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CONTENTS

THE POSTAL ELECTRICAL SOCIETY OF VICTORIA

EXAMINATION NO. 2377.—ENGINEER—LINE CONSTRUCTION

J. R. Newland

Q. 1.—(a) Describe the methods you would adopt to ascertain the sag in copper wire erected on a trunk route, and how you would know the sag is correct. Describe briefly the principles on which each method depends.

(b) Describe the tests you would make and the methods you would adopt to ascertain whether the following materials comply with the Department's standards:—

(i) Samples of insulators for use on trunk and telegraph circuits.

(ii) A coil of 200 lb. mile H.D. copper wire.

(iii) A coil of 220 yards outside distributing twin wire.

(iv) A drum of 220 yards 800 prs. 10 lb. conductor P.I.L.C. star quad local cable.

A.—(a) There are two methods in general use of measuring sags in aerial wires. The first is the direct measurement of the sag by sighting, and the second, which is less accurate, but serves as a check on the first or to equalise other wires when one wire in the span on the same crossarm has been adjusted, is the direct measurement of tension by the "beat" method.

The direct measurement of sag may be taken by sighting from a sag gauge to the lowest point of the wire in the span and aligning to a similar sag gauge placed at the adjacent pole. These gauges consist of a vertical scale graduated in inches and so arranged that zero may be set at the wire level after adjusting the position of a clip constructed so as to fit over the crossarm. On this vertical scale is a sighting board which may be moved in a vertical plane, normal to the wires and clamped in any desired position.

If the wire under test is situated at the extremity of the crossarm, it may be necessary, in order to indicate the wire at mid-span, for a stick to be held lightly against the wire at that point. Otherwise, by offsetting the sag gauges to a position near the pole at one end of the span and at the end of the crossarm at the other end and sighting obliquely across the wire, greater accuracy may be obtained.

The actual measurement is taken by adjusting each board so that when they are at equal levels the wire at the point of maximum sag is aligned. The second or "beat" method consists of causing the wire to oscillate at one pole by striking the wire a short distance from the insulator and measuring the time taken for the wave so caused to travel to the next pole and return twenty times. It is desirable for the purpose of check to obtain two readings in this way.

The principles on which the first method depends assume that the curve taken by the wire is a parabola which is reasonably accurate for average spans. The relationship between the tension and the sag of wire is—

$$S = Wl^2/8d \quad \ldots\ldots \quad (1)$$

where S = tension in lbs. of wire at the given temperature.

W = weight in lbs. of one foot of wire.

l = length of span in feet.

d = sag of wire in feet at the given temperature.

The second method is derived direct from the expression governing the natural period of vibrations in a stretched string, the relation being—

$$S = Wl^2/8t^2 \quad \ldots\ldots \quad (2)$$

where t = the time of one complete oscillation.

From equations (1) and (2)—$d = t^2$ .... (3)

Therefore, the sag is directly proportional to the square of the time of oscillation.

For greater accuracy it is usual to measure the time taken for 20 oscillations, and even for this number the order of accuracy is approximately ½" variation in sag per ½ second variation in time for the twenty vibrations. The tension S is predetermined as being the minimum required to ensure against contacts between wires, having in mind the expansion and contraction due to temperature variations, wire separation, span length, and velocity of prevailing winds.

(b) (i) The tests applied to trunk porcelain insulators are as follow:—

Appearance: The porcelain should be non-porous and free from cracks, blow holes, etc. They should be glazed all over with the exception of the screw thread and ivory white in colour.

Thread Test: The specified thread gauge is screwed into the insulator to the full extent possible by hand. The insulator should then fit without play or rocking, the skirt should be located within the limits marked on the collar of the gauge.

Insulation Resistance: The insulators are inverted in a tray of water and immersed to within ½" of the end of the skirt and filled inside the skirt to the same level. After soaking for at least 12 hours the resistance between the water in the tank and that inside the skirt is measured with a direct current e.m.f. of between 250 and 500 volts and should read at least 100,000 megohms.

Load Test: The insulator is mounted on a suitable spindle held in a tensile testing machine and a load applied to a wire looped around the wire groove of the insulator transverse to the axis of the spindle. The insulator should withstand, without cracking or failure, a load of 1,500 lb.

Porosity Test: Freshly broken pieces of the insulator after immersion in an 0.5% alcoholic solution of fuchsin die at a pressure of 2,000 lb. per square inch at normal temperatures for at least 24 hours should not show signs of impregnation when broken further.

Autoclave Test: The insulators must not show any signs of cracking, crazing or loss of insulation resistance after heating in an autoclave in steam atmosphere of 150 lb. per square inch for two hours.

(ii) Hard drawn copper wire 200 lb. per mile should withstand the following tests:—

The wire should be in one continuous length, free from welds or joints and coiled compactly so that the "eye" of the coil is at least 19", but not more than 20" in diameter. The weight of the coil should be between 75 and 140 lbs. The wire should be circular in cross-section, of diameter between .1108 and .1130", pliable, free from scale, inequalities or splits.

Lapping Tests: The wire should bear without breaking, being closely lapped six times around wire of its own diameter, uncoiled and again similarly lapped in the same direction.

Twisting Test: The sample of the wire is marked by means of ink with a straight line parallel to the axis, then held in a vice at each end, one of which is made to revolve at a speed not exceeding one revolution per second. The line then assumes the form of an helix. The wire should withstand without failure an amount of twisting not less than 20 revolutions for each 3" in length.

Tensile Test: When tested in a horizontal tensile testing machine, the wire should withstand a load of 640 lb. before breaking. As near as possible $^9/_{10}$ths of

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AUGMENTING THE TELECOMMUNICATION FACILITIES OVER THE TRANSCONTINENTAL ROUTE BETWEEN ADELAIDE AND PERTH

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Introduction.—For many years past, the landline communication facilities available between Western Australia and the Eastern States has been limited in number because of the comparatively few physical lines existing over the long section of line between Port Augusta and Kalgoorlie. In recent years, it had been planned to increase both the telegraph and telephone facilities by the erection of an additional copper wire to provide two through physical pairs and install two 3-channel carrier telephone systems, catering for through telegraph facilities by a multi-channel voice frequency telegraph system superimposed over one of the telephone carrier channels. Both line and equipment work involved a project of some magnitude and heavy pressure of work for the Defence services in other States prevented a commencement being made with the erection of the additional wire required until well into 1942.

During 1942 it became necessary to provide some additional telephone and telegraph facilities in advance of the completion of the line work. The only "through" copper metallic pair was at that time carrying the physical telephone channel between Adelaide and Perth and two composite telegraph channels, while the "carrier line" was occupied by a "B" type telegraph system of 6 channels with a carrier broadcast programme channel superimposed upon it, thus using the whole of the frequency spectrum up to 15 K.c.'s, so that a change-over to a multichannel carrier telephone system on the same pair of wires, involving alterations at the terminals and at seven intermediate repeater stations of the physical, carrier and programme circuits, while maintaining service in the meantime on the all-important interstate telegraph channels, presented a unique problem.

The manner in which this problem was solved and the extra facilities set up and finally brought into service without appreciable disturbance to the working circuits, together with a general description of the facilities, both before and after the change-over, is described in the following article:—

Facilities Prior to the Additions. — Prior to 1942 the facilities available between Perth and Adelaide were restricted by those which could be provided over the lengthy transcontinental section between Port Augusta and Kalgoorlie, where the only departmental wires available were three 300 lb. per mile copper wires. One wire, known as line No. 747, was operated as a high-speed duplex telegraph circuit between Adelaide and Perth with repeaters at Port Augusta, Cook and Kalgoorlie. The other two wires formed a telephone pair, known as line No. 800, and this pair accommodated a two-wire repeatered telephone circuit, two composite telegraph legs, a B type telegraph carrier system equipped for 6 duplex channels, and a non-reversible carrier programme channel transmitting in the Adelaide to Perth direction. The single Adelaide-Perth trunk line was actually made up of the two-wire physical circuit between Port Augusta and Kalgoorlie with intermediate repeaters at Tarcoola, Cook and Rawlinna, and linked by four-wire connections at Port Augusta to a Port Augusta-Adelaide carrier channel, and at Kalgoorlie, to a Perth-Kalgoorlie carrier channel. The composite legs were repeatered at each station by a composite duplex repeater. One of these composite legs carried inter-office telegraph traffic and the other was modified so that a selective call-in system could be operated over it for establishing communication with the repeater stations.

Between Adelaide and Port Augusta, and similarly between Perth and Kalgoorlie, there are other telegraph and telephone channels in addition to the inter-capital circuits mentioned above. Due to the lack of facilities on the Port Augusta-Kalgoorlie section, telephone communication between repeater stations could not be quickly established by ordinary means. The call-in system overcame this difficulty as, by means of this device, any station, by dialling two appropriate digits over the circuit, could operate a bell at any other station predetermined by the digits dialled. At the repeater stations, the call-in circuit could be switched over to operate a bell in the Repeater Attendant's home nearby, so that when he was off duty he could be called in an emergency. The Repeater Attendant, on being called to the station in this way, would monitor and speak on the physical telephone circuit.

Fig. 1 shows the disposition of the repeater stations on the Adelaide-Perth route and the distances separating them. Fig. 2 is a block schematic diagram showing the connections of the circuits which previously existed.

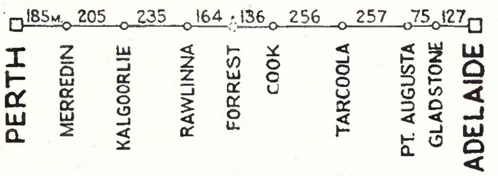


Fig. 1.—Adelaide-Perth Route Disposition of Repeater Stations.

The approximate frequency allocations for the various equipments in use were:—

(a) 0-200 c.p.s. composite telegraph channels.

(b) 200-3,000 c.p.s. voice frequency telephone circuit.

(c) 3 to 6 K.c. p.s. carrier telegraph in the Perth to Adelaide direction.

(d) 6 to 10 K.c. p.s. carrier telegraph in the Adelaide to Perth direction.

(e) 10 K.c. to 15 K.c. programme carrier system in the Adelaide to Perth direction.

Within the band width indicated for the telegraph carrier system, it is practicable to operate up to 10 telegraph channels. However, equipment for six telegraph channels only was available and the lowest frequency used for this purpose in the direction Adelaide to Perth was 6,000 cycles per sec. The programme carrier system used the lower side band of a 15 K.c. carrier and extended down to approximately 10 K.c.'s; the directional filters of the telegraph carrier repeaters "crossed over" at about 6 K.c., having no upper cut-off in the high frequency direction. The telegraph system operated in the reverse direction to the usual frequency poling arrangements, the high frequencies being transmitted from Adelaide to Perth instead of in the usual West to East direction. This arrangement was adopted with intention some years ago, to enable the programme carrier channel to operate through the amplifiers of the existing carrier telegraph repeaters in the Adelaide to Perth direction, so that these amplifiers handled a complex wave made up of the telegraph carrier frequencies East to West and the transmitted frequencies of the programme circuit. Due to this arrangement the programme channel was necessarily always set up in the direction Adelaide to Perth and was thus non-reversible. However, this arrangement of common amplifiers and direction of operation proved very convenient in connection with the cut-over of the new equipment, as will be explained later.

Additional and Re-arranged Facilities. — The complete programme of additions to the interstate channels contemplated the following:—

(a) The erection of one 300 lb. per mile copper wire to pair with Line No. 747 to provide a physical telephone line and a carrier line for a 3-channel telephone carrier system.

(b) The installation of two 3-channel carrier telephone systems.

(c) The replacement of the B type telegraph system by a V.F. telegraph system superimposed on one of the carrier telephone channels.

(d) The re-arrangement of the existing and new telephone channels to provide—

3 through speech channels.

1 carrier channel for V.F. telegraph purposes.

1 carrier (two way) broadcast programme channel.

1 physical (reversible) broadcast programme channel.

1 physical omnibus telephone channel.

The realisation of this full programme required the completion of the 2 physical pairs and, although authority to undertake the full programme had been given in 1941, for various reasons, more particularly the very heavy demands on available materials and labour for important Defence projects, it had not been possible to make any appreciable progress with the erection of the new wire until well into 1942. In the meantime the need to provide some, at least, of the additional facilities had become more urgent and as delivery of a carrier system having the required number of intermediate repeaters had been made, an investigation was undertaken to determine whether some of the additional facilities could be placed in service ahead of the linework.

As a result, it was decided to undertake the installation of the first of the 3-channel systems on the existing physical line and re-arrange the other facilities. Since the carrier system required for its operation, the frequency spectrum between 5,000 and 30,000 cycles, this necessitated the displacement of both the programme channel and the "B" telegraph system.

Once the physical line could be freed, the programme channel could be provided thereon, subject to the provision of intermediate amplifiers at each repeater station. Furthermore, such a programme line could be reversible. With respect to the telegraph system, trials previously undertaken between Melbourne and Adelaide and between Sydney and Brisbane with "B" type telegraph carrier channels had indicated that, with suitable modifications, it would be practicable to superimpose "B" type telegraph channels over a telephone carrier channel. Subsequent to these trials a system of 4 telegraph channels had been placed into operation in this manner between Adelaide and Port Augusta.

Since no V.F. telegraph system was yet available to replace the type "B" system, it was decided to adopt the existing "B" type system for operation in this way over one channel of the new 3-channel system, and at the same time to extend the existing system by two additional channels.

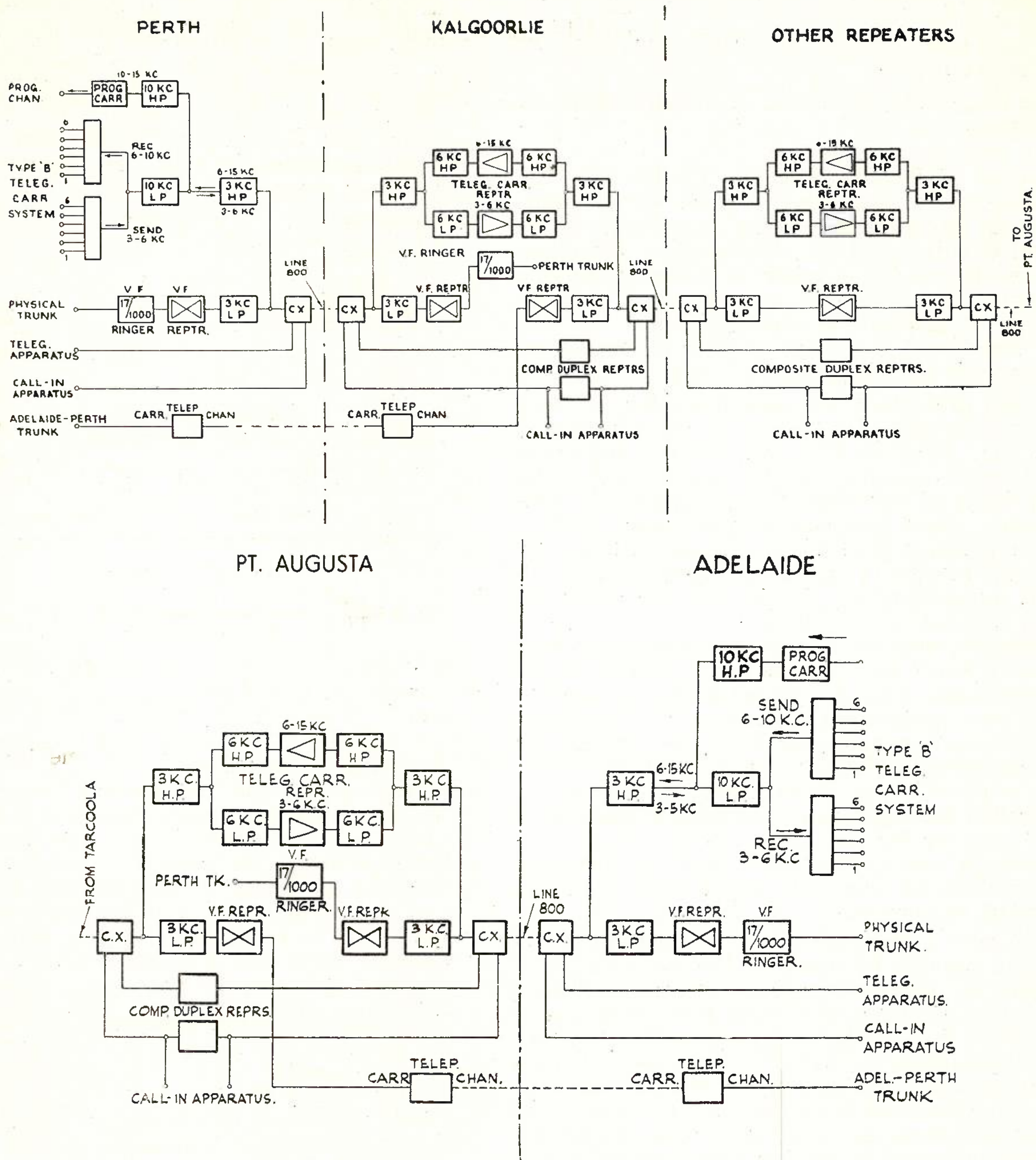


Fig. 2.—Connections Before Re-arrangements.

The re-arrangement decided upon thus aimed at the provision of the following "through" services:—

2 "through" carrier telephone channels Ade-

laide to Perth (in lieu of 1 part carrier, part physical channel).

1 physical reversible programme channel (in lieu of 1 non-reversible carrier programme channel).

8 "through" carrier telegraph channels (in lieu of 6).

The frequency allocations of the equipment as it existed, and of the new equipment as proposed, are shown in Fig. 3.

Method of Re-arranging the Facilities. — The problem was to perform the work with a minimum of interruption to the important inter-capital circuits existing. There were difficulties in this, due to the number of repeater stations concerned, the distances between them and the scarcity of alternative communications. A plan was worked out to do the cut-over by a step-by-step process occupying several days.

In the first place, the equipment for the new carrier telegraph channels, that is, two-channel ends for Adelaide and two-channel ends for Perth, were manufactured in Adelaide under the supervision of the Supervising Engineer, Transmission. These telegraph channels were replicas of the existing type "B" channels, and, as the type "B" system is capable of being extended to a full complement of 10 channels, the two additional channels were well within the capacity of the system, and no special maintenance or line-up tests would be involved by the addition. It is of interest that Australian-made components were used practically throughout. Previously the inductances and coupling transformers for the oscillators and filter circuits of this system were procurable only from overseas sources. An Australian firm produced the special inductance coils required for the tuned circuits to the Department's specification and the performance finally obtained was fully equal to that of the imported equipment.

Although a complete type "B" telegraph system can provide 10 channels, the Adelaide-Perth system as operated prior to these alterations could not accommodate more than 6 or, at a maximum, 7 channels. This was due to the fact that the portion of the frequency spectrum normally available for the upper end of the type "B" allocation was taken up by the "cross-over" of the frequency attenuation curves of the programme channel separating filters which segregated the telegraph carrier frequencies from the programme carrier frequencies. Furthermore, the telegraph system amplifiers, as has been explained, carried both telegraph and programme channels and the addition of further channels under these conditions of operation would have required a reduction of transmission levels to avoid the possibility of overloading of amplifiers and consequent inter-channel modulation. This would not have been practicable without some deterioration in signal to noise ratio. On such a long circuit, where noise conditions were already critical, this would have resulted in degraded transmission. The new method proposed for operating the telegraph system offered, as will be explained later, the distinct advantage of being able to increase the channels in the telegraph system, if required, to the full complement of 10 channels. The two new telegraph channel ends to be added were, therefore, placed in position and tested out locally, but in order to fit in with the cut-over arrangements they were not connected in with the other channels until a later stage.

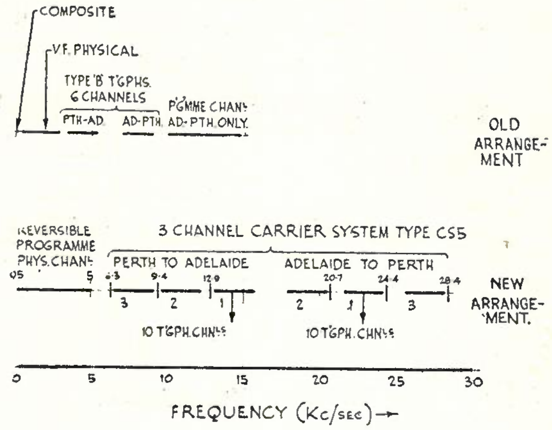


Fig. 3.—Frequency Allocations Before and After the Re-arrangements.

The 3-channel carrier telephone system selected for use on this work was a W.E. type C.S.5 system. A system of this type with the required number of repeaters had been delivered to Australia about May, 1942. The frequency allocations of the channels coincided with those of "S" type systems already in use in Australia, but this American-made system incorporated a feature making it particularly suited for a long circuit such as between Adelaide and Perth, in that it was equipped with an automatically controlled pilot to hold the sectional and overall attenuation practically constant with all changes of weather and temperature.

The 3-channel carrier equipment was installed at the terminal and repeater stations and all the local tests possible were completed at each station. By taking the line for brief intervals in the early mornings, the repeater sections were gradually checked for equaliser and pilot adjustment and, later, a preliminary overall line-up was made by temporarily interrupting all services at a suitable time and setting up the complete 3-channel system and testing each of the three channels in both directions. The overall equivalent was fixed and quality tests made. The original conditions were then restored.

It will be seen by reference to Fig. 3 that the frequencies of the Adelaide to Perth direction of the 3-channel system, being above 15,000 cycles, fell above and clear of the frequencies of any of the existing equipment and, further, this block of frequencies lay adjacent to the Adelaide to Perth direction of the common circuit comprising the telegraph carriers and the programme channel. This indicated that it was possible to pass the whole of the existing and the proposed Adelaide to Perth carrier frequencies through the directional filters of the existing carrier telegraph repeaters. This circumstance permitted the important facility of setting up and cutting in the Adelaide to Perth direction of the new 3-channel system without interfering with any of the existing services. It was also of further advantage in that it permitted the telegraph channels to be re-arranged and increased without interruption.

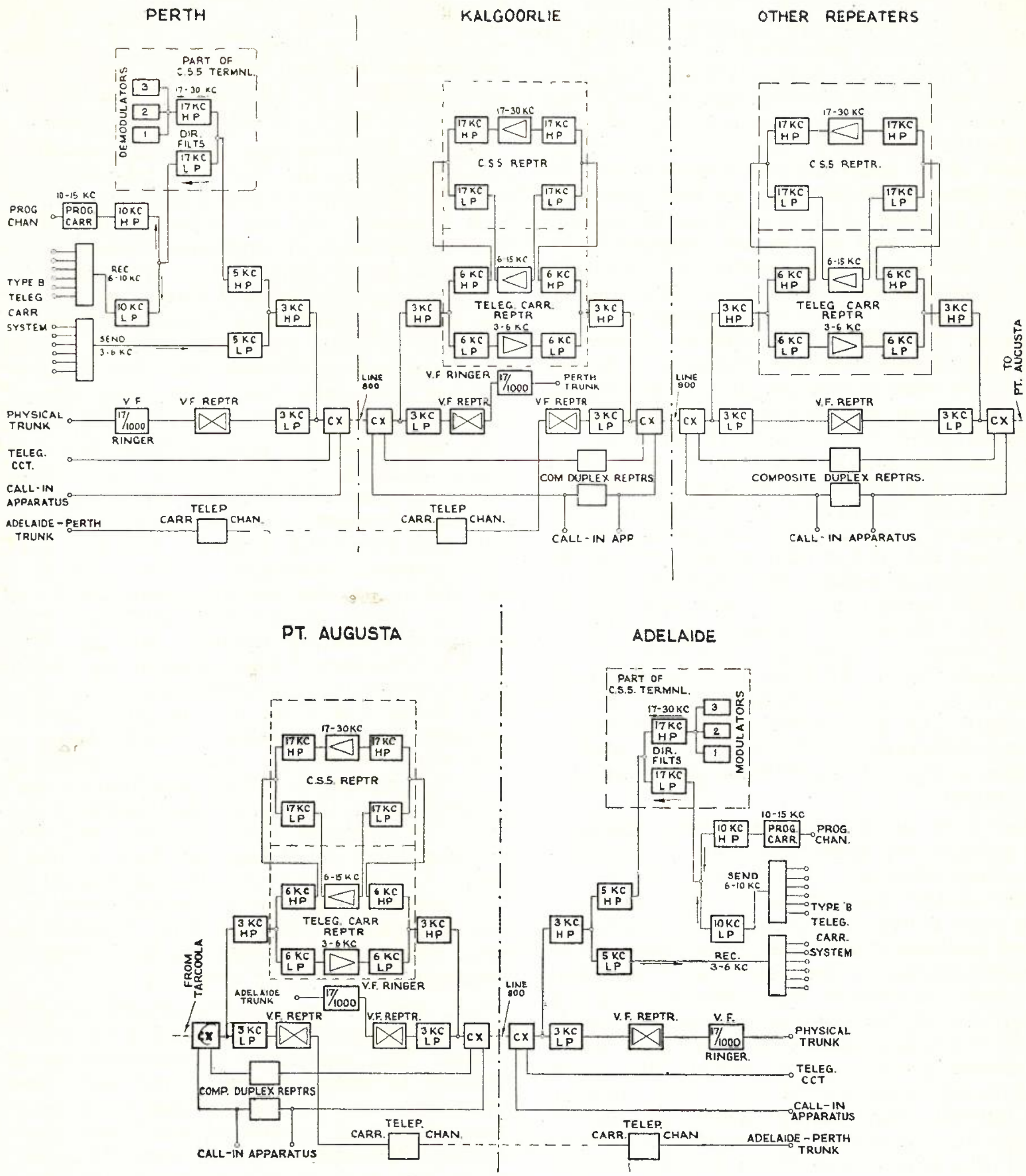


Fig. 4.—Temporary Connections to Place Into Operation the Adelaide to Perth Direction of the C.S.5 System.

Arrangements were made as a first step, by temporary connections at each repeater and terminal station, to superimpose the Adelaide to Perth direction of the 3-channel system above the existing telegraph and programme channels. The connections to the various directional filters were made at each station by patching-cords in order to permit rapid alteration to the connections at a later stage. Fig. 4 shows the connections at the repeaters and terminals at this stage of the cut-over.

In operating the Adelaide-Perth direction of the C.S.5 system over the existing equipment, the C.S.5 system was connected so that the telegraph and programme channel frequencies were together isolated by the directional filters of the C.S.5 system, but amplified by the original telegraph repeater amplifiers, while the C.S.5 carrier frequencies were amplified by the new carrier telephone repeater amplifiers. At first glance it may appear to have been superfluous to amplify separately these two groups of frequencies in the one direction as the deletion of the type C.S.5 directional filters would have permitted all of the Adelaide to Perth frequencies to have been passed through one amplifier. However, very careful attention to the question of transmission levels was necessary, and if a common amplifier had been used a special adjustment of levels would have been necessary in order to avoid overloading, and it was more convenient to leave the existing adjustments intact, especially as this was only an interim arrangement. This patching was left up continuously and it enabled a lengthy test out of the pilot adjustments to be made in the one direction, and experience to be gained in the operation of the new system. It also permitted telephone messages to be transmitted to Perth by speaking over one of the new channels from Adelaide, although Perth could not reply except by indirect means. This proved useful, as throughout this period telephone and telegraph traffic was heavy and it was otherwise exceedingly difficult to contact the Perth terminal.

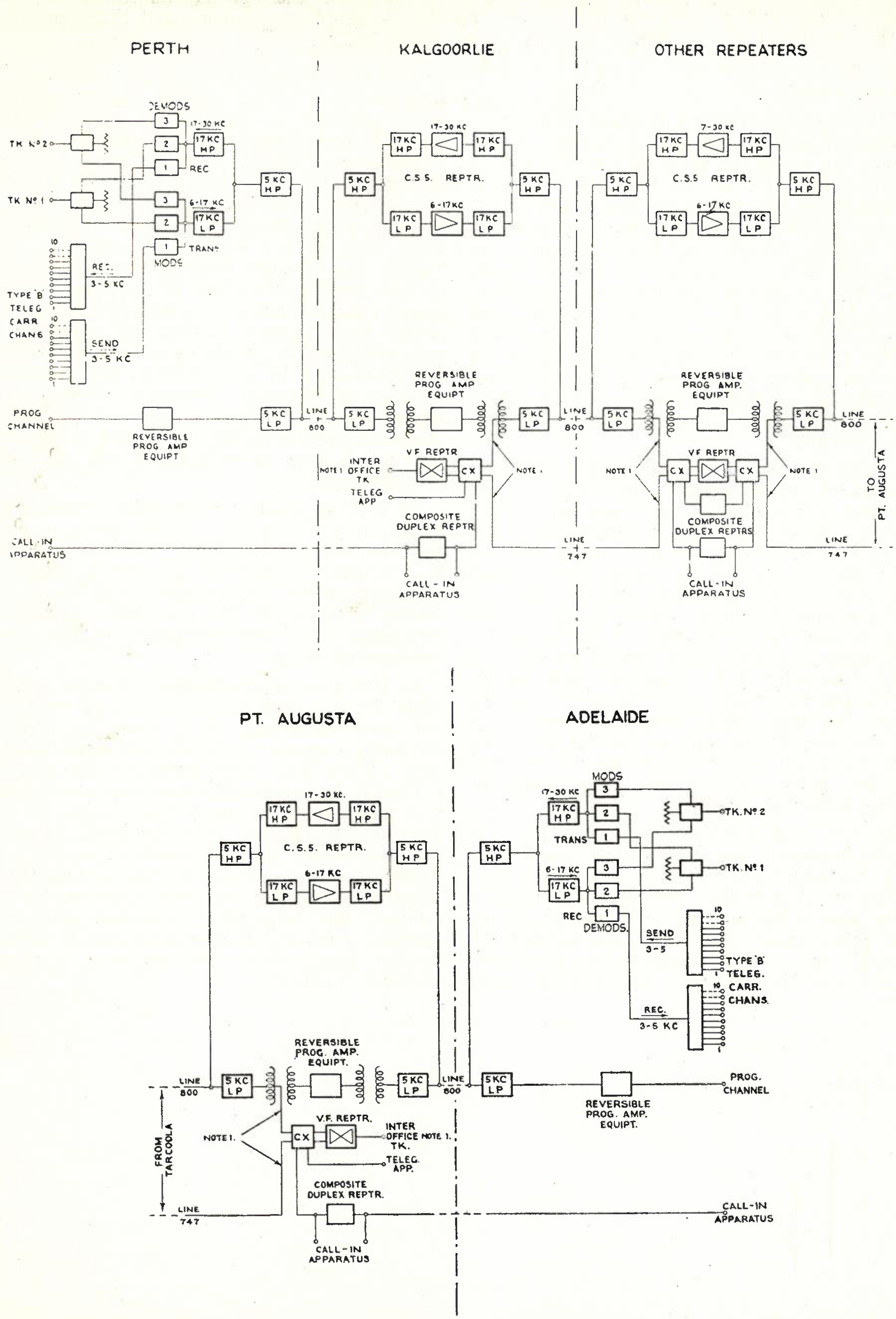
Channel 1 of the C.S.5 system was allocated for the purpose of operating over it the telegraph carrier channels. To enable this to be done, and as the frequencies of the telegraph channels were above the normal V.F. range, the modulator oscillators and the demodulator oscillators were altered in frequency so that when the telegraph frequencies were injected into the modulator, one of the side bands produced would fall within the pass range of the band pass filters of the carrier channel. This method has been discussed in an article in the June, 1942, number of this Journal, viz., "Re-allocation of Channel Frequency for the Type 'B' Telegraph Carrier System." The Adelaide to Perth direction of the telegraph carrier system was using the higher group of channel frequencies. This group is normally spread over too wide a band to permit the full 10 channels being operated within the band width of a voice channel, but as the whole system was now to be worked over a carrier telephone channel, on a "4-wire" basis, this presented the opportunity, by retuning the oscillators and filters of the higher group of telegraph carrier frequencies, of re-arranging them to the same frequencies and spacing as in the lower group of telegraph frequencies and thus permitting each direction to operate within the limits of the band width of a telephone carrier channel. The type "B" system is provided with variable tuned circuits in the oscillators and filters and they can be tuned to any of the required frequencies without difficulty. Therefore this re-arrangement of telegraph frequencies in the Adelaide to Perth direction was adopted.

Before disconnecting and retuning the telegraph channels, the two new telegraph channel ends for Adelaide to Perth operation which had been prepared for the cut-over and tuned to their appropriate frequencies beforehand were connected up to channel 1 of the telephone system. After satisfactorily lining up these channels, traffic circuits were transferred one by one from the existing telegraph channels, and as the old channels were thrown free they in turn were re-tuned to suitable frequencies, and brought into operation again over the telephone channel.

At this stage the position was that the telegraph channels in the Adelaide to Perth direction were now all operating over channel 1 of the C.S.5 system, and the programme channel only was operating through the old Adelaide-Perth repeater amplifiers. The physical trunk was still in use for the interstate trunk channel and the Perth to Adelaide telegraph channels were still operating through the old "B" type carrier amplifiers. The programme channel is not continuously in use throughout the day, and at a convenient time it was shut down, thus releasing the old Adelaide to Perth carrier amplifiers which were still temporarily patched into the C.S.5 repeaters. These amplifiers were then removed from the circuit and replaced by the Perth to Adelaide C.S.5 system amplifiers so that the latter could take up their normal functions. The way was now clear to connect up the C.S.5 terminal equipment for the Perth to Adelaide direction. This was done, thereby providing 3 telephone channels in that direction in readiness for the next step.

This was to transfer the Perth to Adelaide telegraph channels to channel 1 of the C.S.5 system. The equipment of the two new Perth-Adelaide telegraph channels had been tuned to appropriate frequencies for this to be done, and these were first connected and lined up. The existing telegraph channels were then cut over one by one as had been done with the channels in the other direction. Minor adjustment to the tuning was all that was necessary in this case, as the channels were already operating in the lower frequency group and the total number of channels could be readily accommodated within the band width of the carrier telephone channel. The complete telegraph system was now operating over the C.S.5 system.

The complete displacement of the telegraph



Note 1.—Temporary inter-office telephone circuit pending erection of new wire to pair with line 747.

Fig. 5.—Connections After Re-arrangements.

carrier system now permitted the 3 K.c. line filters previously in use throughout the circuit to be replaced with 5.6 K.c. line filters in preparation for the use of the physical line as a programme circuit.

The V.F. repeaters on the physical trunk were then removed and an inter-office telephone circuit set up by using the split of line No. 800 as one leg and line No. 747 as the other leg. It was necessary to disconnect the composite equipment from line 800 in order to give a programme channel with a satisfactory low frequency response and free from composite telegraph interference. The composite equipment was now connected to the inter-office telephone circuit, one of the derived composite legs being used for inter-office telegraph purposes and the other for the repeater station call-in device. The physical line programme amplifying and switching equipment was then connected to provide the programme channel.

This, with the necessary testing out and final adjustment of all circuits, completed the re-arrangement of facilities for the time being. The connections under the new arrangements are shown in Fig. 5. When the erection of the 4th wire on this route is completed, the second "carrier line" thus provided will be used to operate a second 3-channel telephone system on which it is intended to combine 2 normal width carrier channels to provide a second programme channel. Two-wire V.F. repeaters will be installed on the new pair and this circuit will be used for the inter-office telephone traffic. A cailho telegraph circuit will be derived over this new pair to which the call-in device will be connected, the cailho on line 800 being used for inter-office telegraph traffic.

Before the 2nd carrier telephone system is ultimately brought into use it is intended to establish an additional repeater station at Forrest, Western Australia. The existing stations on either side of Forrest, at Cook and Rawlinna, are 300 miles apart and the additional station will provide more satisfactory power level conditions and provide a margin for operation under emergency conditions in the event of an adjacent repeater station having to be temporarily patched out for any reason.

The two telephone channels that have been provided to Perth from the Eastern States are each superior in quality of transmission and stability to the part physical, part carrier circuit existing previously. The physical programme channel which has been provided is superior to the channel previously in use, while the transmission of programmes at voice frequencies permits each of the repeater stations to monitor readily the through programme. Further, it can be reversed in direction as required. The telegraph channels are giving equally efficient service under the changed method of operation while two additional channels have been provided. As the limitation to still further extension of the number of telegraph channels has also been removed by the changes, equipment for two more channels to fully equip the system to 10 channels has since been manufactured and will shortly be installed.

It will be readily appreciated, from the description given of the various steps involved in the complete change-over, and bearing in mind the number of stations concerned, that careful planning of the arrangements and timing of the various stages of the complete operation was necessary to ensure continuity of the important services existing.

In the plan of operations followed, every possible feature and characteristic of the old and the new equipment that could be utilized to advantage appear to have been exploited to the full. This plan was prepared by Mr. F. P. O'Grady, Acting Supervising Engineer, Adelaide, and great credit is due to him; to Mr. K. Taplin, Divisional Engineer, Transmission, Perth; and the Engineers and Mechanical staffs of the Transmission Sections of South Australia and Western Australia who were associated with the project, and who all co-operated splendidly to produce a smooth change-over and a finally successful result from the series of complicated changes involved.

INSTALLATION OF 2 V.F. TERMINAL EQUIPMENT IN VICTORIAN COUNTRY CENTRES

M. J. Brady

The conversion to V.F. operation of the country terminal ends of the Victorian trunk network system was commenced in July, 1940, and the initial cutover was effected in September, 1941. The purpose of this article is to present a picture of the preparations for these installations and of the problems encountered during the course of the work. The technical details of the system were covered by Mr. A. E. Bayne's articles in Vol. 3, No. 5, page 289, and Vol. 4, No. 2, page 88, and it is not the intention to enlarge on this aspect, but rather to indicate the general outline of the work as it affected the country end.

Before commencing the work, a comprehensive geographical plan of Victoria was prepared, setting out the centres which were to be converted to the new system. This plan indicated the power supply systems at each centre, the drawing numbers of office plans or circuits concerned, and the facilities for transport. It was necessary to check over office layout plans, make detail investigations of floor space available, arrange for building additions and extensions where required, and to rearrange and complete office layout details. In addition, a detailed check of equipment was made, provision made for storage pending installation, and recruitment of technical staff who could be trained to undertake the work in any part of the Victorian network.

The transport of this equipment to the various centres called for careful planning, as did the general programme of work required to tie in with the initial cutover. In order that the district mechanical staff could gain a knowledge of the new system from its inception, arrangements were made for at least one member of the staff of each centre to take part in the actual installation. This not only enabled them to become conversant with the actual wiring and cabling details, but also to gain an intimate insight into the general assembly and functioning of the system. This arrangement worked so well that the initial cutovers at the country ends were handled by these officers.

The whole of the work, including the outer Metropolitan centres, was carried out by a Foreman Mechanic in charge of the special staff recruited for the purpose, under the general direction of the Supervising Engineer, Country.

The keenness displayed by the installation staff in their application to the work was reflected in a very successful cutover which took place on September 27th and 28th, 1941.

The country terminal equipment is in rack form, the dimensions of each rack being 6′ 6″ high, 2′ 9½″ wide and 1′ 3½″ deep; each rack is designed to carry five both-way trunk line circuits. The racks are designated respectively A and B, A1.B1, the only difference is that the B B1 racks are not equipped with the common signalling equipment. Each rack carries the following equipment fitted on the "jack-in" principle, except the power and alarm apparatus.

A Rack

5—trunk line relay sets.
5—2 V.F. receiver circuits.
1—600 cycle oscillator.
1—750 cycle oscillator.
1—relay interrupter set.
1—power rectifier.
Fuse alarm relays.
Valve test set.

B Rack

This rack is similar in dimensional details to the "A," but carries only trunk line relay sets and 2 V.F. receivers.

Fig. 1 is a photograph of an A rack (with covers removed) and a B rack. A summary of the apparatus fitted to these racks is given briefly:—

Trunk Line Relay Set: Trunk line relay sets mounted on shelf A, comprising 19 relays for two-wire working, but extending to 23 per relay set for four-wire working, take care of all the functions needed for a call to appear on the switchboard after it has passed into the system, and also function as an impulse transmitter of tone pulses on an outward call. The relays are of the 3000 type except the impulsing relay, which is of Siemens' high-speed type. They are all base mounted and "jack in" on the rack so that they are easily removed for inspection.

2 V.F. Receiver Set: These receivers mounted on shelf B carry 3 valves and associated tuned circuits, and the "X" 750 and "Y" 600 cycle tone relays per set. The relays are of the high-speed type and respond to incoming signals after they have passed through the valves. This apparatus does not function on an outward call.

Tone Oscillators: These are of two frequencies, viz., 600 and 750 cycles per second, and supply the tones for the functioning of the system. They are valve operated and very stable in operation, and are mounted on "jack-in" bases on shelf C. Removal of these from their jacks interrupts the signalling system, but does not prevent speech passing over trunk lines.

Relay Interrupter Set: The interrupter set, also mounted on shelf C, takes care of the time pulses, in that it applies the tones to their respective circuit on a definite time basis, as it is essential that the speed of the relay operation be kept constant, in order that the timing of the signals is effected in correct sequence. Condenser strappings are provided to take care of any adjustments.

Transrector: The power supply to the unit is A.C. single phase, and is fed direct into the

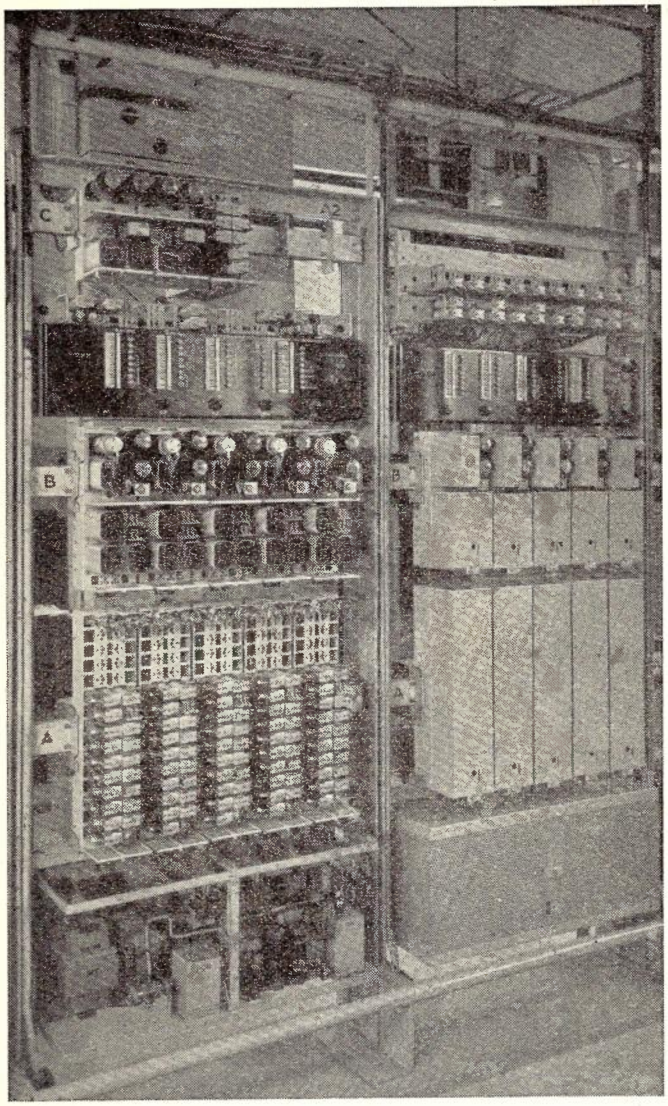


Fig. 1.—A and B Racks, 2 V.F. Equipment.

transrector, which, in turn, supplies 46 volt A.C. for filament lighting, 50 volt unsmoothed D.C. for relay operation and 50 volt smoothed D.C. for plate circuit functions. This apparatus is mounted at the bottom of the rack, is self-regulating and operates within limits of plus or minus 5% of mains' voltages. Tappings are provided to cater for commercial systems operating at higher or lower voltages than 230 volts.

Emergency Power Supply: In the case of large installations which will be provided in the near future, in addition to mains operation, a standby battery is to be installed with automatic change-over arrangements in case of local power failure.

Alarms and Valve Tests: Should the local power supply fail, relay operation is effected which brings into service an audible and visual alarm indicating to the telephonist that a power failure has occurred and that emergency calling arrangements must be instituted. This is taken care of by the use of emergency whistles which have been supplied to all installations, and comprise a 600 cycle and 750 cycle specially tuned whistle which when blown into emits the two tones for signalling purposes. These are impressed on the country telephonist's transmitter and enable the system to function, but do not provide for dialling. The circuits then become simply order wire trunk working. By the aid of the valve test set, the local mechanic is able to check up operating characteristics, should he suspect that a valve is not functioning at its correct values.

Since the 2 V.F. system depends on tones for signalling purposes, the usual switchboard indicator terminations for trunk lines are not suitable and it becomes necessary to make a conversion to lamp signalling for this purpose. The switchboards installed in the country are magneto operated and it was never contemplated that any additional signalling devices would be needed, consequently the jack appearances are not suitable for 2 V.F. operation. It has been necessary to rearrange and, in some cases, completely rewire trunk positions in order that space could be made available to accommodate the jack and lamp field for the new system. In all cases the anticipated development has been catered for, enabling future additional trunk circuits to be fitted without any further structural and wiring operations. All that is needed is to equip the rack with the necessary relay sets and receivers, jumper the lines and the new circuit is ready for operation.

In some cases where carrier operated circuits are to be switched, four-wire working has been introduced and this requires additional jack and cord circuits on the magneto switchboards and additional relays have to be fitted on the racks for this purpose. The system will take care of multiple trunk operation and will accommodate a maximum of five multiple appearances.

Where the installation is to cater for one to five trunk circuits, an A rack is installed, but if the number of trunk lines to be connected is from 6 to 10 then a B rack is installed adjacent to the A. Should the installation have to provide for a greater number of circuits than ten, then providing the floor space was available, the layout would generally be one line of racks in the following order:—

A, B, A1, B1.

An alternative layout in offices in which it was not possible to erect four racks in alignment was to erect racks in suites of two with 3′ 9″ centre to centre spacing between suites. In these exchanges, racks A and B form the first suite and A1 and B1, the second suite. As a definite order of installation had been laid down, it was necessary for building plans to be prepared well in advance to enable the work to be carried out. Where building alterations were necessary, the plans were designed to provide space for future needs. In some cases, where buildings were extended, action was taken to shift the existing equipment or to install new switchboards where these were required. This aspect of the work presented many problems, but the earnest co-operation of all Branches concerned helped considerably in their solution.

Where possible the new equipment was installed in apparatus rooms, but where such did not exist then it was necessary to erect it in the switchrooms. At first it was thought that relay operations would distract the telephonists, but such a condition did not arise and many installations were carried out under these conditions.

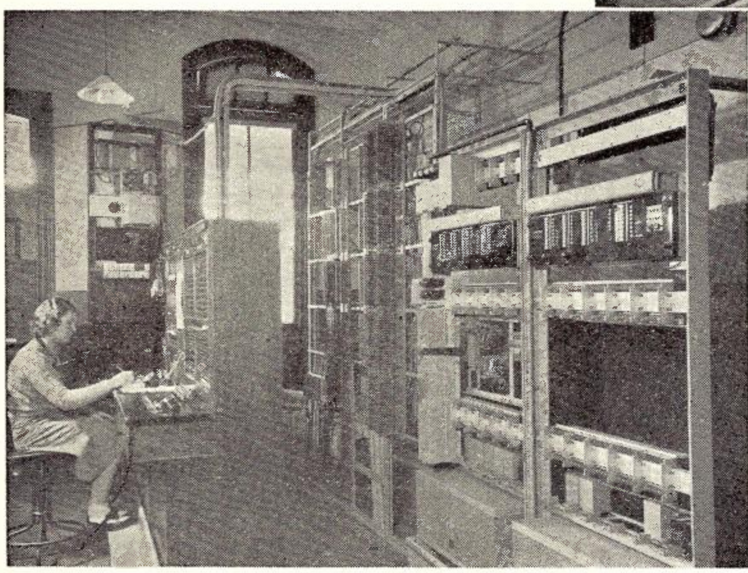


Fig. 2.—Racks Installed in Switchroom.

Fig. 2 indicates a two-rack suite during its installation and, in this particular case, the trunk switchboard and trunk test panel had to be completely rewired to provide the necessary standard of insulation.

Fig. 3 shows a three-rack suite installed in an apparatus room and lined up with a test panel and long-line equipment. Portion of the M.D.F. is shown on the right of the photograph.

The 2 V.F. dialling system has been designed to work over a line limit of 15 db. Contrary to expectation, the system functions satisfactorily over noisy line conditions, provided that no D.C. leaks are impressed on the circuit, and in one case a system operated over extremely heavy power induction, although speech was almost unintelligible. It has been found that the system becomes unstable when worked over C.X. circuits, but by the addition of a suitable filter these effects were eliminated.

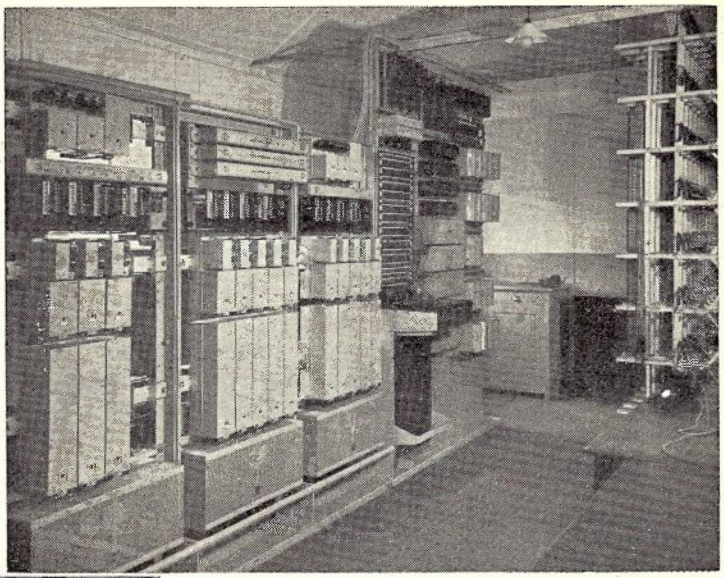


Fig. 3.—Racks Installed in Apparatus Room.

To assist in the maintenance of the system and to ensure that the country apparatus was functioning within its limits, test centres have been established where testing equipment has been installed. So that a mechanic at any station served by this centre may have his equipment lined up, specially designed carrying cases were manufactured and placed at these centres so that when a mechanic at a distant exchange requested an overhaul of one of his equipments, the test centre simply forwarded the spare set held at this location in the carrying case to the mechanic concerned and received the faulty apparatus in return. This system is operating well and enables the test centre mechanic to become expert in the testing procedure.

Faults at the country terminal apparatus have been remarkably light, notwithstanding that the apparatus has been in service in many cases for approximately 18 months, and is generally coping with traffic in a very satisfactory manner. The period since its inception has imposed heavy demands of the system, particularly in those areas serving military needs.

In a subsequent issue it is proposed to describe features of installation procedure and maintenance methods in detail.

TELEPHONE ARRANGEMENTS IN THE NEW G.P.O., SYDNEY

Evan Sawkins, B.Sc.

This article describes, in a general way, the manner in which the new G.P.O. building in Sydney has been fitted out for telephone service. As with all wartime jobs of this magnitude, it has been hard to find time to do it and hard to find material to do it with. However, despite these handicaps, every endeavour was made to provide the best facilities possible; and strong endeavours were made, because with big jobs experience has shown that if a high standard is not set and good work not done in the beginning, it is difficult to make amends afterwards.

It is desired to point out now that not all of the equipment and circuits provided in this building and described hereafter are recommended for general installation.

The article is divided into the following sections:—

Brief Description of Building:
- General Remarks.
- Summary of Telephone Needs.

Cabling Arrangements:
- Cabling and Distribution Scheme.
- Distribution Facilities.
- Bringing of Cables up on to Tables.

Types of Non-switching Units Installed:
- General Comment.
- Circuit Arrangements.
- Side of Table Mounting.
- Front of Table Mounting.
- Pedestal Mounting.
- Top of Table Mounting.

Telephone Arrangements for an Engineering Division:
- General Comment.
- Type and Mounting of Equipment.
- Facilities Provided.
- Circuit Details.

Conclusion.

Brief Description of Building

General Remarks.—The building adjoins the old G.P.O. building and has a 150 ft. frontage to Pitt Street. It comprises 11 floors, including a ground floor and basement. Corresponding floors in the old building are on the same level as the new floors, and generally there is free passage between them. The floor structure consists of a reinforced slab averaging 6 ins. in thickness with the usual surface rendering underneath for the ceiling. The ceiling is of the coffer type with no boxing between beams or false ceiling, except where required to cover plumbing, etc.

Wooden flooring boards are laid on joists, which in turn rest on 3 in. x $1\frac{1}{2}$ in. battens, running the same way as the flooring boards. The battens are omitted on floors given over to mail handling plant, etc., and here also hardwood flooring boards are used in lieu of Cypress Pine boards. Linoleum covering is used on most office floors and some rooms are carpeted. All walls carry a wooden skirting board, but no picture rail.

Summary of Telephone Needs.—The ground floor, which is mostly public space, and the 1st, 2nd and 3rd floors, which principally accommodate mail handling plant, required very few telephones. An exception was the Wireless Branch occupying portion of the 3rd floor. A number of non-switching units and amplifying equipment, etc., associated with the examination rooms was provided here. Some 50 examination tables were also wired. A number of non-switching units was provided for the Telegraph Branch on the 4th floor. The old telegraph operating room extends into this floor and it will also eventually accommodate the new Phonogram Room. Special floor chases, etc., were provided here, and an automatic equipment room adjoins.

A section of the Accounts Branch occupied the 5th floor and is provided with about 12 non-switching and other special units. The Telephone Branch occupies the 6th floor and the Engineering Branch the 7th floor, and both floors are densely served with telephones. A standard telephone arrangement is provided in all divisions of the Engineering Branch. The 8th floor is shared by the Drawing Office of the Engineering Branch, the Commonwealth Medical Officer and the Postal Institute Offices and Library. The Drafting Section, which, incidentally, is finely equipped, is well provided with telephone facilities, including some 14 non-switching units. The 9th floor is given over to Dining Rooms, Cafeteria and Billiard Room and required few telephones.

Cabling Arrangements

Cabling and Distribution Scheme.—The M.D.F. for both old and new buildings is on the 3rd floor of the old building in the room which houses the automatic switching equipment associated with the G.P.O. P.A.B.X. The P.A.B.X. manual cabinet is on the 4th floor of the old building.

The new building is served by three principal riser chutes. These also accommodate other services, but one face is reserved for telephone cables and distributing frame equipment. A chute makes a room about 10 ft. x 5 ft. on each floor. There is a full length 6 in. slot between the wall and the floor on three sides of these rooms. This will eventually be filled in with a soft cement mixture. An intermediate distributing frame is housed in each of these rooms and serves a third of the floor area. Distribution cables radiate from each I.D.F. to final distribution boxes in the walls and pillars. These cables are laid under the wooden flooring. Final distribution cables to service points are also run under the wooden flooring; the skirting boards are not used in any way in the cable distribution scheme.

Distribution Facilities.—The cement covering on walls and pillars is shallow and does not provide sufficient depth to permit distributing boxes to be fully recessed. However, small cast-iron boxes having 1½ in. depth have been mounted at chosen distribution points in the walls and pillars and provided with flush fitting covers. Two 1 in. conduits are attached to the bottom side of the box and reach below the wooden floor level. The rear wall of the box is tapped to take the mounting screws of a No. 6 Terminal Block.

If the No. 6 Block is not sufficiently large, a 40/40 distributing box can conveniently be mounted by inserting the mounting screws into the cover screw holes of the cast-iron box. If two new holes are drilled through the backboard an 80/80 box can similarly be mounted on the cast-iron box. The bottom edge of the backboard of a 40/40 or 80/80 box requires to be slotted to provide entrance for cable from the conduit.

Removable floor boards are provided about every 6 ft. throughout the floor area. These are fitted in 6 ft. lengths with tongues run off and ends splayed to facilitate removal. They are screwed through brass collars to alternate joists (which, in turn, rest on battens running the same way as the flooring boards). Where possible, the linoleum has been laid in 6 ft. widths so that the edges lie along the removable boards. An 18 ins. x 12 ins. brass framed trap is provided in the floor immediately in front of each distributing box. This greatly simplifies the problem of handling cable at this point. Special care was taken to keep floor traps out of passage ways. Once the linoleum is raised there is very little difficulty in bringing cable from a distributing box to any point on the floor. In the initial installation most of the cable was in position before the linoleum was put down.

Bringing of Cables up to Tables.—All tables are served with cable from the floor and a standard floor outlet fitting has been used throughout the building. (See Fig. 1.) The fitting consists of cover strip welded to a length of flat iron. A short piece of seamless conduit is fitted and welded to the bottom end and the flat iron is turned over to provide a mounting lug. The cable, which already projects through a hole in the wooden floor, is threaded through the fitting and the conduit end of the fitting pushed into the hole in the floor. When the lug is screwed down the fitting stands rigidly upright.

There are two mounting holes at the top end of the upright and a handset terminal strip or a side table mounting non-switching unit can be fitted here. Therefore, all telephones and non-switching units of this type may be cabled and tested out before the tables are in position. Eventually the upright is screwed to the side rail of the table in an appropriate position, such

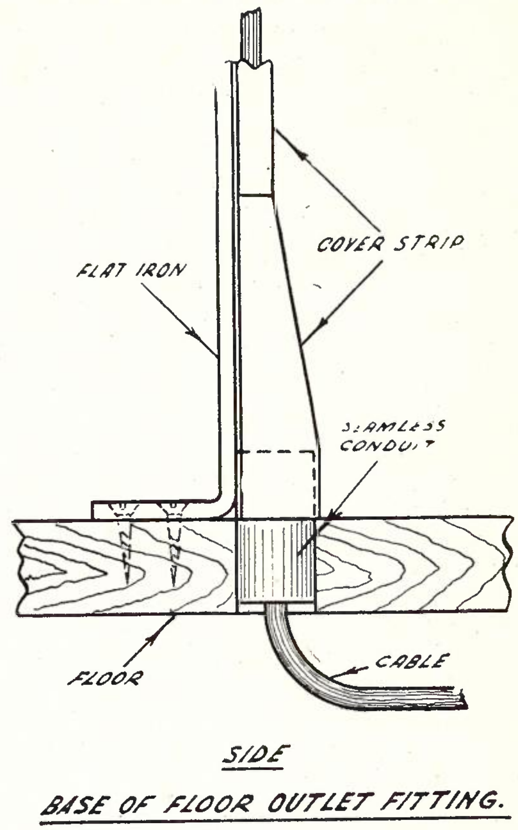


Fig. 1.—Detail Showing Base of Floor Outlet Fitting.

as behind the L.H. front leg. The fitting has been used also to bring cable up on to the table for connection to non-switching units of types other than the side table mounting type. It is neat and made up in three sizes to take cable up to ¾ in. diameter and has been finished in either black or brown. If provided with a larger mounting lug it is suitable for use on concrete and composition floors.

Types of Non-Switching Units Installed

General Comment.—Requirements of an ideal non-switching unit are:—

1. The keys should be within easy reach of the user; the lamps and designations easy to see, and it should be possible to instantly associate an answering key with a calling indicator.
2. The operating procedure should be simple and straightforward, the various circuit conditions and switching operations being set up by simply pressing a key. The keys should be restored mechanically by the handset cradle switch or be of the non-locking type. Adequate supervision should be provided by means of lamp indicators.
3. The non-switching unit housing should be neat and plain and blend in with its surroundings.

4. The circuits should provide the exact service required.
5. It should not be easy to accidentally operate any of the keys.
6. It should not be difficult or costly to install.
7. All equipment should be readily and fully accessible for maintenance with a minimum of inconvenience to the telephone user. The cost of maintenance should be reasonable.
8. The unit should not cause irritation to the telephone user. For example, it should not be in the way of any movement and the bells or buzzer should not be too loud. Generally, this condition follows if the other conditions are met.

The need to have the keys within easy reach of the telephone user suggests that a good place for mounting them is on the body of the telephone itself or in a compartment associated with the telephone. A few keys can be mounted on the 332 Handset Telephone between the cradle wings either immediately in front or immediately behind the handset itself. In either position, unless they are of the flush mounting type, the keys are likely to be operated accidentally as the hand removes the handset. There are other disadvantages, including the difficulty in mounting lamp jacks. The only satisfactory position for keys on an automatic telephone is at the front of the instrument. There is no room in this position on the 332 model. The conclusion is reached, therefore, that if keys and lamps are to be mounted with a handset telephone either a design different to the 332 would be necessary or a separate key and lamp compartment would need to be attached to it (for table use) or the telephone, together with keys and lamps, mounted off the table on a separate pedestal stand. The first alternative implies the introduction of types after the style of A5 and A10 inter-communication telephones. Once the keys are mounted outside the telephone body it is no longer possible to provide for the mechanical release of operated keys by the action of replacing the handset on the cradle. However, another mechanical device wherein the action of operating any key mechanically restores the key previously operated could still be utilised.

In the new G.P.O., the mounting of keys on handset telephones was confined to certain telephones used in Divisional Engineers' offices. In this case one plunger type key only is mounted on each telephone.

With the exception of the pedestal stand already referred to, all non-switching units in the building were provided with the keys and separate from the telephone. Although the keys and lamps (see later comment) were mounted in a variety of ways, the side of table mounting was used in the great majority of cases. The other types were installed in the case of higher executives only, and were designed to satisfy particular needs. Wherever possible, equipment has been finished so that it is as inconspicuous as possible and to blend in with surroundings and furnishings.

Only operating and signalling equipment (keys, lamps, buzzers) have been mounted in keyset assemblies, and all other circuit components have been grouped on wall racks. Normally, each rack contains relays, etc., for more than one non-switching unit. Terminal blocks and jumpering facilities are provided also on the rack so that, where installed, it replaces a distributing

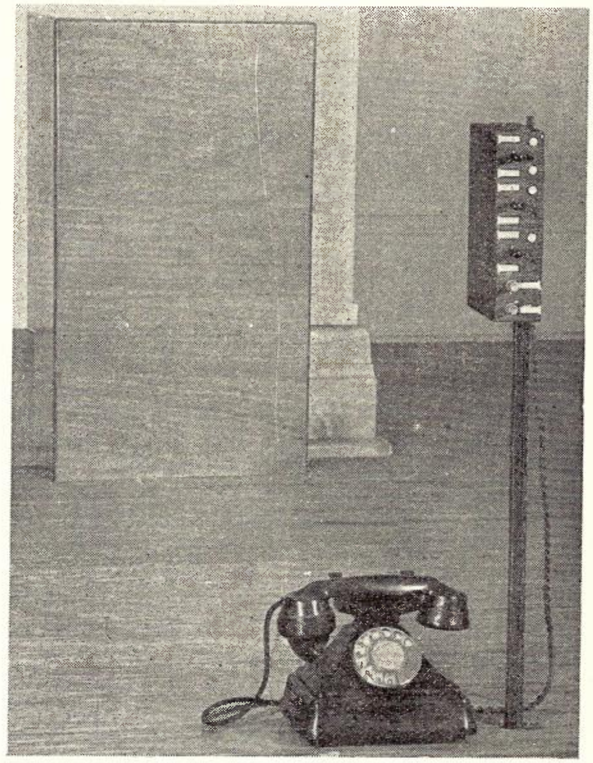


Fig. 2.—Relay Rack Against Pillar; Telephone and N.S.U. in Foreground.

box. There are three groups of terminations on these racks. One group is the termination of the riser cable from the I.D.F. room, the second comprises the final distribution cables to service points and the third group is made up of the relay rack terminals. Jumpers are provided between the three groups as required. The racks are on walls and pillars in locations where they can be attended to without interference to telephone users. A relay rack is shown against a pillar in Fig. 2. Battery feeds to relay racks are wired through alarm type fuses, which are mounted in the I.D.F. rooms on each floor. The power lead to each I.D.F. room is fused in the P.A.B.X. room on the 3rd floor.

Circuit Arrangements. — Except for circuits specially designed for executives, all circuits of a similar type are of uniform design throughout the building. Key operation has been made as simple as possible but with mechanical arrangements out of the question, the only major simplification that could be introduced was the use on direct C.B. lines of a non-locking plunger type key associated with a relay locking up from a battery feed relay contact. This type of arrangement is expensive with relays, and was provided on non-switching units for executives only. Generally, simplicity in key operation involves either the greater use of relays and increased circuit complications or mechanical contrivances, so that it is only possible to achieve operating simplicity at a cost.

When locking type keys are used on direct C.B. lines, the caller frequently forgets to restore the calling key, in which case the called person receives a second calling signal when he replaces his handset. Alternatively the called person may forget to restore his key and this places a direct line out of service. A.C. signalling is sometimes used on direct lines, but this complicates the operating procedure. The direct C.B. lines provided for executives in the new G.P.O. have non-locking plunger type keys at both ends. To call and speak to his deputy, an executive lifts his handset and presses the appropriate key. Afterwards he merely restores the handset. The called person answers the call in exactly the same way.

Either of two methods was used for signalling with the non-locking plunger key circuits. In one method, the buzzer at the distant end sounds only whilst the caller has the non-locking key pressed. In the other method, once the calling key is pressed, the buzzer at the distant end sounds continuously until the answering button is pressed.

The use of non-locking keys greatly simplifies operation on direct lines. Non-locking keys have not been used on exchange lines (except in a few instances) because with these the lock up feature can only be secured by adding an additional set of make springs to the telephone switch hook assembly or by the use of a series relay in the line; both of which alternatives are undesirable.

Another operating simplicity that has been introduced in a limited way, has been the restricted use of hold keys or the provision of automatic hold where desirable. Very frequently, hold keys are provided on non-switching units when they are not warranted. Hold keys should not be provided when the incidence of their use is low. If provided, a guard lamp should be fitted, which will light when the hold key is operated.

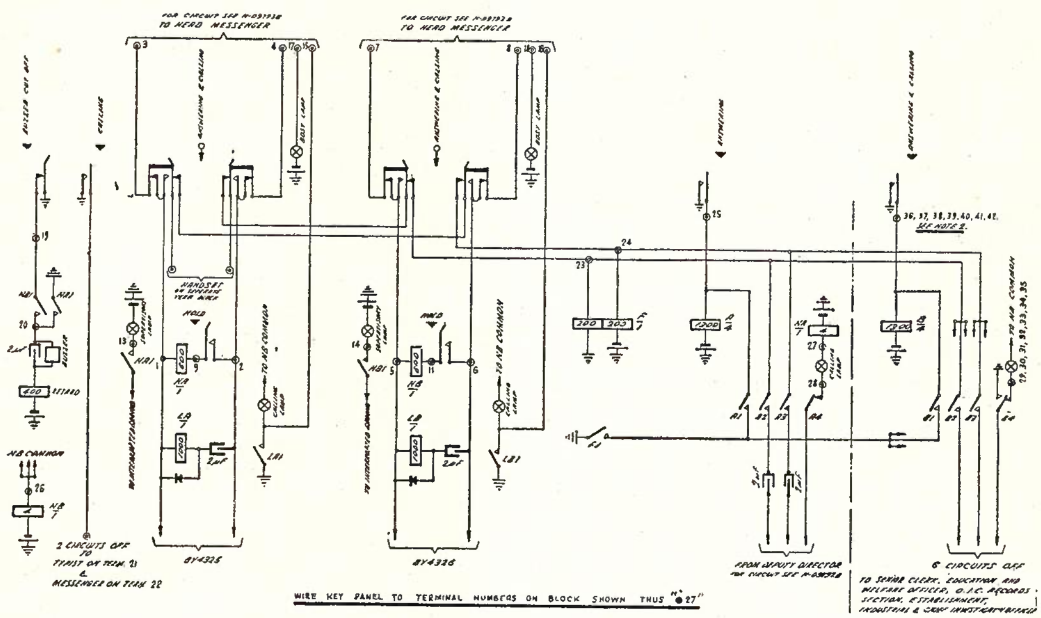
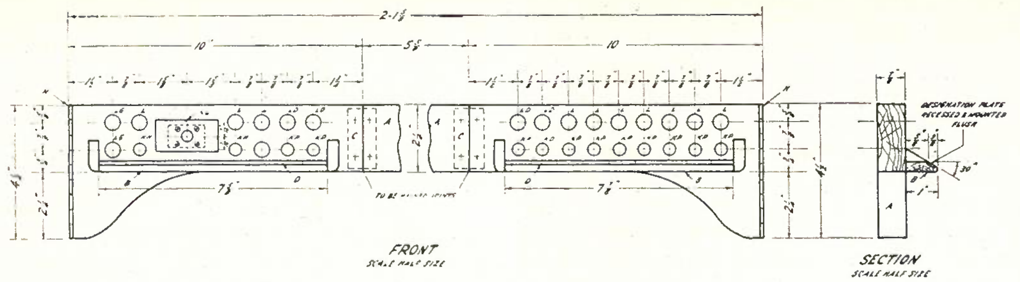
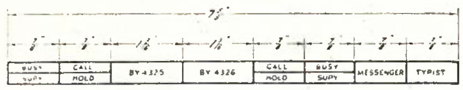


Fig. 3.—Circuit of N.S.U. Provided for Higher Executive.

Where bells and buzzers associated with exchange lines or direct lines are located in rooms where they would not be heard if the occupant of the room was absent, arrangements have been made to ensure that the call receives attention. A device often used in the past is the transfer key, which the room occupant would operate before leaving the room, and so transfer his line temporarily to another position. This is cumbersome and a guard lamp is advisable to warn the room occupant against restoring the transfer key on his return if it so happens that a call is being answered by his deputy at that moment. Frequently, the transfer key is forgotten and not operated when the room is left unattended and not restored promptly when the occupant returns. An improvement would be to provide a non-locking transfer key. A much better arrangement is to place the line permanently in parallel with an outside telephone,





DETAIL "D"

For L.H.S. Gate. Scale Full Size.

1. For schematic circuit, see Dwg. N-D 9795B.
2. Drill to clear $\frac{1}{2}''$ dia. for lamp sockets.
3. Drill to clear $\frac{3}{8}''$ dia. for plunger keys.
4. Cut $1^{3}/_{16}''$ x $\frac{3}{4}''$ and let $2\frac{1}{8}''$ x $1''$ for lever key.

DETAIL "D"

For R.H.S. Gate. Scale Full Size.

A.—Knee rail of the table of best selected cedar. Hinge on both sides as shown and polish to match existing table. B.—Key guard and designation holder of $\frac{3}{8}''$ cedar. Finish to match. C.—1′ x $2\frac{1}{8}''$ x 16 gauge M.S. for locking flaps. Mount on rear. D.—Designation plate of $\frac{3}{8}''$ erinoid. Engrave and fill black on white. See detail. H.—Continuous hinge $4\frac{1}{2}''$ long. KL.—Key L.V.C. mounted horizontally on 1″ key plate fitted flush. KP.—Plunger type register key to serial 23/17 non-locking. KH.—Plunger type register key to serial 23/17 locking. KD.—Fit dummy key. L.—Lamp socket to serial 10/29 fit white cap serial 10/17. LG.—Lamp socket to serial 10/29 fit green cap serial 10/19. LD.—Fit dummy lamp cap.

Fig. 3A.—Details for Keys and Lamps Mounted on Knee Rail of Table.

and arrange so that when the executive uses the line it is cut off from the outside telephone. The calling signal operates simultaneously at both positions and if the call is not taken by the executive it is answered outside. A special buzzer cut-off key was frequently provided to enable the executive to disconnect the audible signal on such lines when he wished all the calls to be intercepted by his deputy. In such cases a direct line has also been provided between the two positions.

Fig. 3 is typical of circuits provided for high executive officers. The mounting of the keys and lamps for this unit is in the front rail of table. (See Fig. 3A.) Provision is made for two exchange lines and eight direct lines as well as

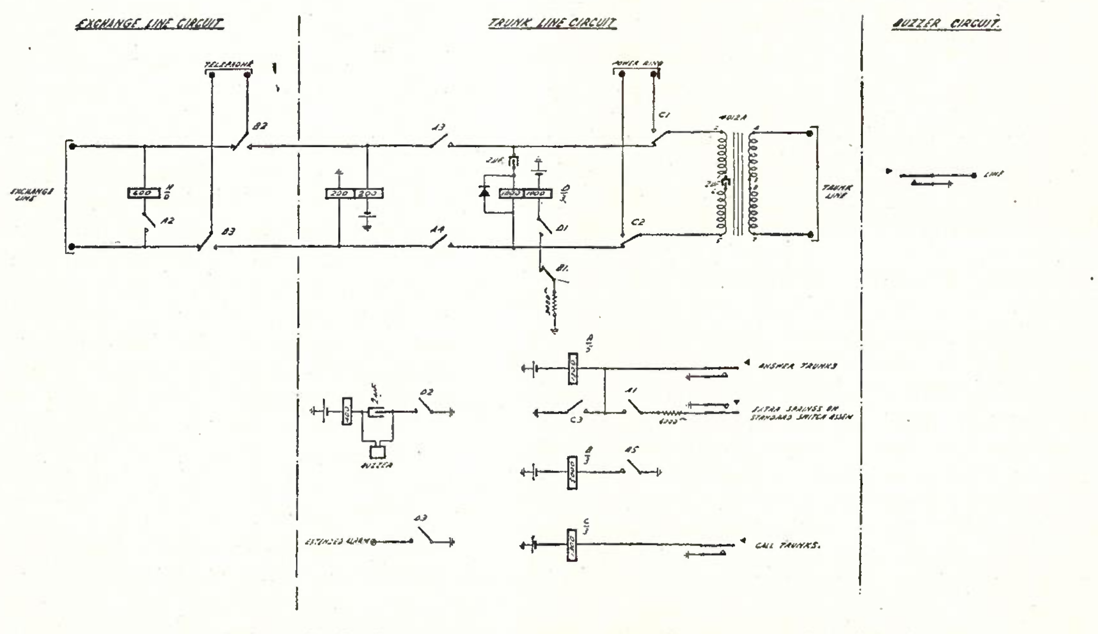


Fig. 4.—N.S.U. for Higher Executive—Schematic Circuit.

for two buzzer circuits. Various features already discussed will be observed in the circuit.

Fig. 4 and Fig. 5 indicate the arrangements provided for a high executive officer who occupies his room only infrequently. In the circumstances simplicity in operation was essential. It will be seen that direct in and out exchange service is available on the telephone without the necessity of operating any key. Four push keys are provided in the front rail of the table. Two are buzzer keys and two are associated with a direct line to the Trunk Exchange. To call the Trunk Exchange it is necessary to lift the handset and push the appropriate non-locking key. To answer a trunk call the handset is lifted and the answering key pushed once. It was presumed that whilst engaged in a trunk call no interruption was desired and the exchange line (Departmental P.A.B.X. line) is therefore automatically busied when the trunk line is in use.

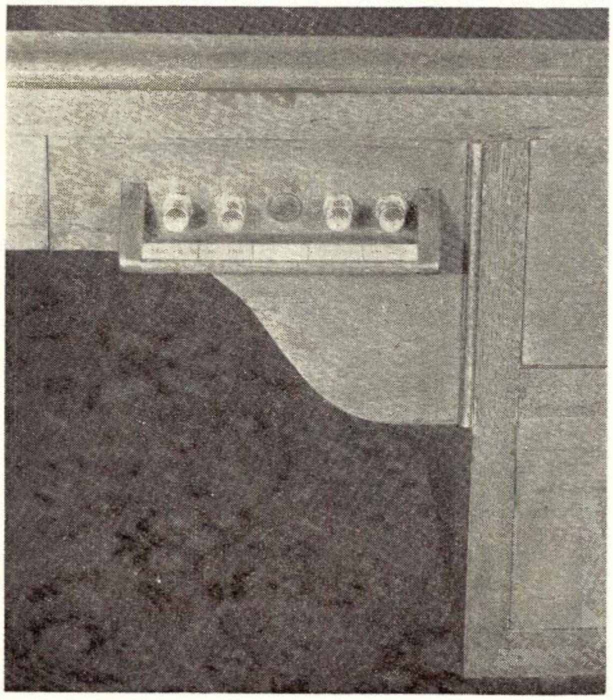


Fig. 5.—Keys Mounted in Knee Rail of Table.

Side of Table Mounting.—The majority of the units provided in the building are of this type. (See Fig. 2.) The unit is capable of being mounted on the floor outlet fitting and cabled and tested before the table is in position. It is made up in the form of a rectangular box from mild steel plate and is in three parts. The side plate, which is attached to the outlet fitting, carries a terminal strip (and buzzer, if necessary). The keys and lamp jacks are mounted on the front face, which is turned over at one lower corner and hinged to the side plate. The remaining four sides of the box are in one piece. There is a bushed hole for the telephone cord in the side plate in a position where it will be below the level of the side rail of the table. When two screws are loosened the front plate drops down to a horizontal position and the remainder of the box is detachable from the fixed side plate. The keys, jacks, terminal strip and wiring are thus fully revealed for inspection.

If the table is occupied it is unnecessary for the occupant to move whilst an inspection of the key set is taking place. The unit is of such a width that, if necessary, a movable table can be butted against the table carrying the non-switching unit so that the unit is available equally to the occupant of either table. On the front plate there is room for mounting three lever keys and two plunger type keys or alternatively four lever keys. In addition, there is adequate room for lamp jacks and caps and designation strips. A larger size of unit mounting twelve lever keys and one plunger type key is also in use in connection with the Engineering Division circuit. This unit is the same width as the smaller size and is generally similar in details of construction. The units are cadmium plated and provided with black crackle finish. Whilst the side table unit is easy to operate, it is difficult to designate the keys and lamps so that the designations are clearly visible from the user's chair. This weakness is offset by the fact that the keys on the unit are in a single row and distinctly separated so that once the operating procedure is memorised it is unnecessary to refer to designations.

Front of Table Mounting.—One of the disadvantages of a drawer mounted non-switching unit is that the handles of the near keys obscure the designations underneath the distant keys, and it is not always immediately obvious which key is associated with a particular lamp indicator. These disadvantages are not entirely overcome by building a sloping front to the drawer or by other expedients that have been adopted such as the use of plunger type keys with sloping key knobs carrying the designations. Also these variations introduce other disadvantages. The method of front of table mounting adopted in the new G.P.O. building is shown in Figs. 3A and 5. The front rail of the table has been cut and portion hinged to form a gate. If necessary, the strength of the table is restored by building in a second rail about 6 ins. back and in a parallel position, or by installing angle brackets. Lamps and keys are mounted on the gate and a sloping designation strip is fitted into the key guard. A dust cover for the keys and lamps is provided underneath. This type of non-switching unit is exceptionally easy to use.

Pedestal Mounting.—The pedestal type of non-switching unit has been designed for the executive who likes to have his telephone and keys off the table. The unit is the same height as a table so that the 332 handset mounted on the pedestal is about 6 ins. lower than when it is resting on a table. To the average person sitting in a swivel chair the dial is much more clearly visible at this level because its slope is then roughly perpendicular to the line of vision. The slope of the key panel is the same as the slope of the 332 handset dial. The panel is hinged at the top and lifts up, being held in the operated position by a knee type catch. The panel is made from fibre-faced wood and can be coloured to match the telephone; the door knob could also match this colour. The cord of the telephone is stored in the built-in box at the back of the top bookshelf and, if desired, at any time the telephone may be lifted off the pedestal and placed on the table. The pedestal is intended to be placed on the left hand side of the chair and manipulated entirely by the left hand (which holds the handset). However, if desired, the keys and dial can be conveniently operated with the right hand, especially if the user is in a swivel chair.

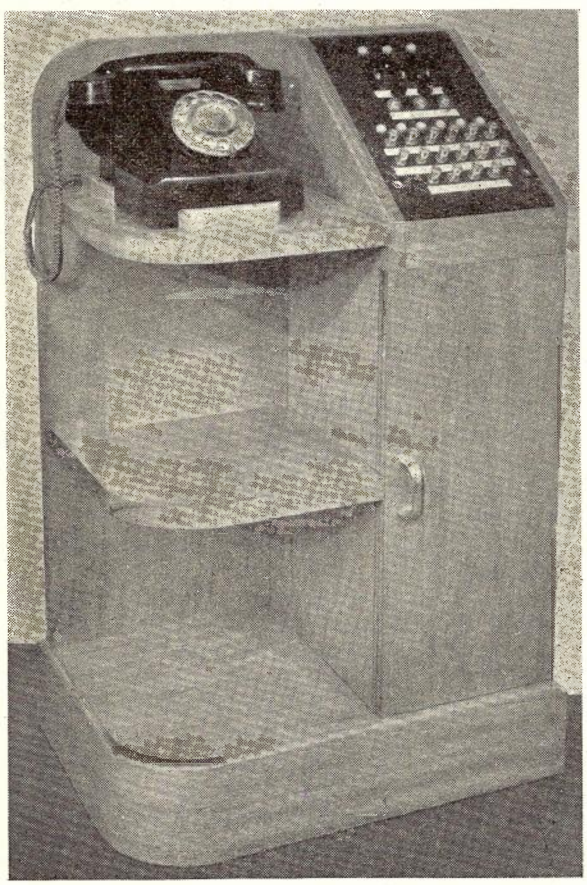


Fig. 6.—N.S.U.—Pedestal Mounting.

It will be noticed from Fig. 6 that the pedestal includes two bookshelves and a small cupboard for housing the telephone directory and foolscap folders. The unit is served by flexible cable from an enclosed terminal strip fixed to the skirting board. There is provision for securing the flexible cable in the base, which is hollow, and taking it into the key compartment. The telephone cord also terminates in the key compartment. A disadvantage of the pedestal non-switching unit is that it constitutes another item of furniture in a room. However, this disadvantage is reduced if the room is large and spacious. An advantage is that the table does not become a fixture, as is the case with all other types of non-switching units.

Top of Table Mounting.—If a non-switching unit is mounted on the table without being included in the telephone, it is best placed directly in front of the user, or mounted flush with the table top on the left side. If it is placed in front of the user, it is best combined with paper trays to form a single mounting. (Refer Fig. 7.) Units of this type were provided in the Drawing Office of the Engineering Branch. Care should be taken with a table top box to ensure that equipment is fully accessible for maintenance purposes. A detachable top is not sufficient as a rule unless the box is shallow.

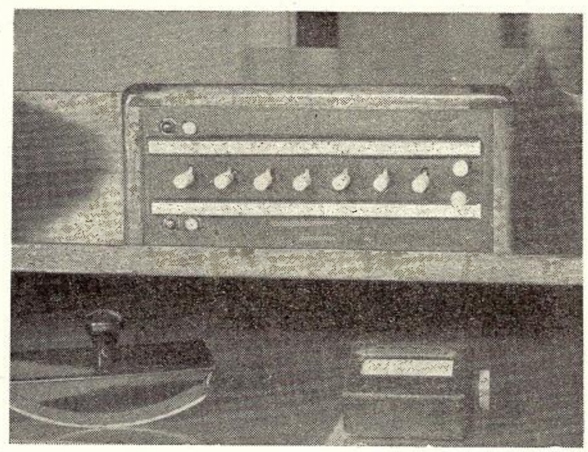


Fig. 7.—N.S.U.—Top of Table Mounting.

Telephone Arrangements for an Engineering Division

General Comment.—The office staff of an Engineering Division consists of a Divisional Engineer, from two to four Engineers, from one to three Clerks, and often from one to six other persons. In the new G.P.O. the staff of each Engineering Division is all together and the space occupied is surrounded by a half glass partition. The Divisional Engineer's office is a partitioned space within the area. The Clerk and Assistant are seated close to the Divisional Engineer's office and have a view of all the tables in the area.

Incoming calls are received by all members of a Division and, with the exception of the clerical staff, each person spends a good deal of time away from his table. It is desirable from the point of view of quietness that all telephones on the floor be answered promptly and that bells are not allowed to ring because some officer is temporarily absent. Often it is necessary for an incoming call to be connected in succession to more than one officer.

To handle inward traffic two (or more) rotary lines are provided and concentrated at one answering and switching position. The answering position is the Assistant Clerk's table, but the key set has been mounted on the side of this table, which abuts the Clerk's table. Either officer may answer and switch an inward call without leaving his table.

The circuit arrangement is such that a call is switched by the operation of a key and interrupted ring is put out on the extension. If the extension telephone is already engaged the calling person is advised accordingly by the operator when the call is first answered; however, the operator switches the call, which is automatically stored and does not interfere with the conversation in progress on the extension telephone. When the extension handset is restored the extension telephone rings and the stored call is then answered.

All members of a Divisional Staff require to make out calls. It has been possible to provide each telephone with a separate out line (in some Divisions two persons share the one telephone). The "out" lines connect to line switches in the P.A.B.X. room. The handset telephone of each Engineer in a Division is equipped with a push button which provides a call back facility. Other extensions may similarly be equipped, if necessary. An important feature of the telephone arrangements is that three wires only are required to each table where a call back facility is required and two wires only when a call back facility is not required. These wires are terminated on the relay rack provided in each Division. Also terminating here is a cable to the answering operator's key set.

Type and Mounting of Equipment.—The answering key set is made up in the form of a side table non-switching unit. There is a vertical row of keys for each incoming exchange line (generally there are two). Each extension is represented by a key in each row. Surmounting each row is a calling lamp and an operator's key. A hold key associated with the operator's "out" line is also provided on the key set. All relay equipment is mounted on a wall rack. (Fig. 2.) The relays are mounted on repeater bases. The wiring of corresponding relay bases is the same in all Divisions. There are two different types of relay sets and a spare set of each type is held and is available for jacking in should any working relay set require overhaul or adjustment, which are carried out on an adjustment bench.

Telephones with a call back facility have a push key mounted on the body of the telephone. The telephone of the Divisional Engineer is also equipped with a non-locking push key but the operation of this connects the telephone to a direct exchange line. Three non-locking push keys are also mounted on the front rail of his table. One is a call back key, one operates a buzzer circuit to the Divisional Clerk, and the other a call line to the Typist.

Facilities Provided.—An incoming call is made evident by a lamp lighting and a buzzer sounding. A Clerk answers the call by depressing the operator's key associated with the calling lamp and speaking on the operator's telephone. When the person required is ascertained, the call is switched by the operator depressing the extension key associated with that particular incoming line. The operator then restores his own key. The call is made evident to the extension by the telephone bells ringing. When finished the extension restores his handset and a clearing lamp lights and a continuous buzzer sounds at the operator's key set. The operator thereupon restores the extension key.

If a call for the same person arrives whilst he is answering a call on the first line, the operator depresses the extension key associated with the second line (which is next to the key which will have already been depressed). The operator then restores his own key and when the extension restores his telephone the bells immediately ring again. The operator receives a clearing signal in connection with the first call.

An "out" exchange line key and a hold key are provided on the answering key set for the use of the operator. If the operator is making an "out" call when an incoming call is received, he may operate the hold key and proceed as already explained, afterwards restoring the hold key and continuing with the original conversation.

When any handset in the Division is lifted, except when answering an "in" call, the telephone is connected to an "out" line through the P.A.B.X. Any telephone can be provided with a call back key to enable the user to make an "out" call whilst holding an "in" call.

In addition to having the same facilities as other officers in the Division, namely ability to receive "in" calls via the transfer unit and make "out" calls via the P.A.B.X., the Divisional Engineer is provided with a direct exchange line. An "in" call on this line is made evident by a buzzer on his table sounding at ring intervals and is answered by lifting the handset and depressing a non-locking push key mounted on the telephone. An "out" call on the direct line is made in the same way, namely by lifting the handset and pushing the non-locking key. If an "in" call is switched to the Divisional Engineer by the Key Set Operator when he is speaking on the direct line, it is stored and when the handset is replaced the telephone bell rings and the call is taken when the Divisional Engineer again lifts the handset. In the Divisional Engineer's absence a call on his direct line may be answered by the Clerk, whose table is equipped with a key for this purpose. When the Divisional Engineer speaks on the direct line, the parallel circuit to the Clerk's table is disconnected. The Supervising Engineer is provided with a direct line to each of his Divisional Engineers. Such a call is made evident to the Divisional Engineer by a continuous buzzer note and is answered by lifting the handset and pressing the call back key (which is mounted on the knee rail of the table). No matter on what line the Divisional Engineer is already engaged the buzzer sounds when the Supervising Engineer is calling, and the Divisional Engineer may answer the call by pressing the call back button. The line he leaves is automatically held. When the conversation with the Supervising Engineer is completed, the Divisional Engineer may revert to his original conversation by restoring the handset momentarily.

Circuit Details.—The operation of the incoming exchange line circuit is as follows. (Refer to Fig. 8.) :—

Interrupted ring operates A/2. A1 lights calling lamp on key set. A2 operates buzzer.

Operator throws answering key and connects his telephone to the line. The ring is tripped when the operator's handset is lifted.

When person required is ascertained the operator throws appropriate extension key, restores answering key and replaces handset.

When key is thrown a hold coil is placed across the exchange line and a testing circuit is set up from ground on call back key (or switching key) through key springs, B/4, B2, key springs, private wire to P.A.B.X. line switch, to D.M. battery via B relay of line switch.

If extension is busy on "out" call the testing circuit is open at the line switch contact A1. If the extension is busy on an "in" call the private wire is earthed from ground at B2 of the 2nd incoming exchange line circuit.

If the extension is disengaged B/4 operates and also B relay of the line switch.

B3 and B4 (line switch) disconnect the out line from the called extension telephone.

B/4 relay of the incoming exchange line circuit locks up from ground on call back key, B/4, B1, F4, to battery through 500 ohm resistor.

B2 guards private and also retains B relay of line switch in operated condition.

Interrupted ring is put out on extension line via 200 ohm winding of F/6, B3, F2, key contacts, telephone bell, key contacts, C/1, F3, B4 to ground.

When extension handset is lifted F/6 operates. C/1 also operates.

F1 provides a locking circuit for F/6 via key contacts and ground on call back key.

F2 and F3 switch call through to extension telephone.

F4 opens the locking circuit of B/4.

F5 extends ground at call back key to line switch B relay which remains operated when holding circuit is opened at B2.

F6 relights calling lamp which then acts as a busy lamp.

C1 breaks circuit of clearing lamp which would otherwise light via F1 and call back key earth.

The release of B/4 leaves the private wire earthed only at the call back key via F5 and key contacts.

When the extension handset is restored C1 releases and lights clearing indicator. Relay NA/1 also operates and sounds buzzer.

The operator restores transfer key to normal.

F relay restores also B relay of line switch.

The B relay of the 2nd incoming line circuit is slugged at the armature end to eliminate the danger of the B relays of two incoming exchange line circuits operating simultaneously if a call is waiting on each line for a particular extension to become free.

The operation of the call back facility is as follows:—

If an extension is engaged on an incoming call and the call back key is pressed, the locking circuits of both B/4 and F/6 are broken and the two relays release.

F2 and F3 disconnect the incoming exchange line (which already has a hold coil connected across it).

Relay B/4 of the line switch also releases when the call back key is pressed and completes the circuit for A/4 (line switch) at B3 and B4 through the extension telephone loop.

B/4 relay (incoming exchange line circuit) cannot re-energise when the telephone user takes his finger off the call back button because the private wire is now open circuit at A1 (line switch).

When a free trunk is secured B/4 (line switch) operates again and switches the extension telephone through to an "out" line at B3 and B4.

When it is desired to revert again to the waiting "in" caller the handset is restored momentarily. This releases A and B relays of the line switch but B/4 operates again from ground on the private wire. Relays B and F of the incoming exchange line operate and the incoming line is switched through to the telephone at F2 and F3.

The additional facilities provided for the Divisional Engineer operate as follows (Refer part 4 of Fig. 8.) :—

To make an outward call on the direct line the handset is lifted and the exchange line key (mounted on telephone) is pressed.

Relay D/3 operates and switches telephone over to direct line at D1 and D2.

D3 opens private wire and so sets up busy condition to guard against any call being switched through on the transfer unit.

Relay C/1 operates when the exchange line is looped and C1 energises relay B/4.

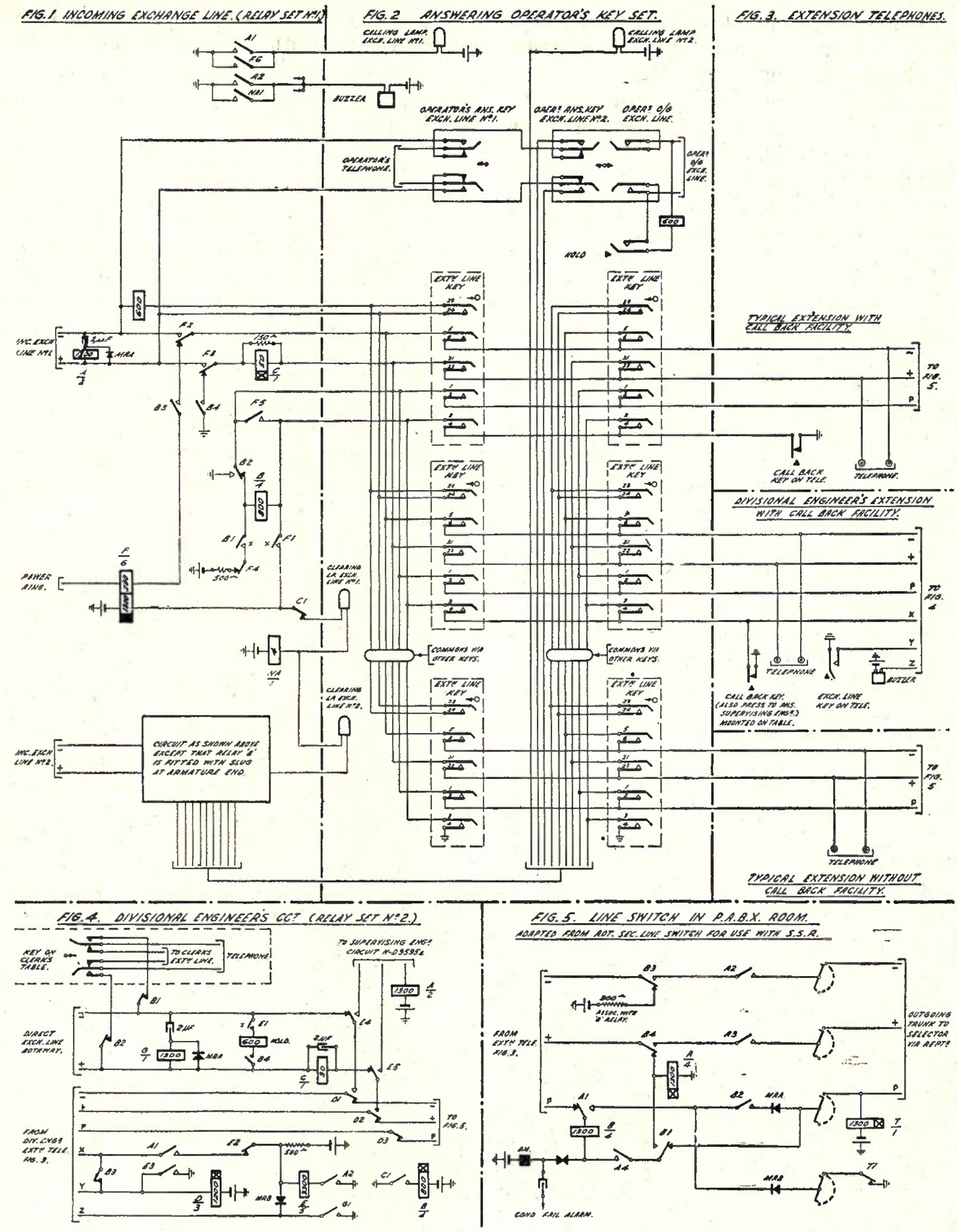


Fig. 8.—Circuit of Telephone System in an Engineering Division.

B1 and B2 contacts disconnect parallel line to the Divisional Clerk.

B3 provides a locking circuit for D/3 back to ground on the call back key.

B4 prepares a holding loop on the direct exchange line.

When conversation is finished the handset is restored and C/1 releases, in turn releasing B/4. The locking circuit of D/3 is broken at B3 and the circuit is again normal.

An inward call on the direct line operates G/1 which sounds a buzzer at ring intervals. The handset is connected to the line as already described when the exchange line button is pressed.

When the Supervising Engineer calls the Divisional Engineer relay A/2 operates, and the buzzer is energised from ground at call back key, A1, E2, MRB, buzzer to battery.

Ground at A2 shunts relay E/5.

When the handset is lifted and the call back button pressed relay E/5 operates from ground, A2, E/5, 500 ohm N.I. resistor to battery.

The opening of E2 contacts safeguards E/5 from being shunted when the call back key earth is restored.

E3 operates relay D/3.

Contacts D1 and D2 together with E4 and E5 switch telephone over to Supervising Engineer's line.

D3 opens private wire and thereby sets up busy condition to guard against "in" call being switched from transfer unit.

If the direct line had been in use when the Supervising Engineer had called, B4 contact would have been closed. The operation of relay E/5 would have then completed the holding loop on the line at E1. If a call from the transfer unit had been in progress the operation of the call back key would have held this in the normal manner. When the Supervising Engineer restores his handset A/2 releases and in turn releases E/5 at A2.

E/5 releases D/3 at E3. The Divisional Engineer automatically reverts to the direct exchange line if a call had been in progress on this line as D/3 will have remained operated from earth on call back key via B3. If it is desired to revert to a call that had been switched from the transfer unit it is necessary to momentarily restore the handset after the conversation with the Supervising Engineer.

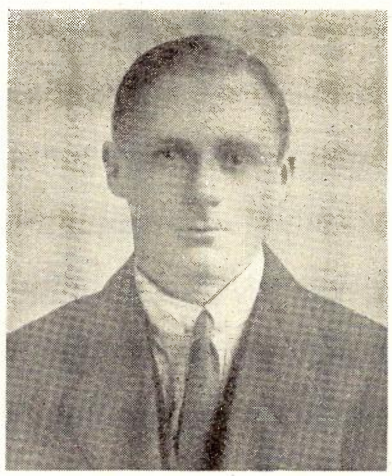
Conclusion

The author took over this work only in the closing stages. A great deal of the developmental and installation work had already been done by Mr. C. M. Lindsay before he was transferred to another State. Whilst on this subject, it is also desired to mention the names of Mr. J. C. Gardner and Mr. A. R. Leebold, officers on the staff of the Chief Inspector, Postal Services, who closely watched the Department's interests during the construction of the building and assisted in respect to accommodation for telephone cable and equipment.

MR. A. R. GOURLEY, A.M.I.E. (AUST.)

In May, 1932, at the old Research Laboratories, Melbourne, a meeting was held amongst a few persons interested in reviving the activities of the Postal Electrical Society of Victoria, which had ceased active work some 10 years previously.

As a result of that meeting the Society was reconstituted and Mr. A. R. Gourley was appointed Honorary Secretary, a post which he occupied for 10 years. During this period he saw, and was chiefly instrumental in bringing about, a growth in membership from about 200 Victorian subscribers to a figure which now approaches 3000, dispersed throughout the Commonwealth. He has seen the Telecommunication Journal, which first appeared in June, 1935, extend, from an ambitious but relatively small half-yearly periodical of 32 pages with a circulation of about 400, to its present form.



The undoubted success of the reconstituted Society and the Journal during their relatively brief existence is due almost entirely to the enthusiasm, vigour and ability of Mr. Gourley. His intimate knowledge of technical subjects likely to prove interesting to members, his extensive acquaintance with men of similar interests throughout the Commonwealth, and, above all, the unstinting way in which he gave hours of his leisure time each week towards the furtherance of the objectives of the Society made success almost inevitable, despite the fact that many difficulties and obstacles inherent in the developmental stages of any new project had to be met and overcome.

At the end of 1942, Mr. Gourley informed the Committee of the Society that he felt that after 10 years he should relinquish the Secretaryship to another. The Committee with great reluctance, but recognising the wisdom and practical concern for the welfare of the Society which have characterised all Mr. Gourley's actions, accepted his resignation. Opportunity was taken, however, at the Annual General Meeting to place on record the profound appreciation of all members for the work performed by Mr. Gourley during his period of service. Subsequently the Committee, by unanimous consent, elected him a life member of the Society, a distinction held previously only by Mr. J. M. Crawford, who was Chief Engineer when the Society was reconstituted.

Not only do members of the Society and subscribers to the Journal owe a debt of gratitude to Mr. Gourley, but the Department itself has benefited in no small measure from his activities as Secretary of the Society, which have been performed without thought of self-interest or personal reward.

Fortunately the Journal is not to be deprived of Mr. Gourley's services, as he will still act on the Board of Editors and will, in this capacity, continue the work which he started and of which he has carried the major proportion of the load.

All readers of the Journal will doubtless join in expressing their appreciation of Mr. Gourley's services, and in wishing every success to Mr. W. H. Walker, who has taken over the onerous duties of the Secretaryship of the Society.

RESISTORS AND NON-INDUCTIVE RESISTANCES

H. Clennell

Resistors or non-inductive resistances are used extensively in telephone circuits and a survey of the types available and the factors restricting the field in which the various types are used will be of interest.

The main design factors to be considered in designing or selecting a resistor for a particular purpose are:—

(1) The value of the resistance in ohms should be close to the nominal value of the resistance required. The resistance is measured at 20°C. (68°F.) and a tolerance of $\pm 2\frac{1}{2}\%$ is permitted. Resistances can readily be wound within this tolerance.

(2) The value of the resistance when hot should be reasonably close to the normal resistance; that is, the temperature co-efficient of the resistance wire should be low. A tolerance of from 2% to 4% is commonly allowed for the increase or decrease in resistance when hot.

(3) The mechanical design of the resistance spool or coil should be such as will facilitate mounting.

(4) The resistance spool or coil should not occupy more space than necessary.

(5) The continuous rating of the resistance in watts should be sufficiently high to ensure that the heat produced as the result of the I^2R loss can be safely dissipated without introducing a fire risk or causing any harmful effects to the resistance or neighbouring items of equipment.

(6) The first cost of the resistance should be as low as possible, taking into consideration the requirements which have to be met.

(7) The inductance of the resistor or resistance should be low, but in most cases resistances wound inductively on a non-magnetic core are suitable.

Resistance wires commonly used are nickel silver, nickel copper and nickel copper manganese alloys. The specific resistance and temperature co-efficient of various resistance alloys are listed in Table 1. Copper is included for comparative purposes.

The values quoted are approximate. Accurate information is issued by the manfacturers of resistance wires respecting their own products. Nickel silver and copper nickel alloys are commonly used for resistors, but copper nickel manganese alloys may be used particularly where a low temperature co-efficient is important, such as in the manufacture of standard high quality resistors. Manganin has a zero temperature co-efficient at 25°C.

In most cases, a resistance wire with a high resistance per unit length is desirable because this enables the resistance to be obtained with a minimum length of wire, thus ensuring a compact winding with minimum self-inductance. A low temperature co-efficient is desirable to ensure that the resistance of the coil, when hot, does not differ greatly from the normal resistance at room temperature.

TABLE 1.

Conductor	Specific Resistance in micro ohms per cubic centimetre	Temperature coefficient per degree Centigrade
(1) **Nickel Silver Alloys:**		
(a) Average commercial grade (Cu 55%, Ni 18%, Zn 27%)	29	.00027
(b) Platinoid (Cu 62%, Ni 15%, Zn 22%)	34	.00025
(2) **Copper Nickel Alloys:**		
(a) Constantan (Cu 60%, Ni 40%)	41	.000008 .000002 @ 25° C.
(b) Advance (40 to 45% Ni, balance Cu)	48	.00002
(c) Ferry (Henry Wiggins Alloy, approximately 40 to 45% Ni, balance Cu)	48	.00002
(d) Eureka (45% Ni, 55% Cu)	47	.00005
(3) **Nickel Copper Manganese Alloys:**		
(a) Manganin (Cu 84%, Ni 4%, Mn 12%)	44	.000006 .000000 @ 25° C.
(b) Tarnac (Henry Wiggins Manganin)	39	.000017
(4) **Copper**	1.78	.00428

The insulating materials used should be non-hygroscopic, capable of withstanding high temperatures and sufficiently strong mechanically for the purpose. For resistors with a high continuous rating insulating materials such as mica, micanite, phenolised asbestos glass and porcelain are suitable. For resistances with a low continuous rating a moulded insulation, such as phenol formaldehyde, is suitable.

Enamel or textile covered wire is required where a bare wire cannot be used. Enamel covered wire is most suitable for Australian conditions. Coils wound with textile covered wire must be thoroughly impregnated with a suitable non-hygroscopic impregnant for use in localities subject to adverse humidity conditions. Owing to the increased space factor a coil wound with textile covered wire has a continuous rating approximately 50% greater than a coil wound with enamel covered wire.

The continuous rating in watts of a resistor or resistance coil depends upon

(a) the permissible temperature rise as fixed by the resistance variation;

(b) the ability of the insulation used to withstand the temperature attained.

The temperature rise may be fixed by the permissible resistance variation when hot. In any case, there is a definite limit to the permissible heat loss for any particular resistor. The rate at which heat is radiated from the resistor depends upon its physical size or effective radiating surface and the temperature difference between the resistor and the surrounding atmosphere. When the resistor is switched into circuit the heat generated as the result of the I^2R loss heats the conductor and raises its temperature, thus enabling heat to be given off to the surrounding atmosphere. The temperature gradually increases and with this increased temperature the heat dissipation increases until a heat balance is obtained between the heat developed in the resistance and that lost or radiated to the surrounding atmosphere. The temperature then remains stationary at this point and the resistance must be designed to allow this stationary temperature to be attained before the insulation materials used are damaged.

If a resistor is to be placed under continuous load without being damaged, its continuous rating in watts is checked by practical tests. For example, resistor No. 9 has a continuous rating of 10 watts. If a load of 20 watts is applied, the enamel coating is exuded in drops of liquid which again gradually harden. If a load of over 35 watts is applied, inflammable gas is given off, which introduces a fire risk. With a load of 60 watts the resistor reaches a dull red heat and thereby introduces a contact fire risk. The maximum permissible heat dissipation of resistor No. 9 is, therefore, fixed at 10 watts and this ensures that the resistor can be loaded continuously without risk of damage to the resistor or surrounding equipment.

Resistors are wound inductively because this is the simplest and cheapest method of winding. As the core or spool is non-magnetic, the inductance of the resistor is comparatively low.

The inductance in microhenries for typical resistors No. 9 is set out in Table 2:—

TABLE 2.

Resistance in ohms	Turns	Measured Inductance in microhenries (μH)
1	10	3
10	31	20
100	46	40
1000	141	390

However, where necessary, resistors can be wound non-inductively to meet special conditions.

The resistors generally available are listed in Table 3:—

TABLE 3.

Resistance	No. of Terminals	Resistance in ohms	Max. permissible heat dissipation in watts	Size
1. Resistance Spool, No. 1	2	3 to 10,000	$4\frac{1}{2}$	$4\frac{5}{8}$″ x $1\frac{1}{2}$″
2. ,, ,, No. 2	3	3 to 5,000 each winding	$4\frac{1}{2}$	$4\frac{5}{8}$″ x $1\frac{1}{2}$″
3. ,, ,, No. 6	2	10 to 200	—	$\frac{5}{8}$″ x $^{19}/_{64}$″ diam.
4. ,, Coil, No. 9	2	1 to 500 500 to 2000	10 8	1″ x 1″ diam.
5. ,, ,, No. 12	2 or 3	1 to 20,000	2	$\frac{5}{8}$″ x 1″ diam.
6. Commercial resistances, various radio types	2	up to 5 megohms	$\frac{1}{2}$, 1, etc.	Various $1\frac{7}{8}$″ x $\frac{1}{4}$″ diam. with 2″ pigtails is typical.
7. Resistances added to relays	as required	as required	Heat loss from all windings not to exceed rating for relay.	Added to winding space on relay bobbin.

In each case the maximum permissible heat dissipation is given, but it will be appreciated that this rating is dependent upon the location of the resistor with respect to neighbouring equipment and the heat generated in these neighbouring items of equipment.

Resistance spools Nos. 1 and 2 are shown in Fig. 1. These resistors are used extensively in C.B. manual exchanges. Resistance spool No. 1 is provided with two terminals and can be wound with resistance values ranging from 3 ohms to 10,000 ohms. Resistance No. 2 is provided with three terminals and between each pair of terminals windings of 3 ohms to 5,000 ohms can be provided.

The permissible heat dissipation is $4\frac{1}{2}$ watts. These resistors are non-inductive because the resistance wire is wound on a flat core of phenolised asbestos which ensures that each half turn is closely associated with the adjoining half turn of the winding and inductive effects are thereby neutralised. Bare resistance wire is used and the turns are carefully spaced to prevent contacts between adjoining turns.

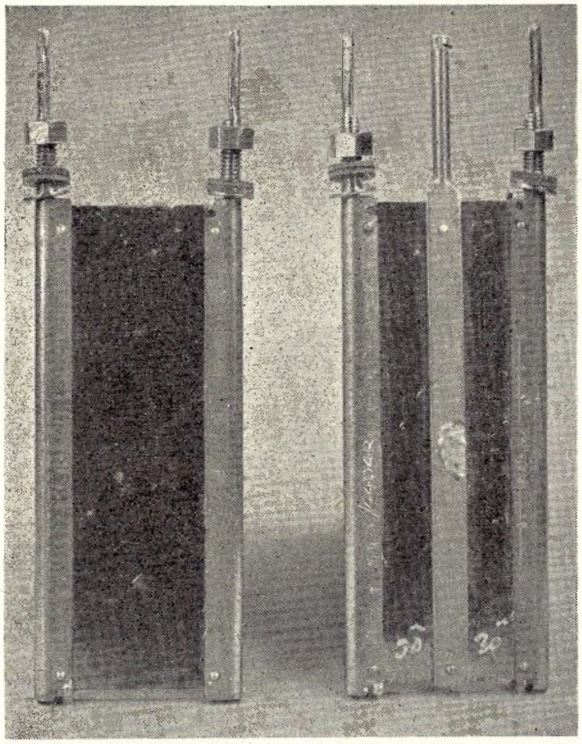


Fig. 1.—Resistance Spools, Nos. 1 and 2.

The resistance wire wound on the flat core is enclosed between two mica sheets and the assembly is clamped together by brass end pieces and riveted. The end pieces are extended to form the terminals.

These resistors are not now extensively used because they require a rigid mounting plate specially drilled and provided with insulation bushes in the mounting holes because the terminals are used to fix the resistors in place. In general, resistance No. 9 is now used where a high heat dissipation is required and resistance No. 12 where the heat load will not exceed 2 watts.

Resistance coil No. 6 is shown in Fig. 2. It is a small resistance finished with a vitreous

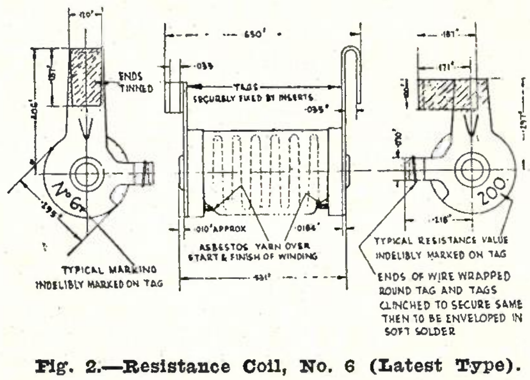


Fig. 2.—Resistance Coil, No. 6 (Latest Type).

enamel and with the ends designed to provide tags which can be readily clipped and soldered to, say, a condenser terminal when these resistance coils are used as spark quench resistances.

No heat rating is quoted for this resistance coil because it is only used in situations where it is required to carry comparatively small currents.

The resistance values normally obtained and the colour code used to provide a means of discrimination are listed in Table 4:—

TABLE 4.

Resistance in ohms	Colour Code
200	Grey
100	Blue
10	Yellow

The dimensions of the spool are $^{21}/_{32}$″ x $\frac{5}{8}$″ diameter.

An earlier form of resistance coil No. 6 is shown in Fig. 3. This resistance is wound on S.R.V.P. board or red fibre.

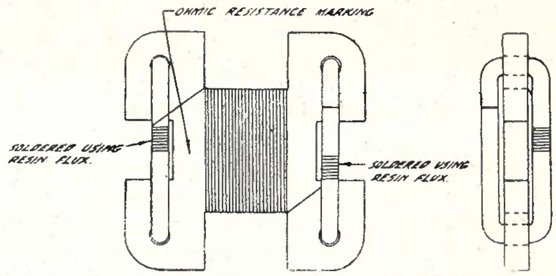


Fig. 3.—Resistance Coil, No. 6 (Early Type).

Resistance coil No. 9. It is a resistance wound on a ceramic bobbin. For resistance values up to and including 500 ohms the resistance is obtained in a single layer and the heat rating in free air is 10 watts. For resistances between 500 and 2,000 ohms a multilayer coil is used consisting of an odd number of layers. The heat rating for these higher resistance values is 8 watts.

Resistance No. 9 is very satisfactory for general purposes. It has a high heat rating and is very compact, its dimensions being 1″ x 1″ diameter. It can be readily fixed to a mounting plate already drilled for relays, or if it is necessary to drill specially, the drilling is simple as these resistors are fixed by a No. 3 BA screw or stud. Two resistances No. 9 and one resistance No. 12 can be secured on the same stud with the standard mounting plate and cover.

The resistance tolerance is ±10% for resistances up to and including 1 ohm, ±5% for resistances between 1 ohm and 10 ohms and $\pm 2\frac{1}{2}$% for resistances over 10 ohms.

Fig. 4 shows two types of resistances No. 9, one type is an earlier form which is grooved in the form of a spiral, the other figure shows the latest type in which provision is made for the resistance wire between two raised portions provided at the ends. The latter form is cheaper because the ceramic is of simpler design.

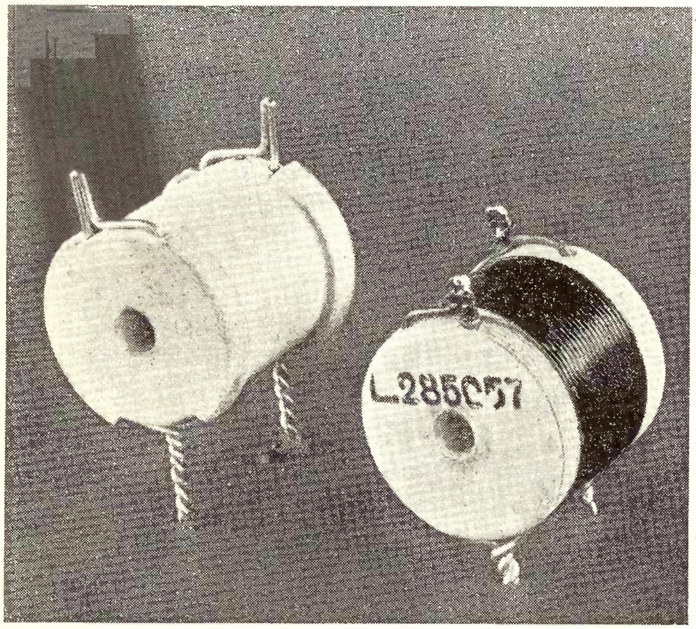


Fig. 4.—Resistance Coil, No. 9.

Resistance coils No. 12 are shown in Figs. 5 and 6. Resistance No. 12 is a resistance wound on a moulded spool of phenol formaldehyde (see Fig. 5) or alternatively the coil bobbin may consist of a brass tube with S.R.V.P. board checks.

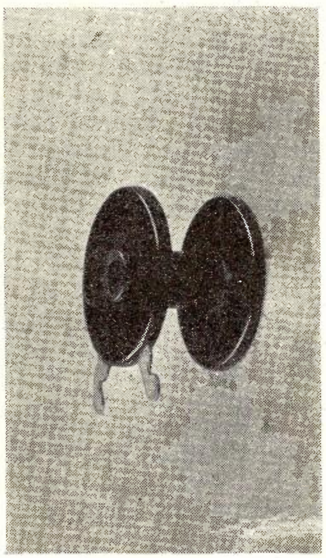


Fig. 5.—Resistance Coil, No. 12—Moulded Spool Shown Unwound.

The maximum permissible heat dissipation is 2 watts. In general, these coils are wound inductively, but where specified non-inductive windings can be obtained, although this is seldom necessary.

The coil winding is protected against mechanical damage by $1\frac{1}{2}$ layers of undyed empire cloth which is secured by Necol or other approved cement. The surface temperature of any coil should not exceed 55°C. (131°F.) after a continuous heating test of 2 watts for 30 minutes. Resistance coil No. 12 is cheaper than resistance No. 9 and is, therefore, used where the lower heat rating is suitable. The dimensions of the spool are $\frac{5}{8}''$ x 1″ diameter.

This resistance can be obtained with two or three terminals according to the resistance windings desired. These resistances are readily mounted, a No. 3 BA screw or stud being used as for resistances No. 9. Three to six resistances No. 12 can be readily assembled on a stud when a moulded spool is used with the terminals moulded on the inner face of one of the cheeks.

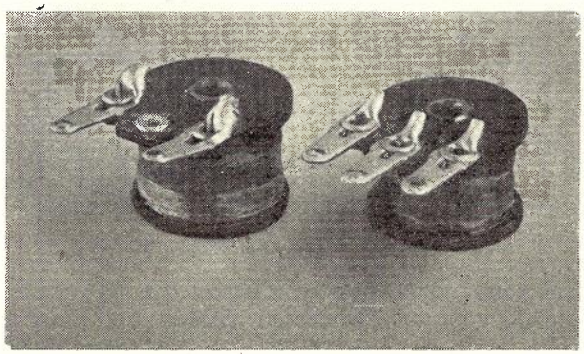


Fig. 6.—Resistance Coil, No. 12, with Terminals Riveted on External Face.

Some manufacturers supply resistances No. 12 with the terminals riveted on the outer face of one of the cheeks (see Fig. 6). In this case a small cylindrical brass distance piece is necessary between adjoining resistances No. 12 mounted on the same screw or stud.

Commercial resistors of various types used extensively in radio work are available and in some cases they may be conveniently used where ratings of 1/2 watt or 1 watt are suitable. These resistances are manufactured with a resistance tolerance of $\pm 10\%$, but if necessary a resistance tolerance of $\pm 2\frac{1}{2}\%$ can be obtained. These resistances are carbon metallised filament or wire wound. Carbon type resistors are subject to the disadvantage that under service conditions their resistance may depart appreciably from their initial resistance.

The construction of a metallised filament resistor is shown in Fig. 7. The metallised filament is produced by spraying a homogeneous resistance film consisting of carbon particles with a synthetic resin binder on an insulating base consisting of a glass tube, glass rod or ceramic tube. The resistance coating is applied and cured at a high temperature. The result is a non-ageing, moisture-proof resistor capable of fulfilling most requirements if a proper selection is made of one of the types available. Modern resistances constructed on the metallised filament principle can be obtained with comparatively low operating temperatures and comparatively high heat dissipation in a conveniently small and sturdy resistor provided with maximum protection against adverse humidity conditions. A range of resistance values up to 5 megohms is available.

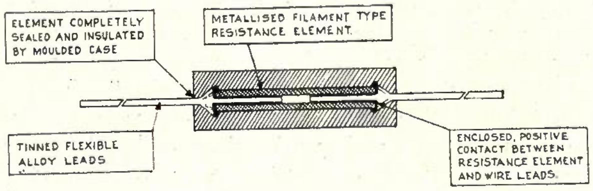


Fig. 7.—Metallised Filament Resistor.

The temperature co-efficient of these resistances is comparatively high, typical values being 0.02% per degree C. to 0.05% per degree C. This is much higher than the temperature co-efficients quoted in the table for the resistance wires used in our standard resistances. However, in some cases this higher temperature co-efficient is not disadvantageous.

In wire wound resistors of the radio type the resistance wire is wound on a textile core of small diameter (see Fig. 8). Wire terminals are provided and securely crimped under pressure to each end of the element. The entire assembly is moulded at high pressure in a phenolic compound, thus ensuring the maintenance of a permanent and positive contact. These resistances are wound with $\pm 10\%$ tolerance, but for special purposes a resistance tolerance of $\pm 2\frac{1}{2}\%$ can be obtained.

The coatings applied to radio type resistors vary according to the desired use, one type of coating is an organic material which is suitable for use where low cost and good protection for adverse humidity conditions are desired. In this case the coating has a temperature rise limitation of 130°C. based on a 30°C. atmospheric temperature.

The second type of coating is designed for relatively low range high temperature requirements where the wire sizes are sufficiently large to ensure dependability. The wattage ratings obtained with this coating are based on a 250°C. rise and this coating is suitable for normal atmospheric conditions.

A third type of coating is available which has been specially developed for the most adverse conditions encountered such as on shipboard, in tropical countries and in conditions where extremely adverse humidity conditions are experienced.

Resistances wound on relays. In addition to the various types of resistances specified above, it is frequently practicable to secure the resistance desired without introducing any mounting difficulties by adding a resistance winding to a relay with which the resistance is associated in the circuit. A case in point is the 70 ohm non-inductive resistance associated with the 30 ohm supervisory relay in the standard "A" position cord circuit.

In this case space is available on the relay spool for the resistance and as the resistance is connected across the relay terminals special wiring is unnecessary. It is important to check the total heat loading which will be experienced owing to the inductive and non-inductive windings on the relay and to verify that this total heat loss is within the maximum rated heat dissipation for the relay concerned.

In some cases the resistance may be wound inductively. A case of this nature is the 2,300 ohm meter used in automatic exchanges. In this case a copper winding of 500 ohms is used and the balance of the resistance is made up with nickel silver wire, wound inductively.

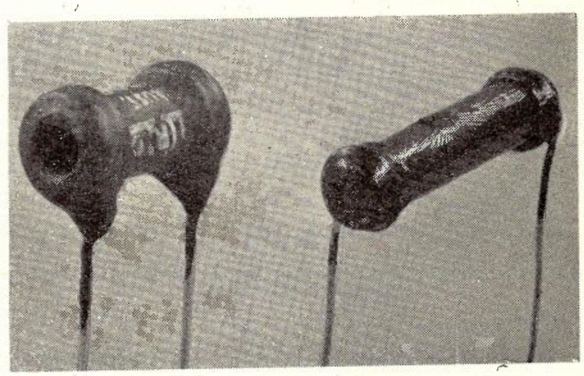


Fig. 8.—Wire Wound Resistors (Radio Type).

Resistances can be added to relay spools where the following conditions apply:—

(1) The resistance is associated closely with the relay in the circuit.

(2) The total permissible heat rating of the relay is not exceeded.

(3) Space is available on the relay spool for the resistance winding.

In some cases it is possible to arrange that the resistance shares either one or both terminals with the inductive winding.

The main consideration in all cases is to select within the desired tolerance a suitable resistance which is cheap to manufacture, mount and wire in the circuit concerned.

A THREE PHASE AUTOMATIC CONTROL RECTIFIER

E. J. Bulte, B.Sc.

It has been well established that the most satisfactory and economical method of operating telephone exchange power plant is to float the exchange load in parallel with a secondary battery across the terminals of the charging equipment. The general principles of the floating procedure are described in the article, "Features in the Power Supply to Automatic Exchanges," Volume 3, No. 5, page 269.

For large exchanges, in general, motor generators are the source of the 50V. D.C. supply, but in many exchanges it is of advantage to provide a rectifier in addition, to take the load during slack hours and so relieve the drain on the battery during periods in which it is uneconomical to run a motor generator because of the relatively small load as compared with the rated output of the generator. In small automatic telephone exchanges, single phase automatically controlled valve or metal rectifiers have been used extensively as the source of the 50V. D.C. supply —see Volume 1, No. 1, page 20; Volume 2, No. 5, page 305; and Volume 2, No. 6, page 369. In general, the output of rectifiers of the types described has been less than 50V. 30A. and the introduction of three phase metal rectifiers with an output of 50V. 30A. is of interest.

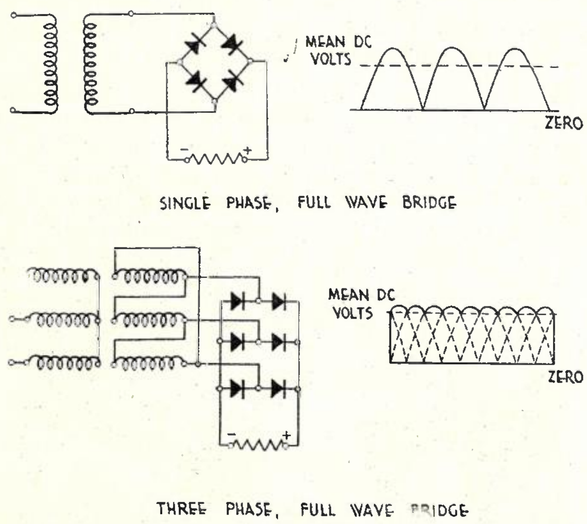


Fig. 1.—Schematic Circuits and Wave Form of Single and Three Phase Rectifiers.

For the operation of telephone exchanges on a floating basis, the charging equipment must have a smooth output, and as shown in Fig. 1 the output from a three phase rectifier has only a small alternating component as compared with that obtained with a rectifier connected to a single phase supply. Therefore, the cost of the smoothing equipment-chokes and/or condensers is much less with a three phase rectifier than is the case with a single phase rectifier of similar output.

It is necessary for the rectifier to maintain the voltage on the exchange busbars either close to the upper limit stipulated for the switching equipment or alternatively within the voltage range for satisfactory operation (46V. to 52V. for nominal 50V. equipment). Also it is desirable to maintain the battery voltage at approximately 2.15V. per cell and avoid discharging which results in loss of specific gravity which can be raised again only by overcharges which are inconvenient to apply with single battery installations. Therefore, automatic voltage control is essential and with these rectifiers the control unit used embraces a relay set with micrometer adjusted relays as described for the valve type rectifier in Volume 2, No. 5, page 305.

A typical circuit for a 24-cell single battery installation is shown in Fig. 2. The method of operation is to float the rectifier on the stop at which its output will be approximately equal to the average drain throughout the business portion of the day. When, due to decreased load, the voltage of the battery rises to the upper limit, the rectifier is automatically changed from three phase to single phase operation, thereby reducing the output. At the reduced output, the idle rectifier bank acts as a smoothing element and due, partly to this, no ripple is introduced under this condition.

When the rectifier is switched on and assuming the battery voltage is less than 52 volts and greater than 49 volts, then relay B is operated and closes the third phase lead from the transformer to the rectifier pile. The rectifier supplies current to the battery and load via relay C, which operates and at contact C2 closes the circuit of relay D which, however, will not operate until the battery voltage rises to 52 volts. When this occurs, relay D operates (the contact arrangements at D2 being to ensure quick and reliable operation) and at contact D1 closes a circuit for relay A which is energised and locks through contact A1. The operation of relay A causes the release of relay B whose 30 amp. mercury tube contact opens one phase lead between the transformer and the rectifier pile, thus converting the rectifier to single phase operation. Under these conditions the current output is reduced to approximately one-sixth in value. Relay C is adjusted to release with single phase charging and releasing restores relay D. When the battery voltage drops to 49 volts, relay A releases, operating B. Subsequently C operates as the full charging current is applied when B operates. The full charge continues until the voltage again rises to 52 volts. When operating

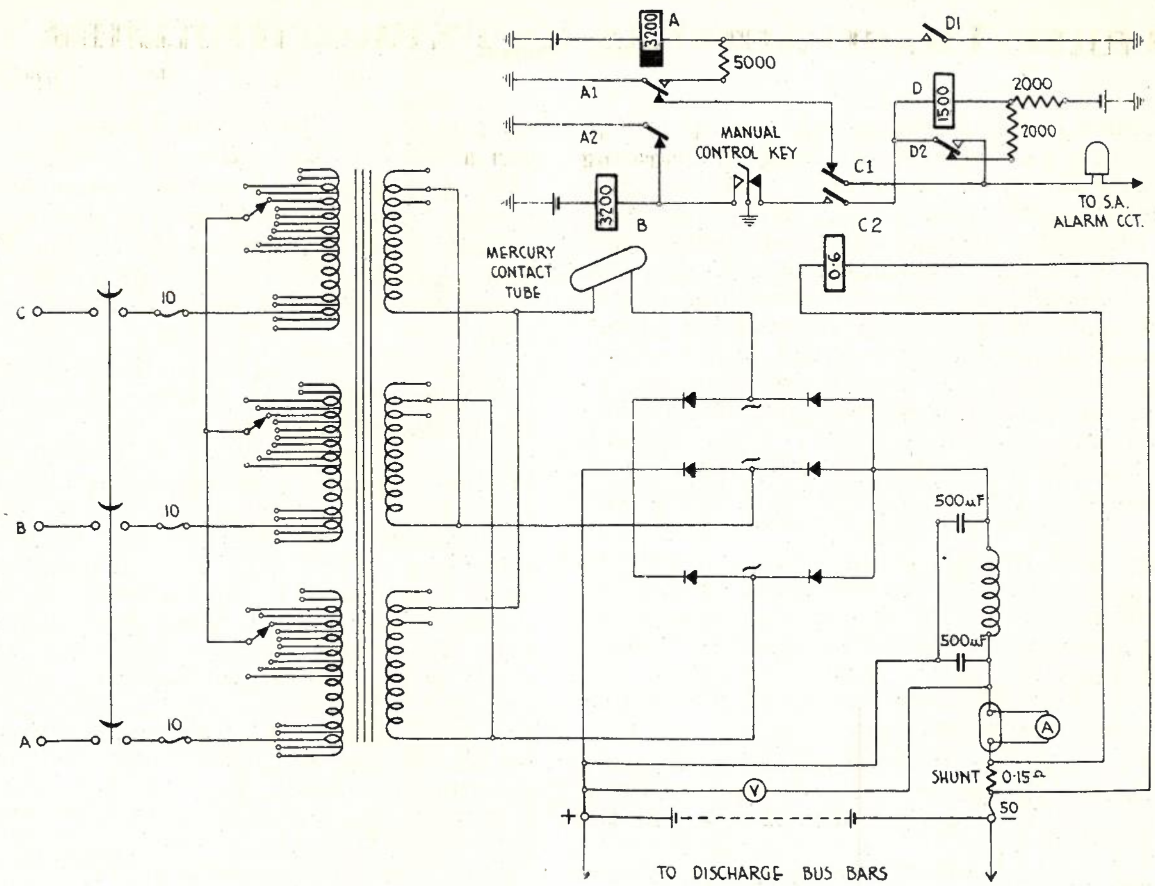


Fig. 2.—Three Phase Rectifier and Control Circuit.

under these conditions, although a certain amount of cycling of the battery occurs, the specific gravity is maintained close to its maximum value.

In some exchanges where contact voltmeters are available, use has been made of these to control the output. By using the existing contact voltmeters a more reliable control is achieved with the addition of a simpler relay set. A typical circuit is shown in Fig. 3, the operation thereof being as follows: — When the battery voltage falls to 50 volts, relay LV operates and locks via LV2 which also provides a circuit for relay C. C operates and the 30 amp. mercury tube contact C1 closes the circuit of the third phase lead between the secondary of the transformer and the rectifier pile. A full charging current now flows. When the battery voltage reaches 52 volts, relay HV operates opening the circuits of LV and C at HV2 and locking its own circuit at HV1 when LV releases. The mercury tube contact C1 opens the circuit of the third phase lead, thus reducing the output of the rectifier to about one-sixth of its original value.

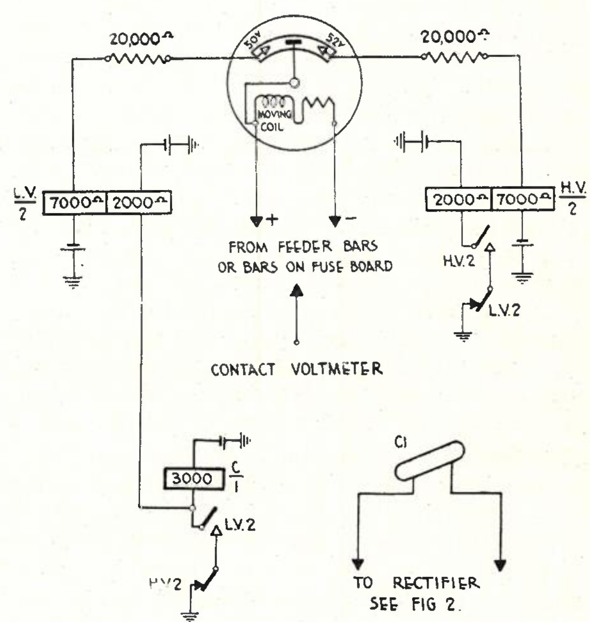


Fig. 3.—Control Circuit Utilizing Contact Voltmeter.

AUTOMATIC ROUTINERS IN TYPE 2000 EXCHANGES

T. T. Lowe

Résumé of First Section.—In the last issue of the Journal (Volume 4, No. 2, October, 1942), the first section of an article describing Automatic Routiners installed in 2000 Type Exchanges was included. Routine testing and manual routine test sets were discussed briefly. The considerations which justify the provision of automatic routiners were then referred to, followed by notes on the development and design of automatic routiners. A brief description of the automatic routining equipment installed at Rockdale, Sydney, which is a 2000 Type Exchange, was followed by a detailed description of the operation of the Rockdale Final Selector Routiner when testing P.B.X. Final Selectors.

Figs. 3 to 12 only, of the detailed description, were included in the October issue. Fig. 1 is a photograph of the Routiner and Access Control Rack and the Access Selector Rack at Rockdale Exchange. Fig. 2 is a trunking diagram showing the schematic arrangement of the routiner and access equipment.

Figs. 3 to 17 indicate the circuit operations of the Access Equipment on a General or Group Routine. (Figs. 13 to 17 are included in this issue.) The Start Key "K.S.," one of five Control Keys mounted on the routiner rack, is operated (Fig. 3). The Rotary Distributor Switch steps to No. 2 position (Fig. 4). The Bimotional type Access Selector connected to the second contact of the distributor switch then takes its first vertical step (Fig. 5). The Access Selector then makes the first rotary step (Figs. 6 and 7). and the Routiner is connected to the first switch to be tested. The routine test, which will be described in subsequent issues of the Journal, is then performed on the switch (Fig. 8). When the test on the first switch is completed, the access selector takes the next rotary step (Fig. 9), and the next switch is routined. Fig. 10 shows the conditions when the access selector steps over unequipped positions. When the access selector reaches the 11th rotary position, it releases in the normal manner (Figs. 11 and 12).

Résumé of this Section.—In this issue of the Journal, Figs. 13 to 23 complete the description of the operation of the access equipment, associated with the final selector routiner. Figs. 24 to 29 refer to various alarms. Fig. 13 shows the conditions when the access selector is stepped to the third level, assuming that the second level is unequipped, the switches connected to the third level being then tested in turn. Fig. 14 shows the circuit operation when the access selector is stepped to the 11th rotary contact, on the last equipped level, and the distributor switch is stepped to the next access selector. Unequipped positions on the distributor switch are connected as indicated in Fig. 15.

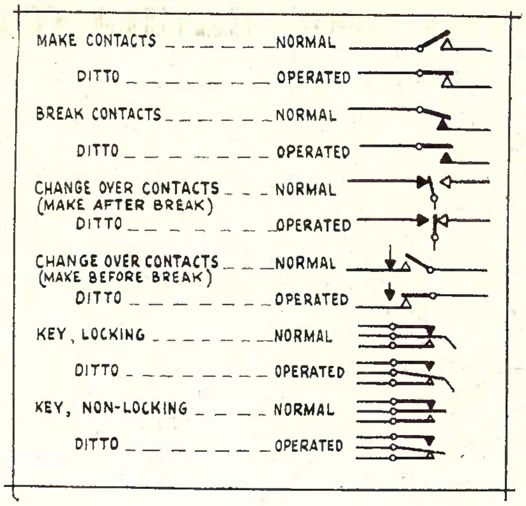
When a general or group routine is finished the last access selector reaches the 11th rotary contact on the last equipped level (Fig. 16). The Start Key is then restored to normal and the access and distributor switches return to normal (Fig. 17).

When it is desired to continuously routine a particular switch (see October issue, page 115), the Continuous Routine Key "KCR" is operated and the distributor switch is stepped manually to the required position, using key "KDS" (Fig. 18). The appropriate access selector is then stepped vertically to the required level using key "KVS" (Fig. 19). The access selector is next stepped to the required rotary contact on the selected level using key "KRS" (Fig. 20). The routiner is now connected to the desired switch and to continuously routine this switch it is necessary only to operate the Start Key "KS" (Fig. 21). The routiner may be reset at any time during a continuous routine by operating the Reset Key "KR" or by plugging a short-circuited plug into the appropriate jack provided on the switch racks (Fig. 22). (See October, 1942, issue, page 114, for Remote Control of the Reset Feature.)

When a group routine is being performed, and a fault is detected, operation of the Step On Key "KSO" resets the testing circuits to normal and steps the access selector to the next switch to be tested (Fig. 23).

Various Alarms.—If a switch fails to operate satisfactorily under the test conditions applied, the routiner stops and the testing mechanic's attention is drawn to the fault by means of the Rack Alarm lamp and bell and the appropriate Test Lamp associated with the routiner (Figs. 16 and 24). If the rotary distributor switch or the rotary test or auxiliary test switches associated with the routiner fail to return to the home position, the Routiner Switch Release Alarm lamp glows (Fig. 25). If the access selector vertical magnet is held operated for an unduly long period, the Permanent Vertical Alarm lamp will glow (Figs. 25 and 26). If the access selector fails to release due to its "B" relay holding, the Access "B" Hold lamp will glow (Fig. 27). If the access selector fails to release when its "B" relay is normal the Access Switch Release Alarm lamp glows (Fig. 28). A Test Start Fail Alarm lamp is provided also (Fig. 29).

In this and subsequent issues, relay contacts are shown in accordance with Drawing C.654 as follow:—



Although this was not strictly adhered to in the last issue of the Journal, no difficulty should be experienced in following the various circuit operations. In Figs. 3 to 12 included in the last issue the following are make contacts shown in the operated positions, which could be designated thus ⊖ in red:—

Fig. 3—H5, shown as H21, 22.
Fig. 4—H1, H2, H6, H8, MD4.
Fig. 5—H4, B1, B6, B7.
Fig. 6—EQ2, EQ4, EQ5, H4, MD1, B1, B7, TF5.
Fig. 7—EQ1, B1, B4, TF1.
Fig. 8—HD1, HD4, H3, WW1, TS4, EQ3.
Fig. 9—TS6.
Fig. 10—B1, B2, B3, H7.
Fig. 11—B1, H8, MC3, MD4.
Fig. 12—LF1.

The Start Key "KS" is a locking key and is shown in the operated position in Figs. 3, 5 and 8. The Step On Key "KSO" is non-locking and is shown in the non-operated position in Figs. 1 and 8.

Access Selector Steps to the Next Level to be Tested (Fig. 13). — When the access selector reaches the normal position, the "N" springs operate B relay, which locks as in Fig. 5. The vertical magnet is energised when B relay operates and closes the V springs which operate TF relay (Fig. 5).

When the vertical wipers reach the first level, no circuit is available to operate relay EQ, so relay TF re-operates and operates the vertical magnet again to step the selector to the second level. As the second level is unequipped no circuit is available to operate EQ and TF relay operates again and steps the switch to the 3rd level. Relay EQ operates on the 3rd vertical step from ground via H 8-9 operated, AW 1 wiper and vertical bank, relay TF 500 ohms, relay EQ 700 ohms to battery. Relay TF releases, followed by relay PD (Fig. 6), and relay HD operates (Fig. 8). HD 23-24 operated opens the circuit to MC and MD relays which release (Fig. 11). The selector rotary magnet operates as in Fig. 7 and the final selectors connected to this level are tested in turn.

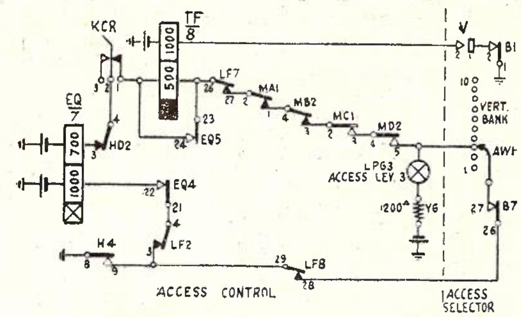


Fig. 13.

The Distributor Switch Steps to the Next Access Selector (Fig. 14). — When the access selector has stepped to the 11th contact on the last equipped level, the "S" springs operate and the distributor drive magnet, D50, is energised from ground via S 1-2 operated, distributor drive magnet, relay RA4 to battery. After the release of TF relay, LF relay operates (Fig. 11) and opens the circuit to the distributor drive magnet which releases and steps the distributor switch to the next position.

The first equipped level on the second access selector is marked by MD relay operating from ground via B 1-2 operated, W6 wiper and bank, vertical equipped strap, relay MD 1300 to battery. Relay MD locks from ground via H 28-29 operated, relay MD 1300 ohms to battery.

When the distributor steps to the next position the second access selector functions similarly to the first (Fig. 5) and all tests are carried out as previously described.

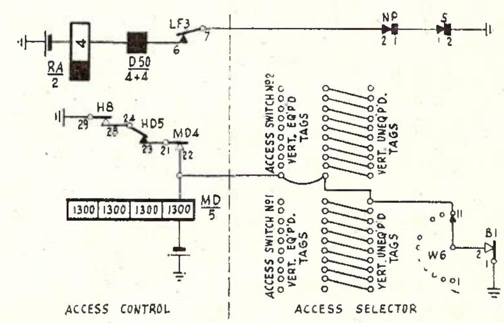


Fig. 14.

The Distributor Switch Steps Over Unequipped Positions (Fig. 15). — Unequipped positions on the distributor switch are strapped to the unequipped tags and ground via relay PD 3, key KCR 21-22 normal, distributor unequipped strap, distributor 1 and 2 bank and wiper, Ddm, distributor drive magnet, relay RA 4 ohms to battery drives the distributor switch to the next equipped position.

General or Group Routine Finished (Fig. 16).—When the last access switch reaches the 11th rotary contact on the last equipped level, the "Routine Finished" lamp lights and relay AL

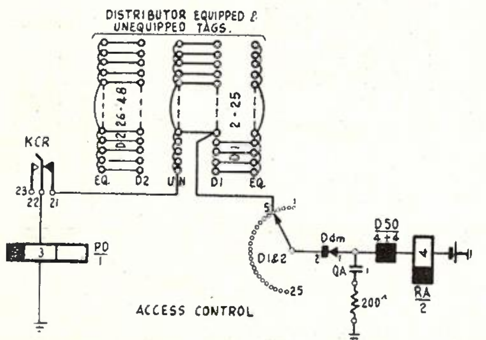


Fig. 15.

operates from ground via B 1-2 operated, "Routine Finished" lamp, relay AL 1000 to battery. Relay AL operates and locks from ground via H 6-7 operated, KSO 4-5 normal, relay AL 1000 to battery. Ground via H 8-9 operated, relay B 2000 to battery, holds B relay operated and ground via AL 3-4 operated, relay TF 1000 to battery holds relay TF operated. Relay AL closes the rack alarm bell and lamp circuit from ground via AL 23-24 operated, alarm bell to battery, and ground via AL 23-24 operated, key KMA 21-22 normal, rack alarm lamp to battery.

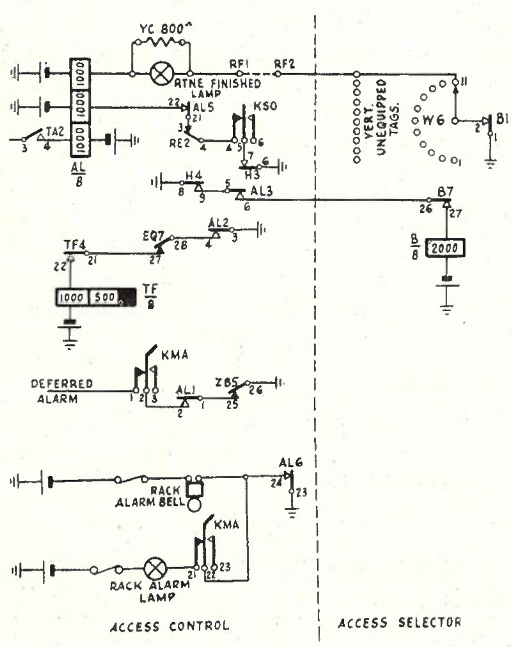


Fig. 16.

AL 1-2 operated, closes circuit to the deferred alarm from ground via ZB 25-26 normal, AL 1-2 operated, key KMA 1-2 normal to the deferred alarm lead.

The Start Key is Restored to Normal (Fig. 17).—The release of the Start Key, K.S., disconnects the circuit of relay H (Fig. 3) which releases, followed by relay AL (Fig. 16). As the distributor is standing on the 50th contact, having driven over unequipped positions, the release of key KS closes a circuit from ground via KS 4-5 normal, distributor 1 & 2 wiper and bank, Ddm, distributor drive magnet, relay RA4 to battery. The distributor switch drives to the home position.

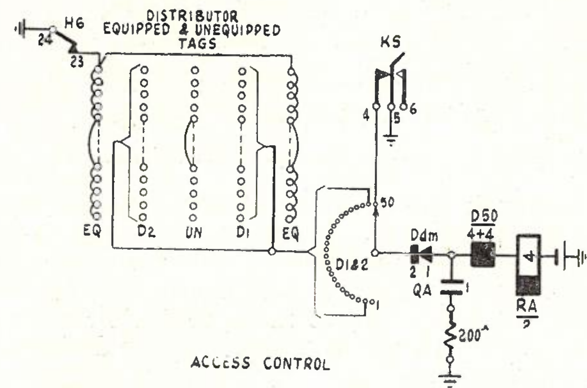


Fig. 17.

Stepping the Distributor Switch to the Required Access Selector (Fig. 18).—When a particular switch is to be routined, the Continuous Routine key KCR is operated. Relay H operates from ground via KSO 24-25 normal, KCR 31-32 operated, relay H 1000 to battery. H relay locks from ground via KCR 11-12 operated, relay H 1000 to battery.

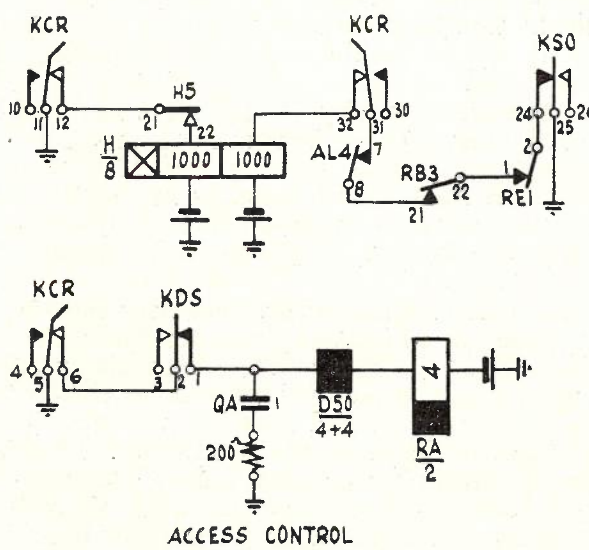


Fig. 18.

The distributor is stepped by operating key KDS which connects ground via KCR 5-6 operated, key KDS 1-2 operated, distributor drive magnet, relay RA4 to battery.

Stepping the Access Selector to the Required Level (Fig. 19).—The Access Selector is stepped to the required level by the Vertical Stepping key, KVS. When key KVS is operated the "B" relay in the appropriate selector operates from ground via key KCR 5-6 operated, key KVS 1-2 operated, LF 8-9 normal, distributor 5 and 6 wiper and bank, N 5-6 normal, relay B 2000 to battery. B relay locks to ground at H 8-9 operated. The vertical magnet is energised from ground via KCR 5-6 operated, KVS 22-23 operated, vertical magnet to battery. Each time key KVS is operated, the access selector wipers are stepped up one level.

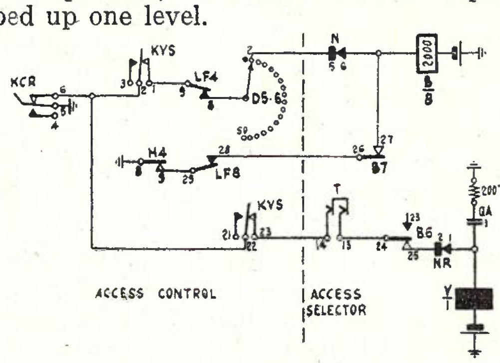


Fig. 19.

Stepping the Access Selector to the Required Rotary Contact (Fig. 20). — When the access selector normal springs close after the first vertical step, the access selector can be stepped to the switch required on the selected level by operating the Rotary Stepping key KRS. The rotary magnet is energised from ground via key KCR 5-6 operated, key KRS 1-2 operated, rotary magnet to battery.

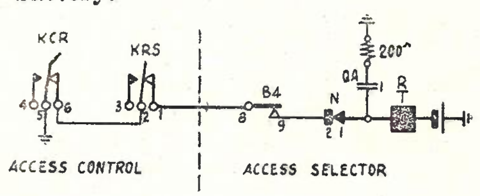


Fig. 20.

Continuous Routine (Fig. 21).—When the access selector is positioned on the switch to be tested the Start Key KS is operated and relay EQ operates from ground via key KS 25-26 operated, key KCR 2-3 operated, relay EQ 700 to battery. Relay EQ locks from ground via H 8-9 operated, relay EQ 1000 to battery. Relay EQ operating, operates relay HD and the routiner starts testing as described in Fig. 8.

As the rotary magnet circuit is open at key KCR 4-5 the access selector does not step to the next rotary contact at the completion of the test cycle, and the test is repeated on the same switch.

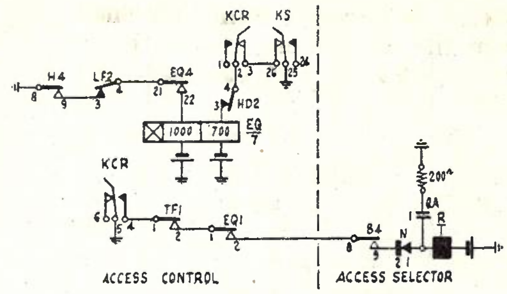


Fig. 21.

Routiner Reset (Fig. 22).—The routiner may be reset at any time when the Continuous Routine key is operated, by operating the Reset key KR or by inserting a short-circuiting plug in the jacks provided on the final selector racks. Relay RE 2000 operates from ground via key KCR 8-9 operated, key KR 1-2 operated, relay RE 2000 to battery.

The operation of relay RE 2000 disconnects the test start lead at RE 21-22 operated (Fig. 8) and the Test Switch in the routiner returns to the home position. RE 3-4 operated disconnects the holding circuit to relay AL (Fig. 16) and RE 1-2 operated, disconnects the holding circuit of relays TA and ZA (Figs. 24 and 25).

Restoration of the Reset key releases relay RE and relay TS reoperates (Fig. 8).

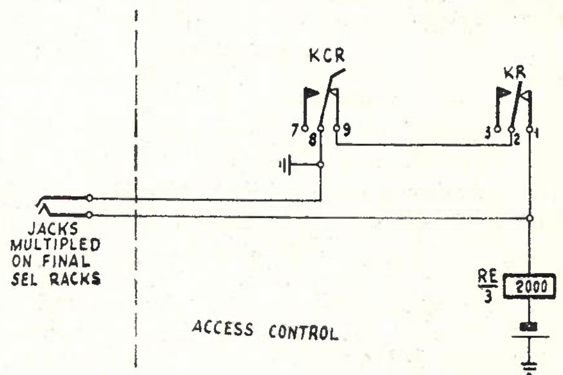


Fig. 22.

Access Selector Step-On (Fig. 23).—The routiner may be reset and the access selector stepped to the next switch by operating the Step-on key KSO. The test start lead is broken at KSO 7-8 operated, and relay TF is operated from ground via H 6-7 operated, KSO 5-6 operated, relay TF 1000 to battery. Relay HD releases and the access switch is stepped to next position (Figs. 8 and 9).

Fault Alarm (Fig. 24).—Should the final selector under test fail under the applied test the routiner will stop. Relay RB in the routiner will not have operated in series with the Test or Auxiliary Test drive magnets. Relay TA will

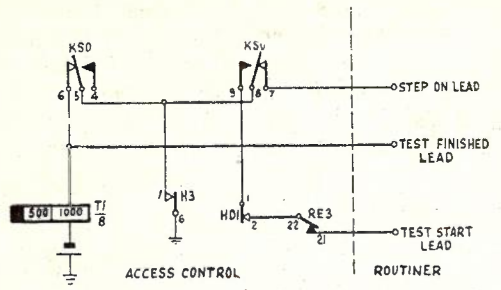


Fig. 23.

operate from ground on the delay set "S" lead via key KAS 2-3 normal, key KS 8-9 operated, RB 3-4 normal, AL 27-28 normal relay TA 1000 to battery.

After the delay period, ground is returned from the delay set on the "Z" lead via key KAZ 4-5 normal, TA 3-4 operated, relay AL 1000 to battery. Relay AL closes the rack alarm lamp and bell and the deferred alarm circuits (Fig. 16).

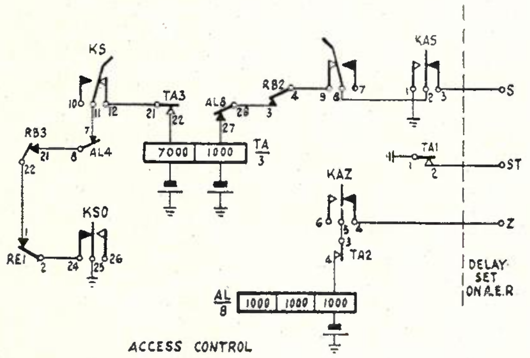


Fig. 24.

Distributor and Test Switches Release Alarm (Fig. 25).—Should the Distributor switch or the Test or Auxiliary Test switches in the routiner fail to home, relays RA or RB will remain operated. Relay ZA will operate from ground on the 9-second delay set "S" lead, ZB 3-4 normal, RA 1-2 or RB 1-2 operated, relay ZA 1000 to battery. ZA locks from ground via key KSO 24-25 normal, RE 1-2 normal, RA 21-22 operated or RB 22-23 operated, ZA 21-22 operated, relay ZA 7000, "Routiner Switch Release" lamp relay ZB 1000 to battery. After the 9-second delay period, relay ZB operates from ground via the "Z" lead, ZA 3-4 operated, relay ZB 1000 to battery, and the "Routiner Switch Release" lamp lights from ground via key KSO 24-25 normal, RE 1-2 normal, RA 21-22 operated, or RB 22-23 operated, ZB 1-2 operated, "Switch Release" lamp, relay ZB 1000 to battery. ZB 24-25 operated, closes the prompt alarm circuit. ZB 21-22 operated, closes a circuit for relay AL which operates the rack alarm lamp and bell (Fig. 16).

Access Selector — Permanent Vertical Alarm (Fig. 26).—If the vertical magnet is energised for over 9 seconds due to a fault, relay TF will remain operated from ground via B 1-2 operated, V 1-2 operated, relay TF 1000 to battery. Ground via KS 5-6 operated, YAA 50, YAB 200,

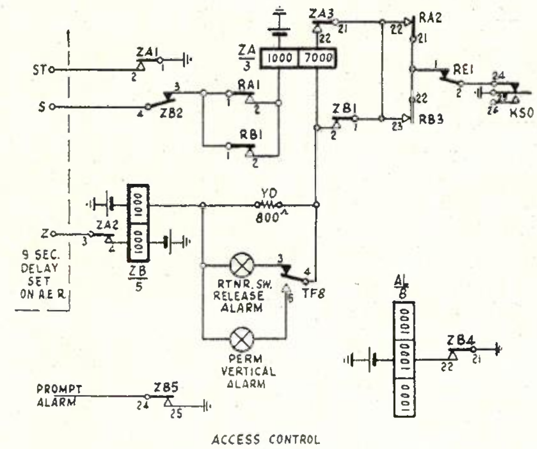


Fig. 25.

TF 7-8 operated, relay RA4 to battery, operates relay RA and the same conditions as in Fig. 25 apply, but in this case relay TF is operated and the "Permanent Vertical" lamp will light instead of the "Switch Release" lamp from ground via key KSO 24-25 normal, RE 1-2 normal, RA 21-22 operated, ZB 1-2 operated, TF 4-5 operated, "Permanent Vertical" lamp, relay ZB 1000 to battery (Fig. 25).

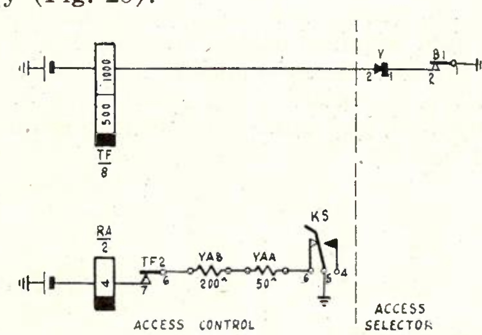


Fig. 26.

Access Selector — B Relay Held Alarm (Fig. 27).—If the access selector fails to release, due to relay B not releasing, relays TA and AL will operate (Fig. 24), and relays LF and PD will remain operated (Figs. 11 and 12) and the "Access B Hold" lamp will light from ground via AL 25-26 operated, "Access B Hold" lamp, YS 1200 to battery. The deferred alarm is brought in by the non-operation of relay RB (Fig. 24).

Access Selector—Release Alarm (Fig. 28).—If the access selector fails to release when B relay is normal, an alarm is given from ground via H 3-4 normal, PD 1-2 normal, TF 25-26 normal, EQ 5-6 normal, HD 25-26 normal, T 13-14, B

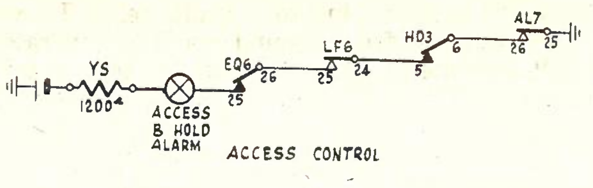


Fig. 27.

23-24 normal, N 3-4 operated, "Access Switch Release" lamp, relay AL 1000 to battery. Relay AL operates and the rack alarm as described in Fig. 16 is given. This alarm is additional to the standard release alarm (Fig. 12).

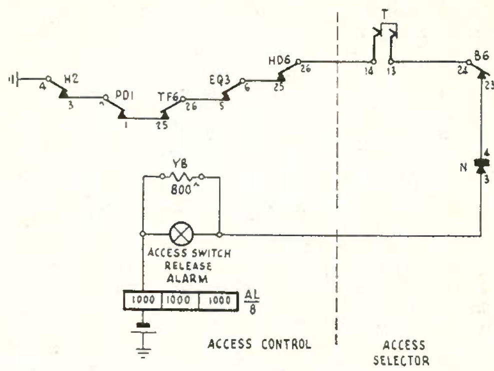


Fig. 28.

Test Start Fail Alarm (Fig. 29).—If relay HD (Fig. 8) fails to operate, the Start signal is not sent to the routiner, relay RB will not operate and relays TA and AL will operate (Fig. 24). The "Rack Alarm" lamp and bell will function (Fig. 16) and the "Test Start Fail" lamp will light from ground via AL 25-26 operated, HD 5-6 normal, LF 23-24 normal, "Test Start Fail" lamp, YP 1200 to battery.

The operation of the Access and Access Control Equipment has now been described. In the next issue of the Journal the description of the operation of the routiner when testing a 200 outlet 2-10 line P.B.X. Final Selector will commence, Figs. 30 to 45 being included. Figs. 30 and 31 indicate how the routiner, when testing, discriminates between 100 outlet ordinary, 100 outlet 2-10 line P.B.X. and 200 outlet ordinary and 200 outlet 2-10 line P.B.X. Final Selectors. In Figs. 32 and 33, the Test Start condition is shown and the guarding of the Final Selector under test against intrusion by ordinary calls.

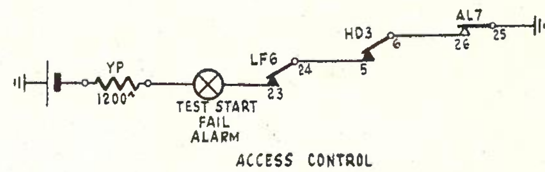


Fig. 29.

Delayed stepping arrangements are shown in Fig. 34. Figs. 35 to 45 indicate the circuit conditions when the Final Selector is tested for the following:—

(1) To ascertain if the switch is free or busy.
(2) The conditions of the incoming negative and positive lines are tested.
(3) The selector is tested to ensure that it guards itself against intrusion when it is in use.
(4) The selector "A" relay is tested for satisfactory operation and release.
(5) Release timing is tested.
(6) The selector is tested under short-line impulsing conditions at 10 impulses per second.

Figs. 46 to 75 will appear in subsequent issues and will complete the description of the routiner when testing final selectors.

(To be continued.)

A NEW INDICATOR FOR MAGNETO SWITCHBOARDS

B. Edwards

For many years, ironclad drop indicators have been used as line and clearing indicators on magneto switchboards. Whilst this type of indicator has proved generally satisfactory in service, there is a disadvantage from the viewpoint of switchboard operation in that the overall dimensions of the indicator necessitate the mounting of line indicators at $1^1/_8$" centers, whereas the associated jacks are on 1" centers, therefore the positions of the indicator and jack individual to a subscriber's service do not line up. Recent developments in basic materials and in manufacturing technique have made possible the redesign of the indicator. The new indicator, which is depicted in Fig. 1, is in production in the Melbourne Workshops.

The design differs considerably from that of the indicator in general use, and has been developed with a view to obtaining improved electrical and mechanical efficiency and a resultant decrease in fault liability and also a simplification of the manufacturing processes. One important advantage is that the reduced overall dimensions will permit the indicators to be mounted on 1" centers, which is the same spacing as that of the line jacks on magneto switchboards.

Another feature of interest is that strips of indicators mount on 1" vertical centers instead of $1^1/_{16}$" as with the old type. On new switchboards this permits the use of a standard stile strip for strips of jacks, lamp sockets and indicators, so that when the new indicator is mounted on a stile strip alternate drillings only are used.

A comparison of the overall dimensions of the old and new indicators is shown in Table 1:—

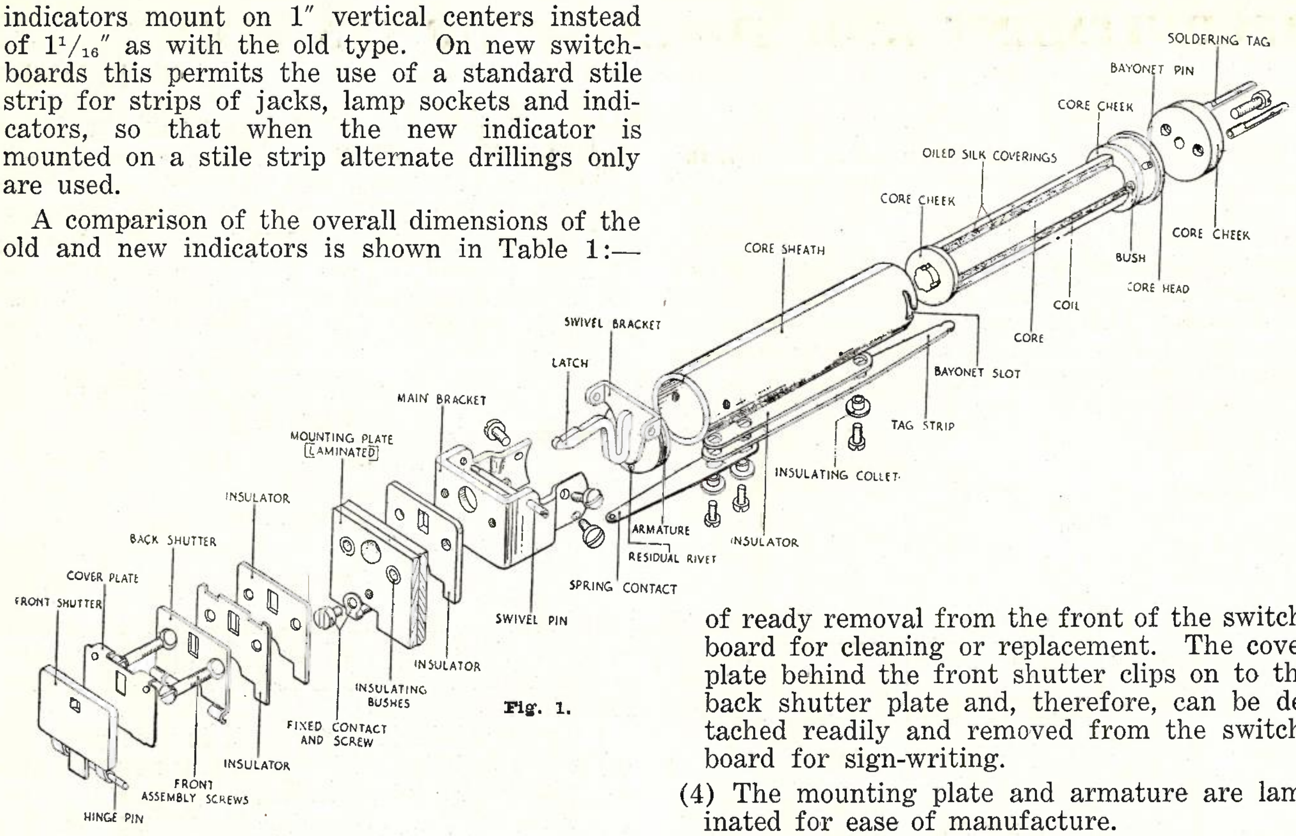


Fig. 1.

TABLE 1

Part	Old	New
External diameter of core sheath	0.875"	0.75"
Length of core sheath	2.43"	2.656"
Height of shutter	1.0"	0.969"
Width of shutter	1.0"	0.937"
Height of mounting plate	1.062"	1.0"

Features of interest are:—

(1) The attachment of the core assembly to the sheath by means of a bayonet socket and pin arrangement which permits of ready removal and replacement of the coil without dismantling the main assembly and without effecting the adjustment of the armature, shutter or night alarm spring assembly.

(2) The armature is opposite to the front instead of the rear of the core; this permits of a more reliable adjustment of the latch and reduces the possibility of alteration with the adjustment during the assembly of a switchboard or in maintenance work.

(3) The fitting of the night alarm contact on mounting plate by means of a screw permits of ready removal from the front of the switchboard for cleaning or replacement. The cover plate behind the front shutter clips on to the back shutter plate and, therefore, can be detached readily and removed from the switchboard for sign-writing.

(4) The mounting plate and armature are laminated for ease of manufacture.

The materials from which the main components are manufactured are:—

Soft magnetic iron—armature, core and core head, and core sheath.
Brass—front shutter, cover plate, back shutter, main and swivel brackets, latch and soldering tags.
Silver steel—hinge swivel pin.
Mild steel—mounting plate.
Nickel silver—spring for night alarm.
S.R.V.P. board—insulating plates and strip.
Enamel-covered wire—coil.

The resistance of the indicators is 1000 ohms for line and clearing indicators for subscribers' lines and 2000 ohms for line indicators for trunk lines. The resistance, when measured with direct current at 60° F., must be within ± 5% of the specified resistance. After assembly, the indicators must function satisfactorily under the following test conditions which are applied in sequence:—

(1) An E.M.F. of 60 volts D.C. is applied for 30 seconds to saturate the coil. When the current is disconnected, the armature should release immediately.

(2) The indicator should operate satisfactorily with an alternating current of 6 milliamperes and a frequency of 17 cycles per second.

RECRUITMENT AND TRAINING OF LINEMEN

T. P. Wilks

Continued from Vol. 4, No. 2, page 77.

Cable Jointing.—The Cable Jointing School, including the buildings and fittings, can be regarded as another example of Productive "Tool Exercises." The layout covered the provision of pipes, pits, terminal pillars, cable heads, fire alarms, etc., and simulated underground construction in a suburban area. Cable Jointing is carried out under conditions as near as possible to that experienced on the actual job.

At the outset, a brief talk is given outlining the advantages of U.G. cables over aerial wires, stressing such points as low maintenance costs, and greater accommodation. Tools used in this work are then exhibited, and their uses and hazards explained. Then follows a lecture on cables, their make-up and uses.

Before actual jointing is commenced, three "essentials" are stressed—

(1) Ability to concentrate;
(2) Protection of conductors from moisture;
(3) Assurance that a joint, when plumbed, is watertight.

After learning the methods of identifying conductors in various types of cable, the first operation is to instruct the trainee on the correct method of jointing conductors. This process, known as "Straight Jointing," occupies a period of approximately three weeks, stepping from small capacity cables (25 pr.) to larger (300 pr.). The last operation is carried out by two trainees alternatively acting as a Jointer and Mate.

Interspersed with these preliminaries, instruction in plumbing is also imparted, and before wiping a sleeve joint, practice, consisting of wiping a "seam," i.e., jointing together two strips of lead, and the more difficult task of wiping a "ball" on a piece of cable, is learnt. Following Straight Jointing, the more difficult Multiple Jointing is introduced. From the preliminary exercises in which trainees joint three cables in full multiple, i.e., 25 pr. main to 2/25 pr. branches, the jointing is rendered more intricate by varying the number, size, and class of cable and arranging the jointing instructions accordingly.

When completed, each joint is plumbed, affording opportunity of practice on the more difficult branch wipe. After completing each joint, tests are made for accuracy (in the initial stages by using trembler bells). Should mistakes occur, sleeves are blown off and a "post mortem" held.

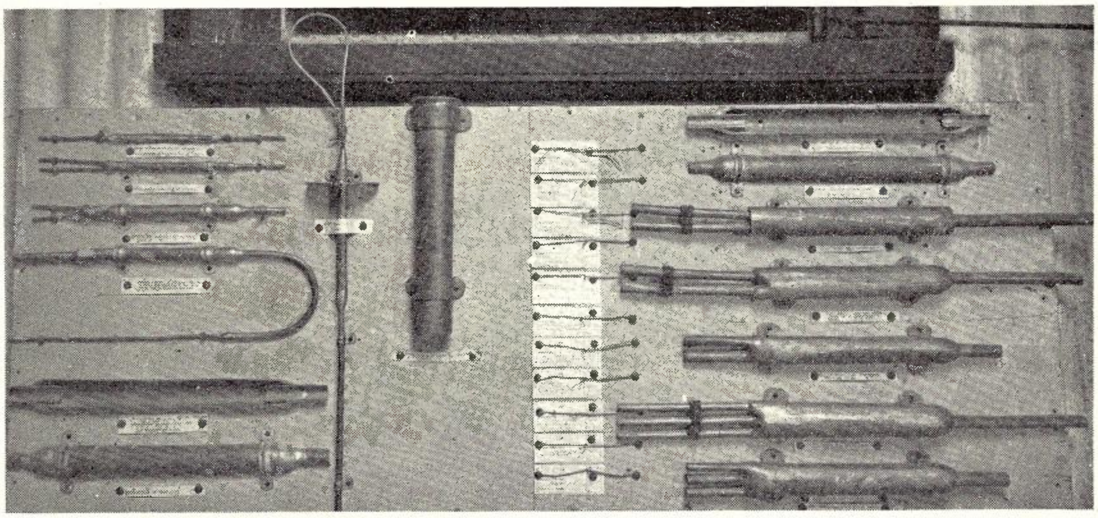


Fig. 6.—Sample Cable Joints.

Any mistakes are then rectified. This "post mortem" facilitates instruction, for practical experience is usually the best safeguard against repetition.

Another exercise introduced at this stage is to use a completed joint as the basis of a multiple alteration. Jointing instructions are supplied. Trainees are required to remove the sleeve and transfer conductors to the new "record" pairs, having full regard for service interruptions.

The next stage is jointing P.I.L.C. cable to S.I.L.C. cable. In this, the colour code is introduced, and the joint is made in a vertical position with the S.I.L.C. conductor terminated on a tag strip.

Having acquired a knowledge of reading cables by the colour code, practice is obtained in wiring pillar terminals. Alternative methods are taught so that pillars could be assembled according to the cable available (S.I.L.C. or P.I.L.C.). Some of the completed terminals are used in the next stage of instruction, which is more comprehensive and creates an opportunity to put into effect the practical side of all the preliminary exercises, which up to this stage have been carried out on the bench. Cables feeding from the main frame are drawn into the pipes laid during conduit tuition. These are arranged to feed two separate routes, one providing facilities similar to the work of accommodating "saturated areas," such as that in which a number of flats are located, and is covered by pillar distribution. The other route, having less development, by pole terminals, some of which are in multiple. Large plans are drawn up and on these all jointing details and allotment of pairs are listed, and from these the necessary particulars are obtained and the work carried out accordingly. Care is taken to effect an equal distribution amongst the trainees.

In addition, training is given in such operations as jointing cables to a jointing schedule determined from capacity unbalance tests, making up potheads and connecting S.I.L.C. cables thereto, jointing loading coil pots, connecting up fire alarms, etc.

The qualifying test at the completion of the course is as follows:—

Section A.—On the Bench—Joint the conductors, sleeve and plumb a large straight joint in which selective splicing is applied to a range of 50 pairs.

Section B.—In a Pit—3-way multiple branch joint, involving a 28 pair cable branching to two 15 and one 10 pair with the 10 pair lateral connected to cable terminal. Fit a sleeve and plumb the joint.

Section C. — On the Bench — Remove sleeve, make multiple alterations to joint made in Section B, refit the sleeve and plumb the joint.

Fig. 7.—Jointing Class at Work.

Conduits.—To facilitate instruction a plan is drawn up which simulates an actual conduit work in the field. This instruction is given collectively, for with work of this nature the best results are obtained by co-operation rather than by individual efforts.

Following lectures on preliminaries dealing with the subjects "Tools and Plant used on Conduit Construction," "Survey of Route," "Departmental Rights and Obligations," a study is made of the plan and the route marked out accordingly. Levels are taken using boning rods and particular attention is paid to the arrangements necessary to provide adequate drainage. The layout is so designed that different classes of ducts or pipes are laid in the different sections; actually this is carried out on a taper system, finishing up with "O" pits and small pipes, similar to the distribution to subscribers' premises, stakes taking the place of building walls. Provision is also made for two cable terminals which occur at the end of each conduit run.

Manholes are also constructed as required, the allotment usually being four trainees per manhole. Associated lectures are given on concrete making, preparation of form work, etc. All sizes of precast pits are used, so as to enable the various methods of pipe entries, and later on the housing of cables to be demonstrated.

Instruction is further supplemented by demonstration and practical experience in the following items:—

Threading and bending pipes.

Splitting E.W. pipes.

Cutting existing G.I. pipe over which a pit is to be installed.

Repairs to broken ducts.

Methods of timbering a trench, etc.

To stress the importance of accurate records, at the completion of the work trainees working in pairs, take measurements of the whole construction, draw a plan and record the measurements thereon.

It is not convenient to carry out a practical test in conduit work and a written test only is applied.

Cable Laying.—Having laid conduits and constructed jointing chambers, the next phase of the training is in cable laying. As with conduits, a plan is prepared in which provision is made to lay different size cables over the varying sections of the layout, commencing at an improvised exchange cable well with a 200 pair cable, and finishing with 1 pair cables leading into "subscribers' premises."

After rodding and cleaning the ducts, the cables are drawn in according to the plan, particular attention being paid to the housing of the cables in the jointing chambers. Following this, the whole of the cables are jointed to a scheme which has also been set out on the plan. Pillars are inserted at suitable points, distribution pairs are provided, and each trainee is allotted a pair at the subscriber's premises and an "exchange" pair at the pillar. After connecting the M.D.F. jumper, the circuit should test out from the M.D.F. to the subscriber's premises. This he must verify by test. Amongst other subjects covered in this course are dessicating cables with carbon dioxide gas, detection of, and precaution against gas in jointing chambers.

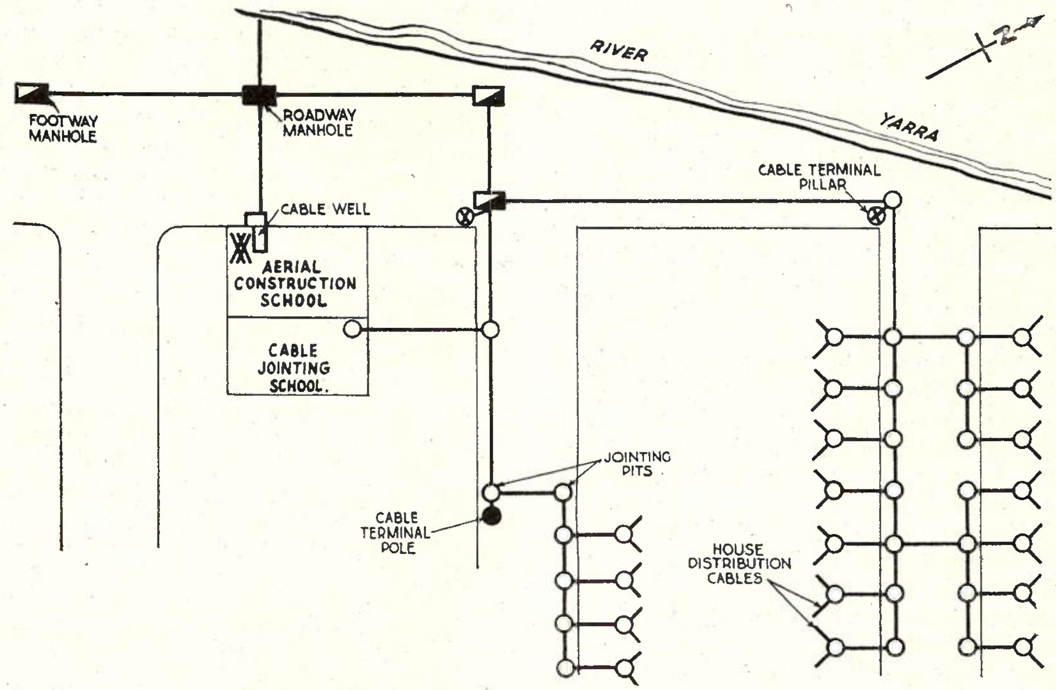


Fig. 8.—Layout of Conduit Construction.

Experience in an Engineer's Office.—To my mind this experience is one of the utmost value, and is introduced at a stage towards the end of the course when trainees have had an all-round experience in construction work. Their presence in the engineer's office gives them the opportunity to acquire a knowledge of the administrative side, and observe the routine of departmental procedure.

Whilst so engaged, they are closely associated with the Estimating Foreman, who allots their tasks and offers that helpful advice so necessary with trainees. It is appreciated that this added responsibility makes demands on the Foreman's time, but in most cases trainees respond to tuition and after a short period have acquired knowledge and confidence which permits them to carry out work tending to assist the Foreman, which to an extent compensates him for the time expended in imparting instruction in the initial stages. This is exemplified in cases such as laying out work and the preparation of estimates and plans.

Whilst at the engineer's office, all trainees spend a short time with the cable recorder, they can then readily appreciate the necessity for co-operation with this officer and so ensure that all cable records are accurate. Another important factor in office experience is that it creates the opportunity for making personal contact with the office staff, which is always an advantage to the man on the job.

Experience in Engineer's Store.—Apart from the training in store duties given in the school store, two weeks' training in the various duties of a storeman at a line depot is given. As an engineer's store is usually associated with the office of the district Line Inspector, trainees acquire an insight into the functions performed by the various officers attached to the line inspector's staff.

Practical Experience in Districts.—Following school instruction, trainees are detailed to various districts to gain practical experience. This usually follows each particular section of the syllabus but is sometimes varied to meet the following considerations:—

(a) Facilities available in the district;

(b) Co-ordination with instructional programme at the school;

(c) Opportunity for experience on special jobs lasting a limited time.

Such being the case, it is usual, especially in the latter stages of the course, to have small quotas of trainees employed on different parts of the syllabus at the one period. In these, they rotate until a specified date, when the whole group returns to the school to complete the final stages of the course. With regard to practical experience in districts, I could not pass this subject without mentioning the assistance and co-operation extended by the Divisional Engineers and their staffs in an endeavour to provide facilities whereby trainees temporarily located in their districts are given the fullest opportunity to further their efficiency.

Telephone Equipment.—This section of training, which is given in the 2nd year, is arranged and supervised by Mr. F. I. McCarter, Supervisor, Mechanics-in-Training. The course is such that the trainee, on completion, is in a position to instal a telephone; clear a simple fault and replace parts in a telephone; renew a jumper at the M.D.F.; clear a fault on an M.D.F. and on a magneto cord or cordless switchboard; test a line with the aid of measuring instruments and have a knowledge of simple telegraph instruments, and circuits.

For field practice, the trainee works in company with a mechanic engaged on subscriber's installation and has the opportunity of making wall fixtures, carrying out wiring and making replacement of parts, etc.

Motor Vehicles.—This section of training given at the school is allotted to Mr. C. Florant, of the Motor Workshops, and, in order to provide facilities for individual instruction in driving, it is usually embodied with the revision of the course over the final three weeks. A series of lectures is supplemented by an exhibition of various motor parts and includes such items as Road Regulations and Courtesy, Safety Precautions, and Care and Maintenance of Motor Vehicles. Driving instruction is given. Trainees holding a driving licence are tested for ability to drive departmental motor vehicles, and if successful their names are recorded as qualified drivers. Other items covered in this subject include lectures and demonstrations with an Air Compressor and Methods of operating Power Winches.

Course Revision.—In the final stage of training a short period is allotted during which a revision is made of the subjects covered in the course. Opportunity is created for trainees to check their efficiency in any particular work, and satisfy doubts which have developed from observations made in field work in the districts. Special lectures are also given at this stage, most of these being delivered by officers who specialise in the particular subjects, such as Electrical Measurements and Cable Testing. Demonstrations are arranged and in these the trainees take an active part, and record data helpful for future guidance.

Technical Instruction.—This instruction is provided at the Melbourne Technical College, and trainees are asked to attend for two hours in their own time, on two nights per week—the fees being paid by the Department.

The course, which co-ordinates as far as possible with school instruction, covers a period of 18 months and is subdivided as follows:—

First Year.—3 terms

Applied Mathematics. — Arithmetic, Mensuration, Algebra, Geometry: 1 hour per week.

Elementary Mechanics and Heat: 1 hour per week.

Laboratory Experiments (practical): 1 hour per week.

Tutorial (Problems, Mechanics and Heat): 1 hour per week.

And in addition to above, trainees are expected to record for reference in a special book examples of experiments carried out in their laboratory work.

Throughout the year two tests are held, mainly to determine the progress made by the trainees. The final examination in the subjects mentioned takes place at the end of the third term, and trainees failing to qualify are asked to sit at a supplementary examination in the second year.

The subjects of instruction in the second year covering two terms are:—

Electricity and Magnetism: 1 hour per week.

Laboratory Experiments, practical: 1 hour per week.

Trade Drawing: 1 hour per week.

Tutorial (Problems in Electricity and Magnetism): 1 hour per week.

As with the other subjects, examples of experiments are recorded in a note book for future guidance. At the completion of the second term an examination is held, and if the trainees have qualified in the first year and are successful in this test, they have completed their technical course. Should their results be below the desired standard, they are not only ineligible for appointment as Linemen, Grade 1, but are expected to continue their studies until they attain the necessary qualification. Any expense attached to this is the obligation of the trainee.

School Record.—To date 102 trainees have entered the School, and of these 69 have completed the course and taken up positions in various parts of the State.

Ten are at present serving as members of our fighting forces; three resigned; one had his services terminated, due to the fact that he was one day too young; leaving 19 in the school who are at present engaged in various stages of training.

It is pleasing to note that up to the present the school record stands at 100%, for every trainee has ultimately succeeded in completing his course, although it has been necessary, in certain cases, to grant extensions for trainees to complete the technical subjects. The averages of grand total aggregates of each group (not including supplementary examinations) are as follow:—

Group	School Subjects	Technical Subjects
1938	79½%	59%
1939A	82%	69%
1939B	80%	67%

The reports on the efficiency of ex-trainees on the job are highly satisfactory and very encouraging. A number are at present employed on important works, such as:—Jointing the Melbourne-Seymour Cable, and erection of Masts and Aerials. It is hoped that by the development of proper co-operation, ex-trainees will prove of value to the various Lines Officers. If this is effected, the advantage would be twofold for, having trained the individual, he in turn disseminates his knowledge to the advantage of others, the ultimate result being reflected in the standard of work, and should emphasise how highly desirable it is that these newly appointed linemen be given broad experience in the early part of their careers. At present there is a tendency to make the ex-trainee a Cable Jointer, thus narrowing down the development of his school instruction and limiting his experience. The ideal arrangement would be for Divisional Engineers to establish a roster, ensuring that each one spends a specified time on each phase of construction, an arrangement which, I feel sure, would react to the benefit of all concerned.

AERIAL LINE CONSTRUCTION

A. S. Bundle

Part 7—Transpositions

This section covers the following:—

- Outline of Transposing.
- Forms of Transpositions.
- Rolled Wires.
- Cutting Transpositions in and out of Working Circuits.
- Erection of Transpositions.

Outline of Transposing

Inductive Interference.—When the intensity of an electro-static or magnetic field *varies* an electro-motive force (e.m.f.) is set up in any conductor within the field. If, for example, two wires run parallel and fairly close to one another and a *varying* current flows in one of these conductors an e.m.f. will be set up in the second conductor. This e.m.f. will be of opposite polarity and lower magnitude, but its variations will correspond with those of the inducing source. This reaction is referred to as induction. In the special case of telephone circuits, it is referred to as inductive interference and the intensity of the induced e.m.f. will depend upon the following factors:—

(i) The distance separating the conductors.

(ii) The distance over which the conductors run parallel or within fairly close proximity (that is, remain in the field).

(iii) The intensity of both the e.m.f. and the current in the inducing conductor.

(iv) The frequency of the variations of current and e.m.f. in the inducing circuit.

(v) The nature of the intervening medium which, in the case of open wire circuits, however, is usually air and is, therefore, fairly constant.

Interference to Telephone Circuits.—Suppose a *pair* of wires forming the two legs of a telephone circuit are within the varying field of a third wire, then e.m.f.'s will be induced in both wires and these will tend to oppose one another so that it will only be the difference between these induced e.m.f.'s which will result in a flow of current around the telephone circuit.

In practice, the principal causes of inductive interference in telephone circuits are:—

(a) Power transmission lines. These frequently run parallel to the telephone lines and carry a considerable amount of power and, therefore, have very strong fields. In addition to the fundamental wave (which is usually 50 cycles per second), these circuits also carry harmonics having higher frequencies which are principally the odd integrals of the fundamental. It is these harmonics which cause most of the interference. This is due to several reasons. Firstly, the higher frequencies are induced more readily than the lower frequencies so that although they are usually of much less power than the fundamental, the value of the induced currents may be quite considerable. Secondly, many of these harmonics fall within the frequency range of telephone speech transmission while the fundamental (50 c.p.s.) does not. Thirdly, this effect is controlled largely by the response of both the telephone circuits and telephone apparatus to these frequencies. The induction from the fundamental may affect the operation of telegraph circuits, especially where sensitive relays are in use.

(b) Other telephone circuits. Although the power in these lines is very much less than an electric transmission line, the spacing between them is also much less and the distance for which they run parallel is frequently so great that the interference is a serious factor. This interference enables conversations on other lines to be overheard and seriously interrupts the speech between the persons talking on the interfered line; such sounds are often more annoying than the steady hum of a power line or the sharp crack of an electric discharge. With carrier systems in which frequencies may range from 5 k.c. to 140 k.c. the interference between systems using similar frequencies may cause mutilation or distortion of the speech sounds or else unwanted tones may be introduced.

(c) Lightning and other atmospheric effects. These effects are frequently very severe in certain seasons and in the case of lightning the discharges are of such magnitude that even although the actual discharge may be several miles away the induced field is strong enough to generate a current audible in the telephone receiver.

Effect of Separation.—The intensity of the induction into each wire varies inversely as the square (roughly) of the distance from the source. Thus, if three wires, A, B and C lie in the same plane and run parallel to one another and the distances separating A from B and B from C are equal, then the induction from A to B will be about four times that from A to C. Hence, if the induced e.m.f. is X units in C it will be about 4X units in B and the resulting e.m.f. across the telephone circuit BC will be about 4X — X = 3X units. (See Fig. 61.)

Transposing.—Suppose, however, that at the mid-way point P along the line, the positions of the wires B and C are interchanged in relation to A. Then, on the assumption that the conditions are the same all along the line, the induction into B over half the distance will be 2X units or about four times the induction into C, which will be about X/2 units; and for the remaining half of the distance the induction into C will be about 2X units, or four times the induction into B which will be X/2, so that over the whole length of the line the total induction into each leg will be about $2\frac{1}{2}$ units and no overall e.m.f. will result across the circuit to cause an interfering current to flow around the circuit. The arrangement whereby the wires B and C interchange their position at P is called a transposition.

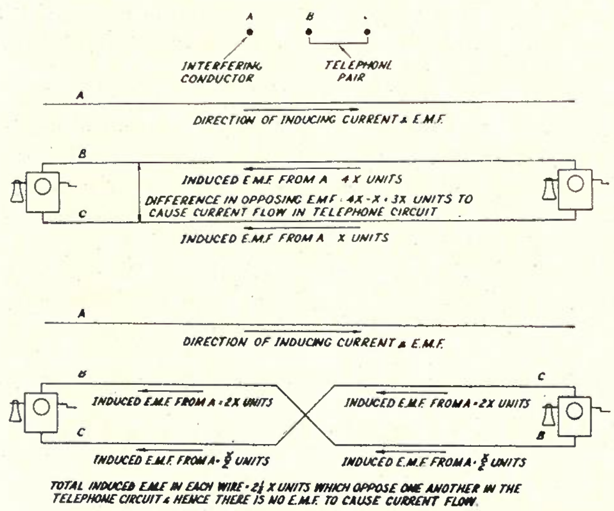


Fig. 61.—Induction into Circuits: A—Untransposed Circuits; B—Transposed Circuits.

Actually, with oscillating currents such as occur in power transmission lines and in telephone circuits, it is not correct to assume that the electrical conditions in an interfering wire are constant throughout its length; if it is very long the potential and current may vary considerably in regard to phase and attenuation so that the insertion of a single transposition at the mid point along the line will not result in a perfect balance against inductive interference, and it is, therefore, necessary to insert transpositions at fairly frequent intervals. The higher the frequency of the oscillations, the more marked are the variations in phase change along the line so that transpositions are required at shorter intervals. For example, at a given instant a 30 k.c./sec. current may be varying from its maximum positive value to its maximum negative value over a line 3.1 miles long, but a current of only 1 k.c./sec. would only vary to this degree over about 93 miles of line. These additional transpositions, however, must not be inserted in a random manner but in accordance with a transposition scheme designed for the frequencies concerned. Otherwise it is quite likely that increasing the number of transpositions may actually increase the crosstalk.

Relative Transpositions. — Suppose now that there are two telephone circuits Y and Z on a route and these are transposed against interference from a power line by the regular insertion of transpositions in both circuits at half mile intervals. In this case the relative positions of the wires forming one circuit compared to those forming the other circuit are not altered and crosstalk may result. Therefore, the two telephone circuits must be transposed in relation to one another as well as in relation to the power

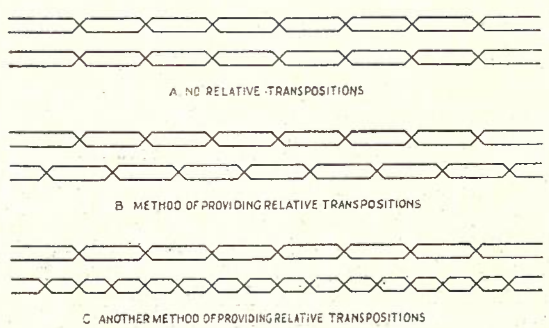


Fig. 62

line. In this simple case and for voice frequency crosstalk, satisfactory conditions would be obtained by transposing circuit Y at every half mile point from the starting point and circuit Z also at half-mile intervals, but commencing the first transposition in Z a quarter of a mile from the start as in Fig. 62B. An alternative would be to transpose Y and Z at the half mile points but also to insert transpositions in one of the circuits at the quarter mile points. (Fig. 62C.) However, as this method would involve more transpositions than the former method, it would not be used unless the closer spacing of the transpositions was rendered necessary by other conditions such as the high frequency of the circuits operating over the telephone lines.

In practice, there are frequently a considerable number of telephone circuits (some of which may use carrier currents of similar frequency ranges) on the one route and the distances separating the different groups of wires may vary greatly so that the problem of transposing all the circuits is a complex one, and beyond the scope of these notes. This aspect has been dealt with in the article "General Principles of Transposition Design," by Mr. W. H. Walker, B.E., Volume 3, No. 2, page 90.

In the case of phantom circuits which are superimposed over four wires using one pair for each leg of the circuit, it is necessary also to transpose the pairs of wires in relation to one another so as to prevent inductive interference into the phantom circuit. Because of the greater separation of the legs of the phantom circuits in relation to the interfering wires, crosstalk conditions are much more severe on this class of circuit and special care is essential in design of transposition schemes and in reducing irregularities.

These "phantom" transpositions may involve merely the reversal of the positions of the two pairs or they may also include a transposition in one or other or both of the side circuits. (See Fig. 63.) Thus, there are four types of phantom transpositions which are known by numbers being as follow:—

Type 1.—Both pairs are transposed and the wires in each pair are also transposed.

Type 2.—The pairs are transposed and a transposition is incorporated in the left hand side circuit only.

Type 3.—The pairs are transposed and a transposition is incorporated in the right-hand side circuit only.

Type 4.—The pairs are transposed but no transpositions are incorporated in the side circuits.

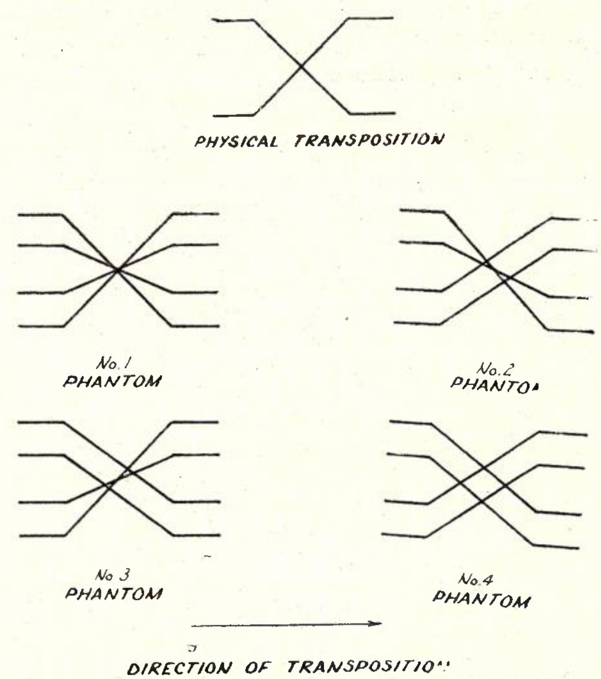


Fig. 63.—Physical and Phantom Types of Transposition.

It has been found that the phantom transposing of circuits has a detrimental effect on the performance of the side circuits. As many of the long physical circuits are required to give maximum efficiency on the high frequency carrier systems which are coming into general use, phantom transposing is not being used very extensively, it being considered better to sacrifive the phantom channel in favour of obtaining effective transmission of the carrier currents for one or two carrier systems.

Physical Transpositions.—The term "physical" transposition is applied to any transposition inserted in a single pair of wires forming a telephone circuit, as distinct from the phantom types of transpositions.

Forms of Transpositions

Numerous methods have been devised for making transpositions, and the following notes outline only some of those most commonly used. To simplify the description it is convenient to refer to the pole before the transposition pole as A, the transposition pole as B, and the pole beyond the transposition pole as C.

It should be explained at this stage that the purpose of a transposition is to change the relative positions of the wires and, therefore, the degree of their exposure to interfering currents. It does not matter, electrically, whether the wires cross right-over-left or left-over-right. There has been a misconception in this regard which was held with Line staffs for many years. The right-over-left rule has been followed for many years merely for uniformity, but, in the plate-type transposition which has been introduced recently, it has been found necessary to depart from the rule in one or two instances of the phantom transpositions.

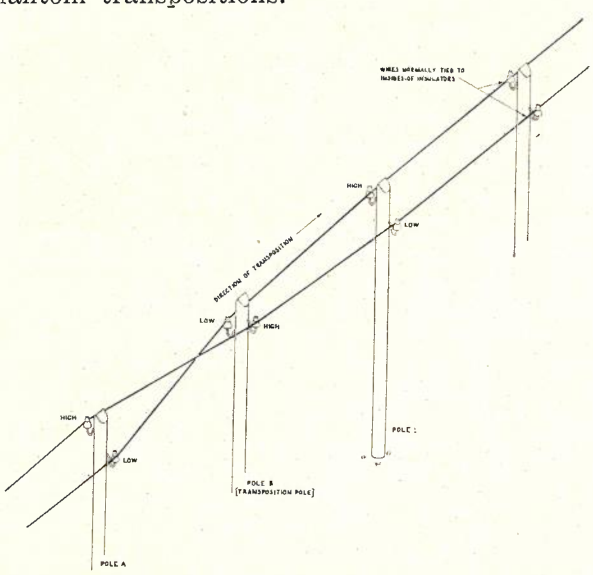


Fig. 64.—Transpositions in Swan Neck Spindle Construction.

Swan Neck Spindle Construction.—These swan neck spindles are used on wood poles where the number of wires is not expected to exceed four. The spindles are screwed into the wood and are fitted alternately on opposite sides of the poles; each spindle usually being fitted 9 ins. below the one on the opposite side. To transpose a pair of wires on this type of construction the two spindles are placed in reversed positions on the transposition pole. Thus, if the left hand spindle is normally above the right hand spindle, then on the transposition pole the right hand spindle is fitted above the left hand spindle. Approaching this pole the upper wire (left on pole A) crosses to the high insulator (right on pole B) and then drops to the low insulator on the right hand side of pole C. With the other wire the reverse conditions occur, it crosses low from right to left and then up to the high insulator on the left. Thus, the two wires over a distance of two spans reverse their relative positions; see Fig. 64.

Double Spindle Transpositions.—A single fitting which holds *two* insulators at different heights and is, therefore, referred to as a double spindle (Fig. 65) is sometimes used to make a transposition on wires fitted on crossarm con-

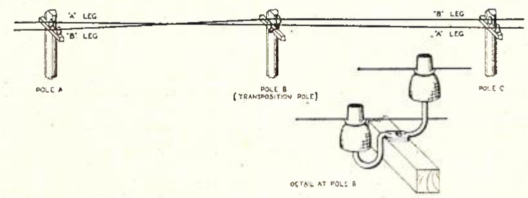


Fig. 65.—Double Spindle Transposition.

struction. In effect the wires exchange positions between poles A and C with the point of crossing occurring near pole B; the wires are separated vertically at B by attachment to the two insulators mounted on the double spindle.

Various other forms of transpositions have been devised, which operate on similar principles to the double spindle type. These include a large variety of patterns in use in America and also the Australian transposition bracket, which consisted of a flat steel strip held vertically against the crossarm with a U-bolt; to this flat steel strip were welded or rivetted two rods bent goose-neck fashion to hold two insulators, one above the crossarm and one below the crossarm. The latter types of fittings have also been adopted to make phantom transpositions by holding two spindles above the arm and two below the arm. By this means the wires may be crossed over a distance of two spans to form any one of the four types of phantom transpositions.

These types of transpositions have, however, largely been superseded by point type transpositions which keep the wires in a horizontal plane right up to the transposition pole and the transposition is made over a length (along the route) not exceeding 15 ins.

Point Type Transpositions. — The forms of transpositions previously described effect the complete reversal of positions over a distance of two spans. This is fairly satisfactory for lines carrying voice frequency circuits only, but for lines on which carrier currents are superimposed having frequencies of the order of 20 k.c. upwards, it is necessary to maintain a more uniform spacing of the wire over the transposition intervals. Thus, the wires should retain their relative pin positions right up to the transposition pole and cross precisely at that point to the opposite positions and continue thus to the next transposition pole. Because the wires are transposed within a distance of a few inches these transpositions are referred to as "point type."

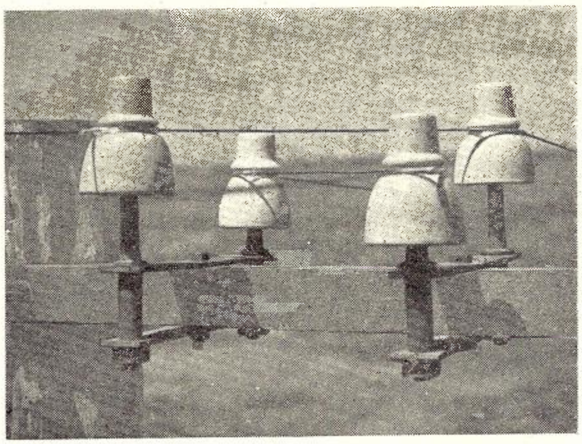


Fig. 66A.—Long and Short Spindle Type of Transposition. A—Newly Erected.

Long and Short Spindle Type.—One early form of point transpositions used in Australia consisted of passing the wires round insulators and spindles attached to two pairs of straight bands 16 ins. long; one band was fitted under and one above the arm and a bolt clamped the two to the crossarm at the centre. One long and one short spindle were fitted through each pair of bands; the long spindle on one pair of bands was fitted at the opposite end from the long spindle on the other pair. One wire passed around the insulator on one short spindle and

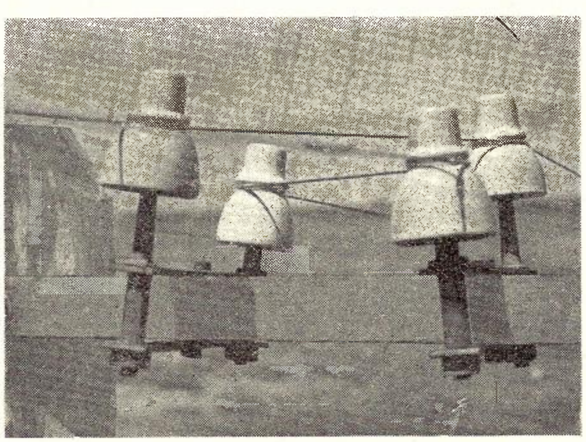


Fig. 66B.—Long and Short Spindle Type of Transposition—showing Distortion when Arm Shrinks.

crossed to the insulator on the other short spindle; the other wire crossed in the reversed direction, passing around the insulators on the pair of longer spindles (see Fig. 66A). This assembly was not very rigid and the spindles tended to cant inwards, thereby showing the unpleasing appearance illustrated in Fig. 66B which has led to this class of transposition being referred to as the "cooing dove" transposition. This effect increased when the arm shrank and the bands tended to become loose on the arm.

Bent Bands.—The problem of providing long and short spindles was overcome by using bands which were offset at one end. The bands were fitted so that the off-set in one pair was at the opposite side of the crossarm from that on the other pair. By this means, spindles of uniform length could be used although the wires crossed at different levels. This type of transposition had a somewhat similar effect as the long-and-short-spindle with regard to the spindles canting in towards one another although the effect was not quite so pronounced.

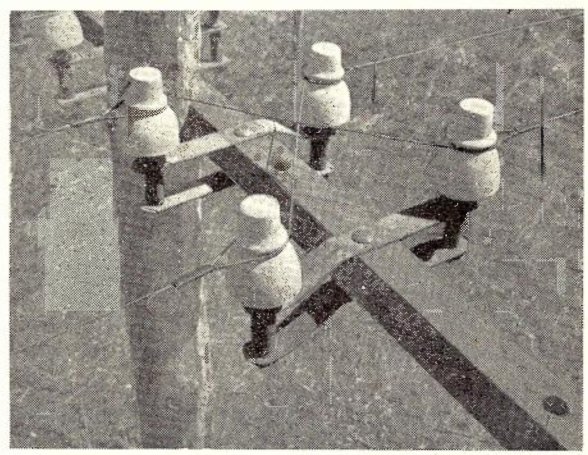


Fig. 67.—Transposition with Bent Bands—Wires Terminated and Looped Back.

Another development was to terminate all the wires but to loop two of them back at one end and pass them around the insulator at light tension (Fig. 67). By this means the tension of the wires was counteracted along the line instead of having a component across the line which would tend to deflect the assembly and permit the spindles to point inwards. Unfortunately the termination which involved the looping back of the wire was of such mass that it formed a serious reflecting point for vibrations and many fatigue failures occurred.

Formed Bar Transpositions.—In this type of transposition straight transposition bands are used and each wire is terminated. The cross-connection is made by means of two stout wires referred to as "formed bars." These formed bars are usually 600 lb. per mile H.D.C. wire .1937 in. diameter with an offset provided in them so as to keep them well clear of one another where they cross. (See Figs. 68-69.) These formed bars are supplied in standard lengths as stock items; they are preformed with each end annealed and tinned to facilitate bending the bar around the insulator and along the termination and down to the drip point of each terminated line wire, and also for soldering them to the drip point.

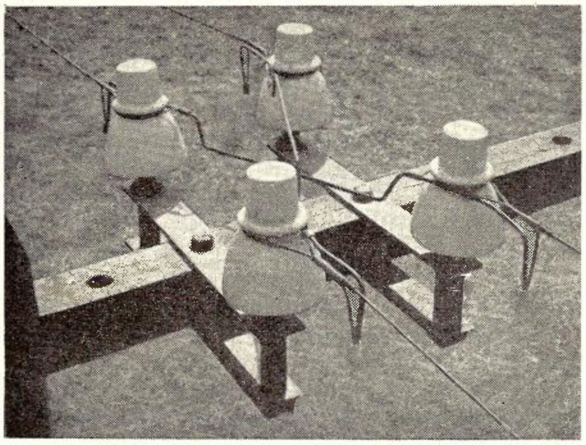


Fig. 68.—Formed Bar Transposition—Physical Type.

Unfortunately the attachment of a stiff bar to the line wire causes a reflecting point to be established for the vibrations which may be set up in the wire and, therefore, increases the likelihood of fatigue failures. The forms of termination now used as shown in Fig. 78 are a recent development designed to overcome this defect as much as possible. This type of transposition is mechanically good apart from the tendency to cause wire fatigue, but is somewhat costly, calling for:—

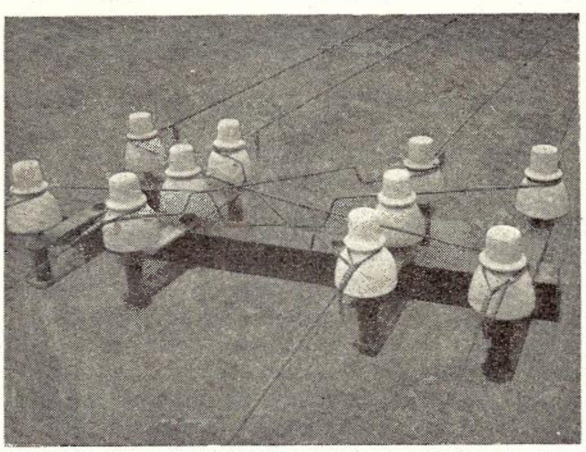


Fig. 69.—Formed Bar Transposition—Phantom Type No. 1.

(a) The termination of four wires;

(b) The supply of special formed bars; and

(c) The execution of a special form of attachment; as well as

(d) The soldering operation.

Phantom transpositions are also made in this form but require a series of specially shaped long formed bars. (See Fig. 69.)

Plate Type Transpositions.—A later form of transposition which is now being used extensively in Australia is termed the plate type, and is illustrated in Fig. 70. Four spindles are held in a specially designed fitting, so that those diagonally opposite to one another are on the same level, but the two diagonals are on different levels $1\frac{1}{2}$ ins. apart. The wires pass round the insulators attached to these spindles and are usually taped but not bound to the insulators. Normally the wires are held firmly in the grooves of the insulators, and it is only at heavy horizontal angles, or at vertical angles, that it is necessary to bind the wires to the insulators. This precaution is also advisable in those districts where heavy birds rest on the wires and cause severe vibration when taking off if scared.

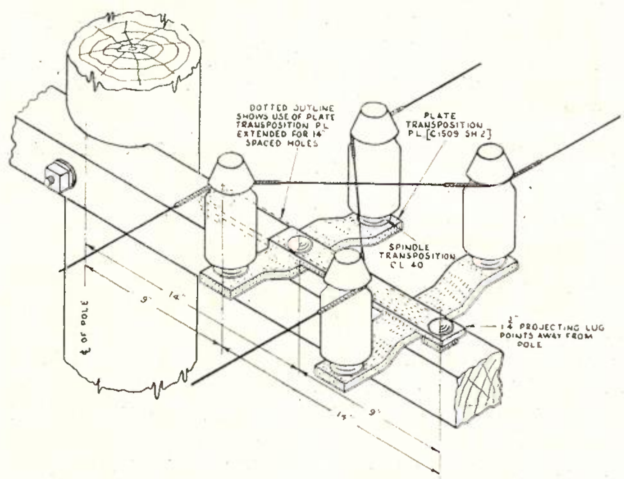


Fig. 70.—Plate Type, Physical Transposition.

This form of transposition, by dispensing with the need for terminations and soldering, saves considerable time in construction and overcomes the possible defects likely in a connection that is soldered in the field. Material costs are about the same as for the other point types described, but the fitting is lighter, whilst a mechanically sound transposition is obtained without need for cutting the wires, thereby obviating possible troubles due to joints. It is expected that with other manufacturing processes a still lighter transposition plate will later be obtained. The hazard of fatigue failures is not entirely eliminated and calls for some form of reinforcing of the wires at the insulators, such as the splint in the American spiral tie described in the last issue of this Journal. Phantom transpositions are also made in this form and Fig. 71 illustrates a Type 1 plate type transposition. The physical plate type transposition is very similar to the latest practice in the U.S.A., but plate type phantom transpositions do not appear to have been used in that country.

B.P.O. Practice.—In the British Post Office physical transpositions are made by means of a form of double spindle shaped like a "U." Each arm of the "U" carries an insulator, whilst the base of the "U" is bolted to the crossarm. One of these fittings is connected into each leg of the line. The wire ends are terminated to the two insulators attached to it and the cross connections to the other wires forming the pair are made by means of fairly long ends of the terminated wires, which are connected together with twist sleeves.

Transposition Insulators.—The transpositions so far described may be referred to as "Open Wire" transpositions, because the crossing is made with wires passing round the insulators and actually crossing in the air. Two special forms of insulators have been patented wherein the wires are passed round the grooved tracks in a specially shaped insulating piece made of porcelain or glass, or other suitable insulating material. The grooves are so designed that the wires are kept separate by a section of the insulating material. In one form the insulating piece is clamped to the cross arm by means of a "U" bolt, whilst the other form may be attached either to a spindle in the crossarm or, if desired, it may be inserted in the span, thereby permitting the insertion of the transposition at the exact point without need to have a pole located there. These blocks must, of course, be designed so that there will be no excessive surface leakage and so that they will be capable of withstanding the mechanical stresses that may be imposed on them.

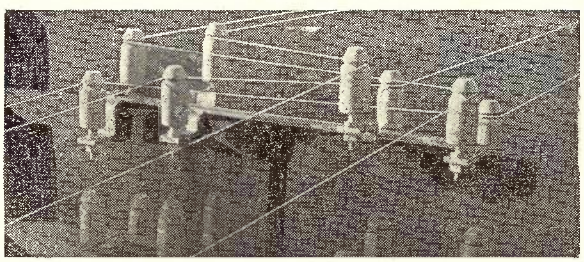


Fig. 71.—Plate Type, Phantom Transposition, Type No. 1.

Pot Head Type of Transposition.—These are so called because they use a special form of terminal insulator which is commonly known as a "pot head" insulator. This type of transposition was designed primarily for phantom transpositions. Every wire is terminated and the cross connection is made with insulated wire. Each wire is terminated in a special type of terminal insulator attached to a "J" type spindle.

One-wire rubber-insulated lead-and-antimony sheathed cable (R.I.L.A.C.) is used to make cross-connections as illustrated in Fig. 72. The connection is made by bringing the one wire R.I.L.A.C. through a hole into a special chamber in the top of the pot head insulator. The lead covering and the rubber insulation is stripped off within this chamber and the bare wire is taken out through another hole and connected to the drip point of the terminated wire. "Henley" type cable clips are used to support the R.I.L.A.C. in position on the under side of the crossarm.

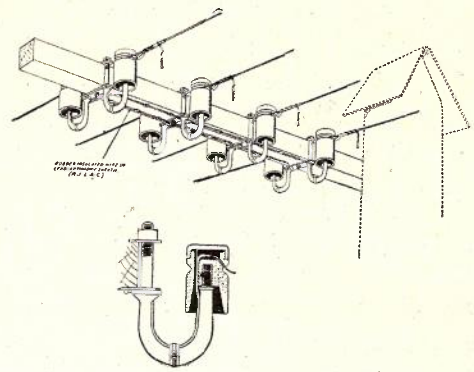


Fig. 72.—Pot Head Type Transposition.

These transpositions have not proved satisfactory in practice for the following reasons:—

(i) The material and fitting costs are high.

(ii) During thunderstorms lightning discharges pierce the rubber insulation and cause faults which are hard to detect.

(iii) Electrolytic corrosion of the leading out wires occurred in salty atmospheres at the point where the lead to the line wire left the insulator.

(iv) Birds, such as cockatoos, galahs and magpies damaged the sheathing and the insulation, causing faults which were also difficult to locate from the ground.

(v) A delivery of R.I.L.A.C. wire with faulty rubber insulation appears to have been used in the early stages of the development of this type of transposition and led to a considerable number of insulation failures developing subsequently.

Transposition around the pole. — The usual practice on modern construction is to have four wires on each side of the pole, but in the past considerable use has been made of 6-pin arms in which three wires were located on each side of the pole. The wires nearest the pole on either side formed a pair which had to be transposed. Because of the intervention of the pole close to the point where the wires would cross a special form of transposition is required.

The problem may be dealt with in two different ways:—

(a) By making a special type of transposition; or

(b) By fitting an 8-pin arm on the transposition pole and shifting the wires across the one side of the pole so that a regular type of transposition can be used.

Fig. 73 shows one form of transposition suitable for the purpose, but it will be noted that this involves the use of two extra insulators and spindles and also of specially formed bus bars. Some consideration is being given to the introduction of a special transposition plate which would permit of the wires crossing at a point

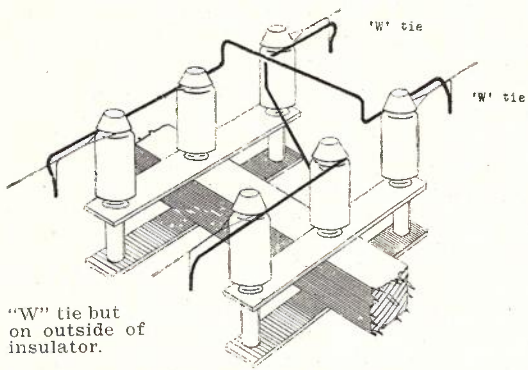


Fig. 73.—Transposition Made Around Pole.

clear of the pole. Method "b" is frequently resorted to, however, as the general practice is to develop towards the 8-pin arm construction

Rolled Wires

One method of overcoming inductive interference into telephone wires is to continuously alter their positions from pole to pole in such a manner that two pairs of wires are rolled as a group. These groups consist of two wires in adjacent positions on one arm and two wires in pin positions immediately above or below the first mentioned wires so that at any pole the positions of the four wires occupy the four corners of a square with 14 in. sides. For example, consider a group consisting of four wires A, B, C and D, in which A and B are on the top arm in pin positions 1.1 and 1.2 and C and D are on the second arm 14 ins. below and on pins 2.2 and 2.1 respectively. (See Fig. 74.) In the first span wire A will cross to pin position 1.2. In the second span it will move down to 2.2. In the third span it will cross to 2.1, while in the fourth span it will move up to the original pin position of 1.1. The other three wires follow in a similar manner. The telephone pairs forming a circuit are taken from the

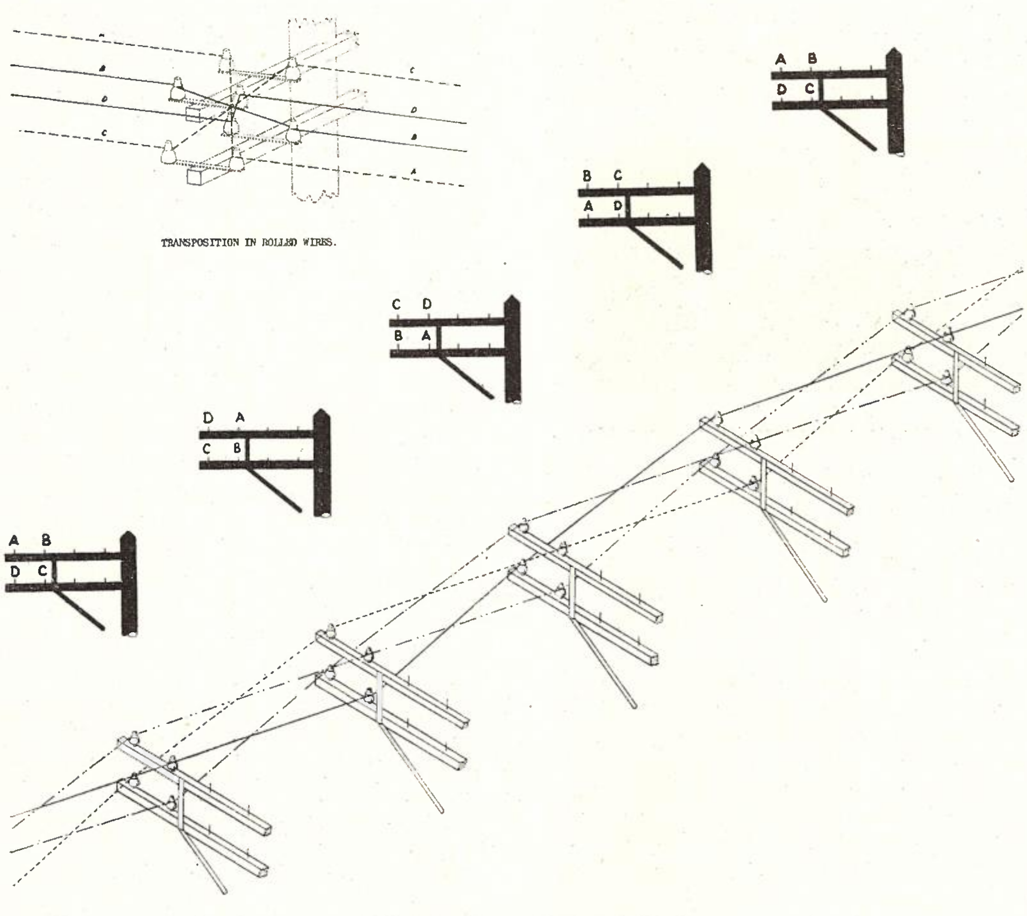


Fig. 74.—Roll or Twist System.

and opportunity is taken during reconstruction works, etc., to replace 6-pin arms with 8-pin arms, thereby providing accommodation for additional wires on the pole route.

diagonally opposite wires (A, C and B D) as in star quad cable. If only one pair of wires is required initially they must be rotated in the diagonally opposite positions, using two arms and the other two wires must be erected subsequently to form the rolled group.

Provided that the spans are of uniform length, rolled groups give good balance against interference from sources external to the route, and also from side circuit to side circuit and from side circuit to phantom circuit within the group. Where, however, two or more rolled groups run parallel over long distances crosstalk may occur between side circuits of different groups. To overcome such crosstalk a form of point type transposition is inserted so that both pairs of diagonally opposite wires in a group reverse their positions. These transpositions are inserted so as to change the *relative* positions of wires in different groups. Thus, in the simplest case of two groups a single transposition inserted in the mid point in one group would balance the exposure in the side circuits to those in the other group.

Rolled wires are not now favoured in Australia and their use is not being extended, the following being the principal objections:—

(a) The cost of running the wires is very high, owing to the special care which has to be taken in altering their positions at every pole. This is particularly the case when a second pair of wires has to be erected to form a complete group with an existing pair.
(b) Two arms are required initially on routes where one would otherwise suffice for many years.
(c) The effectiveness of the system depends upon the spans being of equal length and any subsequent changing of positions of poles or the insertion of additional poles causes deterioration of the balance of the circuits against inductive interference.
(d) There is a greater tendency to faults than with flat-transposed wires because of the wires being closer to one another in the centre of the span. Moreover, crosses are difficult to locate as, viewed from the ground, the wires appear to be crossing normally.
(e) The characteristics of the line are continuously varying due to the continuous interchanging of positions and the fact that the space between wires is continually varying. The diagonally opposite wires vary from 19.8 ins. apart at the poles to 14 ins. apart at the centre of the span whilst the spacing between adjacent wires is reduced from 14 ins. at the pole to 10 ins. in mid span.

Cutting Transpositions In and Out

The demands for telephone and telegraph communication channels between towns and cities served by open wire routes are increasing very rapidly, and in the majority of cases it is found that the best means of meeting this demand is by the use of carrier systems superimposed over the existing wires. The higher frequencies of the carrier currents result in considerably greater inductive interference between these systems and require much greater attention to the transposing of circuits than was necessary in the past, for voice frequencies. This attention includes such matters as:—

(a) More frequent transpositions.
(b) More accurate spacing of transposition poles and the transference of existing transpositions on to extra poles specially erected at the correct transposition points.
(c) Rearrangement of the transposition scheme involving the removal of transpositions at some points and insertion of others at different points.
(d) Alteration of types of existing phantom transpositions.

This re-transposing work is now being carried out very extensively in Australia, and has become an important phase of line work. As the existing wires must, in most instances, be operating close to maximum capacity to require the extra channels, it is most important that they do not suffer interference while the transpositions are being cut out or cut in.

Use of Cross-Connecting Leads.—With a little care it is very simple to cut a transposition in or out with only a momentary interruption which would not appreciably interfere with a telephone conversation nor seriously mutilate a telegraph message. In the case of wires over which Murray Multiplex machine telegraph systems operate, however, several correction signals may be lost and the system may lose synchronism with consequent interruptions to a number of important machine telegraph channels (usually interstate) for periods which may extend to half an hour. It is important, therefore, to ensure that before any work is commenced the lineman-in-charge should contact the mechanic to ascertain over which wires any such system may be operating, and arrange that they be "patched" over to other wires while the transpositions are being cut in or out.

Two flexible insulated wire leads at least 8 ft. long are required, and these should be fitted with substantial clips permitting a good firm contact with the wire to be made quickly. Before cutting-in a transposition, these leads should be connected to the wire, so that one end of a lead is connected to one of the wires at a point about 4 ft. from the pole and the other end connected to the same wire about 4 ft. out from the pole on the other side. The line wire should, of course, be cleaned first with a piece of fine emery cloth to ensure a good connection. The other lead is similarly attached to the other wire. The wires may then be pulled up and held with wire grips and cut at convenient points, without causing an open circuit. The ends of the wires thus cut should be arranged so as not to make contact with other wires. The two leads must then be changed over at one end so as to effect the cross connections. This is the only interruption to the line, and the connections must be changed as quickly as possible. The work of installing the transposition fittings and of making the permanent transpositions may thus be carried out without further interruptions to the line, provided that care is exercised to see that the wire ends are kept clear and do not foul other wires.

A similar method is used for cutting out transpositions, but in this case the flexible leads follow the cross-connection at first, the transposition wires are then cut away, the flexible leads connected straight through, and each of the line wires joined up and attached to the insulator and spindle according to the form of the transposition.

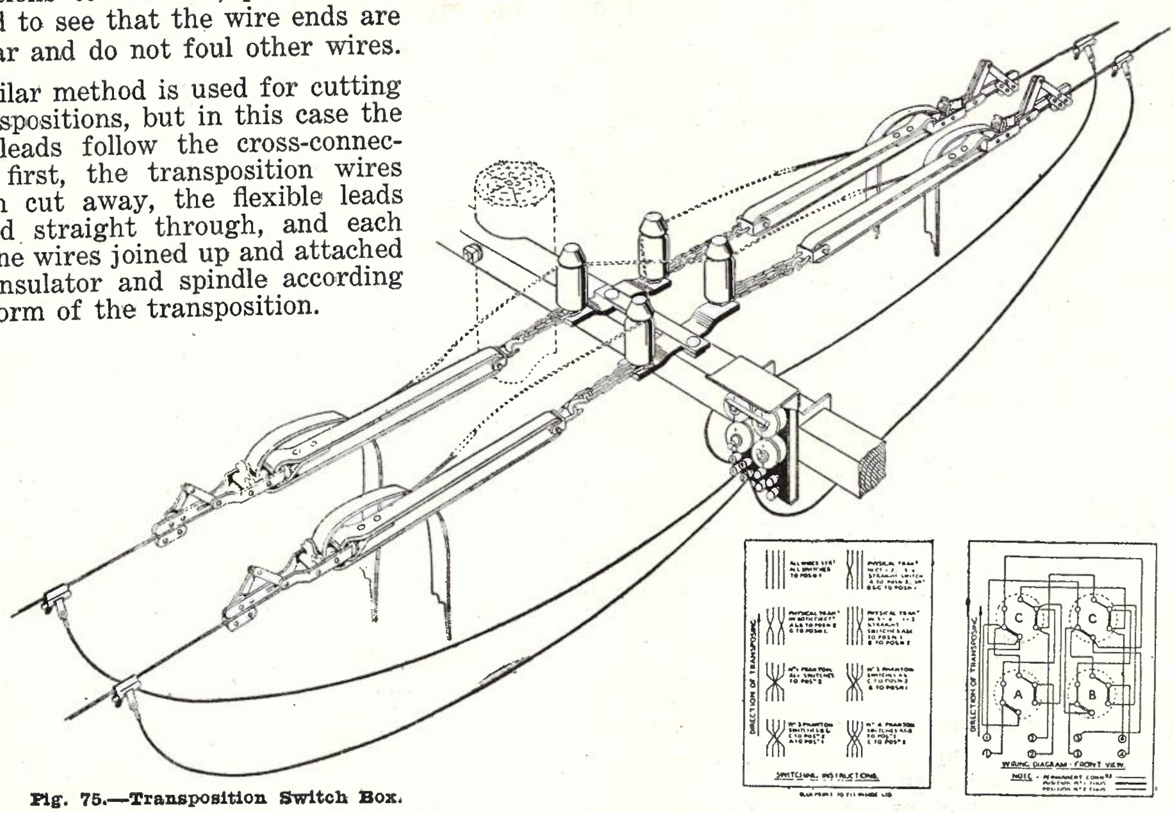


Fig. 75.—Transposition Switch Box.

Transposition Switch Boxes.—To reduce the length of the interruption caused during the cross-connecting of the leads as described above, Transposition Switch Boxes may be used, in which the cross-connecting is done by throwing switches. By this means the interruption to the line is only as long as the time required for the switch to change over on the contacts. These transposition switch boxes are particularly useful when cutting in or out or changing the types of phantom transpositions, as otherwise four flexible leads have to be cross-connected, and some appreciable interruption is sure to be caused. It is also preferable to use them for physical transpositions if they can be made available, so as to minimise the interruptions.

Various forms of these switch boxes have been designed, the objective being to provide a robust box fitted with switches and terminals that make firm connections and are convenient and simple to use. Fig. 75 illustrates one form of switch box using four double-pole double-throw tumbler switches. The box fits on to the crossarm and by means of the various combinations of switch positions the switch connections form circuits equivalent to:—

(a) Four wires untransposed;

(b) One physical transposition in either or both pairs; or

(c) Any of the four phantom types of transposition.

One essential of these boxes is satisfactory flexible leads and connectors which make a firm connection with the line and which will not pull-off or vary in resistance during the working operations involved in connecting the line wires through or fitting the transpositions.

Cutting Transpositions In or Out.—Consider the effect on the working circuits where a physical transposition is cut in or out and the two wires are reversed. On most of the telephone wires this is not important, but on circuits which are composited (i.e., have telegraph or dial or signal circuits operating over each leg of the pair whilst telephone circuits operate over the wires as a pair) this may completely interrupt the circuits. Similarly where a phantom transposition is cut in or out the *pairs* are cross-connected, and one physical circuit will be cut into another circuit entirely while the legs of one or both of the side circuits may also be reversed. In such circumstances, it is necessary:—

(a) To cut in or out *two* transpositions simultaneously, using transposition switch boxes to effect an immediate cut-over. If there are telegraph or signal or dial circuits working over composited legs of these wires, it is necessary to select two phantom transpositions which will not cause any reversal of the legs. It is advisable where possible to see that composite circuits are patched clear of wires which are being retransposed.

(b) To get into telephone communication with the mechanic at the exchange at one end of the route and arrange for him simultaneously to make a temporary reversal of the connections in the exchange (at the patch-board, if possible) until another transposition is cut in (or out) which will restore the positions to normal.

These precautions are unnecessary, of course, where physical transpositions are being cut into or out of circuits which are not composited. Close co-operation with the mechanics at exchanges is advisable when doing re-transposing work so that they may make the best arrangements possible to keep important channels clear of the wires on which the work is to be carried out. It is important to arrange to have a portable telephone connected to one of the least important lines on the route so that the mechanic can immediately get into touch by a code ring in the event of an interruption being caused by some mischance which might pass unnoticed by the men working on the lines.

(To be continued.)

INFORMATION SECTION

ELIMINATION OF RECTIFIER IN B RELAY CIRCUIT OF 2000 TYPE GROUP SELECTORS

All 2000 type selectors in use in Australia at present include a rectifier, type 2N/6A, in the circuit of relay B. Its purpose is to prevent the operating circuit of relay B affecting the release time of the selector magnets. Fig. 1 shows the present circuit of the impulsing element of a group selector. Relay B operates in series with resistance YA and rectifier MRA. When contact C1 closes, however, a parallel battery supply is provided via the vertical magnet and the 5 ohm winding of relay C. Under impulsing conditions, the vertical magnet is shunted by resistance YA and rectifier MRA and unless the latter had been introduced into the circuit the resistance of YA alone is not sufficient to prevent the inductive discharge of the magnet increasing the release lag of the magnet armature to an extent that the impulsing characteristics of the selector are seriously affected. It may be noted that the circuit for relay B via the vertical magnet also provides a possible path for the inductive discharge of the magnet. The impedance of this path is, however, sufficiently high to prevent any appreciable current flow and the effect on impulsing is negligible.

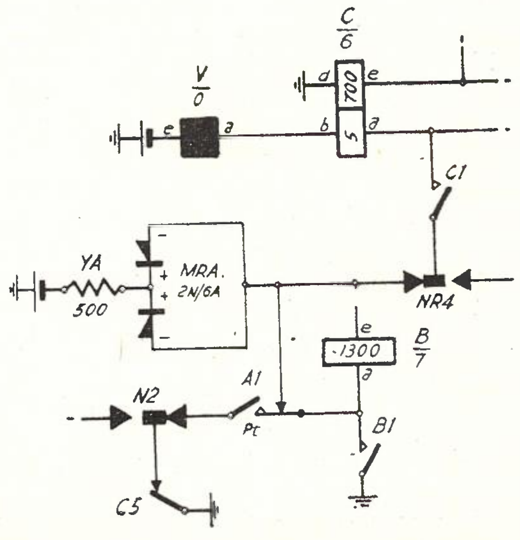


Fig. 1.—Present Circuit.

Recently the B.G.E. Co., England, who are one of the manufacturers of 2000 type equipment, suggested a simple circuit alteration by means of which the rectifier could be eliminated. The modified circuit for the impulsing element of a group selector is shown in Fig. 2.

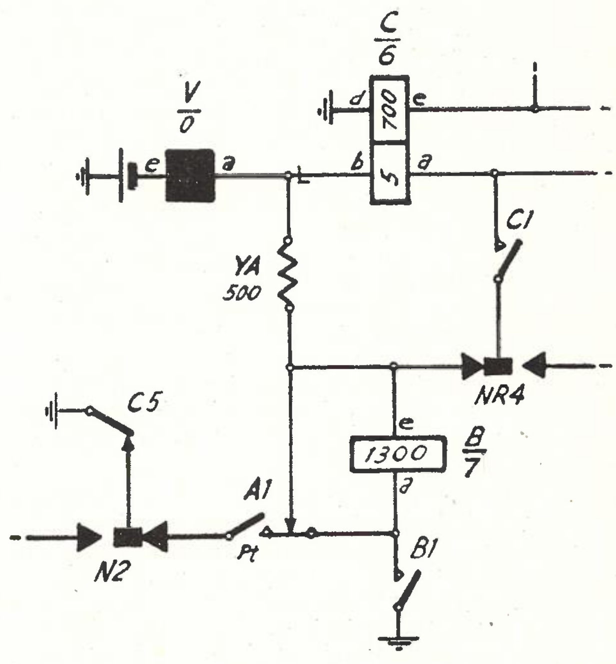


Fig. 2.—Modified Circuit.

The B.P.O. have investigated the suggestion and the results of the tests made have been published in B.P.O. Research Report No. 10701. The scope of the tests covered the effect of the circuit modification on—

(a) the operate and release times of the controlling magnets;

(b) the impulse holding performance of the B and C relays; and

(c) the response of the mechanisms to subsequent pick-up effects.

For (a) it was found that the elimination of the rectifier caused a reduction in the operate and release times of the controlling magnets of the order of 1 millisecond, whilst for (b) and (c) the result of the circuit modification was found to be negligible.

As a result of these findings and the fact that the elimination of the rectifier is in itself a desirable feature, all the circuit drawings to which 2000 type selector equipment is purchased have been amended generally in accordance with the modified circuit shown in Fig. 2.

To those who have occasion to use metal rectifiers it is worth remembering that the modified circuit will make available supplies of rectifiers, type 2N/6A, from existing switches. The rectifiers should not be recovered unless actually required or to meet probable requirements.

Arising from the foregoing it may occur to many to question what effect the current flowing through relay B via the vertical magnet has upon the impulsing characteristics of the selector. The current through the magnet is practically the same in either the present or the modified circuit because in the former (Fig. 1) the heavy shunting effect of the 50 ohm magnet winding plus the 5 ohm winding of relay C reduces the P.D. across MRA to less than 2 volts. Under these conditions the forward resistance of the rectifier is high and its circuit may, in fact, be disconnected without appreciably affecting the amount of current flowing through relay B.

This current is then, prior to the commencement of dialling, about 35 m.a. in both cases. It pre-energises the vertical magnet and this is found to give a definite improvement in the impulsing performance of the selector owing to the fact that the first impulse to the magnet tends to be short due to the saturation of relay A before dialling commences. During subsequent impulses the current through relay B does not have time to rise to more than approximately half of its normal steady value. A further effect of the B relay current upon the vertical magnet is to cause an increase in its release lag of the order of 2 milliseconds. This is offset, however, by the improvement in operate time, which is of the order of 5 milliseconds.

—C.C.

FUSE MOUNTINGS—20 AND 25 PAIRS

The standard fuse mounting in use in the Commonwealth, on exchange and P.A.B.X. main distributing frames, until recently consisted of 20 pairs of 1.5 amp. fuses on a mounting which can be fixed to the M.D.F. lateral by means of two bolts. The standard exchange M.D.F. is an iron frame work made up in vertical sections providing for arrester mountings on the exchange side, and fuse mountings on the cable side. A fuse strip is mounted on the end of each lateral on the cable side, and a protector strip between two laterals on the exchange side. The vertical sections of the M.D.F. are mounted on 6¾" centres, and the laterals on each vertical are mounted on 11⅛" centres. The 20-pair fuse strips are 8½" high and give a space of 2⅝" between strips on the same vertical.

The number of fuses equipped in exchanges is always far in excess of the number of arresters and is generally in the ratio of about 2 to 1.5. This results in a large part of the M.D.F. being equipped with fuse mountings only, and the ironwork and space for the arrester mountings on these verticals lying idle. The need for equalising, as near as possible, the space requirements

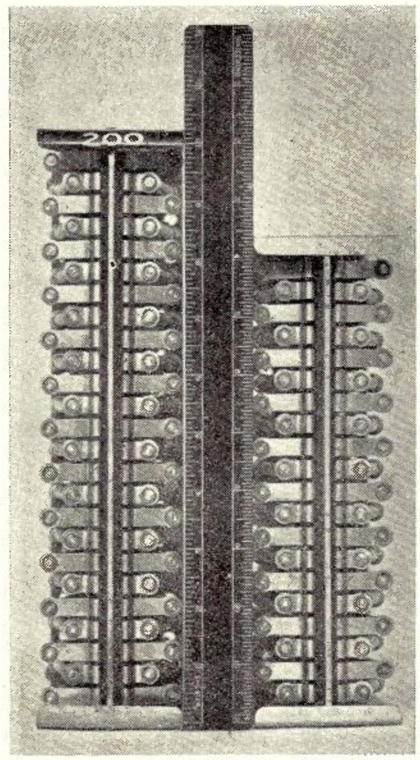


Fig. 1.—20 and 25 Pair Fuse Mountings—Front View.

of fuses and arresters and the consequent reduction of M.D.F. space has led to the recent introduction of the 25-pair fuse strip. Table 1 compares the capacity of verticals using 20-pair and 25-pair fuse strips on the types of M.D.F. in general use.

TABLE 1.

Capacity—Arrester Side	Capacity—Fuse Side using 20 pair fuse strips	Capacity—Fuse Side using 25 pair fuse strips
100	140	175
160	200	250
200	240	300
260	300	375
300	340	425

The construction of the 25-pair fuse strip is similar to that of the 20-pair strip, except that the overall length is 10$^{7}/_{16}$" compared with 8½" for the 20-pair strip. An improved mounting has also been included in the new strip, which includes a channel in the mounting plate into which the M.D.F. lateral bar fits. Two fixing bolts clamp the plate to the lateral. This channel prevents the strip from being forced out of alignment during service.

The following details apply to both 20- and 25-pair strips:—

Frame—Mild steel plate, Nos. 12 and 16 S.G.—Finish zinc dull.

Springs—Nickel Silver.
Insulation—Ebonite quality "B."
Fanning Strips—Maple or other hardwood varnished.

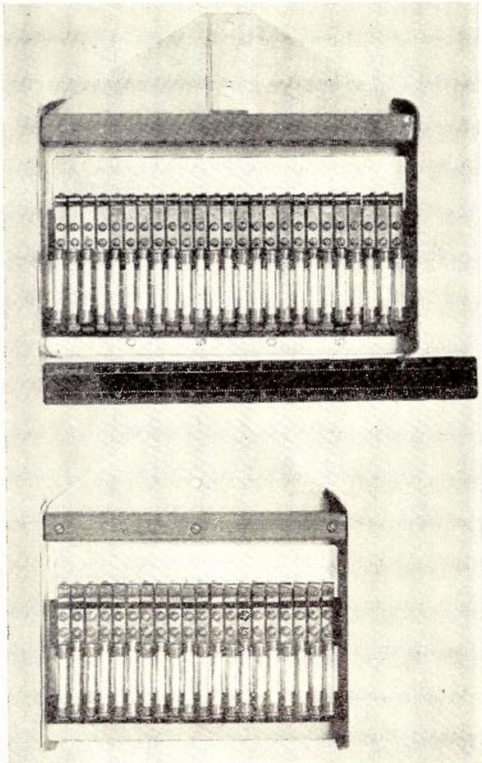


Fig. 2.—20 and 25 Pair Fuse Mountings—Side View.

Fuses—Type T. 1.5. This type has a rating current of 1.5 amps. and should carry the rated current continuously without deterioration. If the current is uniformly increased to twice the rating current the fuse should melt within 30 seconds of twice the rating value being reached.

Insulation Resistance—The insulation resistance between any one spring and the remainder earthed when tested with a 500-volt megger shall be not less than 1000 megohms.

Front and side elevations of the 20- and 25-pair fuse mountings are shown in Figs. 1 and 2. —D.J.M.

INSTALLATION OF LOUD SPEAKERS AT TRUNK LINE CENTRES

In N.S.W. an extensive volume of trunk-line business is conducted of the type where payments in advance for calls are made at post offices or telephone exchanges. The calls so originated are completed or cancelled from public telephones associated with the centre at which the pre-payment was made. To facilitate the disposal of this type of business, a public address system has been installed in each centre where it is considered the number of these calls warrants the installation. As trunk-line calls generally cannot be completed on demand, each caller at a centre where the address system is installed is informed by the official accepting the pre-payment where to wait for an announcement regarding the call. The necessary advice is given by the telephonist over the address system, the caller being directed to the cabinet to which the trunk line is being connected. This provides a facility which obviates both the necessity for the telephonist to leave the operating position or the provision of a message system.

It will be appreciated that, unless an address system is installed, difficulty will arise in those cases where the public telephones on which trunk-line calls are made are situated remotely from the operating centre such as would be the case if the exchange switchboard or pay station was on the second floor of a building and the P.T.'s were on the footpath, or in the vestibule of the building.

Katoomba, N.S.W., is a centre where the facility is of great value and the following information is relevant to the Public Address system which has been functioning satisfactorily at this centre for some years. The apparatus consists of:—

Item 1—Crystal Microphone Type D104.
Item 2—Amplifier 8A.
Item 3—Power Supply Unit.
Item 4—Loud Speaker Rola Type PM. 8-20.

The microphone when not in use rests on a hook, and when in use it is suspended from the switchboard in such a manner that it may be handled by either of two telephonists and is brought into circuit by the operation of a non-locking key on each telephonist's position. The amplifier and power supply unit are both mounted on top of the switchboard in order to keep the microphone leads as short as possible. The screened flexible wiring between the microphone and amplifier is fitted with a cord weight to dispose of spare length of conductor when the microphone is

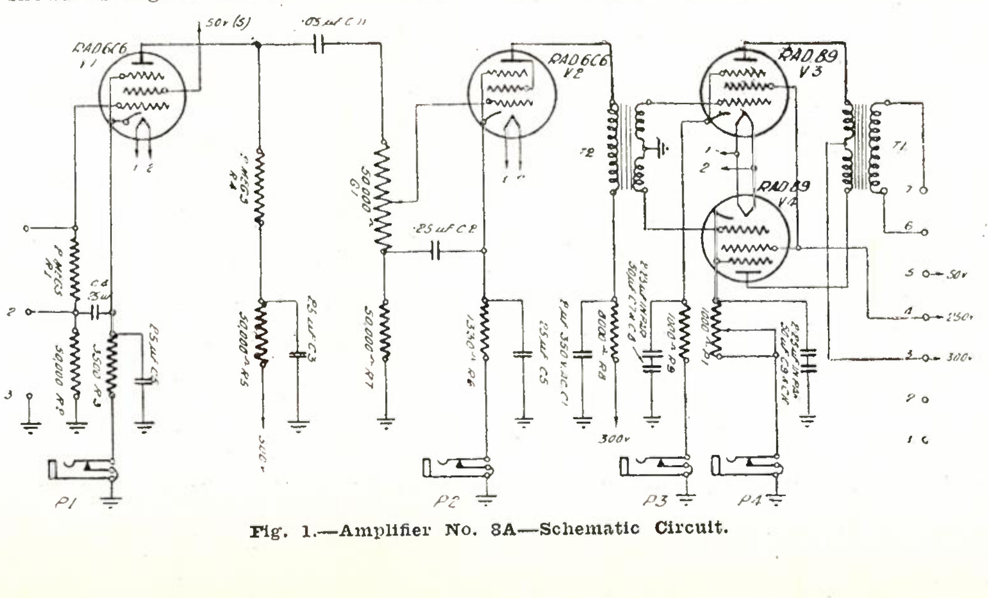


Fig. 1.—Amplifier No. 8A—Schematic Circuit.

replaced on the hook. The amplifier is connected to the speaker with lead-covered 1-pr. cable.

The loud speaker is associated with a transformer which matches the voice coil to 600 ohms, and is mounted on a suitable baffle above the public telephone cabinets in the post office vestibule in a position where malicious damage is unlikely.

The three-stage amplifier shown in Fig. 1 has an output of 7 watts. The first and second stages using type 6C6 valves are resistance capacity coupled, the second stage being transformer coupled to a push-pull output comprising two type 89 valves feeding into an output transformer. The output impedance is 600 ohms. Input impedance is high. For routine maintenance purposes, jacks are provided for the connection of an ammeter to measure the current consumed by each valve. The non-locking telephonist's keys normally short circuit the input leads. The amplifier is fitted with a red pilot lamp and volume control rheostat and, being mounted on top of the manual board, is easily accessible. The pilot lamp is visible to the telephonist and is an indication of whether the amplifier is "ON" or "OFF."

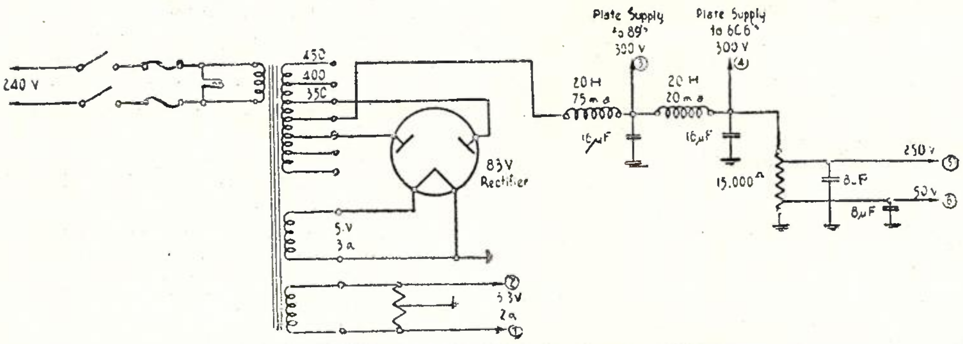


Fig. 2.—Power Supply Unit—Schematic Circuit.

The power supply unit shown in Fig. 2 uses Rectifier Valve type 83V and supplies the following voltages:—

Tag 1—6.3 volt filament supply.
Tag 2—6.3 volt filament supply.
Tag 3—300 volt plate supply 89 valves.
Tag 4—300 volt plate supply 6C6 valves.
Tag 5—250 volt screen supply 89 valves.
Tag 6—50 volt screen supply 1st stage.
Tag 7—spare.
Tag 8—earth.

—P.J.G.

BERYLLIUM-COPPER ALLOYS

Mention was made in Vol. 4, No. 2, page 104, of a beryllium-cobalt-copper alloy as used for the moving springs of microswitches. There is a popular belief that an art of making copper hard by tempering was understood by the ancients, but has since been lost. While it is probable that the method of hardening copper by hammering has been known for thousands of years, there is no evidence that the edges of the copper or bronze (i.e., copper tin alloy) tools of the ancients were made any harder than the hardness obtainable at the present day on similar metals by hammering alone.

The alloying of beryllium with copper is, in its effect, comparable with the addition of carbon to iron as the resulting alloy can be made soft or hard at will, by simple heat treatment (precipitation hardening). Hardness, cutting edges and wear resistance values compare with steel. The fatigue resistance of beryllium-copper under reversing operations encountered in the operation of springs and flexible diaphragms is greater than any other non-ferrous alloy known. Under corrosive influences, such as salt spray, the alloy will outstay steel. The analogy with carbon does not hold from an economic viewpoint as, although only 2% beryllium content is required, its extraction from beryl is not simple.

Hand tools of the alloy are non-sparking and non-magnetic and can be used in proximity to explosives, volatile inflammable liquids, dangerous gases, or other such material.

The addition of beryllium seriously affects the electrical conductivity of copper, as even a 1% inclusion reduces the conductivity to less than one-third of that for pure copper. As a comparison, 1% of cadmium in copper reduces the conductivity by only 5%.

—W.C.K.

ALARM UNIT AND SWITCH—ALTERNATIVE PLAN No. 10 SERVICE

Plan No. 10 in the Standard Telephone Facilities provides for an extension trembling bell operating from the alarm contacts of an indicator which is connected across terminals used for an extension bell. When the indicator is dropped by an incoming ring, the trembling bell continues to ring until the indicator is restored manually. This standard facility is installed in cases where, owing to excessive noise, the ringing of a telephone bell or a magneto extension bell may not be heard.

Recently an alternative plan No. 10 service has been listed in which an AC relay is provided to close the circuit of the trembling bell. A 1000 ohm relay of the 3000 type is used and a 1/12A metal rectifier is connected across the relay terminals. The relay is equipped with a pair of make contacts to close the alarm circuit.

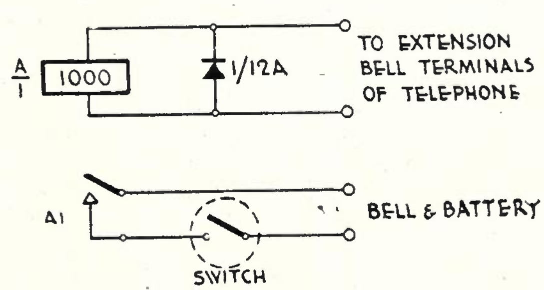


Fig. 1.

The relay, rectifier, switch and terminals are mounted in a suitable wooden box. A schematic circuit of the connection is shown in Fig. 1.

This alternative facility is suitable for use where automatic ringing is provided, such as in automatic exchange areas. The relay operates during the ringing periods and closes the alarm circuit, thus providing an intermittent alarm in synchronism with the exchange ring. This alarm continues until the ringing is tripped by the subscriber lifting the receiver or until the calling subscriber abandons the call.

This alternative facility is advantageous in many cases. Subscribers who must walk a considerable distance to answer the telephone will know immediately if a call is abandoned. It is also unnecessary to reset the alarm and if the alarm bell is not switched off, there is no danger of the alarm bell battery being run down when the service is unattended. The alternative facility cannot be provided in manual exchange areas because machine ringing is restricted to incoming B or automatic A positions. For local calls, where the A telephonist gives only one or two rings, alarm facilities provided by means of an AC relay and trembling bell would probably be inadequate for the average case. In manual areas, therefore, the original plan No. 10 facility consisting of an indicator and trembling bell is still necessary.

Where the original plan No. 10 standard facility, consisting of an indicator and bell, is provided, the indicator must be mounted close to the telephone. This is necessary so that the indicator can be restored when the call is answered. When the alternative plan No. 10 facility is provided, consisting of an AC relay and bell, the alarm unit may be mounted in any suitable position between the telephone and the trembling bell. If the extension trembling bell is fitted a considerable distance from the telephone, it is preferable to install the alarm unit close to the bell, as this reduces the resistance of the local trembling bell circuit and results in more efficient operation.—N.W.

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. 2381.—SUPERVISOR, TELEGRAPHS

R. G. Mills

Q.—Draw a schematic diagram of a Toye Repeater Set and designate each piece of equipment. Discuss the reasons for installing repeaters on a lengthy telegraph channel.

A.—(a) See Fig. 1.

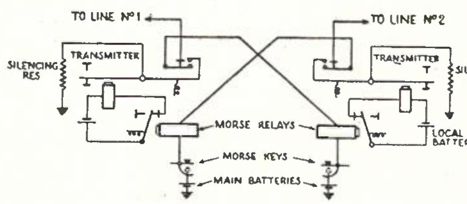


Fig. 1.

(b) The resistance, capacity and leakage of long telegraph circuits are the factors which adversely affect the speed of working. The resistance and leakage effects could be minimised by the use of higher voltages, but there are definite limits to such a practice. Theoretically, the insertion of a telegraph repeater at a suitable office on the route has the effect of increasing the working speed four times as compared with the same circuit without the use of a repeater. The insertion of a repeater also has the effect of increasing the liability to faults due to the additional apparatus and batteries. Generally, the length of the line, the resistance of the conductor, and the climatic conditions of the country traversed determine the necessity for the use of repeaters.

Q.—Explain the function of each of the component parts comprising the balance network associated with a differential duplex.

A.—The circuit is shown in Fig. 2. The function of the balance network of a duplex system is to simulate the effects of the resistance and distributed capacity of the line circuit. The network consists of variable resistances and condensers. One variable resistance is used to balance the resistance of the line circuit while

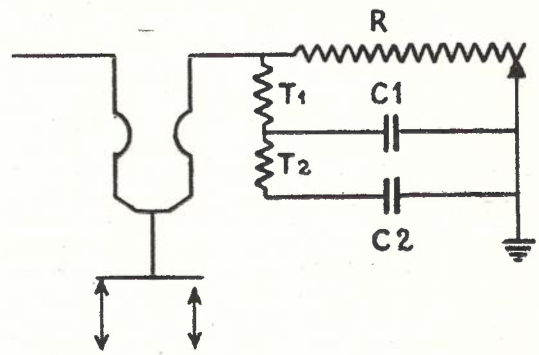


Fig. 2.

two or more condensers, each associated with a variable resistance, are employed to balance the distributed capacity. The variable resistances used in conjunction with the condensers are called timing resistances and regulate the charge and discharge of the condensers. As the effects of the capacity of the nearer portion of the line are greater than that of the remaining section the first condenser is of higher value than that of the second, while the first timing resistance is of a lower value than that of the second timing resistance. A duplex system is considered balanced when the transmission of signals from the balancing office does not affect the operation of the receiving instruments.

Q.—Illustrate diagrammatically the electrical connections of the Murray Multiplex Vibrator and associated Phonic Motor. Describe the method of operation of the combined unit.

A.—(a) See Fig. 3.

(b) The Phonic Motor used for driving the Murray Multiplex distributor consists of a 9-toothed wheel which is kept in motion (after its rotation has been started by other means) by attraction from two electro-magnets which are successively energised by impulses of current through the agency of a Vibrating reed. Each impulse moves the Phonic Motor the distance of one tooth.

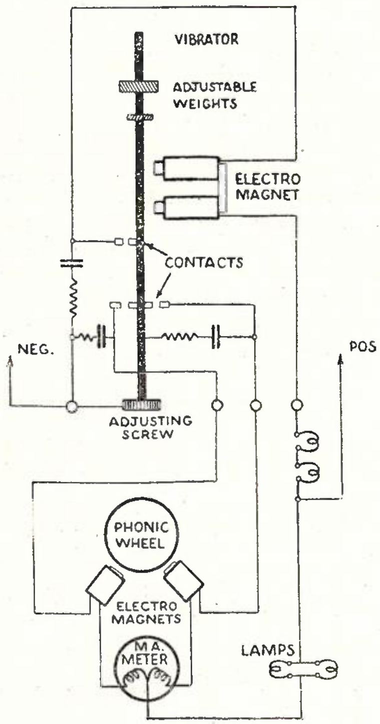


Fig. 3.

The Vibrating reed is driven by an electro-magnet whose circuit is interrupted when the reed is pulled towards it, and completed when the reed moves away from the electro-magnet, thus securing continuity of vibration. Contacts fixed upon the reed are used to control the impulses through the electro-magnets of the Phonic Motor.

The speed of vibration controls the speed of the Phonic Motor and is itself controlled by movable weights placed upon the extremity of the reed. Resistances and condensers are used as shown in Fig. 3 as spark suppressors. A differential milliameter is connected in circuit with the electro-magnets of the Phonic Motor to indicate the duration of the reed on the contacts. The power is derived from the supply mains or other suitable source.

(To be continued.)

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

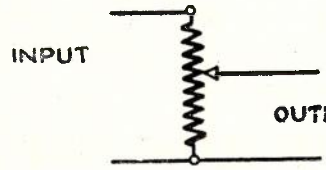
H. W. Hyett

Q. 10.—What is an attenuator? Describe with sketches three types of attenuator commonly used.

Describe how a variable attenuator can be used in conjunction with an oscillator and measuring instrument to determine the gain of an audio amplifier.

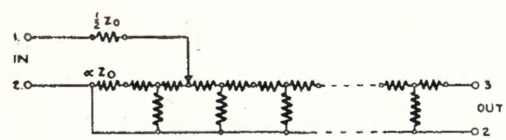
A.—An attenuator is a non-reactive device used to artificially produce power losses in electrical circuits. Three types in common use are shown hereunder:—

(a) The Potentiometer (Fig. 1):—The simplest form of attenuator is the potentiometer, which consists of a bridging resistance fitted with a wiper which moves from one end of the resistance to the other. It is usual to connect the potentiometer so that the signal is fed to the two extremities of the resistor, and the output is taken from the wiper and the low potential side of the resistance. The impedance across the output terminals, i.e., the wiper and the low potential side of the resistance, is not constant, and for this reason its use is limited. Its most common use is as a gain control in the grid circuit of a vacuum tube. It is connected so that the resistance provides the correct termination for the secondary of the input transformer, the wiper being connected to the grid of the tube. In this position it operates satisfactorily as a gain control, as the value of the impedance between the wiper and the low potential side of the resistance is immaterial, because it is connected between the grid and cathode of a vacuum tube.



Q. 10, Fig. 1.

(b) The Unbalanced Ladder type:—The Unbalanced Ladder type usually consists of a number of "T" pads connected in series with a single wiper which moves over 33 studs as shown in Fig. 2. Terminal 2 is common to both input and output circuits, and can be connected to earth if desired. The series of "T" pads are terminated in the characteristic impedance of the circuit "Z_0" at the input end, so that when the wiper is resting on the stud ∞, the impedance at the output terminals 2 and 3 is equal to the characteristic impedance of the circuit.

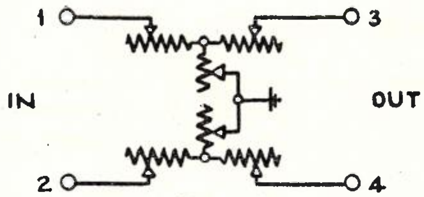


Q. 10, Fig. 2.

A resistance equal to half the characteristic impedance is connected in series with the wiper, otherwise the impedance measured at the input terminals 1 and 2 when the output terminals 2 and 3 are connected to a terminating resistance equal to the characteristic impedance of the circuit would be half "Z_0." The minimum attenuation when the wiper is on step "O" is 6 db, so that with this arrangement, zero insertion loss is never obtained.

The unbalanced ladder is a compromise arrangement, but is satisfactory in practice, as the impedance mismatches at the various settings of the dial are not very great. This type of attenuator is generally used as a fader in a mixer group. The ladder type of attenuator can also be made in the balanced form by using two wipers and a double row of studs.

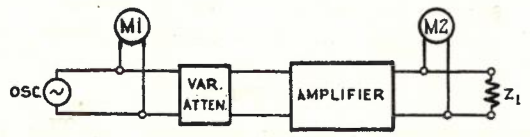
(c) The Balanced "H" type (Fig. 3):—This is the type used for precision measurements, and is comparatively costly to make, as at least five, and if a centre ground is required, 6 wipers, with their associated rows of studs, are necessary. In this type, both the input and output impedances are constant at all settings of the dial, and the minimum insertion loss can be made zero. Furthermore, the device is balanced to ground. The tappings are so arranged on each of the six resistance elements, that for any setting of the dial the resistances in circuit form a true "H" pad. The value of attenuation between each step, the number of steps, and the maximum value of the pad, are made according to requirements.



Q. 10, Fig. 3.

The method of connecting a variable attenuator in a measuring circuit in order to determine the gain of an audio amplifier is shown in Fig. 4.

It is assumed that the input and output impedances of the amplifier, the gain of which is to be measured, are of equal value, preferably 600 ohms. The output impedance of the oscillator, the input and output impedances of the variable attenuator, and the value of the load impedance "Z_L," should, therefore, all be 600 ohms also. The resistances of the A.C. voltmeters M1 and M2 should be high with respect to 600 ohms, so that no bridging loss is introduced. A suitable value for these instruments would be 4,000 ohms. The variable attenuator is set at a value known to be greater than the gain of the amplifier.



Q. 10, Fig. 4.

The output of the oscillator is adjusted to give a suitable deflection on the meter M1 at a frequency of 1000 c.p.s. (This assumes that it is desired to measure the gain of the amplifier at 1,000 c.p.s.) It is essential that the power level in the circuit bridged by the M1 should be within the power capability of the amplifier, in order to avoid overloading.

Having obtained a convenient reading on the meter M1, the loss in the variable attenuator should be reduced until a reading is obtained on meter M2, equal to that shown on meter M1. As the overall circuit now has an equivalent of zero, the value of the attenuation remaining in the variable pad must be equal to the gain of the amplifier.

Q. 11.—How would the overall A.C. plate impedance, the amplification factor and the mutual conductance of two identical triode tubes be affected when they are connected in parallel?

A.—If two identical triode tubes were connected in parallel, the results would be as follows:—

(i) The overall plate impedance would be half that of either of the tubes singly.

The plate impedance is determined by dividing the change in plate current into the change in plate voltage necessary to produce the said plate current change, therefore, when the two tubes are connected in parallel the change in plate voltage can be the same, but the change in plate current will be double that of the single tube, therefore, the impedance will be half its previous value.

(ii) The amplification factor would remain unchanged.

The amplification factor is found by ascertaining the number of volts change in plate voltage necessary to cause the same change in plate current as a change of one volt in the grid voltage would cause. As the change in plate current is brought about either by varying the plate voltage or grid voltage ratio of the latter will remain unchanged for any given change in plate current, therefore, the amplification factor is unchanged.

(iii) The overall mutual conductance would be double that of either of the tubes singly. The mutual conductance is determined by ascertaining the change in plate current which occurs for a change of one volt in the grid volts, therefore, as the plate current is doubled when the two tubes are connected in parallel, for a change of one volt in grid voltage, the change in plate current will be doubled. Therefore, the mutual conductance is doubled.

Q. 12.—Describe meters suitable for measuring—

(a) D.C. currents up to 10 milliamps;

(b) D.C. voltages up to 50 volts.

How could one meter be adapted for both uses referred to in (a) and (b)?

Give a detailed explanation of the action of the meter under both conditions.

A.—(a) A meter suitable for measuring currents up to 10 mA D.C. would preferably be of the moving coil type.

This type consists of a coil of fine wire mounted in the field of a permanent magnet, in such a way that the coil can rotate through a wide angle when a direct current is passed through it. A pointer is attached to the moving coil, and this pointer moves over a calibrated scale as the moving coil rotates.

The number of turns on the moving coil, and hence the sensitivity of the instrument is adjusted so that a full-scale deflection is obtained when a current of 10 mA is passed through the coil.

(b) A meter suitable for measuring D.C. potentials up to 50 volts would be similar in construction to that described under (a), except that a series resistance would be necessary to limit the current to 10 mAs. when the meter was connected to a potential of 50 volts. The scale would be calibrated in volts instead of current.

A meter of this description would not be suitable for reading the voltages in circuits in which high values of resistance existed, as due to the comparatively large current required to operate the instrument the reading obtained would not be identical with the values of voltage existing before the meter was connected. This error would be caused by the drop in voltage occurring through the resistances in the circuit due to the additional current required to operate the meter, flowing through these resistances.

For this reason it is customary to use instruments having greater sensitivity, so that a current of 0.5 or 1 mA will give a full-scale deflection.

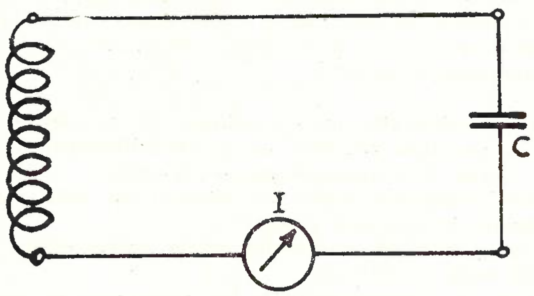
The meter described under (a) could be adapted for the use referred to in (b) by the addition of a series resistance. The value of this resistance would be such that, when added to the resistance of the moving coil, the current would be limited to 10 mA when a potential of 50 volts was applied. A potential of 50 volts would, therefore, give full-scale deflection, and intermediate values would be proportional to the current.

EXAMINATION NO. 2377.—ENGINEER—NATURAL SCIENCE

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

Q. 6.—Draw the schematic circuit of a simple absorption type of wavemeter for radio-frequency measurement. If the condenser of the wavemeter is variable from 50 μ μf to 500 μ μf, calculate the values of the inductors required to permit the wavemeter being used over a frequency band from 150 kilocycles per second to 3 megacycles per second.

A.—(a) The wavemeter shown in Fig. 2 absorbs maximum current as indicated by the meter or lamp I when $f = 1/2\pi\sqrt{LC}$



Q. 6, Fig. 1.

(b) The condenser range in question is 1/10, thus for a given coil the frequency range will be $\sqrt{10/1}$.

The overall frequency range is 20/1 and thus three coils will be required.

Assume ranges.

(1) 120 Kc/s to 120 $\times\sqrt{10}$ = 379 Kc/s
(2) 360 Kc/s to 1138 Kc/s
(3) 1080 Kc/s to 3415 Kc/s.

For the first frequency range the coil required to resonate with 500 μ μF at 120 Kc/s (or with 50 μ μF at 379 Kc/s) is given by

$$L_1 = 1/4\pi^2 f^2 C$$
$$= 1/4 \times 9.87 \times (120 \times 10^3)^2 \times 500 \times 10^{-12}$$
$$= 3518\ \mu H.$$

The second frequency range is 3 times the first and thus the coil required is

$$L_2 = L_1/3^2 = 3518/9$$
$$= 391\ \mu H.$$

The third frequency range is 9 times the first and thus the coil required is

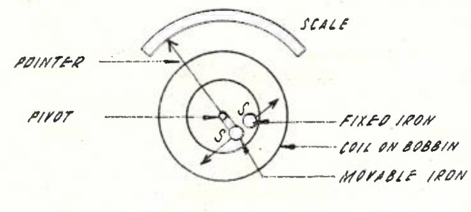
$$L_3 = L_1/9^2 = 3518/81$$
$$= 43\ \mu H.$$

Q. 7.—Draw schematic diagrams of the electric and, where applicable, magnetic circuits of three measuring instruments (current and/or voltage) and for each instrument indicate a total of three characteristic advantages and limitations.

A.—Fig. 1 shows a moving iron ammeter (repulsion type). Current through the coil induces like poles in the "irons," one of which is fixed. The like poles repel each other and the moving iron is attached to a pivoted pointer.

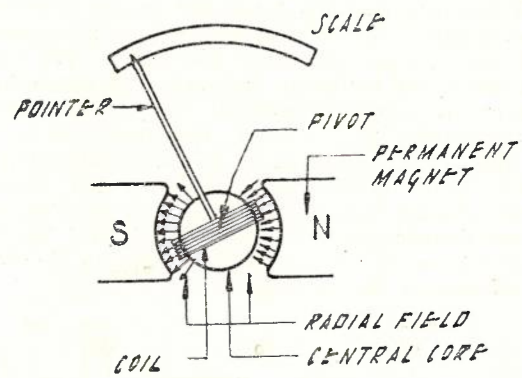
It may be used for AC or DC measurements, but the scale is non-uniform and errors due to hysteresis may occur.

Fig. 2 shows a moving coil ammeter (permanent magnet type). Current through the coil which is situated in a magnetic field gives rise to relative movement. The coil is attached to a pivoted pointer.



Q. 7, Fig. 1.

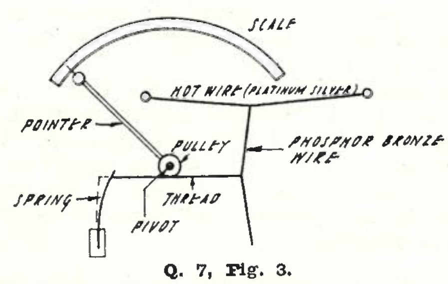
It may only be used for DC measurements unless rectifiers are included, but the scale is uniform and the coil resistance is usually low, giving high sensitivity.



Q. 7, Fig. 2.

Fig. 3 shows a thermal ammeter (hot-wire type). Current through the wire gives rise to heat which causes the wire to lengthen. The wire sags and the "doubled" sag is indicated by means of a thread round a pulley on the pointer.

It may be used for AC or DC measurements and is unaffected by stray fields but the scale is non-uniform.



Q. 7, Fig. 3.

N.B.—For description of other instruments, see Vol. 3, No. 3, p. 140; 8 to 13, No. 4, p. 205.

Q. 8.—(a) State, but do not explain, Hooke's Law as applied to rods and wires indicating the limiting condition under which this law applies.

(b) A round bar having a length of 15 feet is subjected to a pull of 10 tons. If the tensile strength as in normal use is to be 6 tons per square inch, determine the diameter of the bar and its increase in length when the load is applied.

Take Young's Modulus equal to 30 × 10⁶ pounds per square inch.

A.—(a) Hooke's Law states that stress is proportionate to strain, and is true within the elastic limit.

(b) In the question:—

$$\text{Stress} = F/A = 6 \text{ tons/in.}^2 \quad (= 13\ 440 \text{ lbs./in.}^2)$$

$$\text{and Force} = F = 10 \text{ tons}$$

$$\text{giving section area} = A = 10/6 = \pi d^2/4 \text{ where d is diameter}$$

$$\text{Hence } d = \sqrt{4A/\pi} = \sqrt{40/6\pi} = 1.46 \text{ in.}^2$$

$$\text{Again if extension} = e$$

$$\text{length} = L = 15 \text{ ft.} = 180 \text{ in.}$$

$$\text{and Young's Modulus} = Q = 30 \times 10^6 \text{ lbs./in.}^2$$

$$\text{then } e = \frac{F}{A} \cdot \frac{L}{Q} = 13\ 440 \times \frac{180}{30 \times 10^6} = 0.081 \text{ in.}$$

(To be continued.)

EXAMINATION NO. 2295.—ENGINEER—TELEGRAPH EQUIPMENT

S. T. Webster

Q. 4.—Describe briefly the electrical and mechanical operation of Wheatstone duplex system. Explain the functions of the various components in simple language using conventional Departmental nomenclature. Elaborate detailed sketches of components need not be attempted.

A.—The Wheatstone system of machine telegraphy provides a means of transmitting and receiving intelligence at a high speed of transmission. This system makes use of the standard morse code, the signals being transmitted to line in the form of dots and dashes and received in this form on the receiver.

The separate pieces of Wheatstone equipment used and their functions are as follow:—

Wheatstone Transmitter: is a motor-driven unit which transmits double current signals to line in accordance with holes prepared in a perforated tape passed through it.

Perforator, Kleinschmidt: the departmental standard perforator for preparing the tape for Wheatstone transmission is the Kleinschmidt keyboard perforator. The keyboard, comprising 41 keys and a space bar, is somewhat similar to that of a typewriter.

The Wheatstone Receiver: a sensitive polarised instrument which inks a line on a paper slip when a marking element is received.

These instruments can be used for transmission over a physical line, carrier telegraph channel or wireless telegraph link.

The application of Wheatstone instruments to a bridge duplex set is shown in Fig. 1. The circuit, which is here shown in a simple form, is based on the Wheatstone bridge principle.

The polarised vibrating relay R is connected in series with the meter M and shunted reading condenser RC across the ratio arms RA. When the components of the artificial line AL are adjusted to simulate the resistance and capacity characteristics of the line, the set is "balanced" and in this condition the relay is not affected by the reversal of the potential applied to the split of the ratio arms.

Functions:—

Wheatstone Transmitter WT: The tongue is operated in accordance with the code perforated on the tape. Positive and negative potentials are applied to the armature during spacing and marking periods respectively.

Morse Key MK: The transmitter can be replaced by the polechanger PC, which is controlled by the morse key MK for manual operation.

Signalling Condensers SC: are to improve the signals transmitted to the distant terminal and thus increase the speed of working for a given potential.

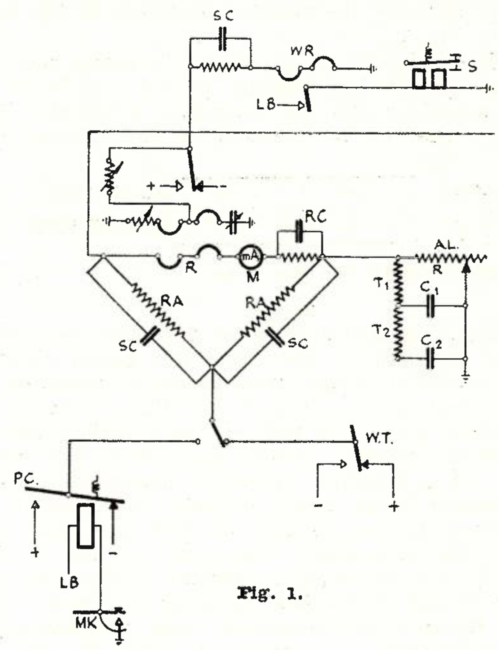


Fig. 1.

Artificial Line AL: is a network adjusted to simulate the characteristics of the physical circuit. The resistance of the line is balanced by the resistance component R while the capacity is balanced by condensers C1 and C2 timed by timers T1 and T2 respectively.

Reading Condenser RC: comprises a resistance shunted condenser employed to increase the speed of working by improving the signal shape of the received signals.

Relay R: is a sensitive polarised relay which operates to marking or spacing as negative or positive potentials respectively are applied at the distant end. For high-speed working, this relay is provided with vibrating or Gulstad windings as shown in the sketch.

Wheatstone Receiver WR: is controlled by the tongue of the receiving relay R through the shunted condenser SC. The receiver prints the received signal in the form of dots and dashes on a paper slip.

Sounder S: is operated by contacts attached to the armature of the Wheatstone receiver and is used for manual reception.

Mechanical Operation:—

Kleinschmidt Perforator: In the Kleinschmidt Perforator the perforating and feeding of the tape is controlled by one solenoid.

Selection of Punches: Every key, on depression, carries with it a corresponding selecting bar. This bar, by means of a projecting tongue, selects a group of T bars and depresses them. Each of these T bars has a connecting bar in mesh with it by means of which the motion is transmitted through connecting links to the punch selectors. The latter when raised assume positions directly behind corresponding punches in the punch head. A starting bar common to all keys closes the solenoid circuit and the plunger is attracted imparting a forward movement to the forward lever. This forward motion in turn moves the punch head forward. The punch selectors raised by the key act as buffers and the corresponding punches are forced through the paper. The upper and lower perforations in the paper represent the message holes, whilst the centre line of holes are for the purpose of feeding the tape forward. A diagram showing the relative positions of the holes is given in Fig. 2.

Paper Feed: Since the characters in morse code are of varying length the feeding of the tape must be variable according to the character selected. This variation is effected by means of a link motion con-

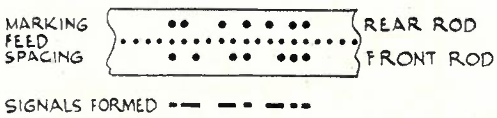


Fig. 2.

necting the feed operating lever with the feed pawl. When the solenoid is energised the punch hammer lever is rotated in a clockwise direction operating, in turn, the feed lever. One of the links, termed the floating lever, during its motion, rests against the lug of the punch selector of the last lower line punch operator. A subsequent forward movement of the punch hammer block locks or holds this end of the floating lever in the position selected and acts as a pivot for the subsequent movement of the floating lever. With the continued movement of the feed lever the forward end of the floating lever is moved to the left and through its associated links withdraws the feed pawl the required number of teeth on the feed ratchet wheel. By this means the amount of tape fed forward is proportional to the length of the character perforated.

The Wheatstone Transmitter is a small and extremely light double current key operated mechanically, its movements to the marking or spacing side being controlled by the positions of the message holes in the tape. The permanent magnet with adjusting screws serves to hold the armature firmly on the side to which it is placed.

Operation: A rocking beam is caused to move up and down, its speed conforming with the rate at which the star wheel feeds the tape through the transmitter. Two pivoted cranks are held against two pins in the rocking beam. From the inner end of each crank rises a pivoted rod and these are presented to the tape in turn. If a hole is over a rod, the rod can pass through, transferring the motion to the armature. Since the movement of the tape is continuous it will drag an entered rod slightly to the left, but when withdrawn the rod is spring restored to its stop. The star wheel which feeds the tape is between the rods, and a grooved roller holds the tape in contact with the star wheel. With no tape in the instrument, the rods will rise alternately and reversals will be transmitted to line, the spacing impulse corresponding to the period when the front rod is in the upper position and the marking impulse corresponding to the rise of the rear rod. If, after the marking rod has risen, the spacing rod is prevented by the tape from rising, marking will be sent until the spacing rod is permitted to rise.

Receiver: The receiver, which operates on a current of about 20 m.A., is very similar in electrical and magnetic parts to a standard relay. It comprises a powerful horseshoe magnet acting on two soft iron armatures placed between two 100 ohm electro-magnets, which may be moved bodily by an adjusting screw. Movements of the armatures produce movement of the ink wheel bringing it into contact with the message tape giving a mark. Ink is fed to the ink wheel via a larger wheel, which almost touches it, but revolves in the opposite direction. This ensures a uniform mark at all speeds. The armature also carries a contact which controls the operation of the sounder in the local circuit.

Q. 5.—Prepare the layout for a telegraph office to be equipped with the following terminal apparatus:—

3 Quadruple Murray Multiplex sets;
1 Wheatstone set;
4 Teleprinter sets;
5 Hand-speed Duplex sets;
30 Simplex sets.

Assume dimensions for operating and power rooms. Indicate necessary lighting, conveyor equipment and apparatus racks. State full reasons for the layout you propose.

A.—A suitable layout for the operating room to accommodate the terminal apparatus stated is given in Fig. 1.

It has been assumed that the office is a C.T.O. in which all of the Multiplex sets, the Wheatstone set and two of the Duplex sets are employed on interstate traffic; also that the remaining Duplex sets and 20 of the Simplex sets are employed on country traffic, while the 10 remaining Simplex sets are used for suburban traffic and the teleprinters are connected as local point-to-point services. The layout has accordingly been arranged in three sections—Interstate, Country, and Suburban—in a single room 47′ x 91′.

All instrument tables are standard telegraph tables 2′2″ x 17′6″, allowing a possible five positions of 3′6″ per table. The tables are arranged in pairs back to back with a V belt table conveyor between them. Each pair of tables thus measures 4′6″ x 17′6″ overall. Spacing between adjoining pairs of tables is 6 ft., while a 2 ft. space is provided between walls and ends of tables to accommodate the main return V belt conveyors. An 8 ft. aisle is provided down the centre of the room. 4′6″ is allowed between the end walls and the operating positions facing them. This spacing will provide sufficient room for the staff manning the positions.

Each arm of a Murray Multiplex set requires two operating positions—one for the perforator and transmitter and the other for the printer. A quadruple set, therefore, occupies eight positions. Another position is required to accommodate the plateau, phonic motor and terminal box. The vibrators would be provided on the basis of three for every two Multiplex sets. Three vibrators would, therefore, be fitted on position V1 and two on position V2.

The Wheatstone set (assumed to be duplex) occupies all five positions of a single table—three for receiving and transmitting and the other two for perforators.

The Duplex sets each occupy two positions—one for sending and the other for receiving.

Simplex sets and Teleprinter sets require one position per set.

As in the practical case, provision must be made for future development, space has been provided for an additional nine half-tables for this purpose. These are indicated dotted in the figure.

To reduce the time lost in internal circulation of message forms in the operating room to a minimum conveyors are provided. Incoming messages received by the operators are placed in V belt conveyors in the centre of the double tables. These feed into floor type V belt main conveyors running past the ends of the tables down the sides of the room and terminating in a bin at the circulation table. The main conveyor on

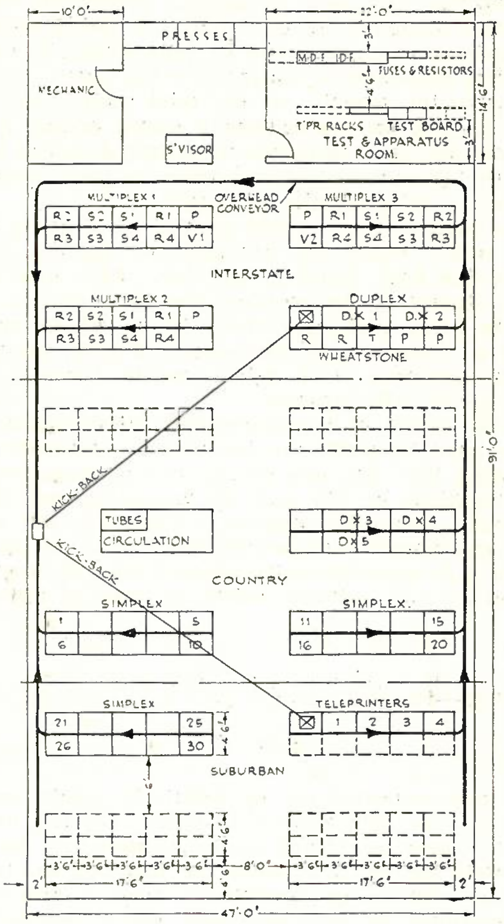


Fig. 1.

the opposite side of the room to the circulation table terminates in a drag-band conveyor which crosses the room overhead and feeds into the V belt discharging at the circulation table. All incoming messages are thus brought to a central point, whence they are despatched by tubes to the delivery room or by kickback conveyors to the distributing positions in the operating room. Forms are distributed by hand from these positions. The direction of flow over the internal circulation conveyors is indicated in the figure.

The MDF, IDF's, Test Board, battery resistance and fuse racks and teleprinter racks are grouped together in an adjoining room for convenience of cabling and in testing and patching. A standard single-sided 8'6" MDF framework with verticals, each accommodating 200 pairs, is employed for both MDF and IDF's. This requires a floor area approximately 7'6" x 2'. The racks are standard 8'6" type with 19" panels. A 3 ft. working space is provided behind the frame and the racks and a 4'6" working space in front of the frame and the test board. Only one rack each is necessary for resistances, fuses and teleprinter sets, but space is available for future development by extending the test room and racks in the directions indicated.

For ideal conditions it would be necessary to provide a good uniform general lighting with little or no shadow and of the order of 25 ft. candles at the operating positions. This would allow a normal minimum effective lighting of 15 to 20 ft. candles, allowing for deterioration of globes, fittings and reflecting surfaces of walls and ceilings. It is important to avoid glare either directly from lighting fittings or reflected from the glasses in printer covers, etc. The most satisfactory lighting would, therefore, be semi-indirect with a large proportion of indirect light. The upper parts of the walls and the ceiling should be coloured a light cream or ivory shade with a matt finish. The height and spacing of the fittings and the power of the globes required would depend upon the ceiling height and the characteristics of the fittings. Natural lighting would be provided by windows opposite each operating table. It would also be necessary to apply sound-absorbing treatment to the ceilings and upper walls to reduce room noise.

Q. 6.—Furnish details of the power equipment you would recommend for satisfactory operation of a telegraph office such as that indicated in Question 5. Prepare a floor plan showing the locations of the various power units and associated apparatus; give reasons for the location you propose.

A.—In determining the power equipment for the systems listed in Question 5 the following assumptions have been made:—

(a) The public supply is 230/460 volt D.C. (the general case in capital cities) and this supply is used on the machine systems.
(b) The Multiplex and Wheatstone sets are worked to carrier channels, operate 24 hours per day and $\frac{2}{3}$ of signalling current is spacing.
(c) The teleprinter sets are local point-to-point services, operating 24 hours per day and marking $\frac{2}{3}$ of that time.
(d) The Duplex sets are operating 18 hours per day; signalling current is $\frac{2}{3}$ spacing and require 180 volts to line.
(e) The Simplex services operate 12 hours per day, $\frac{2}{3}$ of time being closed circuit and require 60, 120 and 180 volts to line—10 sets to each voltage.

Signalling batteries of positive and negative 60, 120 and 180 volts would, therefore, be necessary; a local battery for the sounders, etc., would also be necessary. The daily current drain on batteries would be as follows:—

(a) 3 Multiplex Sets:
    Signalling battery 120V. ±: 25mA each = 75mA.
    Negative = 75 mA for 1/3 of 24 hours = 0.6 A.H.
    Positive = 75 mA for $\frac{2}{3}$ of 24 hours = 1.2 A.H.
(b) Wheatstone Set:
    Signalling on send loop and receiving relay contact 120 volt ±: 25 mA each = 50 mA.
    Negative = 50 mA for 1/3 of 24 hours = 0.4 A.H.
    Positive = 50 mA for $\frac{2}{3}$ of 24 hours = 0.8 A.H.
    Local batteries on sounders and pole changer: 160 mA for 1/3 of 24 hours = 1.28 A.H.
(c) 4 Teleprinters:
    Signalling battery 120V. ±.
    Positive:
        Bias on relay: 15 mA each = 60 mA for 24 hours .... = 1.44 A.H.
        Operating current: 30 mA each = 120 mA for 1/3 of 24 hours .... = 0.96 A.H.
        Relay contact: 25 mA each = 100 mA for 1/3 of 24 hours .... = 0.8 A.H.

Total .... 3.2 A.H.

Negative:
Relay contact: 25 mA each = 100 mA for 2/3 of 24 hours = 1.6 A.H.

(d) 5 Duplex Sets:
Signalling battery 180V. ±: 50 mA each = 250 mA.
Negative: 250 mA for 1/3 of 18 hours = 1.5 A.H.
Positive: 250 mA for 2/3 of 18 hours = 3 A.H.
Local battery for sounders and polechanger:
120 mA each = 600 mA.
600 mA for 1/3 of 18 hours = 3.6 A.H.

(e) 30 Simplex Sets:
Signalling battery 180, 120 and 60 volts:
25 mA each.
10 on each voltage = 250 mA each voltage.
250 mA for 2/3 of 12 hours = 2 A.H. each voltage.
180 volts: 2 A.H.
120 volts: 2 A.H.
60 volts: 2 A.H.
Local batteries for sounders: 40 mA each = 1200 mA.
1200 mA for 2/3 of 12 hours = 9.6 A.H.

The ampere-hour loads detailed above may be summarised as in Table 1:—

TABLE 1.

Set	Local	60 V.		120 V.		180 V.	
		+	—	+	—	+	—
Multiplex ..	—	—	—	1.2	0.6	—	—
Wheatstone	1.28	—	—	0.8	0.4	—	—
Teleprinters	—	—	—	3.2	1.6	—	—
Duplex	3.6	—	—	—	—	3	1.5
Simplex	9.6	—	2	—	2	—	2
Total	14.48	—	2	5.2	4.6	3	3.5

The signalling batteries are arranged in groups of 60 volts. Four such groups are required for the negative potentials—three being on load and the other on charge. A rotary switch is provided so that each group is switched to the 60 volt, 120 volt, 180 volt and charge positions in succession. Similarly, a rotary switch and four 60V. groups are provided for the positive voltages.

Considering a 60-volt group as it is switched through the successive discharge positions 60, 120 and 180 volt respectively. If the loads on these potentials are considered as:—

60V. = a
120V. = b
180V. = c

The group supplying the 60V. load also carries the 120 and 180V. loads. Similarly, the group supplying the 120V. load also carries the 180V. load. The load carried by the group may, therefore, be considered as:

When supplying 60V. = a + b + c
,, ,, 120V. = b + c
,, ,, 180V. = c

Total for complete sequence .... a + 2b + 3c

The total ampere hour load on the signalling batteries if the switch is operated through the complete sequence each day is, therefore:

Positive: 0 + 2 (5.2) + 3 (3)
= 0 + 10.4 + 9 = 19.4 A.H.
Negative: 2 + 2 (4.6) + 3 (3.5)
= 2 + 9.2 + 10.5 = 21.7 A.H.
say — 22 A.H. each.

To this must be added a reasonable allowance, say, 3 A.H., for testing monitoring and miscellaneous purposes, making a total of 25 A.H. per day.

The switching sequences must be arranged to allow time to fully charge the idle bank of batteries during the working day, say, 12 hours. This could be conveniently arranged by operating the switch once per day so that any one group of cells would be on load for three days and be charged on the fourth day. On this basis the capacity of the cells would need to be 75 A.H., but this arrangement would permit a more frequent switching sequence to be introduced at a later date to take care of any increase in load during the life of the cells initially installed.

The local battery would consist of a group of 20 cells which would be arranged to operate floating during the busy hours of the day. Only one battery would, therefore, be required for this purpose. This load is 14.48 A.H., say, 15 A.H., to which must be added a reasonable allowance, say, 5 A.H., for miscellaneous purposes. The battery would, therefore, need to be of 20 A.H. capacity.

In the layout of the power and battery rooms, provision must be made for the ultimate estimated load. Assuming that this was double the existing load, battery capacities of 150 A.H. for signalling and 40 A.H. for loads would be required. Therefore the battery room and power room would be laid out on the basis of 150 A.H. signalling batteries and 40 A.H. locals, but 75 and 20 A.H. batteries would be installed initially.

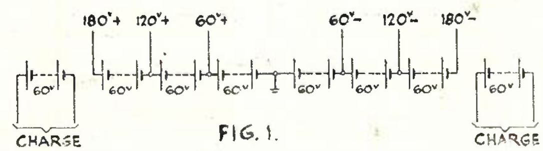


FIG. 1.

As the batteries are of relatively small capacity, enclosed type cells would be used. On the ultimate capacity these would not exceed 8″ wide, 4½″ long and 10″ high per cell and could be installed on two-tier racks or shelves in the battery room. Two 60-volt groups could be accommodated on a two-tier rack 9″ x 11′ 3″ and the 40-volt local group on a single-tier rack 9″ x 7′ 6″. Fig. 2 shows a suitable layout for the battery room; the battery racks being arranged against the walls or back to back. The dimensions given for the aisles between racks are the minimum which would be considered satisfactory.

For charging the 60V. batteries a charging source of 80 volts is necessary. A motor generator set having an output of 3000 watts at 80 volts would, therefore, be provided. This would be sufficient to charge two 60-volt batteries of the ultimate (150 A.H.) capacity in parallel at the maximum 8 hours' rate. Suitable regulating resistors would be provided on the control panel to adjust the charging current between the two parallel batteries.

For charging the 40V. local battery a motor generator having a capacity of approximately 275 watts at 55 volts should be provided.

Fig. 2 shows the layout of the power room containing the two motor generator sets described above, together with a power switchboard comprising:

(a) One 3′ panel for the batteries (for the rotary switches, main fuses, etc.).
(b) One 2′ panel for the charging generators (field regulators, circuit breakers, etc.).
(c) One 2′ panel for the motors of the motor generators (starters, overload and no current release switches, etc.).

Spare armatures would be provided for the motor generators, which would not be provided in duplicate

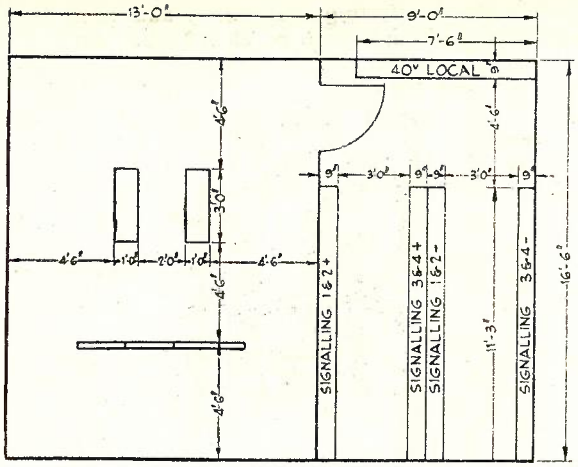


Fig. 2.

as in the event of the failure of the charging sets the commercial 230V. D.C. supply could be used with suitable resistors and switches for charging.

It would be necessary to provide an alternative 230/460V. supply against the failure of the public supply since this is employed on the machine systems, conveyor motors and lighting. As a general rule, an emergency supply for the whole building must be provided and in the absence of an alternative public supply this would be provided by means of a diesel or petrol-engine operated 230/460V. D.C. generator set of sufficient capacity to take the load of the whole building. In a large building such as a C.T.O. this set would not be associated with the telegraph office power room, but would be located in the basement with the machines associated with the ventilating and heating system and other services of the building. This set has, therefore, not been included in the layout shown in Fig. 2.

The power room and battery rooms would be located next to each other to simplify and reduce the length of cabling and the inspection of batteries during charging. The power room should also be as near as possible to the IDF and resistance and fuse panels in the operating room to reduce cabling. Precautions would, however, be necessary in providing the ventilation of the battery room to guard against acid fumes entering either the power room or the operating room.

Q. 7.—Describe, by means of simple sketches, the mechanical and electrical features of four types of telegraph relays.

A.—(a) The Morse Relay: The relay used in C.C. morse working is of the pony type with a winding of 150 ohms resistance. The construction of the relay is shown in Fig. 1. The coil consists of two cores mounted in the form of a U on a piece of soft iron. The armature, which is of soft iron, is pivoted as shown. A retractile spring tends to pull the armature away from the cores of the magnet. When current flows the armature is attracted against the pull of the retractile spring and the contacts of the local circuit are closed. The tension of the spring, and the gap between the electro-magnet cores and the armature are adjustable. This relay has a figure of merit of about 5 m.a.

(b) The Differential Non-Polarised Relay: This relay is mounted in a brass case with a glass cover similar to the B.P.O. standard relay dealt with under (c), the general construction being somewhat similar to Fig. 3. No polarising permanent magnet is provided, and the armatures are extended both sides of the spindle as shown in Fig. 2A. Each armature is separated in the centre by a section of brass to reduce the effects of residual magnetism. The cores are so arranged that when they become magnetised by the passage of current through the windings, the armatures are attracted against the force of the spring attached to the rear extension of the contact lever mounted on the upper end of the spindle, as shown in Fig. 2B. Two wind-

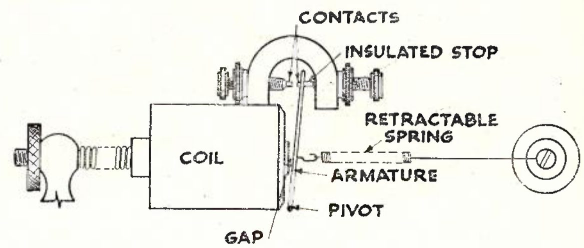


Fig. 1a.

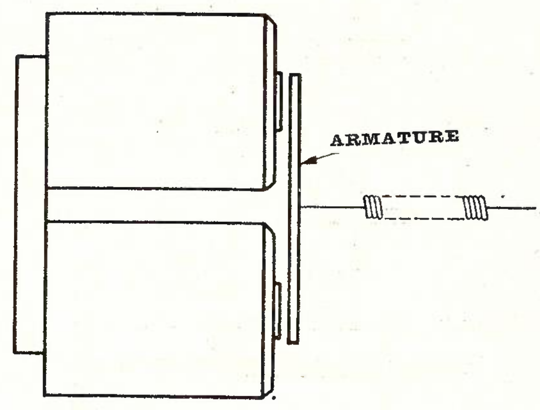


Fig. 1b.

ings, each of 100 ohms, are wound differentially and an equal current flowing from U to D in one winding and from D to U in the other does not magnetise the cores. With both coils in agreement, or with a preponderance of current of sufficient magnitude through one winding, the relay armature is operated irrespective of the direction of the current flow.

(c) B.P.O. Standard Relay: The construction of this relay is shown in Fig. 3. Two electro-magnets are placed side by side and between their poles are two soft-iron armatures mounted on a common spindle which also carries a contact lever at its upper end. The armatures are rendered magnetic by induction from a large horse-shoe permanent magnet P.M., the poles of which are placed behind them as shown. The spindle is pivoted at both top and bottom and the armatures are, therefore, free to move from one side to the other.

Platinum-tipped contact screws, which are insulated from the body of the relay, are mounted on either side of the contact lever and limit the movement of the armature in either direction.

The relay is differentially wound with two windings of equal resistance, D and U being the terminals of one winding, whilst the other is terminated on terminals D circle and U circle, each winding consisting of a winding on each coil connected in series. As the armatures are induced magnets, as shown in Fig. 3, it will be appreciated that the armature is acted on by four forces when current is passed through one winding. The two pole pieces of one core attract the armatures, whilst those of the other core repel them. A reversal of current, of course, reverses the polarity of the cores and, consequently, the direction of movement of the armature is governed by the direction of the current flowing in the winding. The connections are

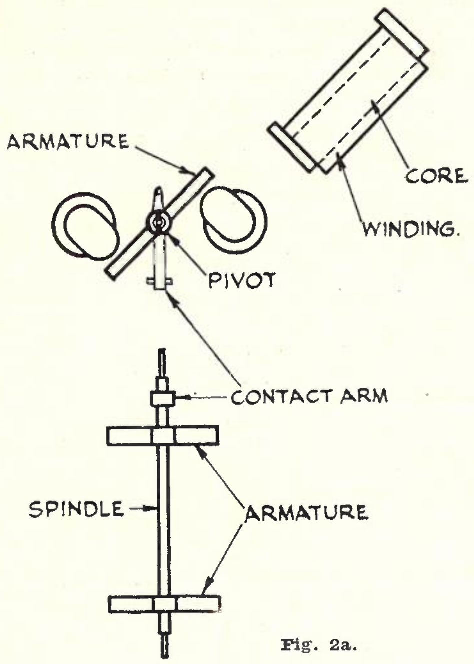


Fig. 2a.

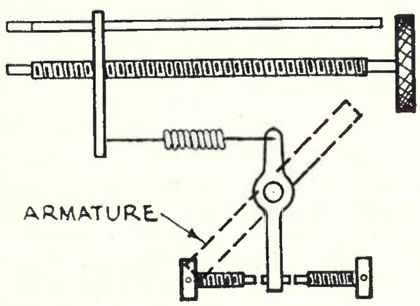


Fig. 2b.

so arranged that the armature is operated to the spacing contact when positive potential is applied to the D terminal.

Being differentially wound, when equal currents are passed through both windings in opposite directions the magnetic effect of one cancels that of the other, with the result that the armature remains unaffected. The relay is set in a neutral condition when the armature will remain on either contact, when no current is flowing in the winding. The contacts are mounted on a carriage which can be moved to either the left or right hand advancing or withdrawing a bias adjusting screw, thus biassing the relay in either direction.

(d) Creed 1927 Type Relay (Fig. 4): The various parts of the Creed Relay, 1927 type, are assembled in a moulded bakelite body, the armature A and pole pieces PP consisting of laminated stalloy. The relay windings are wound in the form of hollow coils, through the centre of which the armature passes. This relay is of the polarised type, the polarising magnetic field being provided by a heavy permanent magnet PM, placed across the lower extremities of the pole pieces as shown in Fig. 4. The line coils are differentially wound and can be supplied with windings of various

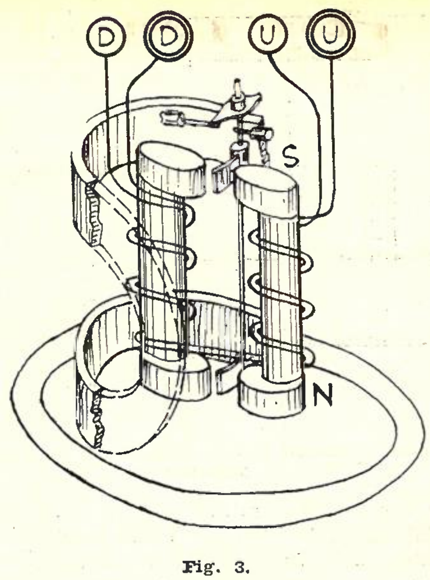


Fig. 3.

resistance values. The relay in general use in the Department is fitted with line windings of 135 + 135 ohms with the addition of auxiliary windings of 66 + 66 ohms for Gulstad operation.

The relay can be biassed by means of the bias adjusting screw which moves the whole relay body about the point X in Fig. 4. The relay body is held against the bias screw by means of the spring and plunger shown.

This relay has a very low figure of merit and satis-

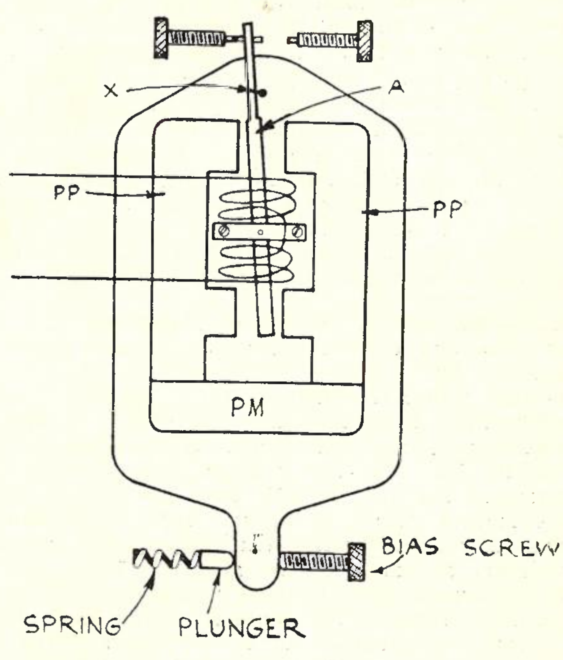


Fig. 4.

factory operation can be obtained with a line current of two to three milliamps through both line windings connected in agreeing series.

The connections of the relay terminate in projecting screws which make contact with springs in the relay base.

Continued from Cover ii.
this load should be applied in five seconds and the remainder applied five seconds thereafter.

Electrical Resistance: Where considered desirable, the resistance of a test piece not less than 1/30th of a mile in length may be measured and, when corrected for temperature, should not be greater than 4.4206 ohms per mile at 60° F.

(iii) A 220-yard coil of outside distributing wire should be submitted to the following tests:—

The conductor should be circular in cross-section, pliable, free from scale, inequalities, splits and other defects. It should be free from joints at all points and have a diameter of 0.044″ ± 0.0007″. The resistance of each conductor should not exceed 28.9 ohms per mile at 60° F., and the resistance unbalance between conductors should not be greater than one ohm per mile at the same temperature. The conductor should be fully annealed and a specimen of length between 6″ and 12″ should be capable of a steady elongation of at least 15% without failure.

The wire should be uniformly tinned and when immersed three times in hydrochloric acid of 1.088 specific gravity for one minute and sodium polysulphide solution of 1.142 specific gravity for half a minute, alternately washing between immersions. No black discolouration should be present.

The dielectric should be good quality, vulcanised rubber of radial thickness .035″. Samples of the dielectric should be submitted to the following mechanical tests:—

(a) A piece marked with two lines 2″ apart after being maintained at a temperature of between 65 and 75° is steadily stretched until the lines are 7″ apart and kept in this condition for 24 hours. On release there should be no signs of cracking and after six hours at the original temperature the distance between the lines should be uniform and not greater than 2.6″.

(b) The tensile strength of the dielectric shall be not less than 2,000 lb. per square inch.

Samples of the dielectric should then be heated in an oven at a temperature of 180° F. for 120 hours and within 24 to 72 hours thereafter the properties mentioned in (a) above should be retained and the tensile strength should be not less than 70% of that quoted in (b). A voltage test may be carried out using 1,000 volts A.C. 25-100 periods per second. This e.m.f. is applied for 15 minutes and no breakdown of the insulation should occur. An insulation resistance test is then applied to the coil using 500 volts D.C. for one minute when the coil is immersed in water at a temperature of 70°. The result should not be less than 150 megohms.

The braiding covering the rubber should not be less than 0.02″ in radial thickness and coated with a suitable weatherproof compound. This compound should not become fluid after heating to a temperature of 125° for 30 minutes and should not give off any greasy substance. The finished wire, if twisted, should have a lay of between 3½ to 6″.

(iv) The following acceptance tests are applied to a 220-yard drum of 800-pair 10-lb. P.I.Q.L. cable:—

Conductors: Each conductor to consist of a solid wire of annealed copper smoothly drawn and approximately circular in cross-section, having a diameter between 0.0245″ and 0.0255″ and a resistance per mile of 87.72 ohms, the conductors to be free from joints except for a small number which may be rendered necessary before sheathing in the process of manufacture. The tensile strength of such joints should be not less than 90% of an unjointed conductor and a length of 6″ of conductor containing a joint should have a resistance not greater than 105% of similar length of plain wire. The number of conductors should be 808 pairs.

Dielectric: The wire is insulated with a helical wrapping of paper, the paper used should be uniform in texture and have a thickness not less than 0.0025″. A strip of this paper should be capable of supporting a weight of 4 lb. for each inch in width and 0.001″ in thickness. Printed on the paper are coloured lines so arranged that when lapped around the wire a group of rings is formed on the outside. The separate wire of a quad should be indicated with 1, 2, 3 and 4 rings in the usual star-quad formation.

Quadding: Quads should show alternately red and blue rings and each whipped with white or black cotton for alternate layers except for the pilot and last quads of a layer which are also whipped with orange cotton. The lay of the conductor forming the quads should be reversed for adjacent quads.

Stranding: The quads are stranded so that the direction alternates in successive layers.

Lead Sheath: The lead sheath should be free from pin holes and joints and should withstand an internal air pressure of 75 lb. per square inch for three hours after the pressure is equalised. The external diameter of a sheath should be 2.38″ and the radial thickness 0.126″.

Insulation Test: When measured with a source of d.c. of e.m.f. between 300 and 600 volts, the insulation resistance of each conductor in the cable measured with all other conductors connected to the lead sheath should be not less than 5,000 ohms per mile after electrification for one minute.

(To be continued.)

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