given on the cord circuit lamps and not on a special lamp associated with the trunk O/G Jack.

The SEIZING signal is sent when the telephonist plugs into the O/G Jack and engaged conditions are applied. The call supervisory lamp in the cord circuit flickers, indicating to the telephonist that the trunk is a dialling circuit. When the dial call key is thrown, the flicker ceases and the circuit is prepared for translating loop impulses from the position circuit to VF impulses on the trunk. Restoration of the dial key causes the supervisory lamp to glow. When the called subscriber answers, the supervisory lamp is extinguished and conversation can be carried on.

The CLEAR BACK signal received when the called subscriber hangs up, lights the supervisory lamp, and withdrawal of the calling plug results in the CLEAR FORWARD being sent to the RC. The RELEASE signal follows.

On a call routed via the Through or Suspense positions the attention of the RC telephonist can be attracted by operating the ring key. The conditions at the RC are as described for a call from the CE magneto.

The foregoing description applies similarly to a call routed from CE (automatic or C.B.) to RC.

Rack Equipment

The 2VF equipment at Country magneto exchanges is mounted on compact unit racks each of which can accommodate equipment for a maximum of five 2VF trunk lines. The racks are arranged in pairs when five trunks per exchange are exceeded and certain equipment common to each ten (or less) lines is mounted on the first rack of the pair.

The equipment per trunk termination consists of a trunk line relay set and a VF receiver. The equipment common to ten (or less) lines includes two oscillators (750 and 600), a relay interrupter set and certain small miscellaneous items such as alarm relays, etc. The arrangement for exchanges with more than one pair of racks (i.e., more than ten trunks) is such that the failure of an oscillator or interrupter of one pair automatically makes available the output of the other pair. A Test Panel (described later) is provided at the rate of one per exchange. No moving parts, other than relays, are contained in the equipment and these relays are of the standard B.P.O. 3000 and High Speed type. The current supply for all the equipment on each rack is provided by a mains unit mounted at the bottom of the rack.

An alarm bell connected to a primary Battery functions as follows:—

(a) Intermittent ringing with a fuse alarm lamp alight: DC fuse blown (on Misc. Panel).
(b) Intermittent ringing without alarm lamp: AC fuse blown (on Misc. Panel).
(c) Continuous ringing without a fuse alarm lamp alight: main power supply has failed.

The 2VF equipment at the Regional Centre is equipped on racks containing 20 circuits each. The racks are arranged in suites of four and a relay interrupter for VF pulse control is provided at the rate of one per suite. These interrupters are interconnected between suites forming a ring main with automatic switching through to the next suite should a failure occur.

Power Supply at Country Exchanges.—See Fig. 11.—The majority of towns throughout Victoria have a supply of AC available and the power supply for the VF rack equipment is supplied from a "Transrecter" mains unit. In view of the desire to keep all exchange equipment uniform, arrangements were made in one or two cases to provide a small rotary converter where the town supply was DC instead of AC.

The mains unit has been designed to operate off 50 cycle AC at voltages of 200, 230, 240 and 250, and it incorporates regulating apparatus for dealing with mains voltage variations up to plus and minus 5%.

The output feeds are as follow:—

50 VOLT DC smoothed—for supplying the Oscillators and VF receivers.

50 VOLT DC unsmoothed—serving the remainder of the equipment requiring direct current for its operation.

46 VOLT AC—feeding the heater elements of the Oscillator and VF receiver valves.

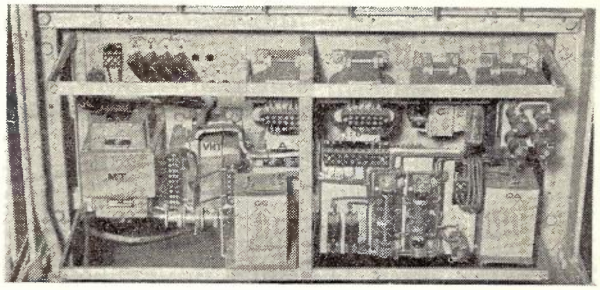


Fig. 11.—Transrecter Mains Unit—Cover Removed.

The mains unit has been designed to give a maximum DC output of approximately 3.5 amperes at 50 volts. The load will differ between exchanges owing to variations in the number of 2VF Trunk Line Circuits, etc., initially equipped, and moreover it will not be constant in individual exchanges as load variation will occur according to whether or not trunk line circuits are in use and also according to their particular stage of operation when they are in use. To limit the extent of DC voltage variation with changing DC load, regulating equipment is incorporated additional to that already mentioned for taking care of mains voltage variation.

A power failure deprives the CE of signalling current, but does not prevent calls being originated over the 2VF trunk line to Melbourne. Special whistles are provided for setting up a connection to the RC and all calls are then reverted from the RC to CE until power is restored—see Fig. 12.

Frequency generation. See Fig. 13.—At large exchanges, such as the RC, the required frequencies are obtained from a generator producing four frequencies as follow:—

500 PS. Not used.

600 PS. 2 VF Signalling Frequency "Y."
750 PS. 2 VF Signalling Frequency "X."
900 PS. Pip-Pip Tone on Trunks at end of 3-minute periods.

Two generators are provided, one for normal running and the other as a standby. Each is run from the exchange 50V supply and the output of the machine is set at 20 Volts. Distribution to the various racks carrying 2VF trunk line circuits is via rack transformers which step the voltage down to that required for application to the line (via a 3 db pad). The impedance looking into the machine is negligible and does not vary appreciably with load. The speed of the machine is 3000 RPM and governor controlled. A specially illuminated stroboscopic wheel on the machine is used in conjunction with a tuning fork to maintain the speed within 9 revolutions either side of the nominal speed.

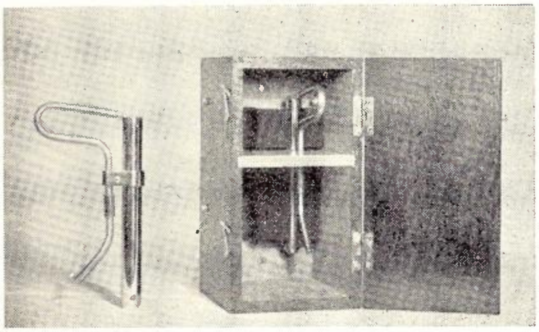


Fig. 12.—Emergency 600 and 750 C.P.S. Whistles.

At country exchanges only 600 and 750 PS supplies have to be generated and this is done by means of oscillators designed to produce the required voltage for feeding direct to line (via 3 db pads). In the case where a country trunk is capable of 4 wire switching, the sending circuit is different from that used in similar conditions at the RC or any other exchange fitted with machine generators. The reason is that the oscillator output varies with the tapping chosen to obtain correct voltage. It is therefore necessary to send on both Line and Net speech paths in parallel to be sure of correctly balancing the terminating hybrid.

Types of VF Receivers.—Two types of Receivers are used in the system as follow:—

(a) 50V DC heating. 50V limiter valve anode: 130 + 50V output valve anodes.
(b) 46V AC heating. 50V limiter and output valve anodes.

Type (a) Receiver uses a high impedance pentode for the limiter valve and triodes for the output valves. Type (b) Receiver uses pentodes for all of its valves.

Current consumption considerations determine the type of Receiver used. In exchanges employing a large number of Receivers, as at the Regional Centre, and in which exchanges there is usually a 130 volt battery (with the negative pole earthed), the type (a) Receiver greatly economises in power consumption. The reason for DC heating, as against what would appear to be the cheaper course of AC heating, is that DC gives the greater factor of safety against total trunk line shut-down in the case of mains failure. The type (b) Receiver, with AC heating and 50V anodes, becomes necessary for the reason that in country exchanges where it is used, the local power plant comprises only a "Transrecter" Mains Unit supplying 50 volts of comparatively small output.

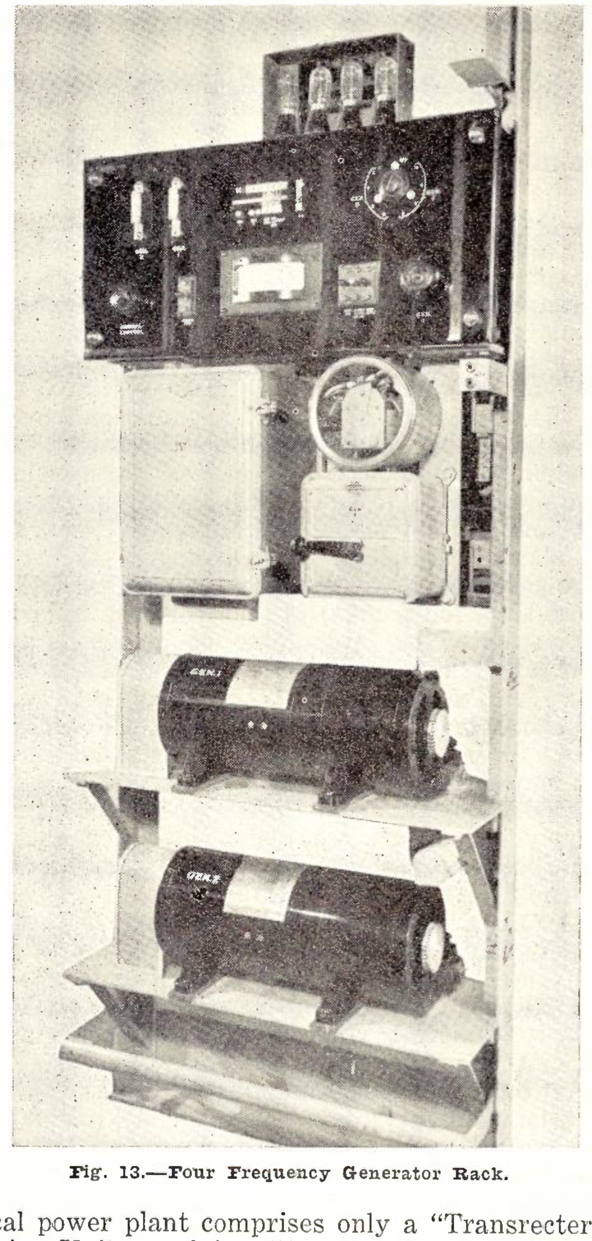


Fig. 13.—Four Frequency Generator Rack.

In country exchanges having a 50V battery, provision can be made for a type (b) Receiver to be heated normally with AC but to be automatically switched to 50V DC heating in the event of mains failure.

Type (a) Receivers are fitted with a battery cut-off relay intended to be operated when a trunk or carrier channel is shut down at night time. This provision enables considerable saving in 50V DC consumption to be made, and under the present conditions it is estimated that approximately 70% of the receivers in use could be shut down for a period of eight hours each day. Quite apart from the saving in current consumption, the life of the valves would be considerably increased by exercising the "shut-down" facility.

Test Panel. See Fig. 14.—As previously stated this panel is provided at the rate of one per country magneto exchange and is designed to apply tests of a simple nature to receivers and oscillators to serve as a general guide to their state of adjustment and as a means of providing rough checks during fault finding.

The circuit operates from the ordinary power supply on the first rack in the exchange and is mounted as a panel at the rear of this rack together with a spare shelf position into which the set to be tested is jacked. The panel includes a milliammeter which can be used to check the voltage of the 50 volt supply as well as the anode current of the receiver or oscillator valves. Key operation permits the application of a frequency of 750 C.P.S. or 600 C.P.S. to the receiver via a resistance network to bring the level down to approximately zero (1 milliwatt into 600 ohms).

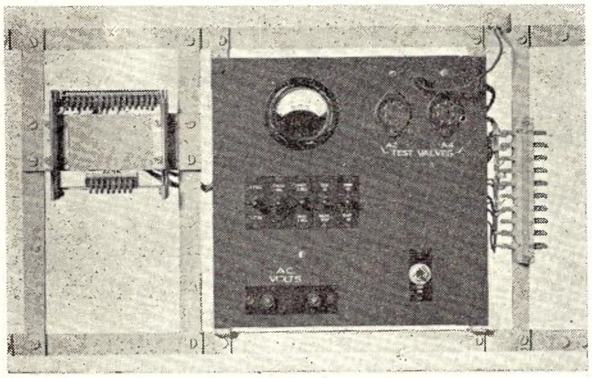


Fig. 14.—Country End (Magneto) Test Panel.

When an oscillator is jacked into the test position, the anode currents of its valves may be measured and terminals are provided for connection to an AC voltmeter which indicates the output voltage of the oscillator, when working into a 600 ohms load. Two terminals are provided so that beats may be obtained on the voltmeter between the locally generated frequencies and a standard frequency which may be obtained from a central exchange.

Provision is made for separately testing valves. The heaters are connected to the appropriate AC supply and the grid in each case is returned via a resistance to a point which is positive with respect to the cathode and adjusted so that the grid current which flows is approximately that required in the tests for the particular valve.

2VF Receiver Tester. See Fig. 15.—This equipment is intended to apply to receivers such tests as will enable the impulsing performance to be measured, the operation of the speech guard circuits to be checked, and the performance of the valves to be tested.

The equipment is self-contained and includes all the necessary instruments and frequency supplies, and is operated from the AC mains via its own Transrecter, which provides a supply of 50 volts DC capable of being switched to 46 or 52 volts and which also supplies power for the receiver under test.

The test panel is rack mounted and carries all the necessary apparatus except the impulse generating device used to supply impulses to the receiver under test. This is mounted as a separate relay set, in a position on a shelf which also accommodates the receiver under test and another receiver which may be heating up preparatory to being tested. Jack strips on this shelf give access to the internal wiring of the receiver, and provide the means of connection between the receiver and the tester.

An oscillator is provided which generates frequencies of 750, 600, 375 and 300 C.P.S., and keys are fitted by which these frequencies may be raised or lowered by approximately 20 C.P.S. to enable tests to be made over the band width of a receiver. In addition, the oscillator can be made to generate two frequencies simultaneously, e.g., 600 and 375 C.P.S., and this can be used to test the effectiveness of the guard circuits in face of the signal frequency. A rectifier voltmeter enables the level of applied frequencies to be checked and attenuation pads internal to the tester allow tests to be made at different levels. The voltage of the 50 volt supply can be checked on one of the instruments provided and adjustments can be made with the help of a resistance in the main supply lead.

A separate tester is incorporated for proving the valves associated with the receiver. The location of these VF Receiver Testers depends on the physical grouping of VF signalling exchanges within a selected area. A Zone Centre would appear to be a logical location and this can be arranged, if necessary, at a later date, as the system develops.

At the Melbourne end a 2VF Receiver Tester is installed which operates from the exchange batteries of 50 and 130 volts and the Transrecter mains unit is not included. As in the Country type testers, switching is provided whereby the voltage of the 50 volt supply may be changed to 46 or 52 and an additional small secondary cell is necessary for this purpose.

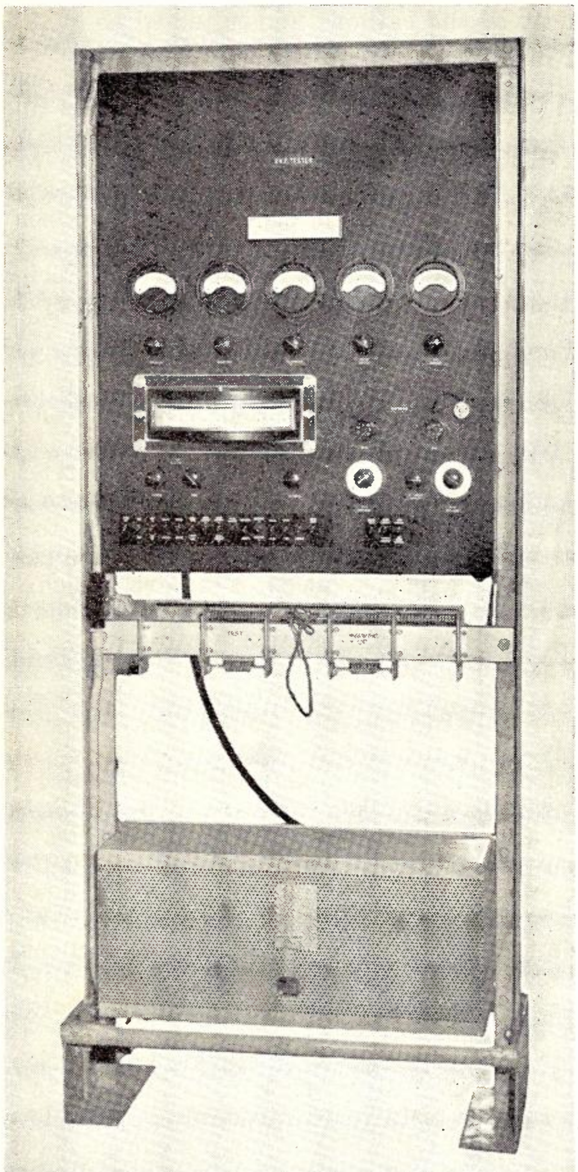


Fig. 15.—2VF Receiver Tester.

Testing of Country VF Equipment from RC.—A special test unit is located at Melbourne for checking as many of the functions of the country equipment as is possible over the trunk lines. While the tester cannot test every function of the remote country equipment, it is capable of testing and recording that the country end sends and can receive all VF signals.

The test unit is capable of measuring the length of VF signals sent by the country end. The result is displayed on lamps, the length of the pulse measured being read as seconds or milliseconds dependent on the test concerned. Means are provided for measuring the dial speed and ratio. The former being displayed on lamps as a direct reading in I.P.S. and the latter measured on a ratio meter. Further, the number of impulses sent by the dial can also be recorded. The test unit is capable of sending VF pulses of minimum and maximum length to check that the country end is in correct adjustment and works within the limits laid down for the 2 VF signalling system. The value of received pulses and dial characteristics as recorded, ensure that the country end is sending signals within the prescribed limits.

The measurement of received signals is made with the aid of a motor uniselector controlled from the 50 c.p.s. mains to drive at a speed of 100 steps per second. This switch is used for sending and measuring signals not exceeding 1 second in length. The accuracy of measurement is ± 10 milliseconds provided the AC mains controlling the motor uniselector are at nominal frequency.

A standard uniselector is used for the sending and measurement of signals exceeding 1 second in length. This switch is stepped by a self-impulsing relay with condenser speed control adjusted to work at 10 I.P.S. Means are provided for checking the speed of the relay by using the motor uniselector. A direct reading of the relay speed is given on the lamp display.

Monitoring equipment in the form of an amplifier and loud speaker is connected across the trunk for purposes of observation during the test and facilities are provided for speaking to the country exchange telephonist or mechanic during the progress of the test.

Testing of VF Equipment Located at RC.—The large number of 2VF trunk lines terminated at Melbourne justified the provision of some automatic means of testing. In view also of the special nature of signalling, and the necessity for measuring pulses and the sequence of pulses an automatic routiner was supplied. This routiner is connected to each trunk line in turn via access switches which are mounted at the end of each suite of VF trunk line racks. The access switches can be separately controlled so that any one trunk line circuit can be selected for test.

The 2VF trunk line circuit is of considerable complexity, with the result that the routiner has a large number of tests to apply. In consequence, the time taken by the routiner to completely test one circuit is approximately 1½ minutes. To facilitate a quicker check of the general functioning of the circuits the routiner can be set to perform a limited routine on a selected portion of the tests. In addition, the tests concerned with N.U. tone and Busy tone may be eliminated when required.

The types of routine test which can be made are as follow:—

(a) Complete Routine Test—90 seconds each circuit.
(b) Complete Routine Test less NU and Busy tests—70 seconds each circuit.
(c) Short Routine Test—25 seconds each circuit.
(d) Single Call Test.

The complete routine test proves all functions of the circuit making more than seventy tests in a series of calls of various types.

The short routine test proves that the circuits are capable of correctly establishing one selected type of incoming and outgoing call. While not testing every function of the circuit some 90% is proved.

The single call test enables a check to be made of the sequence of operations on any one single call and is used for fault clearing purposes. In addition to this it can be used for rapidly applying the routiner to all circuits in turn with the object of proving one particular facility.

The measured length of VF signals produced by the routiner and the measurement of signals received from the trunk line circuit under test is controlled by a motor uniselector driving at 100 steps per second. The motor uniselector is controlled from the 50 cycle AC mains in a similar manner to that described for the remote testing of country equipment pulses not exceeding one second in length—the error being no greater than that of the mains supply frequency.

A standard uniselector is used for the sending and measurement of signals exceeding 1 second in length and also for the sending and receiving of trains of impulses.

Fault indicating lamps are provided for time measurement tests. These indicate whether the time measured is too long or too short. An amplifier operating a relay in its output anode circuit is used for checking the various terminations. The amplifier is used as the measuring instrument in an AC bridge, the X arm of which is the circuit under test.

Two test line positions are provided on the 2VF trunk line selector, one on contact 1 and one on contact 53 (the 1st and 2nd normal contacts). The former is selected by sending a single impulse and the latter by a train of 11 impulses. The failure of any test is indicated on a lamp panel suitably designated and the routiner stops to bring in an alarm.

The routiner is usually run during periods of light traffic and, when connected to a trunk line circuit, operates a routine test relay in that circuit to disassociate the line and apply the TEST BUSY signal.

Trunk Line Detector Unit at RC.—The routiner access equipment is also used for connecting a speech detector unit to each trunk line in turn at any period of the day. Since a VF signalling system is by nature a negative signalling system, that is, a busy condition may be indicated by a state in which no signalling current is passing, it follows that locked-up circuits are more likely to occur due to faults and fleeting interference conditions than with a positive signalling system. The speech detector unit when connected to a busy circuit will give an alarm if no speech or signal frequency is received within a specified time.

Similarly a fault will be indicated if a continuous signal frequency is received. The busy circuit is passed as correct if interrupted signal frequency or speech is present. The unit is also capable of drawing attention to oscillating repeatered trunk lines, being fitted with sensitivity control apparatus for determining the permissible degree of singing before an alarm is given.

The unit cannot be expected to draw attention to every case of a locked up trunk. For example, a very noisy line might upset the VF signalling sequences and thus produce a lock-up, but owing to the continued presence of noise simulating speech the unit would analyse the trunk as being satisfactorily in use. A monitoring amplifier and loud speaker is available for switching in to the detector unit and permits observation of any lines suspected of being noisy.

Conclusion.—The transmission of good speech over long distances no longer represents a technical difficulty but an economic one, and the loss of time resulting from a manual build-up of calls over several exchanges makes VF Tandem Automatic switching a very attractive proposition.

An intermediate stage has been reached with the ability of the telephonist to dial over long distances and the development of the future will no doubt tend to increase the distance over which subscriber dialling will be permitted. In the meantime, the desire to obtain the maximum paid time from all trunks is one which will engage the attention of telephone engineers, and there is no doubt that the introduction of VF signalling and the efficient grouping of trunk line routes will prove a step in the right direction.

Acknowledgments are due to both Siemens Brothers & Co. Limited, London, and the Australian Post Office for permission to reproduce matter contained in this and the previous article.

PORT LINCOLN, SOUTH AUSTRALIA, C.B. EXCHANGE

A. W. Emery, A.M.I.E.(Aust.)

Historical.—One hundred and thirty-nine years ago, Capt. Matthew Flinders in the "Investigator" explored and charted the coast of Spencer's Gulf. A boat's crew had been lost off Cape Catastrophe and the "Investigator" was short of water. A landing was made accordingly on the shore of Boston Bay, where good water from a spring was found. Meanwhile Flinders gave names from his home county of Lincolnshire to the principal features of the harbour and mainland. Thirty-six years later, i.e., in 1839, the town of Port Lincoln was founded on this beautiful bay whose delightful surroundings have made it one of the State's principal tourist resorts. It might be called the capital of Eyre's Peninsula, an area equal in size to Tasmania. The site was indeed considered by Col. Light for the capital of the State when he visited it in 1836, but presumably owing to the nature of the country behind, was rejected in favour of Adelaide.

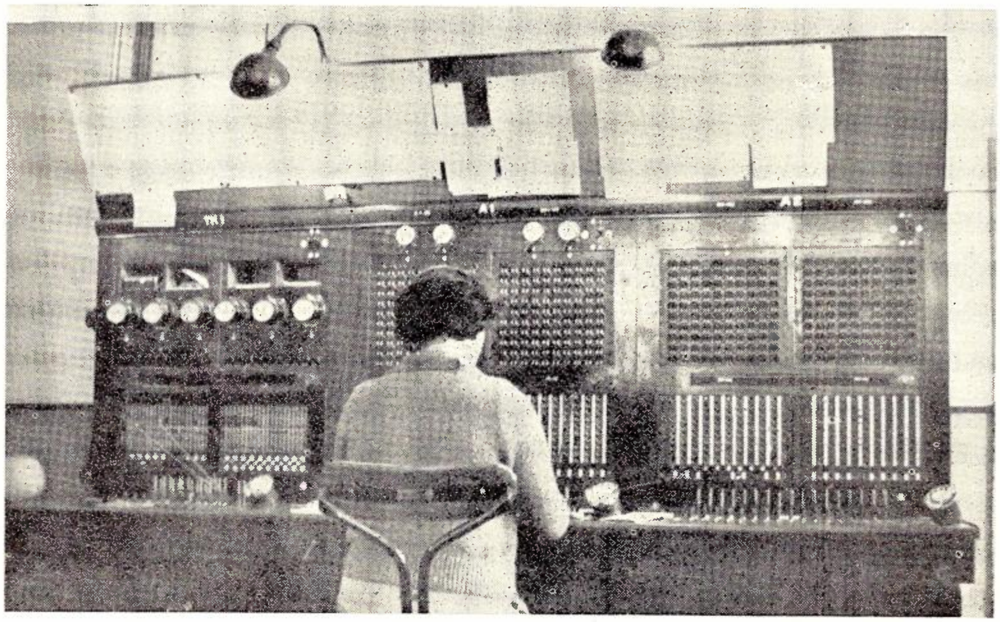


Fig. 1.—Port Lincoln Switchboard.

The development of communications with Port Lincoln started in 1839 when the first Post Office was opened. Telegraph communication with Adelaide began in 1876 and the first Telephone Exchange was opened on January 2nd, 1913, trunk line facilities then being given to Cowell and Streaky Bay. It was not until April 29th, 1927, that a trunk line to Adelaide was placed in service. The line distance being about 410 miles, this is not surprising, and even with a V.F. repeater half way at Port Augusta, the speech level was rather low. The physical circuit was replaced by a single channel carrier on January 1st, 1930; a second one was added on March 27th, 1934, and these in turn were replaced by a 3-channel S.O.S. carrier system on June 16th, 1939, a century after the opening of the Post Office. Port Lincoln citizens thus have the benefit of zero loss circuits to Adelaide for the comparatively low fees calculated on a radial distance of just under 160 miles.

Conversion to C.B.—Following the opening of a fine new Civic Hall beside the Post Office in 1937 and other building improvements, a deputation waited on the then Postmaster-General during a visit in 1938 to ask that the Post Office quarters, which faced the main street, be modernized. After much deliberation the quarters were converted in 1941 into a Telephone Exchange including separate rooms for Carrier Equipment, Power Plant, Batteries, etc., and as has happened in many other country towns, the provision of quarters was discontinued. The Post Office building now presents an appearance in keeping with the town improvements.

It was therefore fitting that the removal of the exchange from the back room it occupied should be made the occasion of another step forward in its conversion from magneto to C.B. working. The fact that the exchange area which contains nearly 300 subscribers, is reasonably compact and enjoys a dry climate further favoured this step. Unfortunately, there was no C.B. exchange equipment available and very little material from which to make it, while due to war restrictions any prospect of getting new ready-made equipment or even components was hopeless. Accordingly the problem of adapting such material as was, or could be made, available was faced. Somewhat reluctantly it was decided to modify two 200-line standard magneto boards for D.C. operation of the indicators through the subscribers' loop. A cord circuit was designed to give standard lamp supervision on either C.B. or magneto lines, the relay equipment being mounted on racks. A multiple trunk position to match the "A" positions was constructed in the Adelaide Workshops. The switchboards and relay rack are shown in Figs. 1 and 2. V.F. dialling to Adelaide was already in use, but the switchboard circuit was modified to eliminate the dial keys. The cut-over took place on March 4th, 1942.

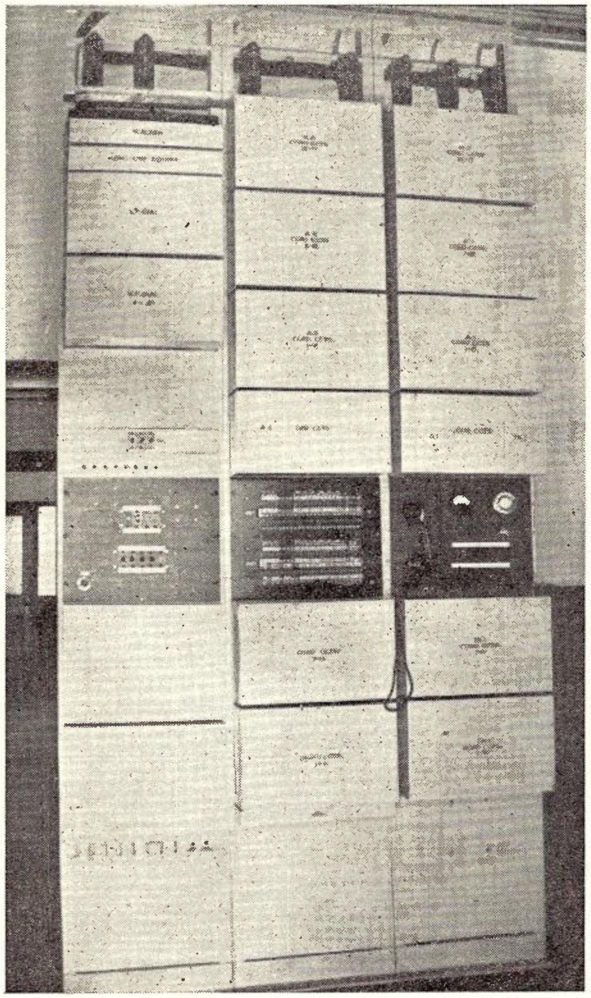


Fig. 2.—Relay Rack.

Development of Cord Circuit. — Relays recovered from P.B.X. switchboards and dismantled equipment had to be utilized, many being rewound, and the circuit design was to some extent influenced by the limitations of the relays available. The aim was to provide a circuit which would function on any type of line, subscriber's or trunk. On a board of this size one operator is able to handle all the traffic during the slack periods of the day, and when two or even three operators are on duty it would be inefficient to use two cord circuits in tandem, to complete an incoming or outgoing trunk call. Furthermore, in the interests of quality of service it is necessary to design the cord circuit to enable an operator to attend to other calls while she is waiting to complete a trunk call, and to do this without inter-connection of the parties through her speaking circuit or changing cords on the trunk call. By simplifying operating, this should also result in staff economy. Discrimination between C.B. and magneto lines is made by connecting 150 ohm and 3000 ohm resistances respectively to the sleeves of the jacks, and the battery feed relay is not connected until the plug is inserted into a jack with 150 ohms on its sleeve. Two keys per cord circuit are provided, one being the normal speak and ring key, and the other, used in conjunction with the first on trunk calls, to speak either on the answering or the calling cord, or separately, to divide the parties until they are introduced. A

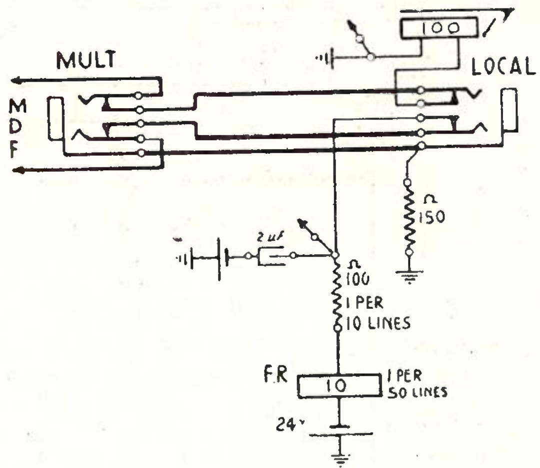


Fig. 3a.—Subscriber's Line Circuit.

common monitoring key switches to a low loss monitoring circuit. Talking battery is fed from a constant potential rectifier and small capacity 48 volt battery, and all other battery from the 24 volt filament supply.

Subscriber's Line Circuit.—Fig. 3 shows the line circuits. The subscriber's indicator (Fig. 3a) is connected from the tip inner spring to earth to avoid operating it while inserting the plug as would occur if connected from the ring side to battery, by earth on the tip of the plug. To reduce their number, the guard resistances are common to 10 subscribers' lines, and to give a visual indication of cable faults or earthed aerial lines; battery to the guard resistances is fed through a 10 ohm relay common to 50 lines. A fault is indicated if the lamp lit on the ap-

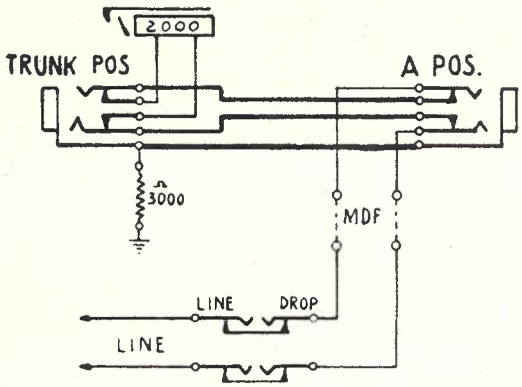


Fig. 3b.—Ordinary Trunk Line Circuit.

paratus rack by this relay glows while there are no un-answered calls. On special lines such as party lines which were left magneto, the indicator was left metallic and a high resistance connected to the sleeve.

Trunk line circuits—Keyless Dialling.—The ordinary trunk line circuit (Fig. 3b) is self explanatory, but not so the switchboard termination of the V.F. dialling trunk. (Fig. 3c.) Reference might be made to the article in Vol. 2, No. 6 (February, 1940), by F. P. O'Grady on "V.F. Dialling over trunk lines in S.A." The modifications to the country switchboard end of this system to enable the dialling keys to be dispensed with is described:—On insertion of the plug into the switchboard jack, relay S operates from earth via the jack contacts. The 500μF condenser in parallel with it, makes it slow both to operate and to release. S2/3 completes a circuit through R, resistance YA and 500 μF condenser QA. R operates while QA is charging and through its contacts 2/3 operates relays T and M, and lights the guard lamp on the switchboard. T provides a holding circuit for S via T2/3 and S2/3 and disconnects S from its operating earth. M connects earth to the V.F. ringer panel which, after a train of operations in the ringer circuit, the carrier system, the V.F. receiver and the relay set in Adelaide, causes a selector to be seized in Tandem Exchange. When the charge of QA is complete, after about 1½ seconds R releases, followed by T and M. The automatic switches are held by the receiving relay set until M sends a releasing signal. The release of R also extinguishes the guard lamp; the telephonist hears dial tone and commences to dial with her speaking key open (see Cord Cir-

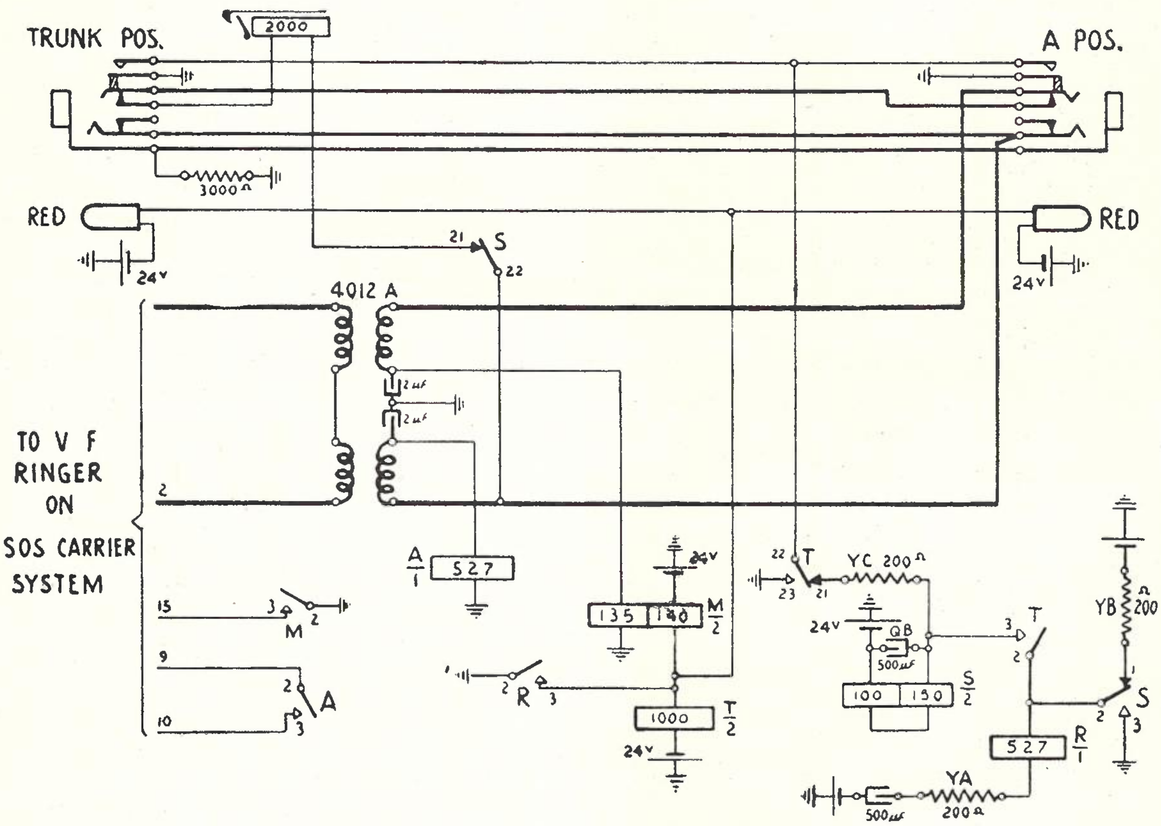


Fig. 3c.—V.F. Dialling Trunk Circuit.

cuit, Fig. 4). On rotating the dial forward its O.N. contacts close and relays D and DA operate. D contacts connect battery via the tip side of the cord circuit, which operates relay M through its 135 ohm winding. DA contacts connect battery through the dial impulsing contacts and the ring side of the cord circuit, which operates the impulsing relay A (this is a W.E. Coy.'s windmill type quick operating relay). Contacts M2/3 prepare to transmit 2200 cycle current through the carrier system but this is short current which are duly rectified at the Adelaide end and delivered to the automatic switches in the same manner as impulses for an A-A repeater. Relay DA is slow to release, causing relay A to be released after relay M, thus ensuring freedom from false impulses. On the withdrawal of the plug, after completion of the call, relay S releases and battery is applied to each side of the charged 500 μF condenser QA, causing it to discharge and re-operate relay R for about 1½ seconds. It re-operates relays T and

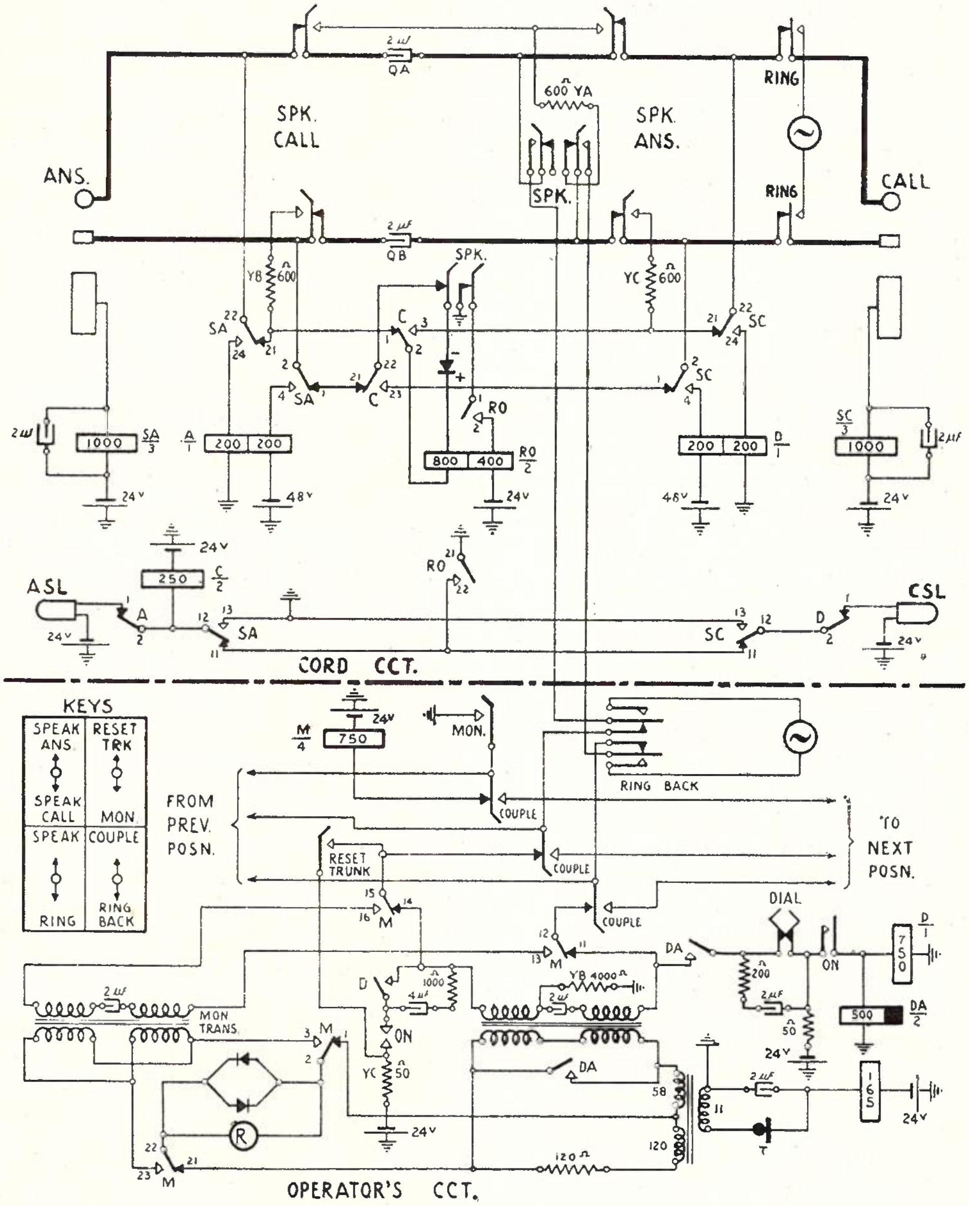


Fig. 4.—Cord Circuit.

circuited by A2/3. During the return of the dial, the train of impulses which is repeated by A is transmitted to the carrier system as a corresponding number of periods of 2200 cycle M and again lights the guard lamp momentarily. Relay M sends the releasing signal, which is transmitted through the carrier system, and causes the automatic switches to be released. The function of the guard lamp is to indicate that dialling must not be attempted during the seizing or releasing stages. This circuit is also in use in some other country exchanges and some of its features are designed to guard against the effects of irregular operation such as indiscriminate plugging and unplugging of the switchboard jack.

Cord Circuit Operation (Fig. 4).—On a local call, insertion of the answering plug operates relay SA to the 150 ohm resistance on the subscriber's jack sleeve. This connects relay A which operates through the subscriber's loop. Relay C also operates but performs no useful function on such a call. The testing of the called number is done in the usual manner, the circuit being from earth through the 4000 ohm resistance at the centre point of the transformer in the telephonist's circuit and, if engaged, the busy click will be heard from battery through another SA or SC relay. Insertion of the calling plug operates relay SC and the CS lamp lights through the back contacts of relay D until the subscriber answers. Only the speak and ring key is used on local calls. Each sleeve relay is bridged by a condenser to prevent shocks to the telephonist. On completion, as each party restores, the corresponding supervisory lamp lights.

If the call is for a trunk line, insertion of the calling plug will not operate the SC relay as it is marginal to the 3000 ohm resistance on the trunk sleeve. The calling cord will have the RO relay line winding connected across it in lieu of the D relay (battery feed). RO 800 is normally across the answering cord but is now disconnected at SA contacts (operated) and C relay, operated from SA, has switched RO to the calling side. (C is a relief relay as the relay used for SA would not accommodate additional springsets.) On completion of this call, the telephonist will get an answering supervisory lamp when the caller restores and a calling supervisory when the called party rings off. Contacts RO1/2 make early and complete a circuit through the 400 ohm holding winding. This is reset when the telephonist opens her speaking key to challenge the line.

On a call from a trunk line to a C.B. subscriber, the operation is similar but the answering and calling sides of the circuit are interchanged. On a trunk to trunk call neither sleeve relay is operated and therefore neither battery feed is connected, leaving the speaking path similar to a magneto cord circuit except for the condensers. When either party rings off, both supervisory lamps light.

Three V.F. terminations are provided to avoid howling of repeaters. With the keys thrown to "Speak" and "Speak Call" the answering plug if in a trunk jack is bridged by resistance YB. Similarly with "Speak" and "Speak Ans." thrown YC is across the calling cord, while if the second key is thrown to either "Speak Ans." or "Speak Call" without the speaking key, the calling cord is bridged with YA and condenser QA and the answering cord with YB.

THE REMOVAL OF A 200 LINE P.A.B.X.

R. H. Byron

Under normal conditions, the removal of a large Private Automatic Branch Exchange from one building to another is generally arranged by installing new equipment and subsequently dismantling the original plant. This method results in a minimum of inconvenience to the subscriber and provides an opportunity for modernising the service. Under the stress of present conditions, with limitations in respect to the availability of both staff and spare equipment, it is not possible to attain the ideal. Therefore, when a subscriber controlling an essential service desired a 200 line P.A.B.X. removed from one building to another across a street, it was necessary to review previous practices.

The subscriber's business necessitates a continuous telephone service, therefore it was necessary to limit to a minimum, the time occupied by the removal, and also to provide for temporary service during this period. A week-end was chosen as the most suitable period in which to effect the removal, and plans were prepared to commence the work at 5.30 p.m. on a Friday, and for the service to be functioning normally by 8 a.m. on the following Monday. Most of the extension telephones were to remain in situ and a temporary service was provided by connecting 70 of the most important extensions to a 2 position C.B. P.B.X.

Layout.—The layout of the equipment in the old building is shown in Fig. 1. The floor space available in the new building was such that it was possible to plan a similar layout except that the positions of the single-sided trunk board and the uniselector units were interchanged and located at right angles instead of parallel to the manual switchboard. Also the positions of the power board and rectifier had to be changed in relation to the automatic equipment. This permitted the use of the original cabling and racking, the only new material required, apart from an M.D.F. and battery stillage, being a few yards of power cable and a short length of runway.

Preliminary Work.—To facilitate the work, before the date of removal, a new 4 vertical single sided M.D.F. was installed and 300 pairs of U.G.

cable were run from a multiple point in a street manhole and terminated. The arrangements of cables in manholes before and after the removal

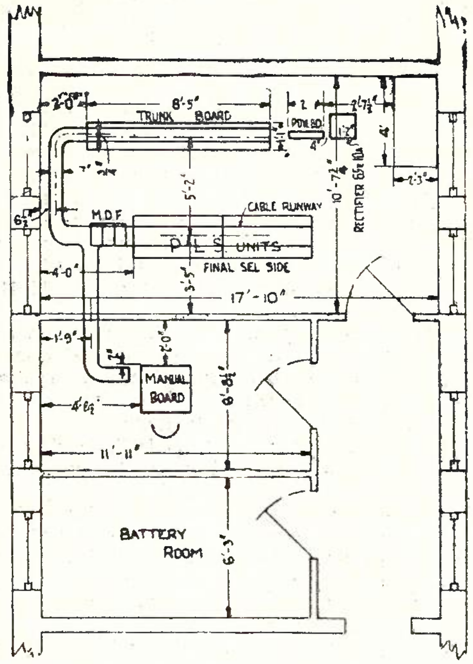


Fig. 1.—Layout of Equipment.

are shown in Figs. 2 and 3 respectively. The original M.D.F. was left in situ to serve as a distributing point for extensions in the original building. Transfers were made in the cables, to group lines as required, on certain sequences of

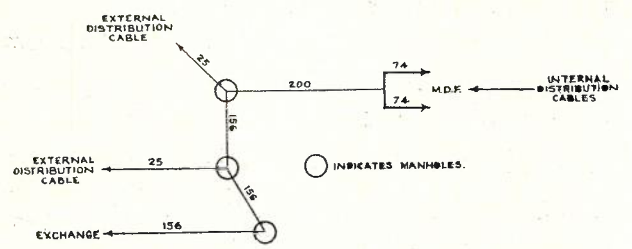


Fig. 2.—Arrangement of Cables in Manholes before Removal.

cable pairs to facilitate prior jumpering of lines on the new M.D.F. Permanent jumpers were run for the exchange lines and external extensions, and left open at the protectors. Temporary cross connecting jumpers were connected in parallel to route these lines through the new M.D.F., thus enabling the cable jointers to complete the work of re-routing the cables. Permanent jumpers were also run for important extensions on which it was essential to avoid interruption to service. Lack of cable pairs prevented the jumpering of the remaining extensions before the disconnection of jumpers on the old M.D.F., but on the new frame, jumpers were prepared and stripped ready for termination. This was done also on the old M.D.F.

In the new rooms, the positions of all items of equipment were outlined in chalk on the floor, walls and floors were plugged and cable openings cut. On the equipment, cables, shelves, terminal blocks, combs, etc., were tagged ready for identification, and lists showing details of cable connections were prepared. The installation of the temporary P.B.X. completed the preliminary work.

Removal.—Two overlapping shifts were employed to provide for continuous work. This arrangement enabled one staff to hand over to the other with a minimum of delay. The disconnection of cables and wires was limited by

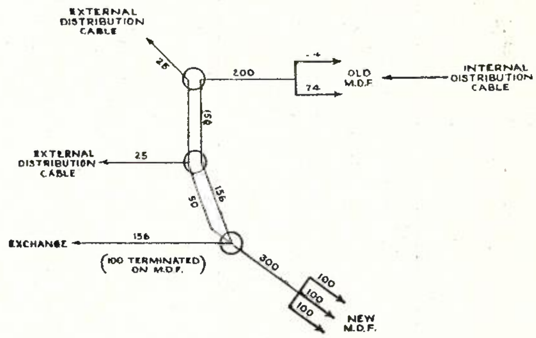


Fig. 3.—Arrangement of Cables in Manholes after Removal.

dismantling jack strips from the manual switchboard and removing combs from the uniselector units and jacks from the shelves, with the wiring intact. The cables were coiled back and tied to the equipment to which the other end was terminated. Details are shown in Table 1.

As each item of plant was dismantled, it was carried to the new location and the work of re-installation proceeded with, simultaneously with the dismantling of other items. The work was planned so that the laying and lacing of cables, manual board assembly and terminating on the M.D.F., and power board, proceeded simultaneously. A temporary battery of enclosed type cells was used for testing, and after the cutover, the permanent battery being removed at a later stage.

Testing was completed and the service restored at 3.45 a.m. on Monday. After this had been done, a small amount of work had still to be performed in respect to the reconnection of less important extensions which had been left open due to the shortage of cable pairs in the distribution cables, but the service was functioning normally by 8.30 a.m. Some unforeseen difficulties occurred in transporting the material, otherwise it is considered that the job would have been completed by 6 p.m. on the Sunday.

To complete the removal in less than 60 hours, the staff worked under difficult conditions for long periods, and the success of the work reflects credit on all concerned.

TABLE 1.

Cable No.	Size	Route	Remarks
1–5	63 wire	Manual board multiple to 200 unit.	Dismantle jack strips from manual board and tie back to unit.
6–10	63 wire	Manual board multiple to 300 unit.	Dismantle jack strips from manual board and tie back to unit.
11–12	105 wire	Manual board cord circuits to shelves E and F on trunk board.	Dismantle jacks on switch shelves and tie back to manual board.
13	21 pair	Manual board information circuits to shelf E on trunk board.	Dismantle jacks on switch shelves and tie back to manual board.
14	11 pair	Information circuits from selector level to information relay sets.	Disconnect at jacks on Shelf E.
15–17	Various	Incoming exchange lines, tie lines, etc., from manual board to Shelf D.	Disconnect from jacks on switch shelf and tie back to manual board.
18–19	21 pair	Incoming exchange lines, tie lines, etc., from Shelf D to M.D.F.	Dismantle shelf jacks and disconnect at M.D.F.
20	33 wire	Level "0" to repeaters.	Dismantle shelf jacks.
21	21 pair	Repeaters to M.D.F.	Disconnect at M.D.F. and tie cables 20 and 21 back to comb assembly on trunk board.
22–23	33 wire	Selector levels 2 and 3 to final selectors on units.	Dismantle combs on units and tie back to comb assembly on trunk board.
24	63 wire	Units to selectors.	Dismantle combs on units and tie back to shelves A and B.
25	6 pair	Special tie lines—Shelf B to manual board.	Disconnect at Shelf B and tie back to manual board.
26–32	4–6 pair	Fuse and supervisory panel to power board, manual board, units and M.D.F.	Disconnect at far end and tie back to fuse panel.
—	—	Power and supervisory leads to shelves, units, etc.	Disconnect at far end and tie back to fuse panel.
33–42	21 pair	M.D.F. to units.	Disconnect at M.D.F. and tie back to units.
—	—	Signal cables between units.	Dismantle combs on units.

THE USE OF MICRO-SWITCHES AND MERCURY CONTACTS ON TELEPHONE RELAYS

W. C. Kemp

Normal telephone type relay springs are not suitable for the switching of electric supply at the voltages delivered from commercial sources, but it is sometimes convenient to achieve this control by means of the small power required to operate a telephone relay armature. The contact system provided must be sensitive and yet sufficiently positive to ensure against incipient arcing and consequent contact damage. The standard spring contacts are generally too small to carry the current requirement or so exposed as to constitute a danger to maintenance personnel. The two commonest conditions to be met are:—

(a) Switching of commercial 50 cps AC supply with an EMF up to 600 volts, but a power less than 1250 watts.

(b) Switching of heavier currents, e.g., up to about 30 amperes at 250 volts AC/DC, or 20 amps at 500 volts AC/DC.

Requirements under (a) may be met by means of a Micro-switch and that under (b) by means of the Mercury contact.

The Micro-Switch. — A micro-switch can be mounted on the yoke of a type 3000 telephone relay by means of a simple angle mounting bracket and mounting screws. As the size of the moulded case containing the spring assembly measures about 2 ins. x 1 in. x 3/4 in., it conveniently takes the place of the standard spring set and uses the same mounting holes in the relay yoke. The two 1/8 in. diameter mounting screws attach the switch by passing through the holes provided in the moulded case and screwing into two tapped holes provided in the mounting bracket.

Fig. 1 illustrates this method of fitting, but omitting the outline of the mounting bracket for clarity. As these switches are normally sealed to render them dust-tight, it is not usually possible to examine the springset, and a description of one particular type, the Burgess Micro-Switch,

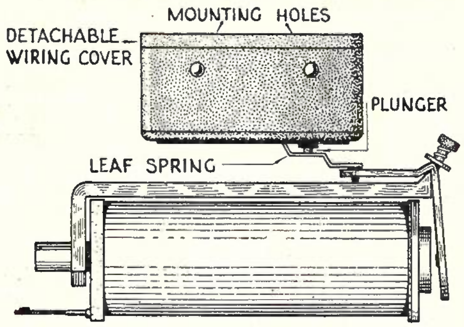


Fig. 1.—Micro-Switch and 3000 Type Relay (less Mounting Bracket).

may prove of interest. The assembly of the switch is shown in Fig. 2.

The moving spring is three pronged or trident-shape, and is composed of a beryllium-cobalt-copper alloy which imparts suitable character-

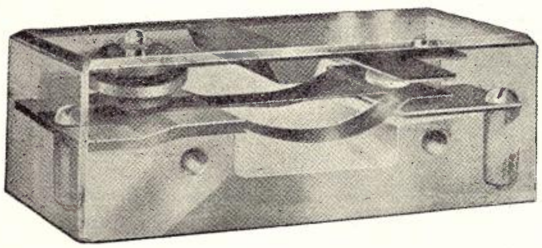


Fig. 2.—The Micro-Switch. Details of Assembly.

istics to withstand the repeated operations during the life of the switch. The noticeable feature of the unit is that it operates decisively at a fixed point in the stroke of the plunger, and that it is not possible to manoeuvre the spring into a half-way mid-stroke or open position. This is due to the manner in which the spring is held in position, the middle tongue of the trident being in tension, whilst the two outer members are held bowed and consequently compressed as they fit in V slots in the brass mounting piece. The shape of the mounted spring is shown in Fig. 3. The moving contact is held normally against the upper contacts as shown, by the force exerted by the two outer members. When pushed down, the plunger applies pressure at a point adjacent to the anchoring screw end. It therefore tends

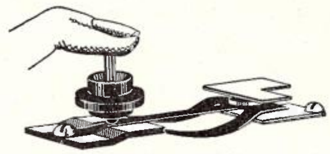


Fig. 3.—The Micro-Switch Spring.

to oppose the upward force exerted by the two compressed outer members, by increasing the tension in the middle tongue and flexing it into alignment with them. At a fixed point in the stroke, the pressure of the plunger first balances, and then, by passing the equilibrium point, causes the central tongue and the two outer members to act in conjunction, and snap the contact rapidly through its stroke.

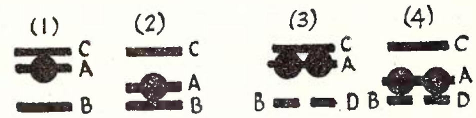


Fig. 4.—Micro-Switch Contact Arrangements.
NOTE: (1) Single contact—normal position.
(2) Single contact—operated position.
(3) Twin contact—normal position.
(4) Twin contact—operated position.

The length of the plunger movement can be less than 1/1000 in., but the type so far favoured in telephone practice is fitted with a leaf spring attachment which gives increased leverage and by flexure of the leaf spring after the contact spring has operated at the end of the armature movement, provides a degree of overthrow which makes for less critical adjustment.

The two fixed contacts are faced with pure silver, the moving spring having a contact of the same material domed shaped on each side and riveted in position. Two types of spring assemblies are made, both of which are single pole double throw but, for use in inductive circuits, the make contact is divided into two parts. The spring assemblies and designations are shown on Fig. 4.

The switches have been approved by Electricity Supply Authorities and the manufacturers' ratings are shown in Table 1.

TABLE 1.

AC Change-over Spring Assembly			DC Change-over Assembly with Double Make Contact			
Volts	Amps	Loading	Volts	Amps	Loading	20,000 ohm Resistor plus Quench Condenser
125	10	Non inductive	125	15	Non inductive	1 mfd. 600V
250	5	,,	125	10	Inductive	1 mfd. 600V
415	3	,,	250	7	Non inductive	1.5 mfd. 600V
600	2	,,	250	5	Inductive	1.5 mfd. 600V

To find the force required to operate a micro-switch fitted with a leaf spring, measurements were made on several micro-switches at a point on the leaf spring opposite the edge of the case (see Fig. 1). This force was found to average 175 grams. Using 3000 type relay data, the ampere turns (A.T.) required when using a plain coil and standard armature with 31 mil stroke are shown in Table 2.

TABLE 2.

1	2	3	4	5	6
Residual Stud (Mils)	Armature Load. (Grams)	Ampere Turns (AT)	Factor of Safety	Design Ampere Turns	Equivalent Standard Springs
4	175	145	2	290	7
12	175	165	2	330	6
20	175	190	2	380	5

Particulars of 3000 type relays which should operate a microswitch satisfactorily are listed in Table 3.

TABLE 3.

1	2	3	4	5
Relay Resistance (ohms)	Wire Diameter (Mils)	No. of Turns on a Full Spool	Current Flow (mA)	Ampere Turns
500	6.0	10,700	36	385
1000	5.2	15,900	24	380
2000	4.4	22,600	17	384
2900	4.0	27,000	15	405

Information in respect to the Burgess Micro-switch and blocks for Figs. 2 and 3 have been kindly made available by James Bell Mineral Products Pty. Ltd.

Mercury Contacts. — Mercury contacts are capable of switching AC and DC and those used in the Department are tilt operated by mechanical or electro mechanical methods. Fig. 5 shows one method of mounting mercury contacts on a relay.

The light weight involved and the fact that no energy is required to maintain contact pressure makes them ideal for use with telephone type relays. Two mercury tubes can be operated by the one relay consuming 0.5 watt DC (100 mA at 50 volts). A type 3000 relay provides an armature movement of about 4°, which can be translated into a tube tilt of 15°. The tubes are made up of sealed-off cylindrical glass envelopes. The tube size is governed by the frequency of operation and the value of inductance and capacity existing in the circuit in which it is employed. The minimum tube diameter should be not less than 7 mm otherwise the surface tension of the mercury prevents free movement, mercury flowing most freely when the blob formation can conform to the influence of surface tension. Cup-like extrusions are formed in the side of the tube to house the electrodes, which are sealed in at these points.

A short section of hard pyrex, quartz glass or porcelain lining may be fused in to form a protective lining inside the tube. The arc which is formed within the tube on the break of circuit will chip ordinary glass, and the protection is furnished to prevent this erosion. The life of the tube is thus extended from many thousands of operations to be almost limitless, and the EMF which the tube can handle is increased. The provision of a liner is particularly apposite when the switch is used in an inductive circuit, DC circuits being more severe than AC. This is because inductance which is present in an AC circuit has a choking effect due to successive cycles having a neutralising action on each other. This restricts arcing at the break of circuit, particularly if the rate of change of current ever exceeds the natural frequency of the circuit. The current is zero at each half cycle, and a break contact operated on AC passes through the same cycle during extinction of the arc, as it would on DC, but the cyclic variations of the current have made the conditions easier. (Reference to the mercury switch design figures reveals that the same switch frequently has a greater current capacity for AC than for DC.)

An alloy of nickel iron is used for the electrode material, but the contact surface may be platinized to reduce resistance. The coefficient of expansion of the electrodes should be the same as that of the glass envelope. The cross-section of the electrodes is proportional to the current rating of the tube. The heating which occurs at the seal is 50% higher than elsewhere in the tube and the seals form the weakest link. If the co-efficients are well matched, the seal can be shortened and the risk of fracture in service reduced to a minimum. The electrodes are first wound with plastic glass thread, fused, and the combination is then sealed into the extruded cups. The tube is then filled with acid to remove any oxide formation, and an AC is passed between the electrodes to expedite the cleansing. Any traces of acid are removed by repeated washing and drying. After the electrodes have been sealed in, the tubes are subjected to a rigidly controlled annealing schedule to remove internal strains. The tube is exhausted of air after being loaded with mercury and refilled with an inert gas such as pure dry hydrogen, which has a very low density, high specific heat and high thermal conductivity, and therefore it is better than air as a heat extractor. The pressure may be varied according to the type and construction of switch. The degree of evacuation may be checked by the glow discharge generated with a portable induction coil. Any harmful chemical action occurring in the tube after sealing is avoided by using at least triple distilled mercury free from oxide or traces of moisture; the electrodes are chemically pure, and any occluded gases are withdrawn by earlier vacuum annealing.

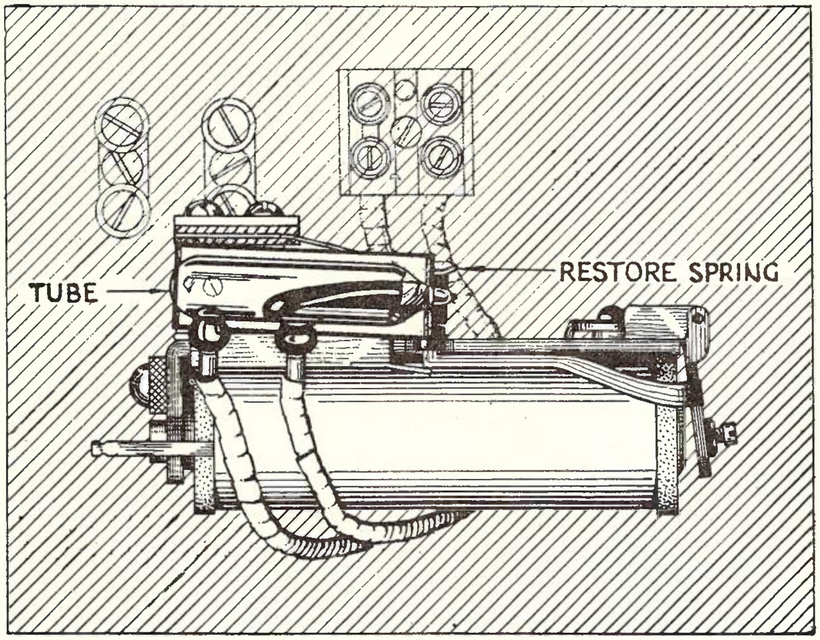


Fig. 5.—Mercury Contact Mounted on Horizontal Switch Type Relay.

Nickel iron forms a suitable material on which to solder the copper flex leads, which are insulated by means of fish spine insulating heads. The best tube design prevents electrode wear by basing them in cups so that in any operating position they are always immersed in mercury so that the arcing which generally occurs at the break of circuit then only volatilises mercury which is condensed and returned to the pool by contact with the glass envelope, so leaving the electrodes unharmed. The tilting results in the mercury drawing out and splashing between the pools with normal velocity of operation. In changeover switches this prevents break - before - make action which may be a circuit requisite. Due to surface tension, this type requires a greater operating tilt.

Various forms of switches are made, plain make and break, and changeover switches fitted with two or three electrodes can be manufactured of either straight or curved tube. Straight tube permits of a minimum angle of operating tilt — this may be as small as 1.5° to 2° for straight tubes about 80 mm long. Tubes curved to a small radius require a much greater tilt but add to the stability if a tube is subject to vibration. Typical straight and curved tubes are shown in Fig. 6. For 250V AC or 50V DC circuits with currents up to 10 amperes, the dimensions in mm. of typical tubes are shown in Table 4.

TABLE 4.

Fig. No.	A	B	C	Angle of Tilt
6 (i)	45	10	15	4°
6 (ii)	80	10	30	2.3°
6 (iii)	55	10	24	± 8°

Fig. 7 shows a heavy current tube with an inner protective lining. This tube is of increased diameter in that the increased volume of the tube assists in dissipating heat generated on the break of a circuit. The dimensions shown (in mm.) are suitable for 250V AC or DC 30A current. The angle of tilt is 5°.

Many special types are manufactured and two of the most interesting are shown in Fig. 8 (i) and (ii) which are for delayed break and make

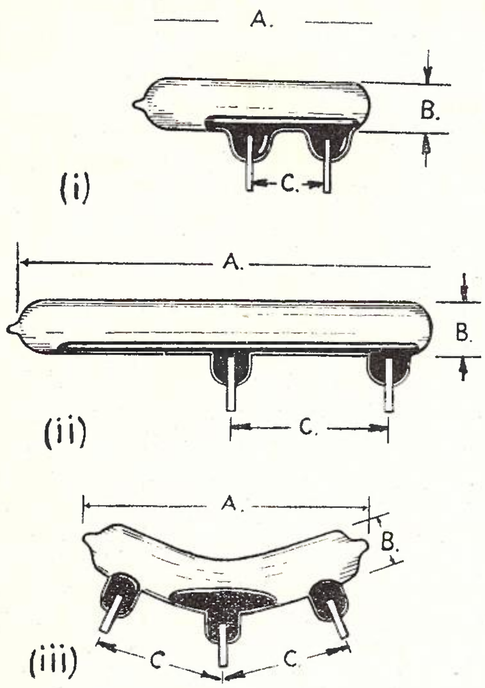


Fig. 6.—Typical Straight and Curved Tubes.

actions respectively. After the completion of the mechanical action of the relay, the mercury flows through a capillary path to make or break

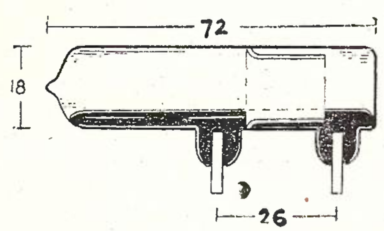


Fig. 7.—Heavy Current Tube with Protective Lining.

a circuit. When the control relay restores, the mercury returns instantaneously through an alternative channel, i.e., the delay is in one direction only. Tubes can be constructed to provide delays ranging from 2 to 15 seconds up to from 90 to 120 seconds. With tubes of this design, a porcelain liner cannot be fitted, therefore the maximum current rating is 10A.

Changeover switches.—Where a break before make feature is required, the electrodes are inserted from above and suitably dimensioned to overcome the trailing tendency of the mercury flow which exists between mercury pools when the electrodes are based in cuplike depressions.

The size of the flexible leads should be as shown in Table 5.

The resistance of a 10A tube averages about 0.015 ohm, and in the tube and lead assembly

TABLE 5.

Rating Amps	Leads, Copper Flex
6	3 x 60 x 0.002″
10	7 x 60 x 0.002″
15	7 x 60 x 0.002″
20	3 x 7 x 60 x 0.002″

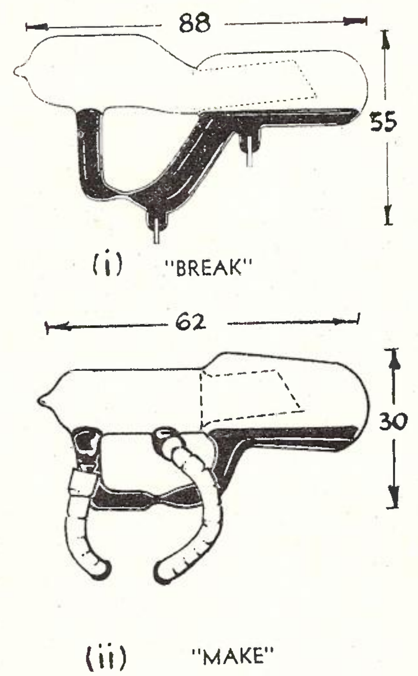


Fig. 8.—Tubes for Delayed Break and Make.

the distribution of resistance may be:—Leads 70%, mercury and electrode contact surfaces 20-25%, with 5-10% in electrodes and mercury proper. The mounting of a mercury switch with its moving parts and flexible leads is more involved than that of a microswitch. The latter switch appears ideal for AC applications in the power range up to 1250 watts, whilst the mercury contact is preferable for heavier DC and inductive circuit applications. A rapid change of current in an inductive DC circuit simply causes a large induced EMF to appear across the switch contacts and forces more current into the arc path. The speed of contact opening in this case does more harm than good, and the standard method of preventing the rapid change of current value is by insertion of a suitable resistance and capacity shunt which introduces a delaying factor. Due to the relative sluggishness in action of mercury contacts they are more suitable for the breaking of inductive DC circuits.

2000 TYPE LINE FINDER AUTOMATIC EXCHANGES—FINAL TEST-OUT PROCEDURE

W. King

Introduction.—It is not the intention to cover the progressive testing and adjustment of the equipment which should be carried out during the installation of a new exchange, but to confine this article to a brief description of the final tests to which the Exchange and substation equipment should be subjected immediately prior to cutover. These tests will be described under the following three main headings:—

Exchange Equipment,
Call Through Test on Exchange Equipment,
Substation Equipment.

Exchange Equipment

Before commencing the final tests on the exchange equipment, the installer should satisfy himself that all preliminary continuity testing has been completed and that all faults have been rectified, also that each switch has been checked for adjustment and correct wiper alignment. This is essential, as the time allotted for the final test is usually limited and all unnecessary delays should be avoided. Alarm fuses of the correct rating must be fitted in all fuse panels and all temporary fuse wire removed. The fuse alarm circuit should also be tested from each fuse panel. Release and supervisory alarms should be in working order and should be checked from each rack. Dial Tone, Busy Tone and Number Unobtainable Tone should be checked from the respective switches and levels to which they are normally connected. Check from each finder and group selector the Test Trunk Buzzer, which indicates switching on the H.B. or upper bank contacts.

The final tests necessary on each type of equipment are described hereunder:—

Line and Cut-off Relays.—A standard test set is provided for testing these relays under limiting conditions. The test is made from the I.D.F. when provided, or in the case of composite racks, from the line finder tag blocks. An additional test which will be found worth while in connection with these relays, is a test for earth on the marking Commons to the W9 line finder vertical banks. The springset terminals on the 600 type K relays are very congested, and unless the wiring and commons are very carefully soldered, contacts between adjacent springs are a distinct possibility. These may easily occur when straightening the wiring after terminating. An earth on the W9 lead on any level will prevent finders from cutting in on that level, and if this trouble is due to K relay springs contacting, it will be intermittent and may only occur while the particular K relay which is causing the trouble, is operated. It is necessary, therefore, to test the W9 lead from each level in all finder groups while each K relay in the groups is held in the operated position. This may be done easily by connecting battery through a test lamp to the common, and operating each K relay armature in the group by hand; the lamp will light should an earth be brought on by the operation of a relay.

Line Finders.—Each Finder should be tested on every contact by means of the Line Finder Test Set. All failures should be carefully followed up and faults rectified. Each allotter switch should be checked for correct stepping. A check that the allotter spark quench condensers are not open circuit should also be made.

Test each control set separately by jacking out the other control sets. Test for dual finder switching by originating two simultaneous calls in the group. Check each control set with all except one T.B. relay operated. Check the S and Z pulse on each control set. Earth the fifth level marking lead on the finder vertical bank, originate a call in the group, and check that the finders do not cut in on the earthed level. This test should be made on each control set. Check all finders on the 7th and 9th levels by means of a hand telephone plugged into the special jack provided. The level 7 and level 9 Routine Test Keys should be operated for this test.

Each finder group should be checked separately for change over from direct to indirect working by busying all direct finders in the group and checking that the change over relay RFZ operates. Busy all finders in a group and check the operation of the group congestion meter. With all finders busy in a group check that relay OFB in the start relay set operates. This proves the valve circuit. Originate a call in the busy group and check that the allotters do not hunt.

Repeat these tests on all groups. The finders should also be exercised frequently on all levels by means of the Routine Test Keys provided. New switches require a certain amount of settling down in their particular banks, and electrical operation under routine test conditions brings under notice any slight irregularities in Wiper Cut In or alignment and also distributes the lubrication evenly over the ratchets, shaft, bearings, etc. Frequent operation of the switches prior to a cutover also brings to light many loose or unstandard mechanical adjustments, no matter how carefully this work has been performed during the installation.

Secondary Finders.—Each secondary finder and allotter switch should be carefully checked for correct stepping and wiper alignment. Check for correct spark quench. Tests should be made also on each switch with the Secondary Finder

Test Set and Routine Test Keys. Test each finder group with each control jacked out in turn.

Group Selectors.—Installation test sets are provided for testing group selectors and all switches should pass the cycle of tests imposed by these test sets.

Automatic Routiners are now provided as standard equipment in all new 2000 type exchanges. The tests provided by these routiners are extensive and cover all functions of the switch. Every available opportunity prior to the cutover should be taken to keep the Routiner progressively testing each selector for the reasons mentioned previously. An additional test for "Stop on Busy" should be performed from each 200 outlet group selector. The wiper to bank alignment on 200 outlet group selectors should be carefully checked, to avoid possible stop on busy trouble. Under service conditions, faults of this nature are difficult to detect, as no alarm is given, but switches will be held and the trunking thereby reduced if this trouble is in evidence after a cutover. Therefore, before cutover, it is necessary to test each switch thoroughly for this condition. The test may be performed by busying all outlets from the first, fifth and tenth levels of each shelf of group selectors in turn, and dialling each busied level by means of a hand telephone. Each level should be dialled several times as the trouble may not occur on every call. A test for switches not stopping on the first free trunk should also be made.

Final Selectors.—An Installation Test Set is provided for testing final selectors during installation and before cutover each switch should be subjected to a final cycle of tests by means of this test set. Automatic Routiners are provided also for testing these switches and each final selector should be subjected to as many test cycles as time will permit prior to the cutover. On P.B.X. Groups, a check should be made to determine that the commoning on each group of P.B.X. lines is correct. This may be done by busying each P.B.X. line in a group and dialling, by means of a hand telephone, the first number of the group and observing that the final selector under test rotates to the last number of the group, when busy tone should be heard.

Repeaters.—Automatic Routiners are provided for testing repeaters and full use should be made of this method of testing. It is necessary also, to arrange for each repeater to be thoroughly tested over its associated junction under both long line and short line dialling conditions. A suitable manual test set is usually provided for this purpose.

Discriminating Selector Repeaters.—Automatic Routiners have recently been developed for testing these switches and will be provided in future installations. These switches with their associated Junction Hunters must also be tested over all available junctions under both long and short line dialling conditions. Manual test sets are provided for this purpose.

Subscribers' Registers.—Each Register should be subjected to a cycle of tests by the Register Test Set. Ten operations of the register should take place under the limiting conditions imposed by the set.

Test Desk.—All circuits connected to the Test Desk should be carefully checked and tested. The associated Test Shoes and Test Jack circuits on the M.D.F. should also be tested.

Call Through Test

This is the final test on the exchange equipment and should be performed after all the tests previously mentioned have been made and after all faults and unstandard conditions detected during the tests have been rectified. The test is performed by making a call from each subscriber's line, under limiting conditions, through the exchange equipment to another line, so that each subscriber's circuit is tested for originating and receiving a call. During this test every switch which is accessible to a local call is brought into use in turn. The test is performed as follows:—

(a) Two testing telephones are connected to test shoes on the Main Distributing Frame. Each telephone is provided with a change over key so that long and short line dialling conditions may be imposed. On the M.D.F. one test shoe is connected to the first line in the exchange, 1001, and the other shoe to a line mid-way in the numbering scheme, say 2001. With the key in the long line position, Testing Officer No. 1 dials the number connected to test telephone No. 2 (2001). The ring is received and the testing officers speak. Both hang up. The key is now restored to the short line dialling position and another call made. Testing Officer No. 2 now calls the line connected to No. 1 Telephone, i.e., 1001 with long line dialling conditions. A call is then made under short line dialling conditions. The test shoes are now moved to numbers 1002 and 2002 respectively and two calls each way made on these lines. This procedure is repeated until all lines have been tested. Should a test call fail, the test is stopped, the call traced through the equipment and the faulty equipment rectified or busied for attention later. Each failure must be recorded and the nature of the trouble indicated.

(b) Each rank of switches must be supervised during the tests and only one switch in each rank should be available for a call, the remaining switches being busied. After each call, the switch previously used should be busied and another switch unbusied, so that each switch is brought into use in rotation.

The procedure at the various ranks of switches is as follows:—

(i) **Primary Finders.**—The "Indirect" Routine Test Key should be operated on each finder group so that all finders both direct and indirect will be allotted in turn. There is no necessity to busy the finders as each finder should be automatically allotted in turn, a failure of the allotter to step on, should be investigated. It will be necessary for the testing officer supervising these switches to have a numerical list of subscribers' lines showing the finder group, level, and bank contacts of each line.

(ii) **Secondary Finders.**—These switches will also be automatically allotted. It should be observed that two different finders are allotted for each call.

(iii) **Group Selectors.**—In the case of main exchanges, the call will pass through three or possibly four ranks of selectors. First selectors will be automatically selected via the primary and secondary finders and should not be busied. Second, third and fourth selectors should have all but one switch in a group busied so that maximum search will take place on the local level of the first selectors, and also on the dialled levels of the second, third and fourth selectors. The officers supervising these switches should be supplied with grading charts to facilitate this work.

(iv) **Final Selectors.**—All but one final selector in each group should be busied, a different switch being used after every two calls.

(v) **Subscribers' Registers.**—A testing officer must watch each subscriber's register for correct operation. It is important to note that the correct register only operates. The O.K. for each call must be given by the testing officer observing the registers before a further call is made. The numbers should be crossed off his list as they are correctly tested.

(c) All faults found on the call through test must be carefully recorded and the equipment cannot be accepted as satisfactory if the number of faults exceed 1 per cent. of the calls made or 2 per cent. of the lines tested. If the faults exceed the above figures by 100 per cent. another call through test should be made, after all faults have been rectified. In the case of branch exchanges where Discriminating Selector Repeaters are used, the above test may be carried out with the junctions to the main exchange disconnected at the M.D.F. as these junctions are usually not available until cutover.

(d) In branch exchanges where Repeaters are used, if junctions to the main exchange are not available for the call through test, the test may be performed by temporarily jumpering the outgoing junctions to the incoming junction switches. In this case the first two digits of each subscriber's number would be omitted.

(e) In main exchanges and D.S.R. branch exchanges, an additional test from the incoming junctions is necessary. One test telephone at the M.D.F. is connected to an incoming junction and a call made to a number in each 100 line group to which the other test telephone is connected. The associated group selectors and final selectors, with the exception of the incoming junction selectors, should be busied as before and the calls supervised. Similar tests should be made on each incoming junction.

Test of Substation Equipment

Prior to the cutover, each exchange line, and extension telephone must be tested from the Test Desk at the new exchange with a mechanic at the subscriber's premises. It is important that this test be made via the Test Distributor and Test Final Selectors to prove that the connection is complete from the final selector multiple. The following tests should be made on each exchange line:—

(i) Conductor Resistance, continuity, and freedom from earth or foreign battery on either leg.

(ii) Insulation Resistance.

(iii) Condenser Capacity and Bell.

(iv) Transmission.

(v) Dial Operation.

Master cards should have been prepared previously for each service and during the substation test the particulars on the cards should be carefully checked and corrections made where necessary. As in most cases, the services will have been previously tested when installed, tests (i) and (ii) are repeated more to ensure that the service is still free from trouble which may have occurred after the previous test. Tests (iii) and (iv) are final tests on the telephone. Test (v) "Dial Operation," is a very important test at this stage, and each operation should be carefully checked. Each dial should be tested for:—

(a) Ratio;

(b) Speed;

(c) Correct number of impulses on each digit.

Dial Ratio.—The ratio is measured direct on the new type test desks and although the loop resistance of each line is compensated for on the desk during the test, it is important to take into consideration the fact that the dialling circuit of the telephone is being tested and not the dial itself. It will not be possible, therefore, to read the correct dial make ratio, i.e., 33 per cent. even though the dial itself is correctly adjusted to this ratio. In modern telephones, the condenser and a 50 ohm resistance is connected across the dial when impulsing, which has a shunting effect, so that the make ratio is increased to approximately 37 per cent. This is the reading which will be observed on the test desk with a 33 per cent. make dial in the telephone. The adjustment of the dial should not be altered to obtain a 33 per cent. ratio reading on the test desk with this type of telephone, as the impulse springs of the dial may be left with very little follow with such an adjustment.

Dial Speed.—A dial speed between 9 and 11 impulses per second is satisfactory, time should not be wasted trying to get the adjustment of speed exactly to 10 impulses per second.

Dial Test on each Digit. — This test is performed to check the dial on each digit. It sometimes happens that a dial is correct on the "0" digit but fails to give the correct number of impulses on intermediate digits.

Tests on Extension Telephones.—On P.B.X.'s each extension telephone must be tested by connecting it through to an exchange line which has previously been tested. The tests on extensions are similar to those indicated for exchange lines.

Conclusion.—The necessity for thoroughly testing the exchange and substation equipment will be appreciated as the conditions required for making such a complete check of the equipment once the exchange is working will disappear, and although maintenance routines are performed to test the conditions of the equipment after the cutover, a complete test similar to that described in the call through test will not be possible under working conditions. The performance of the equipment in the early stages following the cutover is therefore dependent to a very large extent upon the completeness of the installation tests and the care which has been taken during the final test out. It should be remembered that it is very much easier to trace faults and clear troubles before the exchange is working than it is after the equipment is cut into service, and this applies particularly to maintenance staffs who may be comparatively inexperienced on the new type of equipment.

AUTOMATIC ROUTINERS IN TYPE 2000 EXCHANGES

T. T. Lowe

Automatic Routiners used in 2000 type Automatic Exchanges are described in this article. They are supplied at present for testing final selectors, group selectors and repeaters. Automatic routiners will be available shortly also for testing discriminating selector repeaters.

Routiners or Routine Testers are used in automatic exchanges to perform at specified frequencies, operating and other limiting tests on the equipment, under testing conditions more severe than those which are experienced in service.

Routiners are either Manual or Automatic. Manual routiners are operated by the testing mechanic and the time of the testing officer is fully taken up in operating the routine test set, recording the faults located and busying out faulty switches. With an automatic routiner, the testing mechanic is required only to operate a Start Key to commence the routine test, record faults located when the routiner stops, restart the routiner, and later retest the switches with the routiner after clearing the faults.

About one-sixth of the total time spent by the maintenance staff in an automatic exchange is expended on routine testing, therefore considerable time savings are effected by the use of automatic routiners, particularly in large exchanges. It is not as economical to test a switch efficiently with a manual routine test set as it is with an automatic routiner.

The following considerations justify the provision of automatic routiners in practically all modern automatic telephone exchanges:—

(i) Modern switches and switch circuits are rather complicated and the many functions which require to be tested necessitate the design of complex routine test sets. If manual routiners are contemplated, questions of portability, bulkiness, and obstructions to gangways, require careful consideration. If automatic routiners are installed these difficulties do not arise. In addition, routine testing may be performed by a relatively unskilled staff.

(ii) In a large, busy, automatic exchange where the number of major switches to be tested is considerable, routine testing must be performed during slack hours. If manual routine test sets are proposed this creates staffing problems.

(iii) If routine testing is performed manually the labour costs will predominate and it will be necessary to review the frequency of performance of each routine test at frequent intervals to ensure that the results achieved are commensurate with the costs involved. If automatic routiners are provided when the equipment is installed, the frequency of performance of routines on busy and important switches can be increased as required at little or no extra cost. It is desirable that important major switches be routined once daily in busy exchanges. This is impracticable in a large busy automatic exchange unless automatic routiners are provided.

When automatic routiners are provided, common major switches which are very heavily worked can be more or less constantly routined if desired at minimum cost, thus furnishing the maintenance staff with a true indication that the equipment is performing its functions correctly. As routine tests are performed under conditions slightly more severe than the worst service conditions, electrical and mechanical defects should be detected as unstandard conditions before the service is affected. An argument which has been advanced against automatic routining is that switches should be observed by the testing officer for satisfactory operation when under test. This is unnecessary for each individual switch on each routine test, but any "difficult" switch can be placed under "constant routine" and its operation closely observed by the maintenance officer when locating an intricate fault.

Development of Automatic Routiners.—In the development of automatic routiners the following methods of picking up the switches for testing purposes and performing the tests were considered:—

(i) One method considered was to tee on to two subscribers' lines in the local exchange during a disengaged period, set up a connection between them and check the correct operation of the exchange equipment involved in the connection, the procedure being continued by seizing a further two subscribers' lines and so on. In this scheme it was difficult to indicate the exact location of a fault detected in the train of switches set up nor was it practicable to test all the functions of each switch. A further disadvantage was the danger of interfering with subscribers' services.

(ii) Another method which has been tried consists of routine testing all major switches individually but only for one function on each switch at a time. This scheme is not favoured as it cannot be said that a particular switch has been tested to perform satisfactorily all its functions at any particular time.

(iii) A further scheme tried was to use the existing working switches in the exchange as access switches, i.e., to pick up the particular switch under test by means of a preceding switch in the train. This scheme had the advantage that no access switches or additional cabling to the switch under test was required. Disadvantages were that it was necessary to provide an additional switching relay on each group selector, also complicated arrangements were necessary for stepping over unequipped positions and while the scheme was reasonably satisfactory for switches approached from simple gradings, it was difficult to provide satisfactory arrangements for picking up the switches over complex gradings. The introduction of the 2000 type switch which can accommodate up to ten sets of bank contacts made the scheme of providing separate access switches far more attractive, thus leading to the abandonment of the idea of using working switches in the exchange for this purpose.

(iv) The method adopted is to provide separate distributor and access switches associated with the routiner for picking up the switches to be tested, to routine test each switch individually and to test all the functions of a particular switch before passing on to the next switch. It should be pointed out that with automatic routiners all the outlets or trunks between the different ranks of switches are not automatically routine tested. Trunks between switches, however, have a very low fault liability and are subjected to independent routine tests at frequent intervals.

Design of Automatic Routiners

General Features.—Automatic routiners should be rack-mounted and key controlled. When once started successive tests of the various functions of the switch should be applied automatically step by step. Each step forward movement should be dependent on the satisfactory performance of the function tested in the previous step so that failure of any particular function will stop the stepping mechanism.

Lamps should be provided to indicate the location of the switch which is under test and the progress of the various tests. When a function fails under test the relevant lamps should remain glowing and an audible alarm be given.

The tests should continue switch by switch until a failure is encountered or the end of the test cycle is reached.

Severity of Tests.—The tests imposed should be slightly more severe than the worst condition encountered in service, but should not be too severe, otherwise switches which are still quite capable of giving good service, will be classed as faulty. By this means, a defective electrical or mechanical condition on a switch will be detected before service is affected, but a maximum period of usefulness of the plant will be achieved. Faulty switches, when adjusted, should be subjected to tests considerably more severe than those imposed by the routiner. This will ensure that relays and switch mechanisms are adjusted in such a manner that they remain in satisfactory operation for as long a period as possible.

Check of Slow Relays.—The routiner should check the releasing lags within specified limits of important relays such as those which guard the private on release.

Guarding the Switch.—When a routiner takes a switch for testing, it must prevent intrusion by normal calls. The exception is when testing incoming group selectors which can be busied only at the repeater at the outgoing exchange. If an incoming group selector which is being tested by the routiner is seized by a normal call, the routiner must stop, give a visual and audible alarm signal and allow the subscriber's call to proceed without interference.

Camp on Busy.—Automatic routiners should be arranged to camp on a busy switch and give an alarm if the switch remains busy beyond a specified period.

Stepping Keys.—It is necessary to step the access and distributor switches to particular positions when it is required to continuously routine a certain switch or continue a routine test cycle which has been suspended temporarily. This is achieved by non-locking keys capable of stepping these switches one step at a time.

Test Numbers.—It is sometimes necessary to use numbers in the exchange series for testing purposes, these numbers being allocated permanently for routining. The aim should be to employ out-of-reach numbers, i.e., numbers of such a character that the likelihood of the test number being reached by the public is reduced to a minimum.

Traffic Recording Meters. — When switches having traffic recording meters are under test, there should be some indication of the amount of artificial traffic. A meter may therefore, if required, be connected to the routiner and arranged to operate once each time a switch is tested and released.

Fault Imitation Keys.—These keys should be provided to check the more important functions of the routiner.

Test Cancel Keys.—It is desirable in an automatic routiner to provide keys to cancel, when required, tests of certain functions. These keys are of use when a maintenance officer has a particular switch under continuous routine test. After he has proved that certain functions are O.K., the appropriate test cancel keys should be thrown to reduce the time required to deal with the switch. It is essential that test cancel keys when provided be used with discretion otherwise the proper functioning of the routiner will be seriously interfered with. Normally these keys should not be operated when performing a general routine.

Alarms.—Faults detected by a routiner are brought under notice by a lamp which indicates the function which has failed and by the sounding of an audible alarm which is extended to the exchange main alarm system.

Arrangement of Apparatus. — Operating keys and indicating lamps should be mounted on the racks at such a height that they can be operated and observed conveniently by the maintenance officer when standing erect. All apparatus used should be of robust construction and must have minimum fault liability and be readily accessible for maintenance purpose. Relays must be provided with double contacts and all rotary switches should be of the heavy duty type.

Location of Automatic Routiner.—The routiner and access equipment racks should be located as close as possible to the switches to be tested and must be available for use by the maintenance officer responsible for the equipment.

Remote Control of Reset Feature. — Jacks should be provided in multiple, on switch racks, so that by means of a plug, connection can be made via a jack to the routiner circuit controlling the restart of the test on a particular switch. When locating a difficult fault, the maintenance officer operates the continuous routine key on the routiner, steps the access equipment to the desired switch and starts the routiner. The mechanic observing the switch has full control and when the routiner stops due to a failure of the switch under test, he can restart the test as often as desired in order to watch the switch in operation and locate the fault.

Two Routiners for a Large Group of Switches. —When a group of switches is very large and so important that a daily test is essential, two routiners may be necessary to carry out the tests. The best way of connecting the routiners is to divide the plant into two sections and allocate one routiner to each portion. The routiners may be located side by side or may be separated, which ever is best suited to the layout of the plant. Arrangements may be made for either routiner to be capable of routining the whole of the plant. This is accomplished by fitting a Routine Extension key on each routiner. If the key on, say, No. 1 routiner is operated, No. 1 routiner on being started tests its own switches and, when finished, a relay changes the routine test leads to No. 2 routiner access equipment and the test is continued on the second half. It is possible to step No. 1 routiner past the first half of the equipment and proceed at once to test the second half. Fault indication is given on the routiner in use but access switch indication is shown on the relevant routiner even when the extension key is operated.

Fig. 1 is a photograph of an automatic routiner in use at Rockdale Exchange, Sydney, in which 2000 type equipment is installed. The photograph indicates a Routiner and Access Control Rack and an Access Equipment Rack.

Routine Testing Times.—The times taken at Rockdale Exchange to perform routine tests on group selectors are approximately 35 seconds per switch, and on final selectors 65 seconds per switch. When testing a large group of switches time is lost due to the routiner stopping when a busy or faulty switch is encountered, stepping the access equipment over busy or faulty switches, busying out faulty switches, etc. The overall average times taken at Rockdale Exchange are approximately 40 seconds per switch for group selectors and 70 seconds per switch for final selectors.

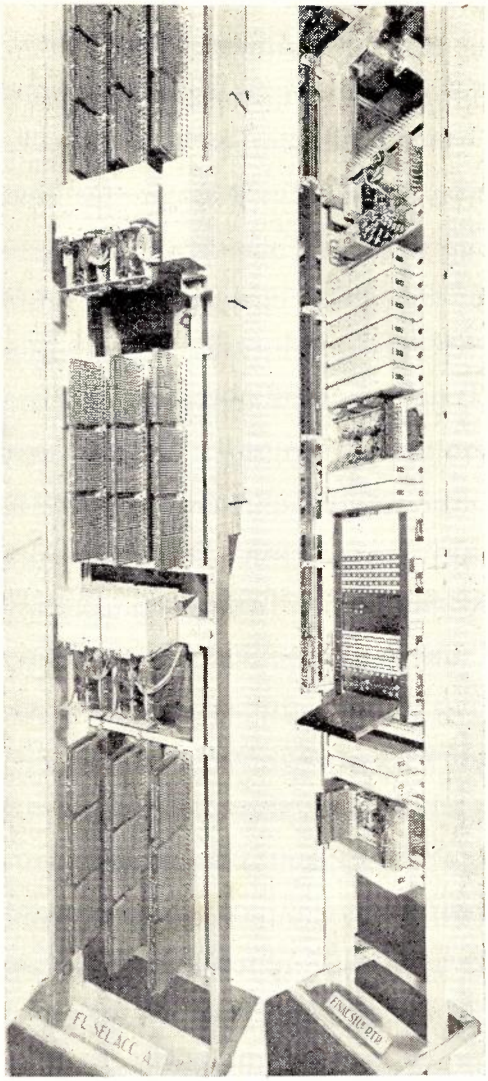


Figure 1

Brief Description of Automatic Routiners at Rockdale

The Automatic Routiners installed at Rockdale Exchange will now be described briefly, after which a detailed description will be given of the operation of the Final Selector Routiner at Rockdale Exchange when testing each function of a P.B.X. Final Selector. It should be mentioned that meters for recording artificial traffic and Test Cancel Keys are not provided on the Routiners installed at Rockdale Exchange.

The equipment is mounted on racks 10 ft. 6 ins. high and 18 ins. wide, one rack being used for the Routiner and Access Control Equipment, and an additional rack being provided for every six Access Selectors. The access selectors should be mounted as near as possible to the switches to be tested to reduce cabling costs.

(i) **Routiner and Access Control Equipment Rack.**—The following equipment is mounted on this rack.

(a) Three, eight level, 25 outlet, heavy duty rotary switches known respectively as the Test switch, the Auxiliary Test switch, and the Sending switch. The Test and Auxiliary Test switches step automatically when the Start key is operated, and apply the various tests in sequence to the switch under test. When a fault is encountered or the switch fails to operate satisfactorily, the test or auxiliary test switch stops, a Fault lamp is displayed continuously, and an alarm signal is operated to draw the attention of the testing mechanic to the fault. The Sending switch controls impulsing and release timing.

(b) One, 8 level, heavy duty rotary switch known as the Distributor switch, which automatically selects the Access Selectors in turn. The access selectors automatically connect the switches under test to the routiner. (See Fig. 2.)

(c) A Multiple Cam Impulsing Machine which generates dialling and release timing impulses. Dialling impulses are at 10 per second and release timing at 20 per second.

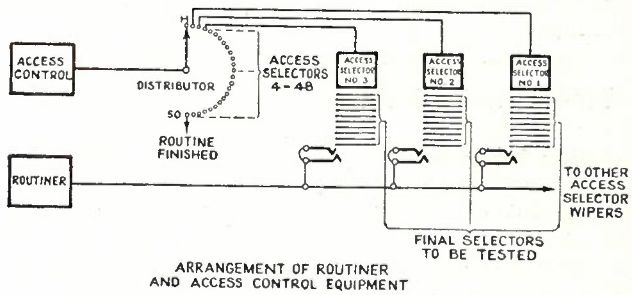


Figure 2

(d) A group of four Fault Imitation or Test Control keys. The fault imitation keys are used to simulate particular fault conditions. The test control keys are used to stop the routiner when the ringing or busy tones are applied, to enable the testing mechanic to plug into the routiner test jack with a buttinski and listen to the various tones.

(e) A group of five Control keys for controlling the operation of the routiner, known respectively as Start, Continuous Routine, Reset and Step On (one key) and two Alarm Keys. These keys are operated as follow:—

Start Key.—When it is desired to commence testing.

Continuous Routine Key.—When it is desired to perform a continuous routine on a particular switch or to obtain connection to a particular switch other than the first before starting a test.

Step On Key.—Operated momentarily when a fault is detected, to restore the testing circuits to normal and step the access selector to the next switch.

Reset Key.—Operated momentarily when the switch fails under a continuous routine test. The testing circuits are restored to normal and testing is recommenced on the same switch.

Alarm Keys "S" and "Z."—To check the operation of the test alarm circuits when operated in the "S" and "Z" directions in turn.

Main Alarm Key.—Operated when the routiner is attended, to disconnect the routiner from the main alarm circuit.

(f) A group of three Stepping keys, one for Distributor switch and two for the Access Selectors, one for Vertical stepping and the other for Rotary stepping. These keys are used for stepping the distributor and access switches to the required position when it is desired to continuously routine a particular switch or to commence the routine at a particular switch other than the first. A chart is provided to indicate the switches connected to the access selector levels.

(g) Five strips of ten Test Lamps to indicate the positions of the wipers on the Test and Auxiliary Test switches and the various tests which are applied from these positions. The test lamps provided on the Final and Group selector routiners respectively are as follow:—

Final Selector Routiner.

Start	Release
Selector Busy	Impulsing Short Line
Incoming Negative Line	Busy
Incoming Positive Line	Wiper Disconnected
Guard	Release
"A" Relay Release	Incoming Positive Line
"A" Relay Operate	Impulsing Long Line (Wiper Switching Relay Operated)
Release Timing	
Impulsing Short Line	
First Test Line Seized	Second Test Line Seized
"P" Wire Earthed	"P" Wire Earthed
Ring	Outgoing Negative Line (2nd Choice)
Ring Trip	
Metering	Outgoing Positive Line (2nd Choice)
Outgoing Negative Line (1st Choice)	"P2" Wiper
Outgoing Positive Line (1st Choice)	Release
	Impulsing Long Line
"P2" Wiper	Busy
Last Party Hold	Release
	Test Finished.

Three additional special lamps are provided also, i.e.,

Private Guard Fail lights if the private is momentarily unguarded during certain tests.

Incorrect Metering lights if metering occurs before the incoming lines are reversed or if more than one meter pulse is received during the meter test.

Release Slow lights when the release timing of the final selector is greater than 350 milliseconds.

Group Selector Routiner.

Start	Impulsing Short Line
Selector Busy	"C" Relay Timing
First Test Line Busy	Second Test Line Seized
Second Test Line Busy	Positive Continuity
"A" Relay Operate	Negative Continuity
Incoming Positive Line	First Choice Wipers Disconnected
Incoming Negative Line	
"A" Relay Release	Release Guard
Loop	Loop
Impulsing Long Line	Impulsing Short Line
"C" Relay Timing	10th Contact
First Test Line Seized	Busy Received
Positive Continuity	Busy Tone
Negative Continuity	"P" Wiper
Second Choice Wipers Disconnected	Release Timing
	Routiner Held
Release Guard	Test Finished.
Loop	

Three additional special lamps are provided also:—

"P" Unguard lamp lights if the private is momentarily unguarded during certain tests.

Release Fast lamp lights if the release time of the selector is less than 200 milliseconds.

Release Slow lamp lights if the release time of the selector is greater than 350 milliseconds.

(h) Three strips of 20 Distributor Lamps associated with the various positions of the wipers on the distributor switch. These lamps indicate the appropriate access selector in use.

(i) One strip of 20 Access Lamps, 10 lamps for the vertical positions of the appropriate access selector and 10 for the rotary positions. These lamps indicate the switch under test which is shown on the chart provided.

(j) One strip of 10 Fault Lamps to indicate faults on the access equipment, etc., as follows:—

Routine Finished lamp lights when a general or group routine is finished.

Routiner Switch Release Alarm lamp lights should the distributor, test or auxiliary test switches fail to home when their homing circuit is closed.

Access Switch Release Alarm lamp lights should the access switch fail to release.

Test Start Fail Alarm lamp lights if at the end of a delay period after the start key is operated the access control circuit fails to send a start signal to the routiner.

Permanent Vertical Alarm lamp lights if the vertical magnet is energized for a period longer than nine seconds.

Access "B" Hold lamp lights if the "B" relay in an access selector is held after the start key is restored.

(k) Other Alarms.—A Fuse Alarm lamp is provided, also a Rack Alarm lamp which lights when any fault other than the blowing of a fuse develops in the routiner or when any fault is in evidence on the circuit under test. A rack alarm bell is provided also to give an audible alarm.

(1) Various miscellaneous equipment also mounted on this rack consists of 3 relay plates associated with the distributor and access selector switches, 8 relay plates associated with the test, auxiliary test and sender switches, sundry resistances, condensers and other equipment.

(ii) **Access Selector Rack.** — On the access selector rack provision is made for mounting six 100 outlet 2000 type bimotional access selectors, each selector being equipped with six wipers and also a vertical bank and wiper. The access selector rotary and vertical banks are cabled to terminal blocks mounted on the rack, the switches to be tested being cabled permanently to these blocks also. Arrangements are provided on these blocks for suitable strappings for equipped and unequipped positions on the equipment racks. The distributor switch banks are cabled to the access selectors through terminal blocks provided on the routiner and access selector racks.

OPERATION OF THE FINAL SELECTOR ROUTINER.

The operation of the final selector routiner, including the access equipment, will now be described. In order to simplify the description, the circuit operation has been broken up into the various functions performed when the Test Control keys are operated and the Distributor, Access, Test, or Auxiliary Test switches step to the various positions. The undermentioned circuit drawings indicate the complete operation of the routiner.

Routiner Access Control for Access Selectors (2000 type)—S 6241 (ND 7419/D).

Routiner for Final Selectors—Access Selector for 200 Outlet Ordinary and 2/10 P.B.X. Final Selectors—S 6259 (ND 7410/D).

Routiner for Ordinary and 2/10 Final Selectors with Last Party Release and Positive Battery Metering—S 6263 (ND 7418/D).

The circuit drawing for the final selector tested by the Routiner in this description is:—

Final Selector 2/10 P.B.X.—LM 2136 (ND 5109/B).

The fundamental arrangement of the Routiner and its Access Control Equipment is shown schematically in Fig. 2. The routiner is connected to the wipers of all access selectors. The access control equipment selects the required access selector by means of the distributor switch and then positions the wipers of the chosen access selector on the appropriate bank contacts which are connected permanently to the switch to be tested.

Starting the Routiner (Fig. 3). — When the start key KS is operated, relay MD 1300 operates from ground via KS 5/6 (shown operated in Fig. 3). Relay H is also operated via its 1000 ohm winding, KS 11/12 and KSO 24/25 to ground. H locks to ground through its make contacts 21/22 and KS 28/29.

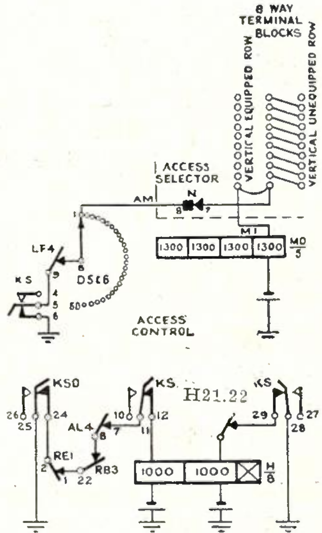


Figure 3

Distributor Switch steps to No. 2 position (Fig. 4).—The operation of relay H completes a circuit for the impulsing machine through contacts H 1/2 and relay MD is operated through H 28/29. The circuit for the distributor drive magnet is completed from ground through H 24/25 and the switch is stepped to position 2. In this position the circuit of the "Distributor Indicating Lamp No. 1" is completed via H 4/5.

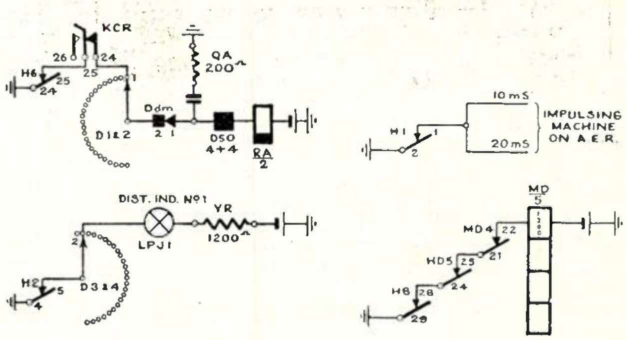


Figure 4

Access Selector, First Vertical Step (Fig. 5).—With the distributor switch in No. 2 position, relay B in the access selector operates from ground via operated contacts KS 5/6, B 2000 to battery. A locking circuit for B is completed via H 8/9. When relay B operates, the vertical magnet is energized from ground via KS 22/23 operated, vertical magnet to battery. The operation of the vertical magnet connects ground via B 1/2 operated, relay TF 1000 to battery. Relay TF operates and breaks the vertical magnet circuit at TF 25/26. The magnet releases.

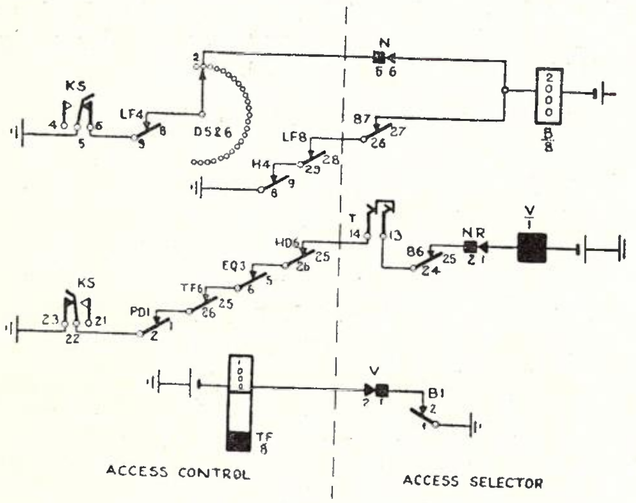


Figure 5

Access Selector, First rotary step prepared (Fig. 6).—When the access selector is stepped to level 1, the "Access Selector Vertical Level No. 1" lamp lights from ground via H 8/9 operated, lamp, YE 1200 to battery. Relay EQ operates from ground at H 8/9 operated, vertical bank, relay TF 500, KCR, EQ 700 to battery and locks via EQ 1000, EQ 21/22 to the same ground. Relay PD is operated through contacts EQ 3/4.

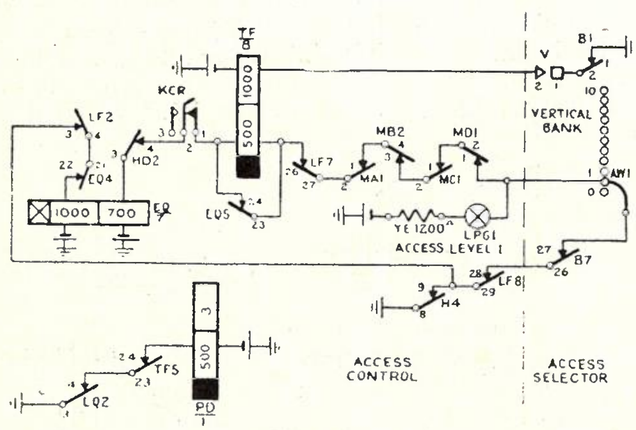


Figure 6

Access Selector; First Rotary Step (Fig. 7).—When the vertical magnet releases, V 1/2 breaks and opens the circuit to relay TF (see Fig. 5) which releases slowly due to its slug and the short circuit across the 500 ohm winding (Fig. 6). Relay TF remains operated long enough to energize the rotary magnet from ground via KCR 4/5 normal, rotary magnet to battery. The rotary magnet then steps the switch to the first rotary contact. The "rotary access No. 1" lamp LPH glows from ground via B 1/2 operated, W6 wiper and bank, rotary equipped strap, lamp LPH 1, YQ 1200 to battery.

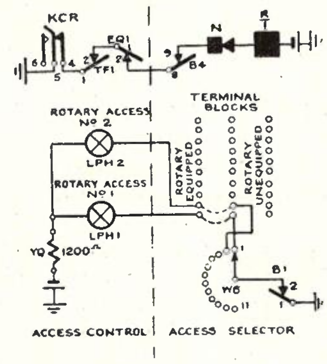


Figure 7

Test Start (Fig. 8).—When relay TF releases, relay PD releases also (Fig. 6) and a circuit is closed for relay HD from ground via KS 22/23 operated, HD 2000 to battery. Relay HD locks from ground via KS 2/3 to battery through its second 2000 ohm winding. Relay HD operating, opens the circuit to relay MD (see Fig. 4) and closes the test start circuit from ground via H 6/7 operated KSO 7/8 normal, WW 2/3 operated, relay TS 2000, T1 wiper and bank, test switch drive magnet to battery.

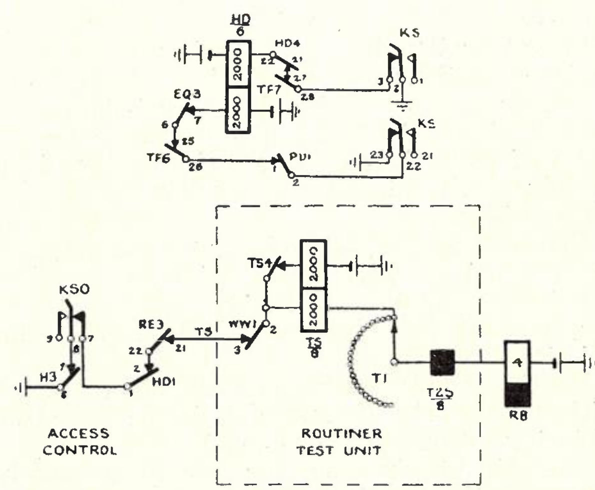


Figure 8

Access Selector Steps to next switch to be tested (Fig. 9).—When the switch is tested, relay TF operates from ground via TS 25/26 operated, T2 wiper and bank, "Test Finished" lamp LPB5, relay TF 1000 to battery. Relay TF operates and releases relay HD which removes ground from the Test Start lead to the routiner (see Fig.

8). TF 1/2 operated closes the circuit to the rotary magnet stepping the access switch to the next switch to be tested (see Fig. 7). "Rotary Access No. 2" lamp lights from ground via B1/2 operated, W6 wiper and bank, rotary equipped strap, lamp LPH 2, YQ 1200 to battery (see Fig. 7). Relay HD reoperates when TF and PD release and connects ground to the TS lead restarting the routiner (see Fig. 8).

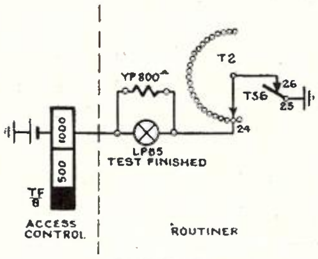


Figure 9

Unequipped Positions (Fig. 10).—Unequipped positions on a particular access switch level are strapped on the terminal strip to the rotary unequipped row. When the access switch steps to these positions, relay TF operates from ground via B 1/2 operated, W6 wiper and bank, rotary unequipped strap, relay TF 1000 to battery. The rotary magnet steps the access switch to the next position (see Fig. 7). The circuit to relay TF 1000 is opened at W6 wiper and bank and relay TF releases. This procedure continues until an equipped position is found and relay HD reoperates again closing the test start circuit.

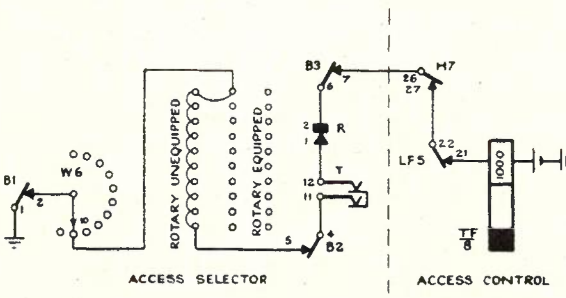


Figure 10

Access Switch Steps to 11th Rotary Position (Fig. 11).—Relay TF operates at the end of the test cycle (see Fig. 9) and relay HD releases. When the access selector steps to the 11th rotary contact, ground is connected to the appropriate "M" vertical marking lead as arranged by the strapping on the equipped or unequipped vertical tags. Should level 2 be unequipped and level 3 equipped, MC and MD relays operate from ground via B 1/2 operated, vertical equipped straps level 3, relay MD 1300 to battery, and relay MC 1300 to battery. Both relays lock from ground via H 28/29 operated, HD 23/24 normal, MD 21/22 operated for MD relay and MC 21/22 for MC relay. The "S" springs are closed on the 11th rotary step and after TF releases, relay LF operates slowly from ground via S 1/2 operated TF 8/9 normal, relay LF 800 to battery.

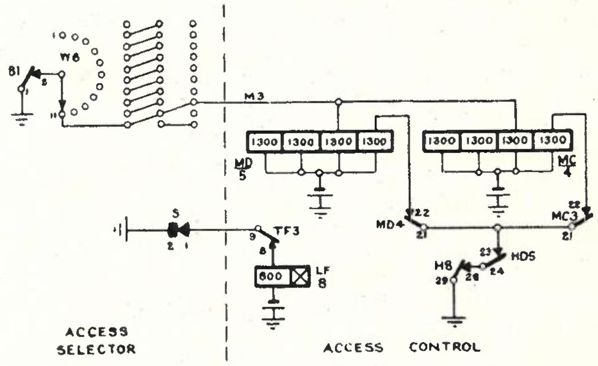


Figure 11

Release of Access Selector (Fig. 12).—When relay LF operates, it releases relays EQ and B (Figs. 5 and 6) and operates relay PD from ground via LF 1/2 operated. When relay B releases, the Access Selector release circuit is closed from release alarm ground via B 28-29 normal, R magnet to battery. The switch restores to normal in the ordinary manner.

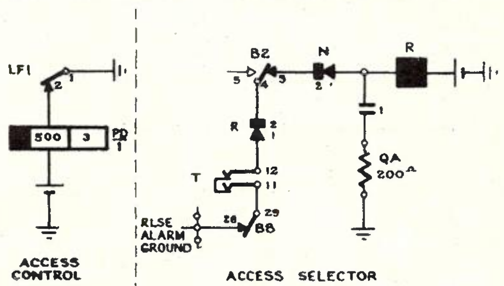


Figure 12

(To be continued.)

ANSWERS TO EXAMINATION PAPERS

The answers to examination papers are not claimed to be thoroughly exhaustive and complete. They are, however, accurate so far as they go and as such might be given by any student capable of securing high marks.

EXAMINATION No. 2364.—MECHANIC, GRADE 2—BROADCASTING

H. W. Hyett

Q. 1.—Define the term "resonance" as applied to electrical circuits.

A condenser of 100$\mu\mu$F is required in parallel with an inductance to tune the circuit to resonance at a frequency of 9.60 megacycles per second. What capacity would be required to obtain resonance at 12.0 megacycles per second, using the same inductance? What is the value of the inductance in microhenries?

A.—When an inductance and a condenser are connected either in series or parallel, resonance occurs when the reactances of the elements are equal. These reactances are opposite in sign and, therefore, cancel under this condition.

In the case of the series circuit, if the circuit contains no resistance, the impedance becomes zero at resonance, whilst in the case of the parallel circuit under the same conditions the impedance becomes infinity.

If the circuit contains resistance, the impedance becomes equal to the ohmic resistance in the case of the series circuit, whereas the presence of ohmic resistance in the parallel circuit has the effect of reducing the impedance of the circuit at resonance, and the larger the ohmic resistance, the lower the impedance is reduced.

At resonance the power factor of both the series and parallel circuits is unity.

In the problem $C_1 = 100\ \mu\mu F$
$f_1 = 9.6$ mC
C_2 is the unknown
$f_2 = 12$ mC

The value of L, the inductance, remains the same in both circuits.

At resonance,

$$2\pi f_1 L = \frac{1}{2\pi f_1 C_1}$$

where L is in henries and C is in farads,

$$\therefore L = \frac{1}{4\pi^2 f_1^2 C_1} = \frac{1}{4\pi^2 f_2^2 C_2}$$

$$\therefore C_2 = f_1^2/f_2^2 \times C_1 = 9.6^2/12^2 \times 100 = 64\ \mu\mu F$$

The value of the inductance L is also found from the expression—

$$L = \frac{1}{2\pi f C}$$

where L is in henries and C is in farads.

$$\therefore L = \frac{10^{18}}{4\pi^2 \times 9.6^2 \times 10^{12} \times 100} = 2.75\ \mu H.$$

Q. 2.—Define the term "decibel."

To what extent would the peak voltage rise in a 600 ohm circuit, if the R.M.S. power level in the circuit was 4 decibels above 6 milliwatts, assuming the alternating current to be of sine wave form?

A.—Two amounts of power are said to differ by 1 db when ten times the common logarithm of their ratio is equal to unity, i.e., if

$$10 \log_{10} \frac{P_1}{P_2} = 1$$

From this relationship it will be seen that two voltages, or two currents, will differ by 1 db when 20 times the common logarithm of their ratio is equal to unity, i.e.,

$$20 \log_{10} \frac{E_1}{E_2} = 1$$

$$20 \log_{10} \frac{I_1}{I_2} = 1$$

The R.M.S. voltage in a circuit when the power and impedance are known is found as follows:—

$$P = E^2/R$$
$$\therefore E = \sqrt{P \times R}$$
$$\text{Now } P = 6 \text{ mW} = 6/1000 \text{ watts}$$
$$\text{and } R = 600 \text{ ohms}$$
$$\therefore E = \sqrt{\frac{6.\ 600}{10^3}} = \sqrt{3.6} = 1.9 \text{ volts R.M.S.,}$$

$$+ 4 \text{ db on } 1.9 \text{ volts} = 1.9 \times \text{antilog } 4/20 = 1.9 \times 1.585 = 3.02 \text{ volts R.M.S.,}$$

$\therefore$ as peak volts/R.M.S. volts $= \sqrt{2}$
the peak voltage $= 3.02 \times 1.4142 = 4.27$ volts.

ALTERNATIVELY:—

$+ 4$ db on 6 mW $= 15.072$ mW,
which is calculated as follows:—

$$10 \log_{10} \frac{P_1}{P_2} = 4$$
$$\log \frac{P_1}{P_2} = .4$$
$$\frac{P_1}{P_2} = \text{antilog } .4 = 2.512;$$

therefore, P_1 must be the greater

$$\therefore P_2 = 6 \text{ mW}$$
$$\text{and } P_1 = 2.512 \times 6 \text{ mW} = 15.072 \text{ mW}$$

$$E_{RMS} = \sqrt{\frac{600.\ 15.072}{10^3}} = \sqrt{9.0432} = 3.02 \text{ volts R.M.S.} = 4.27 \text{ volts peak.}$$

Q. 3.—Describe the phase relationships between current and voltage in a circuit containing—

(a) pure inductance only;

(b) pure capacity only;

and explain the reasons for the conditions which exist in each case.

A.—In an alternating current circuit containing pure inductance only, the current lags behind the voltage by an angle of 90°. This is explained as follows:—

When current commences to flow through an inductance, a counter EMF is set up which tends to oppose any increase in the current, and when the current is ceasing to flow the counter EMF set up tends to cause the current to continue the flow. This action is due to the fact that a magnetic field is created while the current is increasing, and work is done in creating this field. The stored energy is converted to Kinetic energy when the current starts to decrease, which tends to prolong the movement of the electrons in the conductors when the current is decreasing; thus during the period the magnetic field is being built up the current flow is opposed, and during the period the magnetic field is being destroyed the current flow is assisted, resulting in the current lagging behind the voltage.

If the circuit consists of pure inductance, the applied and counter EMF's are equal and opposite in phase, thus the current is zero when these EMF's are at their maximum values, one positive and the other negative, and the current reaches its maximum value when these EMF's are zero. As the maxima and minima of a sine wave occur at intervals of 90°, the current lags behind the voltage by 90°.

In the case of a circuit containing pure capacitance only, when an alternating EMF is applied, the condenser becomes charged, and the PD between the plates becomes equal to the applied EMF. The amount of charge in the condenser (Coulombs) varies in phase with the applied EMF, so that the maximum charge occurs when the voltage is at its peak, and is zero when the voltage is zero. Thus the condenser is charged and discharged each quarter of a cycle; 0° to 90°, and 180° to 270° being periods of charge, and 90° to 180° and 270° to 360° being periods of discharge. At 0° the rate of charge (i.e., the current) is greatest, and is positive in direction. At 90° no change is taking place in the charge, therefore the current is zero. At 180° the greatest change in the charge is again taking place, and the current is, therefore, again at a maximum. At 270° the condition is similar to that at 90°.

Thus, the current reaches its maxima and minima 90° before the voltage and, therefore, leads by 90°.

Q. 4.—What are the main causes of frequency instability in a valve oscillator in a radio transmitter?

Describe how the piezo-electric effect of quartz may be used to stabilize the frequency of a radio transmitter.

A.—The main causes of frequency instability in a valve oscillator in a radio transmitter are:—

(i) Variation in the anode potential due to variation in the supply voltage.

(ii) Changes in circuit values due to heating of the components.

(iii) It can also be caused by variations in the impedance of the plate load of the oscillator, due to improperly designed stages following the oscillator stage, which allow the variations due to modulation being reflected back to the oscillator plate load.

Quartz is one of the materials which have the property of producing an EMF when the crystal is mechanically strained (compressed or expanded). This action is reversible, so that when an electric charge is impressed upon the crystal the latter changes its shape. This characteristic is called the "Piezo-Electric" effect.

This deformation can be made to occur as a cyclic variation, the rate depending on the thickness of the crystal. Thus, a crystal can be manufactured to a predetermined thickness so that its major mode of vibration will be at a given rate per second.

When such a crystal is inserted in the grid circuit of the tube connected as an RF oscillator, the oscillations of the tube are controlled by the crystal, and depend on the thickness of the crystal. The higher the frequency required, the thinner the crystal must be cut. As the dimensions of a crystal will vary with temperature, it is usual to place it in an oven, the temperature of which is maintained within very close limits by means of a thermostat. In this way a very high degree of frequency stability is obtained.

A crystal cut on the "X" axis has a negative temperature coefficient, whilst one cut on the "Y" axis has a positive temperature coefficient. It is possible, therefore, to cut the crystal so that the positive and negative temperature coefficients cancel, thus obtaining a crystal that has a temperature coefficient very close to zero. It is usual to specify a coefficient of less than one part in a million per degree Centigrade for modern broadcasting transmitters.

Q. 5.—What do you understand by the term "Q" of an electrical circuit? Is a high or low value of "Q" desirable in the interstage circuits of a high quality broadcast transmitter? Give reasons for your answer.

How is the value of "Q" controlled in an electrical circuit?

A.—In an electrical circuit designed for operation at radio frequencies, the overall efficiency is dependent on the losses introduced by the component parts. This particularly applies to inductance coils and condensers. The efficiencies of these components are proportional directly to their reactances, and inversely to their effective resistances, thus the ratio of reactances to effective resistance is a measure of the efficiency of the component. This ratio has been termed the "Q" of the component, and may be regarded as its "figure of merit." Mathematically expressed, "Q" $= \omega L/R$ for a coil, and $1/\omega CR$ for a condenser,

where $\omega = 2\pi \times$ the frequency in c.p.s.
R = Effective resistance
L = Inductance in henries.
and C = Capacitance in farads.

In a high quality broadcast transmitter, the R.F. tuned circuits in the stages prior to that in which modulation takes place would require to have a high "Q," so that a high gain per stage would be obtained. Once the carrier has been modulated, the value of the "Q" of the succeeding circuits should be reduced to a point at which the loss at frequencies of 10 kC/sec. either side of the carrier frequency is within 0.5 db of that at the carrier frequency. In order to obtain this condition, a fairly low "Q" is necessary.

The reason for this is because a circuit with a high "Q" has a sharp peak at resonance which would mean that the band width of the transmitted signals would be reduced to a value of 2 to 3 kC/sec. High quality broadcasting plant requires a band width of approximately 10 kC/sec., thus high "Q" interstage circuits after modulation would impair the quality of the transmission.

Apart from design considerations, involving dimensions of the coil, sizes and type of wire, composition of former and core, etc., which all affect the "Q," the value of "Q" may be controlled by the introduction of "damping" resistances, either in series or in parallel with the components. The effect of this is to reduce the "Q," and the resonant peak is flattened, thus resulting in an increase in band width. By varying the value of the added resistances, the band widths may be controlled.

Q. 6.—Explain how the strength of the demodulated signal at the point of reception depends upon the depth of modulation of the carrier as well as the power of the carrier of the broadcasting station.

A.—When an unmodulated carrier wave is radiated from a broadcasting station, the strength of the field at the receiving point depends on—

(i) The power of the carrier wave radiated from the transmitter.

(ii) The type of radiator used at the transmitter.

(iii) The distance to the receiving point;

and (iv) The conductivity of the soil between the transmitting station and the point of reception.

The field strength is measured in millivolts per meter of effective height of the receiving antennæ, and as this is a voltage measurement it will be directly proportional to the amplitude of the carrier wave. Therefore, as the amplitude of the carrier wave is directly proportional to the square root of the power radiated, other things being equal, the field strength at the receiving point will vary directly as the square root of the power radiated; thus, if the carrier power is doubled, the field strength at the given point within the range of the ground wave is increased by a factor of root 2, i.e., 1.4142, which is equivalent to 3 db. Unless the carrier is modulated no signal is reproduced in the listener's set.

In the system of amplitude modulation, which is the type used in the broadcasting stations in this country, the amplitude of the carrier wave is varied by the voice frequency modulating signal in such a manner that when the carrier is fully modulated, its amplitude varies from zero to twice its normal value at intervals corresponding to the frequency of the modulating signal. Under this condition the maximum signal is reproduced by the loud speaker of the listener's set.

If the carrier were modulated only to a depth of 50%, say, its amplitude would vary from a value equal to half its normal value to 1½ times its normal value; i.e., the amount of variation would be equal to the original amplitude of the carrier, therefore, the strength of the signal reproduced by the loud speaker would be just half that which was reproduced when the carrier was fully modulated. The decrease in signal strength would, therefore, be 6 db. Thus, the strength of the signal reproduced by the loud speaker of the listener's set is directly proportional to the depth of modulation for a given carrier strength.

The actual amplitude of the variation of the carrier amplitude will be increased if the amplitude of the carrier in the un-modulated condition is increased. Therefore, if the amplitude of the un-modulated carrier were doubled by increasing the power radiated by the station by a factor of 4, under the condition of full modulation the amplitude of the variation of the carrier amplitude would be doubled. Thus, the strength of the de-modulated signal at the point of reception depends on the power of the carrier of the broadcasting station as well as upon the depth of modulation of the carrier.

Q. 7.—When preparing a room for use as a broadcasting studio, what special structural modifications are necessary apart from the provision of technical equipment?

Why would an ordinary room without special treatment be unsuitable for this purpose?

A.—When a sound is generated in an enclosed space, unless special precautions have been taken with the surrounding surfaces, the sound is reflected from these surfaces from all directions. If a microphone is placed within the enclosed space, the sound waves which travel by the direct route between the source of sound and the microphone will be interfered with by the reflected sound, as owing to the differences in the lengths of the paths there will be a difference in phase. This interference affects the intelligibility of the original sound, and under certain circumstances appears as distortion.

The greater the volume of sound, the greater the interference, as each sound wave will have been reflected a greater number of times before it becomes attenuated to a sufficient degree to render it incapable of causing interference. The time taken for a sound to be attenuated to a value of 60 db below its original value is termed the "reverberation time" of the room.

In order that the reproduced sound may bear a close resemblance to the original, it is necessary to render the enclosing surfaces sound absorbing, so that the reflected sound will be insufficient to cause interference with the sound waves travelling by the direct route. Many different materials have been developed during recent years which have a fairly uniform absorption coefficient over the frequency range 100 c.p.s. to 5,000 c.p.s. By using one or more of these materials as linings for the rooms, the "reverberation time" can be controlled. The greater the surfaces covered with sound-absorbing material, the lower the reverberation time.

All fabrics, carpets, clothing, etc., have sound-absorbing property, but generally their absorption coefficient is greater at the high frequencies, and very small at the lower audio frequencies. Therefore, although it is necessary to take the effect of these materials into consideration when determining the amount of treatment a room shall receive, it is unsatisfactory to rely entirely on these types of material for the treatment.

The "optimum reverberation time" for average-sized studios for musical reproduction would be about 1.2 seconds. This effect would probably be obtained by treating the ceiling and the top three or four feet of the walls with one of the sound-absorbent materials having a uniform absorption coefficient over the frequency range 100 c.p.s. to 5,000 c.p.s. This amount of treatment, together with the room furnishings and clothing of the occupants during a performance, would probably provide sufficient treatment for a studio 30 ft. x 20 ft.

Small studios required for talks and plays are generally adjusted to have a reverberation time of about 0.6 seconds, as at this value the effect of the reflected sound is negligible, and maximum intelligibility is obtained. In large studios required for musical reproduction, a small amount of echo is pleasing to the ear, and gives the reproduction a "live" and natural sound. Longer reverberation times are, therefore, desirable for large studios. A large orchestra performing in a "dead" studio would sound most unnatural, and it would be difficult to listen to the reproduction from such a studio.

In addition to treating the interior surfaces of a room it is proposed to use as a broadcasting studio with sound-absorbent material, it is also necessary to insulate the room from external sounds which may be air borne, or may be transmitted by the various portions of the building structure.

It is generally fairly easy to insulate against airborne sounds by the erection of false walls, ceiling, floor, etc. Sounds transmitted via the structural members of the building are extremely difficult to prevent, and it is either necessary to completely float the studio within the building structure, or alternatively to build a studio on its own foundations entirely separate from the remainder of the building. This latter method necessitates all studios being at ground level, and is the method now favoured in the U.S.A. and in this country.

For the reasons set out above, an ordinary room would be unsuitable for use as a broadcasting studio without special treatment.

Q. 8.—Explain with the aid of a circuit diagram how demodulation is obtained by means of an anode bend detector. What are the factors which limit the linearity of this device?

A.—Fig. 1 shows a schematic circuit of an anode bend detector, and Fig. 2 the manner in which a modulated signal is demodulated in this type of detector.

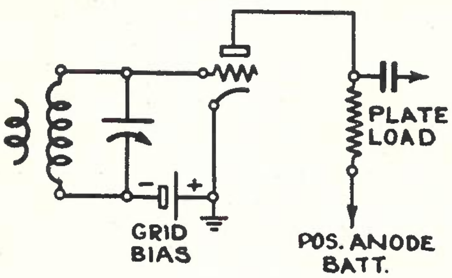


Fig. 1.

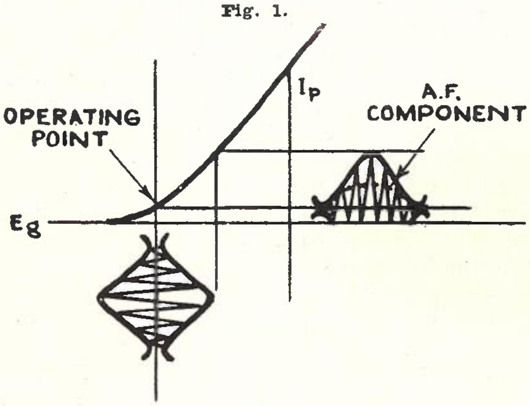


Fig. 2.

For anode bend detection, the tube is biassed almost to the point of plate current cut-off, so that each positive half cycle of the modulating frequency causes a large increase in plate current. Because of the manner in which the tube is biassed, the negative half cycle of the modulating frequency causes only a very slight decrease in the steady value of the plate current; thus the plate current increases in pulses at intervals corresponding to the frequency of the modulating tone. The audio frequency component in the output of a detector of this type is proportional to the average of the positive and negative modulation envelopes. If a pair of headphones is inserted in the plate circuit of the tube, the original modulating tone will be reproduced.

The linearity of this device depends on the signal being of sufficient strength for the grid voltage to swing beyond the lower portion of the grid volts v. plate current characteristic curve where the slope is not constant. If the excursions of the signal voltage are insufficient to pass this portion of the curve, the amplification in the tube will follow a square law, and the signal developed across the plate load will not be the true replica of the modulating signal.

If, on the other hand, the signal voltage is of such magnitude as to cause the grid to become positive during the peak portion of the cycle, grid current will flow and energy will be absorbed at this instant, causing distortion of the wave shape.

For linear detection, therefore, the maximum amplitude of the signal is limited to the value of the grid bias: hence, the power-handling capacity of the tube can be increased by increasing the DC voltage applied to the anode, as the larger the anode voltage, the larger the grid bias voltage required to produce plate current cut-off.

From the above it will be seen that, for a given depth of modulation, the output of this type of detector will be more linear the larger the carrier voltage up to the stage where the grid becomes positive at the crest of the modulation cycle. For a given carrier voltage, however, even though the grid may not be driven positive, the amplitude distortion increases as the depth of modulation approaches 100%. This is because of the fact that the closer the carrier amplitude approaches zero during the negative half cycle of the modulating frequency, the less linear the detector output becomes due to the voltage swing being insufficient to drive the grid beyond the curved portion at the lower end of the grid volts v. plate current characteristic curve.

Q. 9.—Describe the frequency characteristics of the standard laterally cut gramophone record, giving the reasons for these characteristics. How is the programme matter restored to its original form after reproduction from a gramophone record? How does the frequency response vary between the inside and the outside grooves?

A.—A recording head, in which an iron armature to which the cutting stylus is attached moves in the field of a permanent magnet when the field is varied by passing alternating current through a coil placed in that field, has what is known as a "constant velocity" characteristic. This means that if the power fed to the head remains at a constant value, the armature and hence the cutting stylus moves at a "constant velocity" irrespective of the frequency of the applied signal: thus, as the frequency is increased, the amplitude of the movement of the armature becomes proportionately less. Theoretically, a reproducing head made on the same principle of the cutting head reproduces the signal in its original form.

If the excursions of the stylus due to the impressed A.C. signal are lateral with respect to the mean direction of the groove, the recording is said to be of the laterally cut type, which is the type in most common use.

In a laterally cut recording, the spacing between adjacent grooves must be so adjusted that the amplitude of the excursions of cutting stylus is never permitted to reach a value which would cause the stylus to cut into the adjacent groove. At the same time, in order to obtain a reasonable playing time on a disc, it is desirable that the spacing of the grooves should be fairly close.

If all frequencies between 50 c.p.s. and 5,000 c.p.s. were recorded with a "constant velocity" characteristic, the amplitudes of the lower frequencies would be very large, whilst those of the higher frequencies would be extremely small. In order to avoid this condition, gramophone record manufacturers agreed to compromise, and the amplitudes of all frequencies below 250 c.p.s. were limited so that below this frequency the cutting head operates as a "constant amplitude" device. This means that, in the recording, frequencies below 250 c.p.s. are attenuated at the rate of 6 db per octave. (With the "constant velocity" characteristic the amplitude would be doubled for each octave below 250 c.p.s., therefore, as the amplitude remains constant, below this frequency, half the amplitude is lost for each octave; hence the loss is 6 db per octave.)

By adopting this compromise between the "constant velocity" and "constant amplitude" characteristics, it is practicable to space the grooves at intervals of about 100th of an inch, which at 78 r.p.m. permits a playing time of 3½ to 4 minutes being obtained from a 12-inch disc.

Because the low frequencies are attenuated in the recording it is necessary to provide special equalising equipment in the reproducing circuit, so that the proper balance between the low and high frequencies is restored when the record is reproduced. This equalising equipment has a characteristic which gives a constant insertion loss from 250 c.p.s. to 5,000 c.p.s., and a loss which decreases at the rate of 6 db for each octave below 250 c.p.s.

In recording on a disc, the groove radius is constantly decreasing as the cutting stylus moves from the outside towards the centre of the disc. This means that for any given frequency the wave length becomes shorter as the centre of the disc is approached, because the groove speed past the needle point is becoming lower.

As the wave length becomes shorter, the tendency of the reproducing needle point to accurately follow the deviations of the groove becomes less, and the voltage generated in the reproducing device is reduced. Because the wave lengths of the higher frequencies become so extremely short, this has the effect of causing the high frequencies to be attenuated as the reproducing stylus moves towards the centre of the disc.

Provided the radius of the innermost groove is not less than about 3 inches, this effect is not serious when the turntable speed is 78 r.p.m. It does become serious at a turntable speed of 33 1/3 r.p.m., and the intelligibility of the recorded speech becomes affected.

In order to overcome this effect, it is usual to employ an automatic equaliser when recording at a turntable speed of 33 1/3 r.p.m. This device over-emphasizes the high frequencies in the inner grooves by varying amounts, which are predetermined by measurement. Thus, when the recording is replayed, uniform quality is obtained throughout.

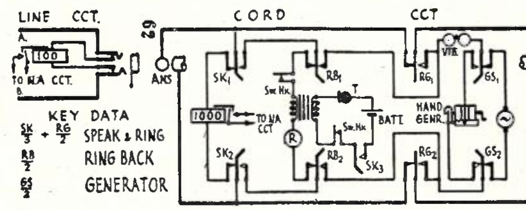
EXAMINATION No. 2363.—MECHANIC, GRADE 2—TELEPHONE INSTALLATION AND MAINTENANCE

W. C. Kemp

Q. 9.—Draw schematic diagrams of the line and cord circuits of a magneto non-multiple cord type floor pattern switchboard, and explain the operation.

A.—The circuit is shown in Fig. 1.

The calling subscriber operates the line indicator by means of a hand generator. The operator answers by plugging the answering cord into the calling subscriber's jack and enquiring the wanted number by pushing the R & S key into the speaking position. The indicator shutter is also restored. The calling cord is then plugged into the jack of the required subscriber. The called subscriber is rung by operating the R & S key into the ringing position. If power ringing is not provided, the hand generator will need to be operated.



Q. 9, Fig. 1.

The R & S key is released to normal and when the called subscriber answers the conversation can proceed. During the call, supervision ensures that it is proceeding satisfactorily. A ring-back key is provided to enable the calling subscriber to be re-called by ringing out on the answering cord as well as the calling cord. The ring-back key is operated together with the relevant speak key and both calling and called subscribers receive a ring.

The clearing indicator (1000 ohms) is shunted across the line to operate similarly to the line indicator, but it exposes the number of the cord circuit on which a call has finished when the shutter falls, due to either or both of the subscribers ringing off. As the clearing indicator is connected across the line during conversation, it has to be of high impedance to V.F. currents. To prevent overhearing there must be no magnetic leakage between indicator coils, and this is prevented by the use of iron-clad coils. On receiving the clearing signal the operator supervises and then clears the associated cord circuit.

Q. 10.—Describe fully the operation of the common battery extension switch, and by means of simple diagrams show the exchange and extension circuits for each of the key positions 1, 2, 3 and 4.

A.—Schematic diagrams are shown in Fig. 1.

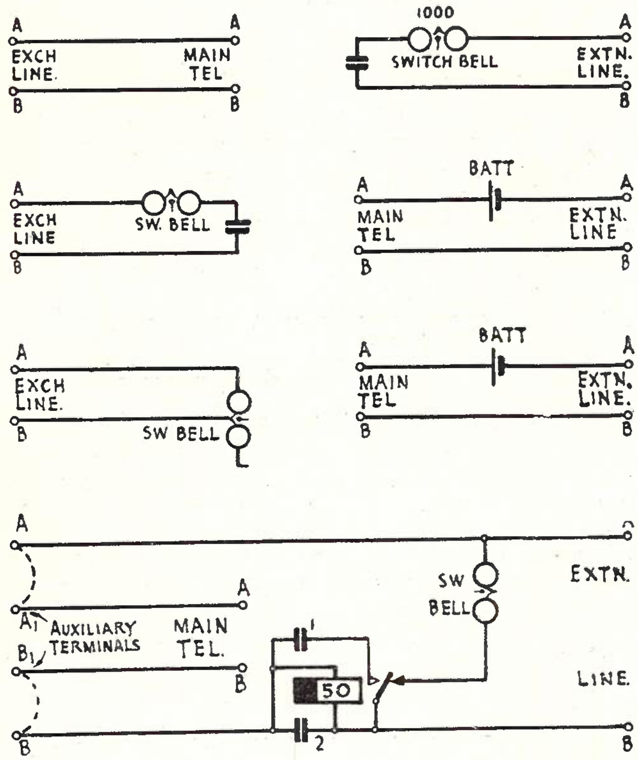
Details of the operation for the four positions of the key are:—

Position 1:—Main to exchange—Extension to switch bell to enable the extension to call the main station by hand generator.

Position 2:—Main to Extension—Exchange to switch bell to enable the exchange to call main station. Battery for transmitter current supply for "main to extension" calls is provided by dry cells. Sufficient cells must be installed to ensure a current of approximately 30 mA through the transmitters of the two telephones;

for example, on a 100 ohm loop use 6 cells; 200 ohm loop use 8 cells; 300 ohm loop use 10 cells.

Position 3:—Main to Extension—Exchange held by 500 ohm loop provided by a single coil of the switch bell. This enables an exchange call to be held whilst an enquiry is made of the extension.



Position 1, Main to Exchange.
Position 2, Main to Extension.
Position 3, Main to Extension Exchange held.
Position 4, Exchange to Extension.

Q. 10, Fig. 1.

Position 4:—Exchange to Extension—Main telephone is in parallel across the line unless the strips between A-A1 and B-B1 are cut when the secrecy feature obtains, i.e., the main telephone may not listen-in on Exchange to Extension conversations. The 50 ohm relay should operate reliably on 30 mA D.C. through the coil. This will expose an aluminium bull's-eye indicator to enable the main to supervise the call. An 11 S.W.G. copper sleeve is fitted on the core so that the relay will hold up during dialled impulses of from 8 to 12 per second with a break period of 63-70%. The changeover spring set removes the switch bell from across the line to prevent impulse distortion during dialling by the shunting effect of the 1 μF condenser and bell. It places a total of 3 μF in parallel across the 50 ohm coil to provide a V.F. shunt across it, and make the relay still slower to release during dialling. A 2 μF condenser is connected in series with the extension hand generator so that it will not loop the exchange line when the extension desires only to call the main station with the switch in position 4. A drop indicator is provided on the switch bell so that the main station may determine whether the telephone or switch bell has rung.

EXAMINATION No. 2295.—ENGINEER—TELEPHONE EQUIPMENT

J. A. Kline, B.Sc.

Question 7.—(a) The departmental standard cord type P.B.X. switchboard is fitted with "AX" relays. Explain fully the reasons for the fitting of these relays in the cord circuit. State any difficulties which are met in service with this type of P.B.X. switchboard and their effect on automatic exchange traffic.

(b) What differences exist between the supervision provided by the cord circuit of the "AX" type P.B.X. switchboard and that provided by the cord circuit of the manual switching cabinet associated with a large P.A.B.X.?

(c) Draw the cord and exchange line circuits of an "AX" type P.B.X. switchboard amended so that an extension will release the exchange line as soon as the receiver is restored to the receiver rest on completion of an outgoing call to an automatic exchange and before the P.B.X. cord circuit has been taken down.

A.—(a) Prior to the introduction of the AX relays to the cord type switchboard circuits, an exchange call extended to, but unanswered by, an extension caused the operation of the two supervisory indicators, associated with the cord circuit. With similar conditions on an extension to extension call, only the calling supervisory indicator would be displayed, whilst on a completed call of either type both supervisory indicators operate.

Thus there was no difference in the supervisory signal provided between an incoming exchange call extended to, but unanswered by, the extension, and a completed extension to extension call. The possibility existed therefore that a "waiting" exchange call might be disconnected in mistake for a completed call, and AX relays were introduced to overcome this difficulty.

Briefly, the AX relays give single supervision on an exchange to extension call unanswered by the extension, and double supervision on the completed call.

Difficulties met in service are:—

(i) The AX type P.B.X. cord circuit places the control of an extension to exchange call in the hands of the telephonist, as the hold coil associated with the cord circuit, prevents the extension from dialling via the cord circuit to an automatic exchange, and the telephonist must dial all numbers required by the extensions. The hold coil also prevents extensions from releasing the automatic exchange apparatus immediately the call is completed, and thus holding time of the switches in the automatic exchange is dependent on the telephonist removing the cord from the exchange jack.

(ii) The telephonist when dialling does not receive an indication of the progress of the call.

(iii) The Called Sub. Held Alarm at automatic exchanges is frequently operated due to the delay in clearing the cords at the switchboard on incoming exchange calls. Final selectors are thus held unnecessarily.

(iv) Cord circuits are electrically coupled at the receiver commons, when two or more "speak" keys are operated together. Thus, should a telephonist be waiting on an exchange line connection and whilst waiting to answer other calls, the first call will probably be released if to an automatic exchange, or a clearing signal may be given if connected to a manual exchange.

(b) Supervisory signals are "eyeball" indicators on AX Type P.B.X. switchboards and lamps on the manual board of P.A.B.X.'s. Supervisory relays are provided in the AX P.B.X. circuit, but not in the P.A.B.X. manual board cord circuit. The battery feed relays in the latter circuits perform the dual functions of providing transmission battery and controlling the supervisory lamps.

The calling supervisory lamp in the P.A.B.X. cord circuit glows intermittently before a called extension answers, and steadily when the extension restores the receiver. This provides a differentiation between unanswered incoming calls to extensions and completed calls to the extensions. This arrangement differs from supervisory facilities provided with the AX type P.B.X. cord circuit explained in the answer (a) above.

(c) See Figs. 1 and 3, Pages 223 and 225, Vol. 3, No. 4.

Q. 8. (a) Trace the development of metering technique in departmental practice in automatic telephony by means of suitable circuit sketches and include schematic circuits of the metering arrangements for the following cases:—

(i) Keith line switch using two coil meter and reverse battery metering;

(ii) Keith line switch with single coil meter and metering trunk relays;

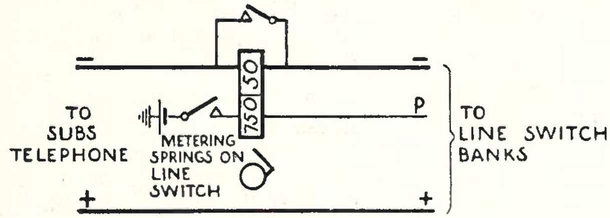
(iii) Uniselector non-homing 4 level with single coil meter. Booster battery metering;

(iv) Uniselector homing 4 level with 100A meter. Positive battery metering.

(b) Give the advantages or disadvantages of each of the above metering circuits.

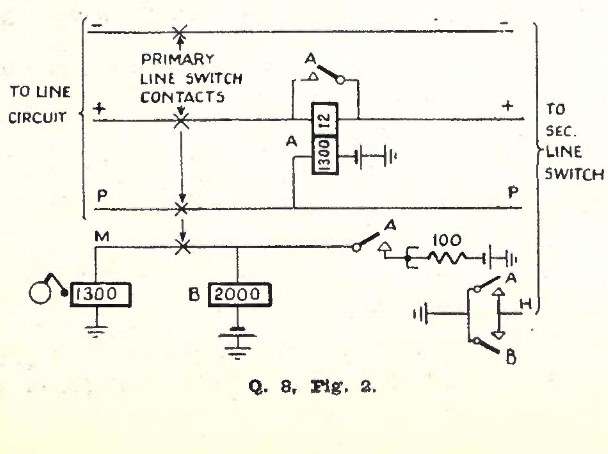
A.—(a) Figs. 1, 2, 3 and 4.

(b) (i) In the two coil meter circuit shown in Fig.



Q. 8, Fig. 1.

1, the 750 ohms winding is for polarizing purposes and the other is the line winding. When the called party answers, the battery is reversed in the line, the meter operates and retains on its polarizing winding.



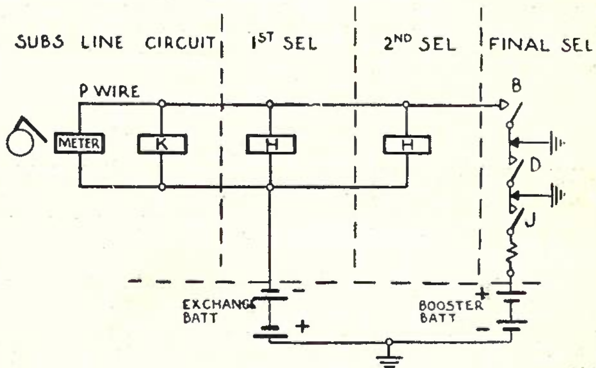
Q. 8, Fig. 2.

The disadvantages of this system are:—

(a) Difficulty of adjustment of meters owing to the variation of current through the line winding with different line conditions.

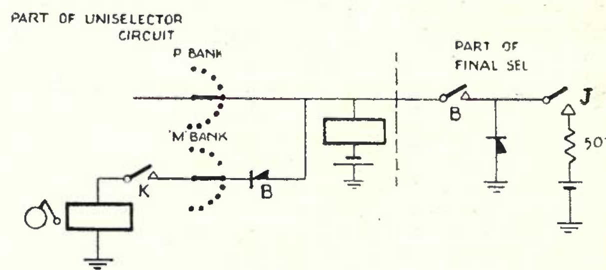
(b) An impedance is included in the line circuit during dialling, and during transmission on some types of calls where a reversal is not given.

(c) Multi metering cannot be provided.



Q. 8, Fig. 3.

(ii) In the next stage shown in Fig. 2, a polarized relay is interposed between the line circuit and the meter, which has a single winding operated in a local circuit. This suffers from the disadvantages (b) and (c) given above. The advantages of this system are that the polarized relay is easier to manufacture and adjust than the polarized meter.



Q. 8, Fig. 4.

(iii) The booster battery metering system is shown in Fig. 3. The meter is connected to the private wire and operates only when the booster battery voltage is added to the exchange battery voltage across the meter.

This scheme removes the objections of the impedance in the line applying to (i) and (ii). Since the meter remains operated during a call, however, it is not suitable for multi-metering. Another disadvantage is that should a disconnection occur in the wire between relay J contacts and the booster battery earth, then connections will be released when the called subscriber answers. This results in complaints of "called no voice" and in slack periods may prevent access to a group of subscribers until the fault is remedied. A further disadvantage is that the meter must be adjusted to a non-operate current.

(iv) Positive battery metering is shown in Fig. 4. The mounting space required for the type 100A meters used with this system is less than that required for other types. The circuit arrangements are simpler and thus maintenance is facilitated. Multi-metering can be provided as the meter does not hold in the operated position.

Q. 9.—(a) To what points would you give particular attention in the design of an economic rural automatic telephone system?

(b) Draw schematic trunking diagrams for any two of the four following types of R.A.X. equipment installed in Australia:—

(i) Siemens type R.A.X. equipment with an ultimate capacity for 200 lines to which the following lines connect:—

34 straight lines;
1 two-party line;
2 three-party lines;
2 direct trunks;
1 omnibus trunk;
1 multi-coin P.T.

(ii) S.T.C. type R.A.X. equipment with an ultimate capacity for 50 lines to which the following lines connect:—

18 straight lines;
2 P.B.X. lines on 1 P.B.X.;
5 direct trunks;
1 omnibus trunk;
1 multi-coin P.T.

(iii) B.G.E. type R.A.X. equipment with an ultimate capacity for 200 lines to which the following lines connect:—

34 straight lines;
1 two-party line;
2 direct trunks;
2 omnibus trunks;
1 multi-coin P.T.

(iv) A.T.M. Coy's. type R.A.X. equipment with an ultimate capacity for 200 lines to which the following lines connect:—

126 straight lines;
1 three-party line;
6 direct trunks;
1 omnibus trunk;
1 multi-coin P.T.;
1 test or control line.

A.—(a) (1) An exchange unit should be capable of working as a single exchange or as part of a network of R.A.X.'s.

(2) It should be possible to provide an exchange economically for groups ranging from 10 to 200 subscribers.

(3) It must be capable of giving service to:—

(a) Exclusive lines.
(b) Party lines.
(c) Single wire lines.
(d) P.T.'s with multi-coin attachment for trunk services.
(e) Both way trunks to parent exchange.
(f) Multi-office trunk lines.

(4) The equipment should be reliable and capable of working for long periods without attention. Important common apparatus such as ringing and tone equipment should be in duplicate with automatic changeover in the event of a fault.

(5) Provision should be made so that if a fault occurs on a line, and common apparatus seized, for the line to be automatically disconnected to free the exchange apparatus and the line held out of service and busy until the fault clears.

(6) It is essential that battery consumption for the operation of the equipment should be low.

(7) It must be possible to charge the batteries from:—

(a) Local power;
(b) The parent exchange over our junction lines;
(c) A local primary generating set.

(8) There should be automatic control of:—

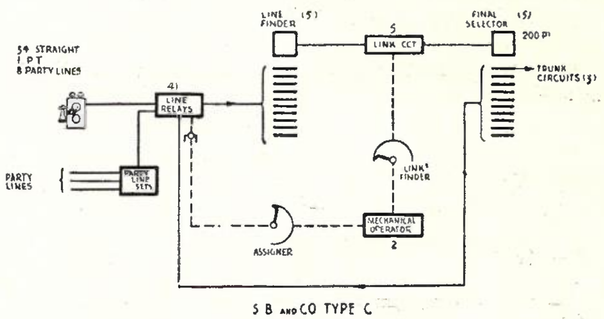
(a) Charging of the batteries as required;
(b) Charging rate;
(c) Changeover of the batteries, where duplicate batteries are provided.

(9) Faults occurring on the equipment or power plant must operate an alarm at the parent exchange, where either the type of fault or the urgency with which it must be cleared should be indicated.

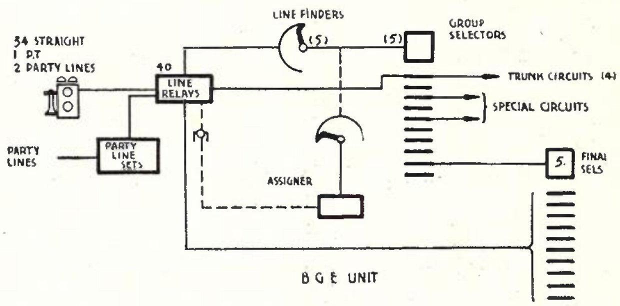
(10) It should be possible to test lines connected to an R.A.X. from the parent exchange.

(11) The equipment should be made up in a self-contained unit, enclosed in a dust-proof and fool-proof cabinet, and need a minimum of installation work. It should be possible to read the meters without opening the cabinet. The units should be capable of extension to a maximum of 200 lines. Each unit should be extensible to its full capacity by adding jacked in relay sets and switches.

(b)



Q. 9, Fig. 1.



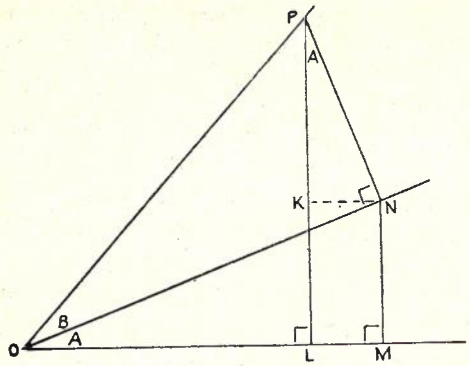
Q. 9, Fig. 2.

EXAMINATION NO. 2377.—ENGINEER—NATURAL SCIENCE

E. H. Palfreyman, B.Sc., B.E.

Q. 1.—Find the expansion of Tan (A + B) by a geometrical construction.

A.—With the construction of Fig. 1 in which (A + B) is less than 90° for convenience—



Q. 1, Fig. 1.

$$\text{Tan } (A + B) = LP/OL = \frac{LK + KP}{OM - LM}$$
$$= \frac{MN + KP}{OM - KN}$$
$$= \frac{MN/OM + KP/OM}{OM/OM - KN/OM}$$
$$= \frac{MN/OM + KP/OM}{1 - \frac{KN}{KP} \cdot \frac{KP}{OM}}$$
$$= \frac{\tan A + \tan B}{1 - \tan A . \tan B}$$

Since triangles NOM and NPK are similar
giving $NM/OM = NK/PK = \tan A$
and $PN/ON = KP/OM = \tan B$

Q. 2.—(a) Differentiate the following functions of "x":—

$$x(1 - x)^2, \frac{1 + x^2}{1 - x^2}$$

(b) Write down the indefinite integrals of the following functions of "x":—

$$x^n, e^{kx}, \sin x.$$

A.—(a)

$$\frac{d}{dx} x(1 - x)^2 = \frac{d}{dx} (x - 2x^2 + x^3)$$
$$= 1 - 4x + 3x^2$$
$$= (1 - x)(1 - 3x)$$
$$\frac{d}{dx} \left(\frac{1 + x^2}{1 - x^2}\right) = \frac{(1 - x^2)(2x) - (1 + x^2)(-2x)}{(1 - x^2)^2}$$
$$= \frac{4x}{(1 - x^2)^2}$$

(b)

$$\int x^n \, dx = \frac{x^{n+1}}{n + 1} + C \quad \text{when } (n \neq -1)$$
$$\text{or} \quad = \log_e x + C \quad \text{when } (n = -1)$$
$$\int e^{kx} \, dx = \frac{1}{k} e^{kx} + C$$
$$\int \sin x \, dx = -\cos x + C.$$

Q. 3.—(a) Express $\overline{a + jb}$ and $\overline{c + jd}$ in polar form and prove that their quotient $= \frac{A}{B} e^{j(\theta_1 - \theta_2)}$. De Moivre's theorem may be assumed.

(b) Evaluate the quotient of the two vectors, $640\angle 60^\circ$ and $80\angle 30^\circ$, and express it in the form $\overline{c + jd}$.

A.—(a)

$$\text{Let } a = A \cos \theta_1 \text{ and } b = A \sin \theta_1$$
$$\text{then } a + jb = A \cos \theta_1 + jA \sin \theta_1$$
$$= A(\cos \theta_1 + j \sin \theta_1)$$
$$= A\, e^{j\theta_1} = A\angle\theta_1$$
$$\text{where } A = \sqrt{a^2 + b^2} \text{ and } \tan \theta_1 = b/a$$
$$\text{Similarly } c + jd = B\, e^{j\theta_2} = B\angle\theta_2$$
$$\text{where } B = \sqrt{c^2 + d^2} \text{ and } \tan \theta_2 = d/c$$
$$\text{thus } \frac{a + jb}{c + jd} = \frac{A\, e^{j\theta_1}}{B\, e^{j\theta_2}} = \frac{A}{B} e^{j(\theta_1 - \theta_2)}$$

(b)

$$640\angle 60^\circ \div 80\angle 30^\circ = \frac{640}{80} \angle 60^\circ - 30^\circ$$
$$= 8\angle 30^\circ$$
$$= 8 \cos 30^\circ + j\, 8 \sin 30^\circ$$
$$= 8 \times 0.866 + j\, 8 \times 0.500$$
$$= 6.93 + j\, 4.00 \text{ approx.}$$

Q. 4.—A telephone relay has a resistance of 1,000 ohms, an inductance of 25 henries, and its operating current is 10 milliamperes. Calculate the time required for the current to reach its operating value when a potential of 50 volts D.C. is applied to the relay.

$\log_e 1.25 = 0.2231$.

A.—With the usual notation

$$I = \frac{E}{R} (1 - e^{-Rt/L})$$
$$\text{Hence } t = \frac{-L}{R} \log_e\left(1 - \frac{R}{E} I\right)$$
$$= (-25/1000) \log_e \left(1 - \frac{1000}{50} \cdot \frac{10}{1000}\right)$$
$$= (-25/1000) \log_e 0.8$$
$$= (+25/1000) \log_e 1.25$$
$$= (25/1000) \times 0.2231$$
$$= 5.58 \text{ milli-secs.}$$

Q. 5.—The armature of a 4-pole D.C. generator is required to develop 256 volts when revolving at a speed of 600 r.p.m. Neglecting leakage, calculate the magnetic flux per pole if the armature is lap-wound and has 128 slots with 4 conductors per slot.

A.—For a D.C. generator (or motor) the e.m.f. in volts is given by

$$E = C\, \theta\, s \frac{P}{p} 10^{-8}$$

where C = total no. of conductors $= 4 \times 128$
θ = magnetic flux/pole (maxwells)
s = speed (revs./sec.) $= 600/60$
P = no. of poles $= 4$
p = no. of parallel paths $= 4$

Since for a lap-wound armature
$p = P$

Hence in this case

$$256 = (128 \times 4) \times \theta \times (600/60) \times (4/4) \times 10^{-8}$$
$$\text{giving } \theta = (256 \times 10^8)/(512 \times 10)$$
$$= 5 \times 10^6 \text{ maxwells.}$$

(Continued from Cover ii.)

The use of 6-volt tungsten filament lamps known as metal filament lamps is being extended considerably. The current consumption of this lamp at standard voltage is rated at 0.040 amps., whereas the 6-volt carbon lamp is rated at 0.19 amps. When use is made of the 6-volt tungsten lamp care must be exercised to ensure that the current passing through the lamp does not exceed the specified maximum, which is 0.045 amps. To limit this current factor on a 50-volt system, a 1000 ohm resistance is wired in series with the lamp and varied accordingly if the potential is decreased.

It is essential that negative battery should be applied through the resistance and not direct to the lamp because of the possibility of earthing one side of the lamp when being placed in the lamp socket, thereby allowing the full battery potential to be applied directly across the lamp. Special care should be exercised at all times to ensure that the wiring is so arranged to meet this condition.

Six-volt tungsten filament lamps manufactured in United Kingdom are supplied having the end of the lamp coloured grey and the voltage (6 volts) clearly indicated on the contact terminals. Recent purchases of 6-volt lamps from U.S.A. are slightly different in construction to those purchased in U.K., and the marking 6C appearing on the base of the American lamp indicates 6-volt tungsten having current consumption of 0.040 amps. H.C.

AUTOMATIC EXCHANGE TEST DESK—HOWLER CIRCUIT

When a subscriber leaves a handset off the rest, the line is looped and extended to a first selector which is held until the handset is replaced. Apart from the subscriber's number testing engaged to callers, it is undesirable to hold first selectors with artificial traffic. When this condition is detected, it is necessary to call the attention of the subscriber but this cannot be done by ringing, in that the bell of the telephone is shunted by the transmitter and will not respond to ringing current. Therefore, a tone in the voice frequency range is applied to the line in order to reproduce a noise or howl in the telephone receiver and so attract the subscriber's attention. If such a tone is applied directly at full volume, a person listening on the line may experience a severe acoustic shock. To provide a safeguard, arrangements are made to apply the tone in gradually increasing volume by means of an automatically controlled shunt across the howler output connections.

The circuit is shown in Fig. 1. When key 20 is operated, relay B operates if the test circuit is connected to a looped line. B1 completes a circuit for relay A from ground via the home contact of uniselector bank 2. B2 prepares a circuit for relay M whilst B3 completes the howler lamp circuit. Relay A operates and locks to A3 whilst A1 and 2 connect the tone relay H to line. A4 connects battery to relay M which operates and at M1 provides ground for the uniselector stepping relays N & P whilst M2 completes the "howler" tone relay H circuit. This relay self interrupts to generate the tone. Relays N and P interact to operate the uniselector DM and step the switch. On the home position of the uniselector, there is a short circuit across the output of H via uniselector bank 1; but with the stepping of the switch, resistance is gradually inserted and the tone which is applied to the line at a low level at first, gradually increases in intensity until maximum volume is reached after about 12 seconds. On reaching the 24th bank contact, the uniselector stepping ceases in that relay N is short-circuited by the ground from the uniselector No. 2 wiper. The tone is maintained on the line until the handset is restored, then relay B, A and M release in that order. The uniselector steps to the home position from ground on M1. If whilst the howler is in use on one desk and it is also applied from another desk, the operation of relay B in the second desk, applies ground to relay M in the common equipment, M releases and the uniselector homes from ground at M1. On reaching the home contacts, both A relays operate from ground through uniselector bank 2 and the operating conditions as described earlier, are re-established, tone being applied gradually to both lines.—K.S.

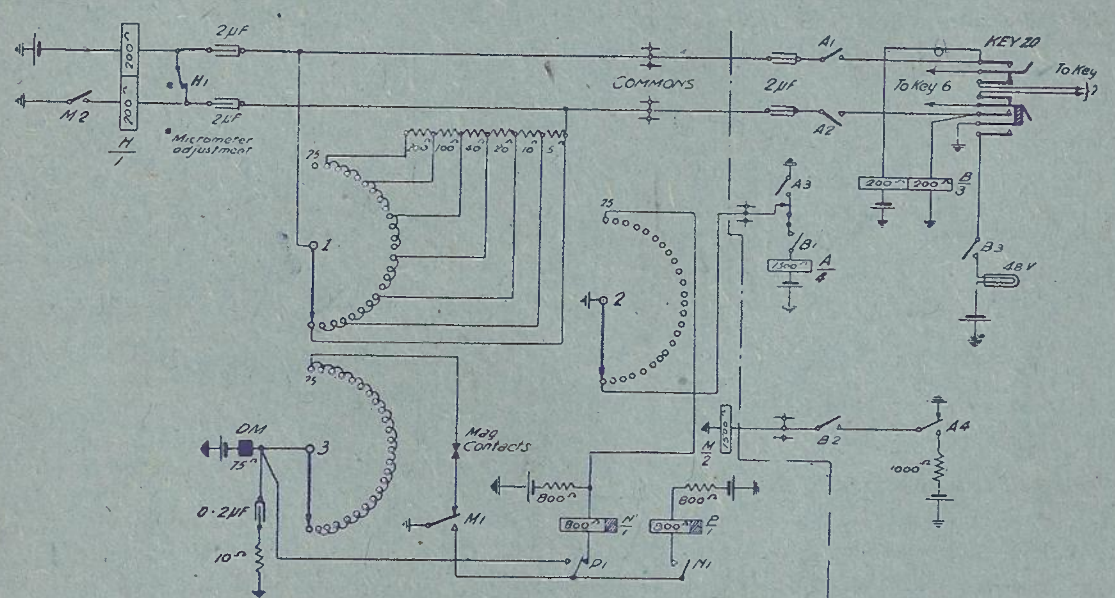


Fig. 1.—Howler circuit.

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