The Telecommunication Journal of Australia

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THE POSTAL ELECTRICAL SOCIETY OF VICTORIA

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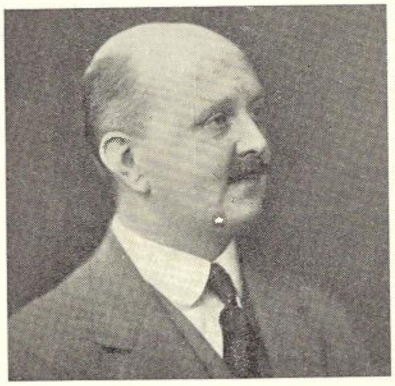
Vol. 2, No. 1. *JUNE, 1938*

SIR HARRY BROWN, K.B., C.M.G., M.B.E., M.I.E.E.

In the recent list of Birthday Honours, the item most interesting to members of this Society was the announcement that a Knighthood had been conferred on the Director-General of Posts and Telegraphs.

Sir Harry Brown served with distinction in the British Post Office for 25 years, including a long period as Staff Engineer in the Engineer-in-Chief's Office, London. He visited India in



SIR HARRY BROWN,
K.B., C.M.G., M.B.E., M.I.E.E.

1913-14 and reported on the telephone, telegraph and railway control communications, and during the Great War was responsible for the telephone plant of the United Kingdom and for emergency communications associated with the system of defence.

At the invitation of the Government of the Commonwealth, Sir Harry came to Australia in January, 1923, as technical adviser in relation to Post Office matters, and at the end of that year he was appointed to the position of Director-General.

One of the outstanding features of the Administration since Sir Harry took charge has been the fostering of a spirit of co-operation throughout the Service. Every officer has been encouraged to feel that whatever his position may be, his work is important to the success of the Service.

Sir Harry has set for himself a high standard of personal service, and does not spare himself in any way in attending to the multitudinous duties associated with his position. In the same way he expects all officers to give of their best in the interests of the Service, but he is most generous in his appreciation of earnest endeavour and is always more ready to praise than to blame.

It will be recollected that when Sir Harry arrived in Australia, a heavy demand for new telephone services, particularly in country districts, was occurring, and that for some years the problem facing the Department was to meet this demand without undue delay. Since then the Post Office, in common with all other interests was faced with the results of the depression, but another period of great activity is now being experienced. Sir Harry has successfully met these varied conditions and has done so under what surely must be the most difficult condition that can be imposed on the head of any large business undertaking, viz., that he is dependent year by year on the will of Parliament for the money required not only for the expansion of, but also the maintenance and operation of the plant of his Department.

An examination of the operations of the P.M.G.'s Department, whether we study the magnitude of the financial and statistical figures shown in the Postmaster-General's report, reflect on the varied nature of the functions performed, or consider the intricate character of many of the services rendered, forces a realization of the very heavy load carried by the Director-General. It is, therefore, very fitting that the onerous service so loyally given should now be recognized. This will be an encouragement to all officers to feel that the value of the Department's services in providing the varied forms of communication essential to the efficiency and well-being of the nation, has been acknowledged.

In 1932, when the Society was reconstituted, Sir Harry Brown delivered the inaugural address and he has always evinced a practical interest in our affairs.

All members of the Society will join in extending to Sir Harry and Lady Brown most hearty congratulations and best wishes for their future happiness.

THE EARLY HISTORY OF THE POSTAL ELECTRICAL SOCIETY OF VICTORIA

E. J. Credlin

Even in the embryonic days of Telegraph and Telephone Engineering in Australia, those directly associated with this important communication industry realized the importance and advantages of a society, embracing officers who controlled and operated the service, to facilitate the interchange of technical knowledge and its practical application.

Thus as early as 1874—even before the advent of the telephone—the first Electrical Society was formed in Victoria by the then comparatively few Telegraph Society workers, who apparently realized that even in those early stages of the development of the telegraphic engineering art, their day to day problems would be lessened and simplified by mutual discussion, and that this society would provide an avenue for the advancement of their technical and practical knowledge.

Unhappily the records of the activities and progress of this foundation body are very scanty. As far as can be ascertained, the subscription was 10/- per annum, and the activities were conducted, during the inception period, by some half a dozen members, who arranged for the issue of a journal, and the preparation, printing, and distribution of technical papers. The subscription fees were intended to provide the funds for this purpose. It is interesting to note that the membership comprised a large proportion of the country postmasters. Presumably, however, the papers issued by the society were of such an abstruse character that they were not always suited to the needs of the general members and as the years progressed the enthusiasm of its sponsors was not maintained. Although it had remained primarily a Telegraph Society, it lost much of its punch, although there were periodic revivals. It was eventually superseded in 1908 by the Postal Electrical Society, which comprised both Telegraph and Telephone Branches, including members of the Traffic Section, who were officers of the Engineering Branch, under the organization existing at that time.

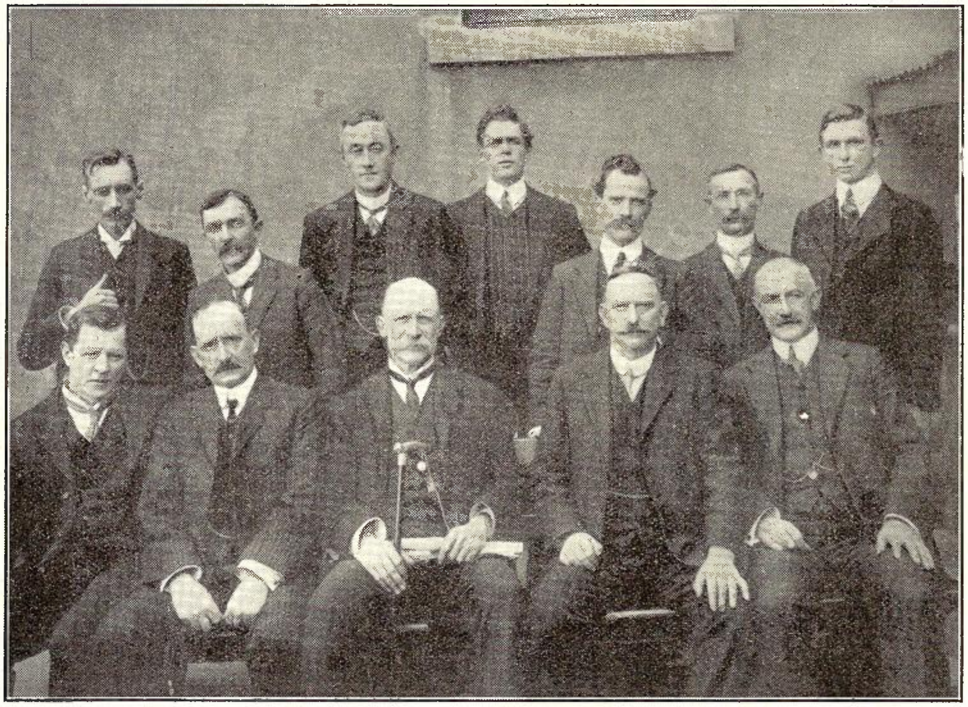


Fig. 1.—Committee—Back row: E. S. Howson, W. J. Dawson, H. J. Rutherford, G. H. Bussell, F. Prior, O. A. Junck, E. A. Batty. Front row: M. J. Fitzgerald, G. H. Morgan, H. W. Jenvey, C. E. Bright, T. Howard.

The inaugural meeting of the new society, viz., the Postal Electrical Society, was held in the old Telegraph Office, located in the Elizabeth Street Post Office—then the General Post Office —on the 11th November, 1908.

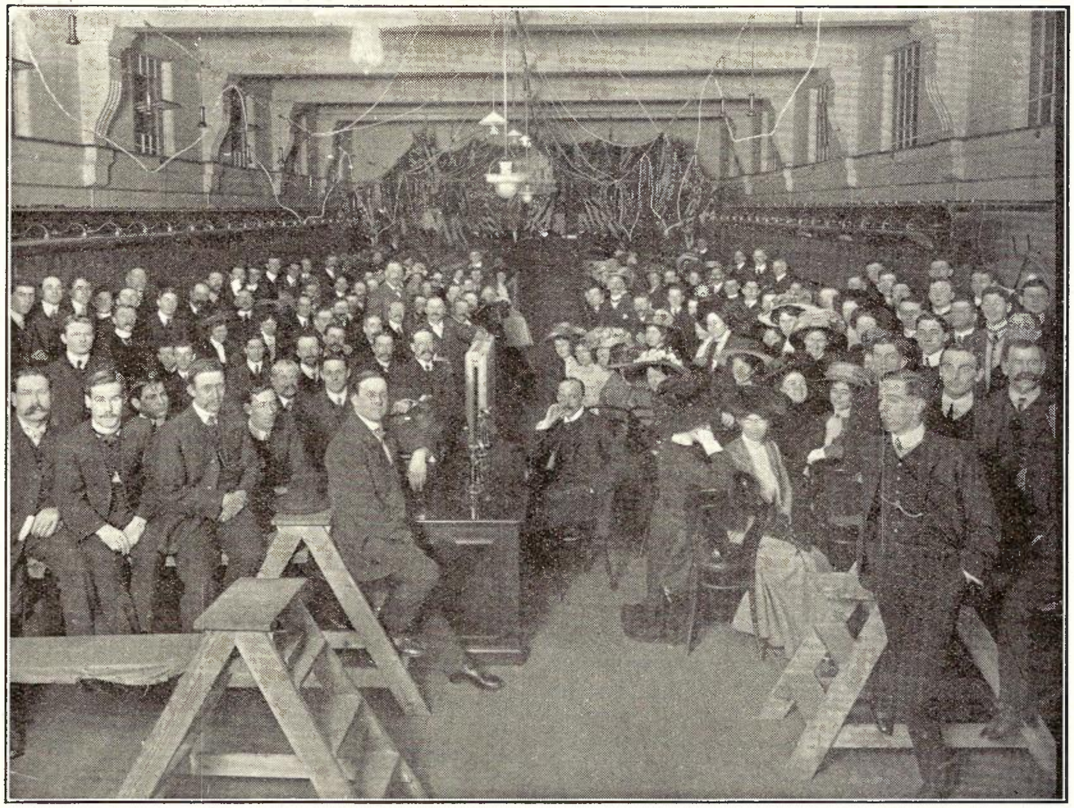
The prime movers in the formation of the new society were Messrs. O. Junck and H. Rutherford. Mr. H. W. Jenvey, Electrical Engineer, Victoria, was elected the first President, while the Vice-Presidents were Messrs T. Howard and M. Fitzgerald. Mr. Rutherford was the first Secretary and was succeeded by Mr. Batty. The Patrons included Mr. C. E. Bright, the Deputy

Postmaster-General, and Mr. J. Hesketh, the Chief Electrical Engineer.

The photograph published shows the members of the first committee, and should be of particular interest to at least the older members, providing as it does, such a tangible link with the early history of the society.

The object of the society was the advancement of Postal Electrical Engineering in all its phases, and for the instruction of members on relative matters of a technical nature. Any officer of the Service was eligible for membership. These objectives were fittingly outlined by the President (Mr. Jenvey) in the following extract from his inaugural address:—

"We have to consider what is really the object of forming a P. & T. Society. In the first place there must be solid co-operation in order to keep it alive. Members should prepare papers and present them for discussion at the meeting. They should also make it a point to attend the meetings regularly and give encouragement to those who contribute papers. The motive of the Society should be to improve the knowledge of the officers—there is ample scope for study in our business without going outside the telegraph and telephone service. The field of study is not only electrical. It is too often thought that knowledge of electricity and electrical laws is sufficient to fit an officer of this branch for his duties—but that is not the case—that fact is becoming more widely recognized in all electrical engineering concerns, whether private or Governmental. Before a person can deal satisfactorily with, and solve electrical engineering problems, whether telegraph or telephone, he must be fortified with sound general knowledge. Knowledge of electrical laws itself is not sufficient, he must have a knowledge of things which are taught in schools and universities—without that knowledge he will always find himself deficient."



Flashlight photograph of welcome to Dr. Graham Bell, at Melbourne Central Exchange, 17.8.1910. Given by Postal Electrical Society of Victoria.

As an indication of the comprehensiveness of the original membership, it included many non-technical officers, in fact, practically the whole of the administrative staffs of the Engineering Branch, Victoria, and those of the Chief Electrical Engineer's Branch.

Meetings were held once a month at the G.P.O., and arrangements were made for a paper, technical in nature, to be read at each meeting. Occasionally, refreshments were arranged for. The early lecturers included Messrs. Junck, Powell, Rutherford, and Howard. Special visit nights were also arranged, and the programme included visits to the Central C.B. Exchange, then in course of installation, the Metropolitan

Fire Station, the 'Age' office, and engineering works.

Although endeavours were made to establish a technical library, this phase of the society's early efforts did not meet with very great success. As an aid to this proposal, the P.M.G.'s Department was approached for a donation of £10/10/- which, however, was refused.

In 1910, Dr. Graham Bell visited Melbourne and inspected the Central C.B. Exchange during its installation. He honoured the society as its guest at a function held in the Exchange just prior to the formal opening. The photograph published shows the members of the party on this occasion. Dr. Graham Bell and other distinguished personages on the platform, however, have not been kindly treated by the photographer, and identification requires the use of a magnifying glass.

The growth and development of the society, and its progressive activities, particularly over the last few years, must surely serve as a splendid testimonial to the original sponsors of this society, whose aims and objectives were so idealistic, but are nevertheless now within the limits of achievement.

[Editor's Note.—As it is desired to compile as complete a history as possible of the early years of the society, members are specially invited to furnish any additional information that may be in their possession. In particular, a complete copy of Mr. Jenvey's inaugural address and early papers published by the society would be welcome.

We are indebted to Messrs. R. F. Archer, E. A. Batty, and H. J. Rutherford, for kindly furnishing the information on which these notes have been based, and for the loan of the photographs.]

THE NEW MELBOURNE TRUNK EXCHANGE

In later issues of the Journal there will be articles giving the many interesting features of the equipment and the installation of this important exchange, but at this stage a general survey of the facilities to be provided may be of interest. An order has been placed with Messrs. Siemens Bros., London, for the apparatus in the trunk exchange and the voice frequency signalling equipment in country centres. There will also be desks specially equipped to give expeditious distribution, pricing and sorting of call dockets, the positions having interconnecting pneumatic tubes.

Calls from Metropolitan subscribers for Trunks will appear on the Demand positions, of which there will be 54, the calls being queued up in the order of arrival. The calls can be answered from a number of positions on which the number of waiting calls will be indicated. By throwing a key the telephonist will be automatically allotted the first call in the queue. Should any call be awaiting attention beyond a prescribed period, say 10 seconds, the display lamp flickers until normal answering conditions are re-established. The telephonist will set up the code for the required trunk line on a key-set sender and by the operation of appropriate keys the connection will be completed through the switches. Timing of the call is started manually but will be completed automatically under the control of the calling subscriber's switchhook. Any of the positions in the Demand suite can readily be converted to delay working when required. If the traffic offering to a country centre precludes the possibility of giving service on demand it is necessary to handle the traffic to that centre on a delay basis, in which case the Demand telephonist simply books the call and the docket is routed to the position set aside to complete these calls when the required trunk is available.

Calls from country centres will be direct dialled over the voice frequency channels to the Metropolitan automatic equipment over incoming selectors in the Trunk exchange. Calls incoming in this way for another trunk line will be directed to "Through positions," six of which will be installed, and the telephonist will set up the connection in the same way as on the Demand position.

Eighteen interstate positions are to be installed initially for handling incoming and outgoing interstate traffic. The interstate circuits are connected to the positions through the switches but are then held during the busy hours of the day and are worked on what is known as a "back to back" basis, that is, a telephonist at each end has exclusive use of two trunk lines and they arrange the traffic in either direction as desired. The wanted subscribers are obtained by means of the keyset senders and are connected as required to the Trunk lines by means of coupling keys. In addition there will be five Trunk Enquiry and three Suspense positions, the latter taking over traffic which cannot be dealt with owing to the called subscriber or a particular person not being in attendance.

All the positions are of the cordless type, the control being by means of keys and press buttons. The equipment will be rack mounted, a particular feature is that the finders and selectors will be the motor uniselector type described in Paper No. 25 issued by the Society. A further point of particular interest is that hybrid coils on the switchboard side of all carrier channels and lines equipped with terminal amplifiers will be automatically switched on a four wire basis, suitable pad switching control being provided as necessary.

Mr. McHenry, of the Chief Engineer's Branch, is at present in England co-operating with the contractors' designing engineers to ensure that the equipment supplied will meet local conditions in every respect.

Ultra High Frequency Experiments Between Victoria and Tasmania

D. McDonald, B.Sc.

Introduction: This article describes experiments which have been carried out on the propagation of radio frequencies in the vicinity of 40 megacycles per second (wave length 7.5 metres). The object of the experiments was to obtain information of the propagation characteristics over a non-optical path with a view to finding the power and aerial requirements needed for ultra high frequency systems. The path chosen for the experiments was from Victoria to Tasmania where the transmission path was completely over sea water.

The details of the work involved and the results obtained are described hereunder.

Direction of Transmission: The direction of transmission was chosen as Victoria to Tasmania, the transmitter being in Victoria and the receiver in Tasmania. It was expected, from the reciprocal theorem, that propagation in both directions would be similar. This theorem due to John R. Carson, states: If an electromotive force E inserted in antenna 1 causes a current I to flow at a certain point in antenna 2, then the electromotive force E inserted at this point in the second antenna will produce the same current (both in magnitude and phase) at the point in antenna 1 where the voltage E was originally applied.

This theorem fails only when propagation is appreciably affected by an ionised medium in the presence of a magnetic field, and thus since the ultra-high frequencies are not propagated in the ionosphere the theorem should hold in the case under consideration.

General: The field intensity received at ultra high frequencies depends upon various factors as follows:—

(a) Distance between transmitter and receiver. The intensity decreases with increasing distance;

(b) Height of transmitter and receiver. The intensity increases if the height of the transmitter or receiver is increased, other things remaining equal;

(c) Frequency: In general the field intensity decreases as the frequency is raised (for equal power and aerial arrays proportional in size to the wave length);

(d) Aerial array. The intensity increases as the area of the aerial array is increased.

In addition to the above, the propagation is effected by such uncontrollable factors as:—

(a) Season;

(b) Time of day;

(c) Weather conditions, state of the atmosphere, etc.; but the extent of the variation due to these causes is unknown. It is hoped, however, that quantitative results may be obtained from a continuation of the experiments outlined below.

Selection of Sites: With the above considerations in view the coast lines of Victoria and Tasmania were investigated. The optimum combination of height and distance was obtained

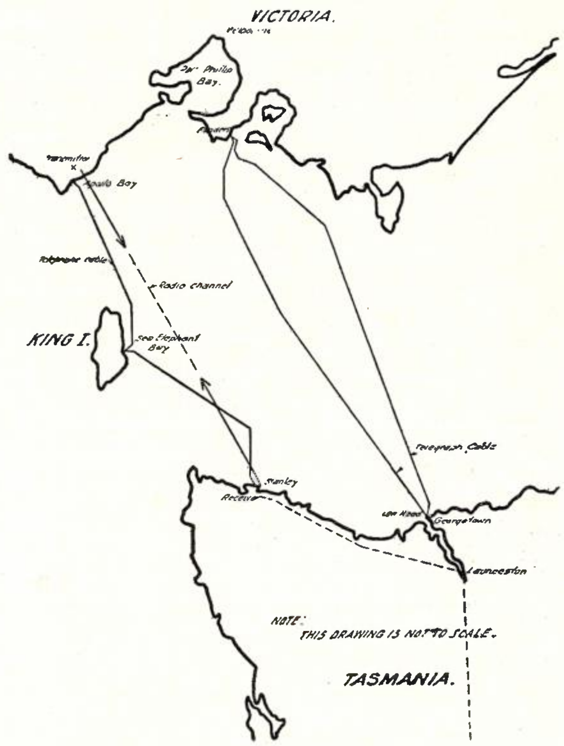


Fig. 1.

with the sites as shown on Fig. 1. The transmitter was located at Tanybryn, nine miles from Apollo Bay, Victoria, and the receiver on a formation known as "The Nut" at Stanley, Tasmania. Both sites overlooked the sea so that the only obstruction between transmitter and receiver was a sea water path. The heights above sea level were respectively 1700 feet and 460 feet.

Optical Path Distances: The approximate distance to the visible horizon from a point h feet above sea level is given by:—

$$d(\text{miles}) = 1.22\sqrt{h}$$

For the Victorian end the distance d was thus 50 miles and for the Tasmanian end 26 miles. As the distance between transmitter and receiver was 170 miles, the ratio:—actual distance/optical distance is $170/(26 + 50) = 2.24$.

Choice of Frequency: Two factors enter into the choice of the frequency to be used:—

(a) As the frequency is decreased, power being constant, and aerial arrays having dimensions proportional to the wave length, the received signal due to the ground wave increases, but the indirect wave from the ionosphere increases, and the signal more readily appears at distances remote from the transmitter. There is a certain critical frequency above which the ionosphere does not return the wave to earth. This indirect wave causes fading at the receiver and may cause interference to other services if propagated to large distances;

(b) An increase in frequency causes a decrease in received field intensity due to the ground wave, but the indirect wave decreases, causing less severe fading, and less possibility of interference to other services.

It is thus necessary to make a compromise in the selection of frequency and in this case the frequency was chosen from a series of curves

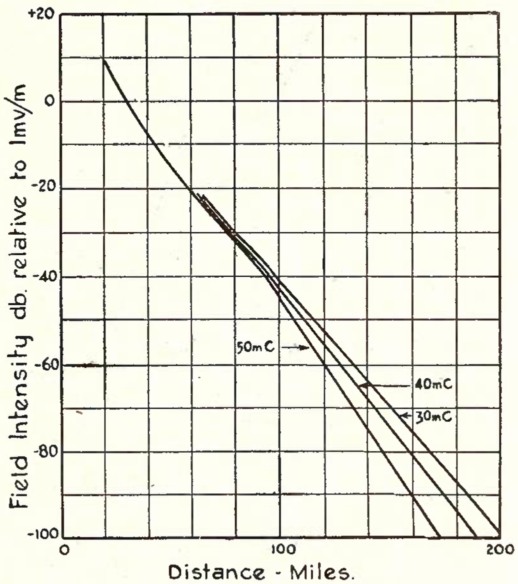


Fig. 2.

such as shown in Figs. 2 and 3. Fig. 2 shows the field intensity expected at various frequencies for a radiated power of 1 kilowatt, the transmitter being 1700 feet above sea level and the receiver at sea level. Fig. 3 shows the gain obtained due to raising the receiver above sea level. The gain is given in decibels as a function of $h\lambda^{-\frac{2}{3}}$, where h is the height above sea level in metres and λ is the wavelength in metres.

From Figs. 2 and 3 for a height of transmitter of 1700 feet above sea level and of receiver 460 feet above sea level, distance 170 miles, the received field intensities at frequencies 30, 37.5 and 50 megacycles per sec. are respectively 71, 75.5 and 81.5 decibels below 1 millivolt per metre.

A frequency of approximately 40 megacycles per sec. was chosen as it was considered that the indirect wave at this frequency would be negligible, and the received signal would be appreciably higher than that for 50 megacycles per sec.

Aerial Arrays: For normal broadcast frequencies 550-1500 kilocycles per second (wavelength 545-200 metres) the use of directional aerial arrays is usually not practicable because of the

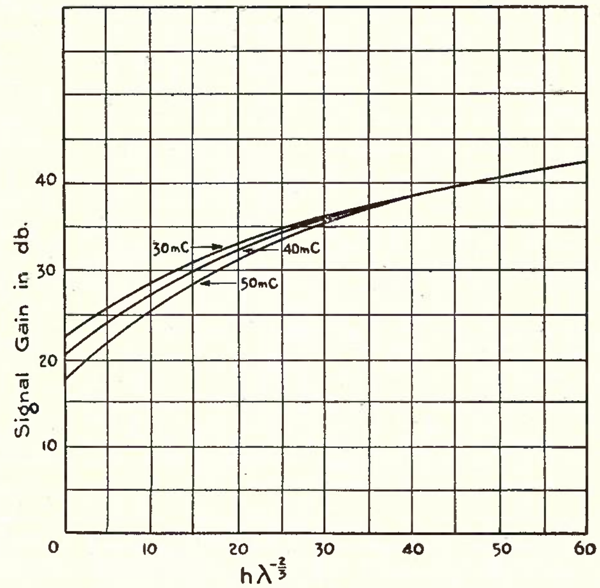


Fig. 3.

large spacing needed between elements of the array. As the spacing needed is usually of the order of one half wavelength, the required space would be large.

In the ultra high frequency range, however, the use of directional arrays becomes practicable and desirable, because the overall dimensions of an array of several wavelengths extent are relatively small.

At the time of this experiment, no experience was available as to the relative advantages of horizontal and vertical aerials for conditions simi-

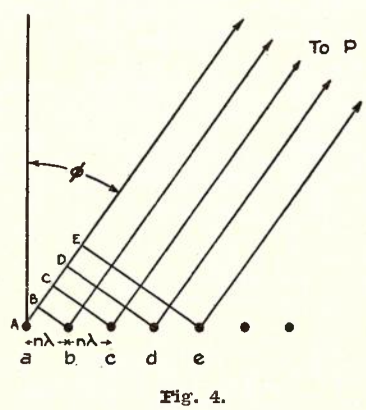


Fig. 4.

lar to the case under consideration, and it was decided to erect both horizontal and vertical arrays. The general principles of an array may be seen by reference to Fig. 4.

In Fig. 4, a, b, c, d, etc., are radiators separated by a definite fraction of a wavelength, the currents in the various radiators bearing some simple phase relationship. In the arrays used the currents in all elements were in phase and the radiators spaced one half-wavelength apart between centres. The function of the array is to augment the radiation in a certain desired direction at the expense of radiation in other directions. In Fig. 4 if N = the number of radiators and $n\lambda$ is the spacing between adjacent radiators, the currents in all radiators being in phase, the field intensity in the horizontal plane at an angle ϕ to the normal to the array is given by:—

$$E_\phi = E \frac{\sin (N \pi n \sin \phi)}{\sin (\pi n \sin \phi)}$$

where E = field intensity due to one radiator.

In Fig. 5 is shown a polar diagram in the horizontal plane of (a) a single half wave vertical aerial and (b) eight half wavelength aerials fed in phase and spaced one half wavelength

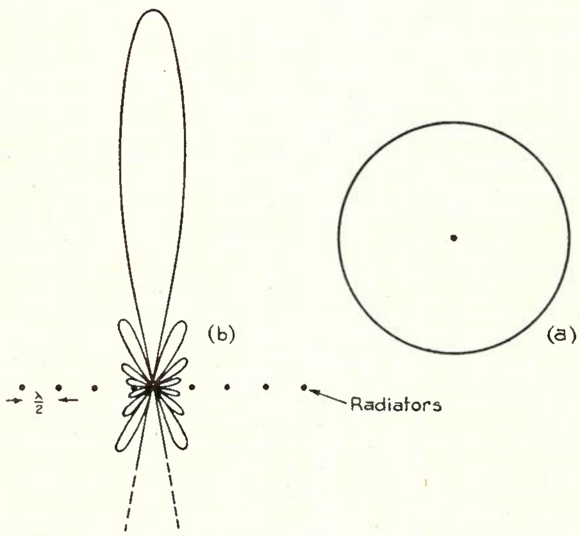


Fig. 5.

apart in the horizontal plane. The gain of the array as shown in the maximum direction is 10 db over a single half wave aerial. By placing a similar set of radiators one quarter wavelength behind the array, radiation in a backward direction is cancelled and the frontward radiation is increased by 3 db, giving a total gain over a single half wave radiator of 13 db.

Fig. 6 shows a layout of the aerials at the transmitting site, both horizontal and vertical arrays being shown. The shape of the radiation diagram for the horizontal array is essentially similar to that of the vertical array shown in Fig. 5. The aerial arrays at receiving and transmitting sites are similar, and were connected to the huts by open wire transmission lines.

Transmitter: The transmitter consisted of an oscillator using 808 type tubes, the frequency being controlled by resonant lines arranged in a spiral form to reduce the required space. The transmitter was modulated by a unit using two 800 type tubes in the final stage, and either continuous tone or speech could be used.

Power supply was obtained from a generator driven by a single cylinder petrol engine; the generator having windings for 3000 volts and 16 volts gave both the filament and plate supplies. A plate voltage of 1500 volts was used for the oscillator, the output under the operating condi-

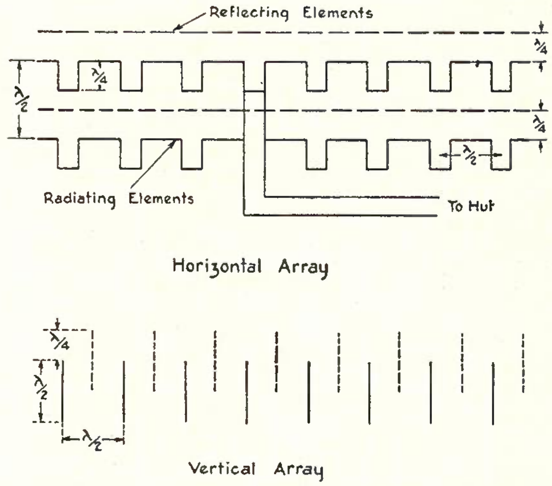


Fig. 6.

tions being approximately 200 watts. Due to the gain of the array in the desired direction, the radiation was equivalent to 13 db above 200 watts (4 kilowatts) from a single half wave radiator.

Receiver: Two receivers were used:—

(1) A super-regenerative receiver (commercial model);

(2) A super-heterodyne receiver (built in the Research Laboratories).

Quantitative measurements of received signal were made by (a) measuring the change in plate current of the superheterodyne receiver with change of signal; and (b) measuring the reduc-

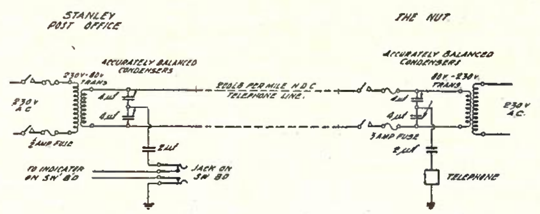


Fig. 7.

tion in noise level of the super-regenerative receiver with increase of signal. Fig. 8 shows the relationship between signal input and noise level in a super-regenerative receiver.

For communication purposes a telephone line was erected between the receiver hut and the Stanley Post Office. The wires were of 200 lb. copper and were used to transmit A.C. power to operate the receivers. Fig. 7 shows the arrangement for supplying A.C. power over the lines;

the telephone circuit worked earth return and the power hum was found to be negligible in the telephone when suitably balanced condensers were used.

Results of Tests:

General: Receiving tests were made for a period of 11 days, from 29/9/37-9/10/37 using both horizontal and vertical aerials.

When transmitting on the horizontal aerial,

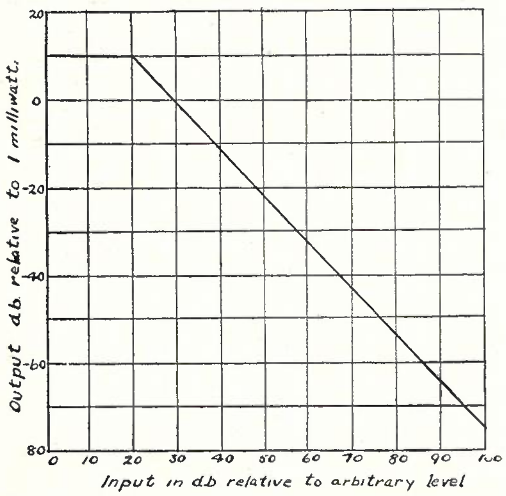


Fig. 8.—Super-regenerative Receiver Noise Level plotted against signal input.

the received level was approximately 30 db better on the horizontal than the vertical aerial. However, when transmitting on the vertical aerial, the received signal was only 10 db better on the vertical than the horizontal. Occasionally when using the vertical aerial for transmitting, the received signal was almost as strong on the horizontal as on the vertical aerial. This would indicate that a change of the plane of polarization was taking place—propagation favouring horizontal polarization.

Aerials: Horizontal polarization (horizontal aerials) proved to be consistently better than vertical polarization, the difference at all times being at least 20 db in favour of the horizontal. In preliminary theoretical investigations it was thought that the horizontal aerial would radiate a large proportion of the energy at high angles to the horizontal (the calculated maximum energy was at 18° to the horizontal). The high value of energy at an angle to the horizontal is caused by wave interference between directly propagated radiation and radiation reflected from the ground, and the above figure of 18° was obtained assuming a flat earth and perfect reflection from the earth. At Tanybryn, however, the ground sloped downwards away from the array and dropped suddenly about 100 feet out, so that the flat earth theory would not apply accurately, and an increased signal in the horizontal at the expense of high angle radiation would be expected.

Fading: The received signal varied in intensity throughout the day but the variations were in all cases of slow period and no distortion was noticed even when the received field was relatively low. At no period during the tests was there a complete absence of signal when transmitting and receiving on the horizontal aerials.

Fig. 9 shows a curve of received field intensity during typical listening periods, and it is of interest to note that the maximum variation expected due to transmitter fluctuations was approximately 1 db.

Effect of weather, time of day, etc.: During the period of the tests the weather had no noticeable effect, but it is possible that seasonal changes may be noticed. This will be investigated by long period observations on the channel.

The signal intensity at night appeared to be the same as during the daytime, the fading noticeable on broadcast and high frequency propagation being absent.

Summary: The tests indicated that communication is possible over distances greater than optical when using a frequency of approximately 40 megacycles per sec. but the long period reliability of such a circuit has yet to be established. The present intention is to instal at Stanley, Tasmania, a transmitter of 200-300 watts power and to take long period recordings

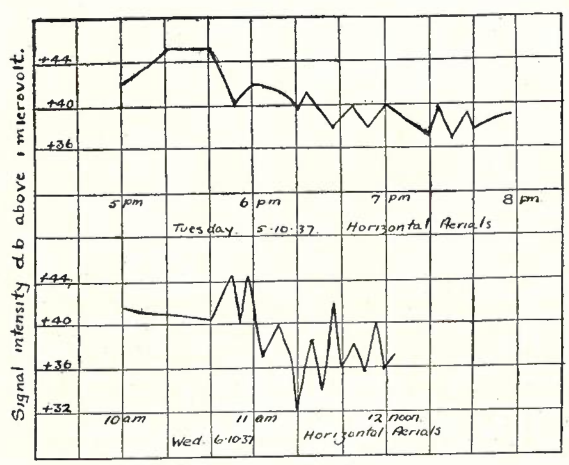


Fig. 9.—Variation of received signal intensity over typical listening periods.

of the field strength received in Victoria. The transmitter will be crystal controlled to prevent any appreciable frequency change, and the receiver will be a superheterodyne type in which the automatic volume control voltage will be used to control the current through a triode tube operating a recording milliammeter. Horizontal aerials will be used at both the transmitter and receiver.

Recently the transmitter and receiver were completed to provide an emergency service, but the tests will be continued.

A SUBMARINE CABLE TRACER

G. N. Smith, B.Sc.

It is almost a platitude to state that submarine cable repairs are expensive. It is therefore important that every effort should be made to facilitate repair work and to make best use of the time for which the repair ship is chartered. As bad weather is the principal cause of delay, any means of using this time to assist the repair is well worth while. This can often be done with the apparatus about to be described.

When a submarine cable is laid, its position is carefully charted and splice sheets are prepared to show the position of splices and the percentage of slack laid over various portions of the route. Owing to tides, currents and submarine disturbances, it is possible for a cable to be moved and so change its course or from similar causes it may be buried. Naturally, either of these effects would increase the time of grappling unless some means is available for detecting the true course of the cable from the repair ship. This facility is provided by the Submarine Cable Tracer which will also show the actual position of an earth fault, thus acting as a confirmation of shore tests. It is particularly useful when land sights are not available for navigation.

Such equipment has been developed by the Research Section of the British Post Office and has been applied to our own requirements for work in Bass Strait, both on the telegraph and telephone cables. The essentials are a low frequency generator and a pair of search electrodes

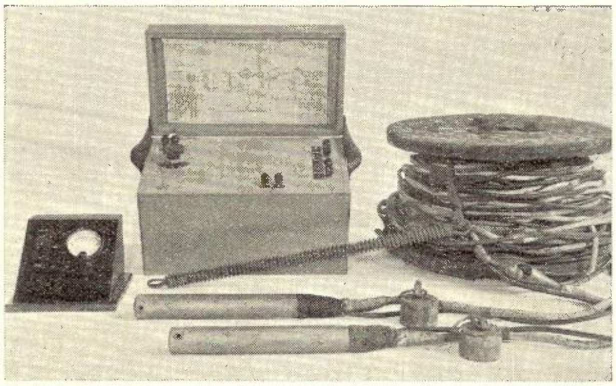


Fig. 1.—Cable Tracer Equipment.

to which are connected a tuned amplifier and galvanometer, these being shown in the photograph herewith. It has been shown that the lower the frequency, the greater the sensitivity of the method. A 16.5 p.p.s. generator with an output of 250 m.A. is connected to the cable and earth at the cable hut so that current paths follow the cable route between the hut and the earth fault (or earth connected to far end of cable) in a fashion similar to lines of force between two unlike magnetic poles. The current paths may be considered as parallel to the cable except near the fault and there are equipotential surfaces perpendicular to these paths, that is at right angles to the cable.

Any two electrodes in the current paths will have a potential difference between them provided they are not both in an equipotential surface. The measurement of potential drop is consequently made along the line of these current paths, the maximum deflection being obtained when over the cable. It is not necessary, however, in practice for the electrodes to be towed exactly along the line of the cable, any crossing up to an angle of 40 degrees being generally satisfactory. A correction is then applied (reading multiplied by cosine of angle of deflection)

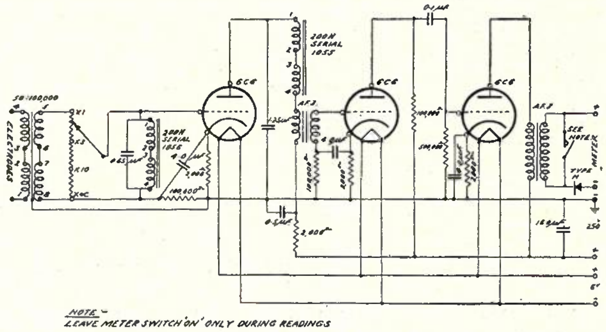


Fig. 2.

to reduce the observed reading to a direction along the lie of the cable. As the ship progresses along the cable towards the earth fault the deflections increase rapidly as the fault is approached and cease abruptly beyond it.

The electrodes may be towed "in line" about 30 fathoms behind the ship or, as is now preferred by the British Post Office, "abreast" of the ship by booms over the side so that they are in a line at right angles to the ship. In the latter case it is necessary, of course, for the ship to cross and re-cross the cable approximately at right angles.

These electrodes consist of two brass log rotators shorn of their fins, with a separation of 10 fathoms between electrodes. Electrical contact is maintained by means of cab-tyre flex. In the case of the "in line" method the tow line is connected to a draw-bar spring and the electrodes are weighted, thus preventing sudden movements and consequent spurious deflections on the amplifier galvanometer. The B.P.O. is now experimenting with electrodes which dive deeper as the towing speed increases thus reducing the tendency for the electrodes to break surface. It has been shown that the sensitivity of the method is independent of the depth of the electrodes except close to the cable route where it increases with depth to some extent. It is usual to tow the electrodes a few feet below the surface.

The amplifier employs three 606 tubes in series and is tuned sharply to prevent interference from power and other sources. A circuit diagram is shown in Figure 2. The tuning is such that the sensitivity at 50 p.p.s. is 24 decibels below that at 16.5 p.p.s. A readable deflection is obtained for an input potential of 10 microvolts, the indicator being a moving coil microammeter in series with a metal rectifier following the last tube. The meter is separate from the amplifier for convenience and it has been used in the wheel room in preference to the compass for keeping the ship on the cable course en route to a fault.

With this equipment it was possible to trace a cable in 30 fathoms of water and locate its position within 50 fathoms. Earth faults have been successfully located in Bass Strait on cables 190 nauts in length and 45 fathoms deep and the cable course has been accurately followed 84 nauts from land on high resistance faults by earthing the far end. On one occasion the cable was found 2 nauts eastward of its charted course, thus giving illuminating information in what was otherwise a blind search. The equipment was used to trace the cable out from Norfolk Island towards Suva in 30 fathoms of water on a cable 900 nauts in length and here again the cable was well off the charted course. Experiments in much deeper water on the Norfolk Island-Auckland cable unfortunately failed owing to a tube failure, but there were indications that the method would still be successful in depths about 300 fathoms.

It will be seen then that this equipment serves like a radio beacon to a befogged aviator and although inexpensive and simple in itself, is a means of making considerable savings in the expensive item of ship's charter. It is hoped that later it may be possible to extend the method for locating buried cables and pipes on land.

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A Further Note on the Submarine Cable Tracer

Since the above article was written, the author has had a further opportunity of using the equipment. The Bass Strait Telephone Cable failed on 19th June, 1938, repairs being completed on 7th July, 1938. During this repair work, the cable tracer was again used and some observations on the experience are recorded herewith.

As it is desirable that, in repairing a multichannel concentric cable such as the Bass Strait telephone cable, the minimum length of cable should be inserted in the repair, the cable tracing equipment was used to confirm the fault location tests made ashore. Tests had shown that the fault was 5.2 nauts south of King Island cable station in about 12 fathoms of water. With a polechanger supplying 16.5 p.p.s. current to the cable at King Island, the cable was readily traced along its course from a point 3½ nauts out to about 5 nauts. Between 5 and 6 nauts from the shore, considerable difficulty was experienced due to seaweed fouling the electrodes. The seaweed, whilst being distinct evidence of rock, made it very difficult to locate the fault to a smaller distance than 0.2 nauts, although, under good conditions it would be possible to do much better.

Owing to the fault resistance on the Tasmanian side being large, it was not possible to trace this end of the cable at a distance of 76 nauts from Stanley.

During this work the following interesting point was observed by the Senior Mechanic at King Island. The current to line at the cable station passes through a milliammeter and it was observed that, when the ship was crossing the vicinity of the cable course, the current to line varied considerably and irregularly. Now the performance of the polechanger had previously been proved quite stable, and this was again proved at the cable station. The current to line depends on the resistance of the cable, the fault resistance and the resistance of the armouring plus the sea water in the vicinity of the armouring. Over a large part of the sea bed in this locality the depth is about 8 or 9 fathoms, and the repair ship was drawing 3 fathoms, so a probable explanation of the shore observation is that the turbulence caused by the steamer's propellor when crossing the cable was sufficient, in shallow water, to vary the resistance of the sea water considerably, and so vary the current to line.

The cable tracing equipment again proved an asset on the cable repair, but as a result of the experience it is probable that improvements will be made to the electrode equipment.

A Panel Mounted Duplex Telegraph Unit

A. J. McDevitt and N. Teague, B.Sc.

The telegraph organization seeks to standardize on a uniformly high grade of service by setting down certain "Permissible Time Lags" for each class of traffic. The disposal of the peak loads within the P.T.L. presents considerable difficulty. These peaks occur frequently and are due to a variety of causes, e.g., Saturday morning sporting traffic, seasonal greetings as at Christmas and Easter, wheat marketing traffic, etc. On these occasions the greatest difficulty arises in N.S.W. in connection with the disposal of traffic to the country districts. In the larger country towns and cities the position has been met by the introduction of machine printing systems, but in the medium size towns with populations averaging from, say, 3000 to 10,000 persons, such action could not be economically justified owing to the fact that the normal load is comparatively light. Additional lines are not available to provide relief circuits and the building of new ones would be too costly. In these circumstances relief is provided by installing duplex sets and thereby giving the line which already serves the office nearly double the traffic carrying capacity.

In the majority of country Post Offices most of the following requirements must be met when a duplex system is installed:—

(i.) Power supply for main and local circuits.

(ii.) Reliable signalling apparatus which requires a minimum of skilled attention.

(iii.) Patchboard to allow sets and lines being switched for traffic purposes.

(iv.) Economy of space.

It is believed that all these requirements have been met in some degree in the panel mounted duplex unit and patching facility, details of which are given below.

As alternating current power supply is available at the majority of towns in N.S.W., copper oxide rectifiers are used to give the 80 or 120 volts positive and negative potential required for the line signalling current. The current for local circuits—sending polechanger and sounder—may be supplied in the same manner, but if a duplex set is to be used on relatively infrequent occasions it may be more economical to use dry cells for this purpose.

In normal duplex operation it is usual to draw the line current from either primary or secondary batteries. In either case space is required in order to accommodate the batteries and in the case of secondary cells, charging facilities are also necessary. The cost of providing the batteries of either type is considerable and mainly on this account the rectifier was preferred. With suitable filtering it gives a performance comparable to that obtained from secondary cells and much superior to primary cells.

As far as possible the apparatus used—jacks, switching keys, relays, etc.—is identical with that employed in standard telephone practice, the most notable innovation in this direction being

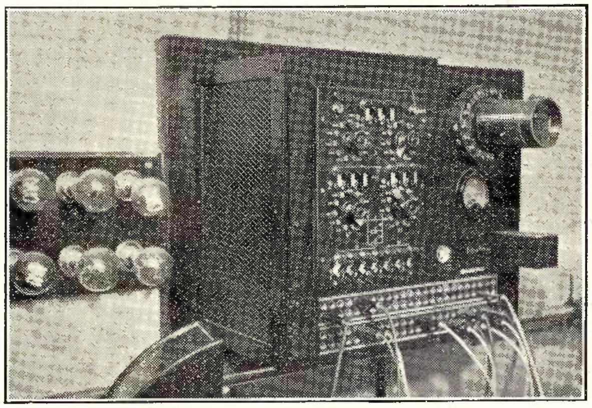


Fig. 1.

the replacement of the usual "walking beam" type telegraph polechanger with a telephone relay.

The patching requirement is met by the provision of four horizontal rows of jacks—maximum 24 jacks per row. Lines are connected to the top and bottom rows, up lines to the top jacks and down lines to the bottom, instruments and any special office facilities being wired to the second and third rows of jacks.

Economy of space is achieved by assembling all the necessary equipment on standard panels 19 inches wide and mounted on angle iron framework ready for attachment to the wall adjacent

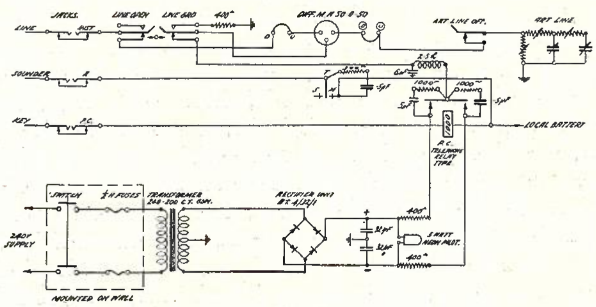


Fig. 2.

to the telegraph operating table in the particular office. The sides, top and bottom are enclosed with perforated metal covers. The overall dimensions of the unit are approximately 20 inches x 20 inches x 10½ inches, and it, therefore, occupies less space than a standard telegraph switchboard with equivalent jack accommodation.

Figure I. is an illustration of the unit installed at Goulburn, whilst in Figure 2 is shown the schematic connections of the duplex circuit and associated rectifier, together with filters, spark quenches, etc.

Costs.—Units of the type described have been made up in the Departmental Workshops and installed in approximately 30 country offices in N.S.W. at a cost averaging a little under £100 for each office. This amount is somewhat less than the combined costs of installing the standard patchboard and the usual table mounted duplex equipment. Battery installation and maintenance charges, which are also involved in the latter case, further improve the position of the new unit as regards relative costs.

Power Unit.—The rectifier is a copper-cuprous oxide unit rated to give an output of 250 mA at 144 volts. The discs are of the BT type and the assembly in bridge form. The rated A.C. voltage input to the rectifier is 215 volts, but on account of the voltage fluctuations in some country power supply mains, it is advisable to use an input voltage that will not rise above the rated voltage of the rectifier when the maximum power fluctuation is experienced. For this reason the power transformer has a primary winding of 240 V. and a secondary of 200 V. The secondary winding is centre tapped. The transformer is rated at 60 w. as there is no economic advantage in using one of smaller design and the liberal dimensions of the 60 w. transformer have advantages, such as size of wire and quantity of iron which make for cool operation when the unit is in continuous use.

The output from the rectifier gives approximately 80 V. + & 80 V. — on either side of the earthed centre tap. This output is smoothed by 2-32 mf condensers before being fed to the polechanger. The ripple content of the output current due to the filtering effect of these condensers is satisfactory for operation over physical Morse circuits and reasonably balanced cailho circuits, but is not quite sufficient for operation over composite circuits. In order, therefore, to make the unit suitable for operation over any circuit a further smoothing of the signal is carried out before it goes to line.

In the design of a smoothing system for telegraph signals when the current is derived from a rectifier, consideration has to be given to several factors that differ from those associated with smoother systems or filters used in connection with voice or high frequencies.

In the latter case it is usual to suppress the ripple from the rectifier unit by means of a low pass filter, the cut-off frequency of which is below the ripple frequency and further the signal is not passed through the filter, but is fed into the signal circuit at a point beyond the filter usually by means of a condenser. This practice cannot be used in the case of the telegraph circuit operated from a rectifier as the signal itself must be drawn from the rectifier. If a filter of the usual type associated with an amplifier were used where the inductance is of the order of 30 henries and the capacity 8 mf the delay through the network to the rise of the telegraph signal wave front would be such that the shorter signals, i.e., the dots would not register; consequently, only a small amount of inductance is permissible in the supply circuit. For the above reason the 2-32 mf condensers (which are of the electrolytic type) are used to absorb the major part of the ripples.

Another factor which has to be considered when designing a telegraph circuit is the possible interference from the telegraph circuit into other telephone or telegraph circuits.

It is well known that, in the formation of square topped double current telegraph signals with the abrupt change from one polarity to the other, transients occur and that these transients contain frequencies which lie within the V.F. carrier and R.F. bands. In the current delivered to line from the duplex unit these transients are somewhat more severe than those usually developed at the polechanger on account of the supply current itself not being entirely free from ripple and a small ripple component is present as well as the high frequencies within the transient part of the signal itself. In order to suppress these transients and at the same time improve the smoothing of the current a smoother unit has been included between the output lead from the polechanger and the point at which the circuit splits on the duplex milliammeter. The inclusion of this unit in addition to the electrolytic condensers entirely eliminates the ripple due to rectification and reduces the interference into the composite circuit from the telegraph signal to about 40 db below the normal voice level.

It is usual on composite circuits to employ a bridge type duplex circuit, using a 5U coil. This type of duplex primarily aims at reducing the interference from the telegraph signal into the telephone circuit, but results obtained from this differential duplex unit compare very favourably with those obtained from the bridge type circuit. Consequently, there is no difference between the units used on composite circuits and those used on the ordinary Morse line. The smoother unit has constants very similar to those of the ordinary composite set. The inductance is 2.5 henries and the shunt capacity 6 mf.

Polechanger. — The standard walking beam polechanger which is in use on normal duplex circuits requires a considerable amount of space for mounting, has heavy moving parts and requires individual adjustment for different senders. This is particularly noticeable when a change of operators is made, one of whom is using a light fast automatic sender and the other man sending by hand. Investigations were carried out to see if an instrument capable of holding a permanent adjustment for all types of sender and still give a satisfactory performance could be obtained. Excellent results were obtained from 1000 ohm automatic switch type relays with a long spring assembly and adjusted as follows:—

(1) Put all springs straight and parallel.

(2) Unscrew residual screw past flush position.

(3) Unscrew armature and place 26 mils from pole face by means of feeler gauge.

(4) Put 6 mils feeler gauge between armature and pole piece at side of residual screw and then screw up residual screw until it just fails to hold the feeler.

(5) With 6 mils feeler under residual stop between screw and pole face the outer contact spring should just make and with 10 mils the inner should just be breaking. Adjust the armature extension to get this condition.

(6) The final test should be made with reversals if they are available and any small bias taken out by bending the centre spring.

(7) Make the play between the back stop and the armature extension as small as possible.

This switch type of relay mounts in a very small space and once adjusted does not require further attention over very lengthy periods. The contacts on the springs have been changed from the usual dome contacts to flat platinum contacts and a spark quench circuit, consisting of 0.5 mf condenser in series with a 1000 ohm N.I. resistance, is provided across both sides of the polechanger contact.

The coils of the relay are shunted by a 1000 ohm N.I. resistance of the radio type. This resistance is suspended in the wiring behind the iron panel. Its purpose is to suppress sparking at the local circuit contacts. With this type of relay used in connection with the 900 ohm ordinary sending sounder it is desirable to use the sounder in series with the coils of the polechanger relay. If they are connected in parallel difficulty is likely to be experienced owing to the inter-action of the field of the two electro magnets and results in sticky signals. Should it not be possible to provide for a series arrangement a swamping resistance of about 400 ohms is required in series with the polechanger coils. Extensive trials have been made of the switch type relay used as a polechanger both at the C.T.O. and country stations, and when properly adjusted these relays give a performance not in any way inferior to the telegraph type polechanger and do not require adjustment for individual senders.

The duplex unit as a whole gives a performance in every way equivalent to that of the best type duplex sets using standard telegraph apparatus. In N.S.W. there are at present approximately 30 sets installed in the country districts, some of them operating over very long distances, for instance, one of these units is installed at Bourke and operates over an iron wire between Bourke and Dubbo and a copper circuit between Dubbo and Sydney without repeaters for a distance of approximately 500 miles. Units are also operating between Sydney and Albury, Sydney and Moree, Sydney and Grafton, and these circuits are all over 400 miles in length.

MOULDINGS FOR TELEPHONE EQUIPMENT

C. Faragher, A.M.I.E. (Aust.)

Each year the range of telecommunication equipment which utilizes phenolic moulded products in its construction increases so rapidly that some information concerning them and later or alternative products is opportune.

A brief history may be of interest. In 1908, Dr. Baekeland, a Belgian chemist in U.S.A., patented a method of controlling important chemical reactions between phenol (carbolic acid) and formaldehyde (the result of a destructive distillation of wood), the product being a yellow-brown fusible and soluble synthetic resin in solid form, which melts at about 120 degrees F. In modern practice this basic material is available as a fusible soluble material (liquid or solid) and used in the liquid form as a varnish and for building up laminated sheets.

The title Bakelite has been applied generally but incorrectly to phenolic moulded products. They are properly described as phenolic synthetic resin mouldings. Bakelite is a product of the Bakelite Corporation, U.S.A., or allied organizations. The equivalent product of other firms is marketed under the trade names of Elo, Nestorite, Moulderite, Rockite, etc.

Phenolic moulded products almost comply with the specification of the ideal material. They are attractive in appearance, light, strong, free from deterioration or odour, are cheap when produced in numbers, can be made with great accuracy, high finish and of intricate form, fitted with metal inserts, provided with moulded threads, or machined, are fire-resisting, possess high surface and volume resistivity, and are unaffected by water and most chemicals.

For mouldings, the basic material used is in powder form. As a moulding of pure material is somewhat brittle, a filler—generally wood flour—is added to the powder. For special purposes other fillers are used, for example, asbestos for heat resistance, mica for greater dielectric strength, canvas or paper for mechanical reasons. The powder is placed in a hardened steel mould consisting of a punch and die fixed in a steam or electrically heated press, and heat and pressure are applied. The powder softens and becomes semi-plastic as the temperature rises and under pressure from the punch it flows into the interstices of the die. With the heat and pressure still applied, a surprising change takes place. The plastic changes into a solid and further heating or pressure leaves it unchanged, i.e., it is now infusible and insoluble, and the production process cannot be repeated or reversed, a new chemical compound having been produced. The temperature, the pressure, and the curing time varies according to the dimensions of the moulded product. The mould temperature varies from 320 deg. F. to 400 deg. F. and pressures vary from 500 to 3000 pounds per square inch. The time for production varies from one to five minutes. The specific gravity of the moulding is about 1.5.

The steel moulds are expensive—one may cost from £30 to £300 depending on complexity. For economic reasons it is usual to mould a number of pieces simultaneously, e.g., a dozen earpieces may be moulded at once on the plate of the press—one per punch and die provided. Moulds for expensive parts of high finish have extremely hard surfaces and are usually chromium plated. Those surfaces of mouldings which appear parallel, on inspection will usually be found to be tapered slightly to facilitate withdrawal from the mould. Machines are available to press the powder into pellets, and so avoid the time lost in measuring powder for each mould cavity. Pellets of the correct number and volume are fed into the cavities by the operator. The volume of the powder is appreciably greater than the finished moulding (bulk factor is 3 to 1), but there is no loss of weight. As the punch enters the die, the excess plastic material is forced out and is called the "flash." The aim is to ensure a complete moulding with minimum waste and good cut-off of the flash. After removal of the moulding, the flash is broken off and any fins buffed away. Most phenolic moulded telephone products are black or shades of brown, as the basic material is yellow-brown. Black or brown mouldings are fast to light. Laminated sheet is usually called S.R.V.P. board (synthetic resin varnished paper). S.R.V.P. board is the yellow-brown sheet material used as relay spring insulation, and for general purposes in modern automatic exchange plant. It is made by impregnating sheets of paper with phenolic varnish and curing it in a hot press. These sheets can be punched readily, have good insulating properties, particularly on uncut surfaces, are not easily scratched, are cheaper and harder than ebonite, and mechanically superior to it. Sheared or cut surfaces having a lower insulation resistance than the natural polished surfaces may be improved by varnishing.

The foregoing applies particularly to phenolic mouldings. Other moulding materials used are of interest and are referred to below.

Cresol formaldehyde is a powder somewhat cheaper than phenol formaldehyde. It has slightly poorer mechanical and electrical properties and finish, but is suitable for certain moulded products used by the Department. A slight remanent odour makes cresol base mouldings unsuitable for drinking vessels. The Australian-made four-part plugs and sockets for portable telephones and the four-way terminal strips No. 1 for telephones are mouldings of cresol base.

A most important moulding material is urea formaldehyde. The basic material is colourless. It has a high resistance to flow and requires pressures up to 5000 pounds per square inch. Urea base mouldings can be distinguished from those of phenol base by their translucency, phenolic base mouldings being opaque. Urea base material can be coloured to produce mouldings in all the colours of the rainbow, and the depth of colour gives them great beauty. All coloured specimens we have tested to date have faded on exposure to light, unfortunately. Coloured telephones are of urea base, as phenol base mouldings can be produced only in darker shades. Samples at present being tested for fastness to light are red, green or ivory. It is interesting to note that in nature urea is produced by the kidneys. In 1828 a German chemist, Woehler, startled the scientific world of that day by producing urea in the laboratory. Prior to this it was considered as fundamental that compounds produced by the living organizm could not be synthesized in the laboratory, and his discovery stimulated the chemical world to other equally important discoveries concerning organic compounds. Some of the trade names of urea base powders are Beetle, Pollopas, Scarab, Mouldrite and Plaskon.

Cellulose acetate is a modern plastic of importance. Handset telephones in Australia are at present provided with cradles and plungers of phenolic base material. To diminish breakages of these parts, the British Post Office is now using cellulose acetate mouldings which have relatively great tensile strength. One form of this chemical compound is used extensively in the Department as artificial silk threads for the insulation of the tinsel conductor of instruments and switchboard cords. After being liquefied in a volatile solvent it is applied as a liquid to the surface of protector carbons, and with evaporation of the solvent it hardens to form the insulating separation of the protector carbons now standard. It is a true thermo-plastic, i.e., as the temperature rises the solid becomes plastic and can be moulded to any shape, and resumes the solid condition on cooling and can be re-used. In this respect it differs from the phenol, cresol and urea base mouldings, which are thermo-setting, not thermo-plastic. Cellulose is a carbohydrate. Although it is principally produced from cotton, many other plants serve for the production of cellulose. The cellulose is treated with acetic acid and the final product is cellulose acetate. It is non-inflammable, and is available as a liquid under controlled conditions and as a solid in sheets, rods, tubes and shapes. Before the application of stains or pigments it is transparent. Cellulose acetate cradles and plungers for handset telephones are on order for trial purposes, as a question still to be determined is its ability to withstand Australian sun temperatures without becoming plastic with consequent indentation. It might be of interest to mention that the striated and mottled coloured composition coverings now to be seen as a sheating over the steel core of steering wheels of motor cars is cellulose acetate. Switchboard plugs were originally built up from machined parts of metal and insulation. Plugs having moulded insulations are now largely used by the Department. In manufacturing these, the metal parts are properly spaced in a jig and a plastic form of cellulose acetate is forced into the interstices and solidifies to secure the parts permanently. Some of the trade names under which cellulose acetate is marketed are: Cellomold, Celastoid, Rhodoid, Trolitul and Lansil.

A compound marketed recently by Imperial Chemical Industries and named Diakon[1] is the most promising material available at present for coloured telephones. Chemically it is a synthetic resin the basis of which is understood to be methylmethacrylate. It is a true thermo-plastic and therefore clean scrap can be re-used. Grade F, which has a high softening temperature, is that specified for coloured telephones. Like phenol base material, it has many of the characteristics of the ideal material. It is available as a liquid or a solid as the base for transparent, translucent and opaque articles in many tints and shades. As a liquid it is used for cementing and in granular or powder form for compression or injection moulding. The specific gravity is 1.19. An interesting difference in moulding technique is that whereas phenol, cresol, and urea base mouldings harden in the mould and can be removed hot, Diakon (and cellulose acetate) mouldings must be cooled somewhat to solidify them before removal. Mould temperatures may range between 260 deg. F. and 400 deg. F. and mouldings are produced at intervals of about two minutes.

Cellulose acetate base and Diakon articles can best be produced in what is termed an injection moulding press, which is not suitable for producing mouldings from the thermo-setting powders referred to earlier. In the injection moulding process the material is made plastic by preheating before entering the mould, and is then injected under pressure to fill the moulding cavity completely, after which slight cooling causes it to solidify, and it is then withdrawn or ejected as the final shape. Under this process articles are produced at high speed.

Celluloid, the base of which is cellulose, is used to a small extent such as a protective covering for trunking charts and designation strips in exchanges. Its inflammable properties and gradual loss of transparency are the chief objections to its use.

Casein is a by-product of the dried milk industry and is available as sheet, rods or tubes, dyed or pigmented in various colours. It is used as insets for jack number plates and as designation plugs in switchboard jack fields. Some of the trade names under which it is marketed are: Erinoid, Galaliath and Lactoid.

In concluding, a reference might be made to cellophane. It is allied to the above compounds and although not used by the Department directly, includes in its manufacture a most interesting process. Fundamentally it is regenerated cellulose, and when it is in the liquid form and ready for production as sheets it is floated out on a water surface, where it solidifies as an extremely thin sheet.

[1]. Diakon: A New Material for Coloured Telephones, C. R. Pearce, M.Sc. (Eng.), D.I.C., "Post Office Electrical Engineers' Journal," January, 1938.

MULTI COIN PUBLIC TELEPHONE ATTACHMENTS

C. Cruttenden

The purpose of multi coin attachments is to enable the general public to make Trunk and Phonogram calls from public telephones situated in unattended locations. This article describes the multi coin attachment standardized by the Department and manufactured by the Hall Telephone Accessories Ltd., England.

There are two types of attachment in use in Australia: the two button type and the one button type. The former is now standard for all purposes, but the latter was formerly purchased for use in Magneto areas. Multi coin attachments of either type are usually referred to as pre-payment or post-payment types and these terms indicate, respectively, whether it is necessary or unnecessary to insert a fee before a call can be originated from the associated telephone. When connected to an Automatic Ex-

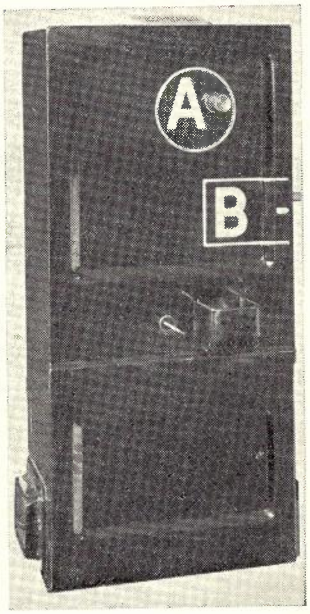


Fig. 1.

change a multi coin attachment is operated on the pre-payment principle, and when connected to a Manual Exchange, on the post-payment principle.

Construction. — The standard attachment is shown in Figure 1, whilst an exploded view, including the self-sealing coin tin, is shown in Figure 2. The outer case is constructed from No. 16 s.w.g. pressed sheet steel with welded joints and is divided into two compartments. The upper contains the mechanism and wiring terminals, the lower the coin tin. The lower compartment is reinforced and underneath the coin tin, holding it in position, is a $\frac{1}{4}$ inch thick iron plate which slides in a slot from the right hand side. At the right hand side a recessed casting welded to the case contains a removable combination lock which secures the iron plate by

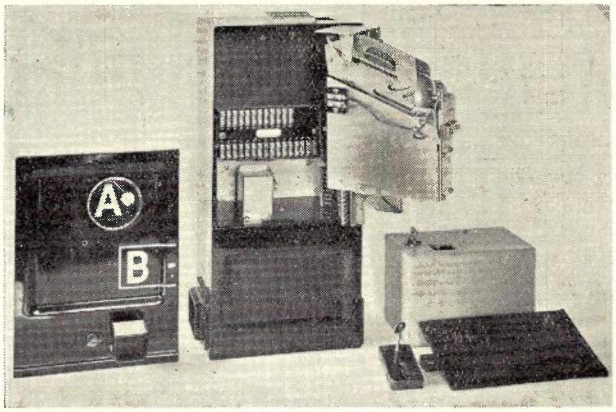


Fig. 2.

means of a projection or tongue entering the recess through a slot. The whole case is stove enamelled black.

Mechanism (Figure 3).—At the top of the

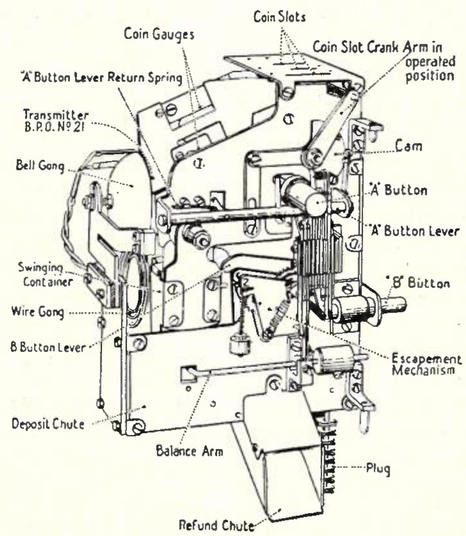


Fig. 3.—Mechanism.

mechanism, in a hardened steel plate, are three coin slots which line up with a sloped casting on the case marked in raised letters from front to rear: "Penny," "Sixpence," "Shilling."

The slots are accurately cut and serve as gauges to prevent the entry of coins larger than the correct denomination and also mis-shapen coins. Immediately beneath the slots are the coin guides, and included in each of these is a coin gauge which rejects coins of smaller diameter than the standard of the correct denomination. The rejected coins are returned to the user via the refund chute and receptacle. The manner in which this is accomplished is interesting: the coin guides are given a downward slope of approximately 25 deg. and a sideways slope or tilt of approximately 15 deg. so that a coin is supported by its flat side at this angle as it rolls down the coin guide. On the section comprising the coin gauge the side wall is punched out to form a flap which is given a further slope of about 33 deg. Across the top of the punched-out portion an adjustable flat metal piece is fixed by two screws at such height that coins of correct diameter are supported at the upper edge by the metal piece and are prevented from falling sideways on to the flap. The upper edges of coins of smaller diameter miss the metal gauge piece, and falling on to the flap slide from this over the narrow ledge which forms the bottom of the coin guides into an opening leading to the refund chute. The foregoing will be clear by reference to Figure 4.

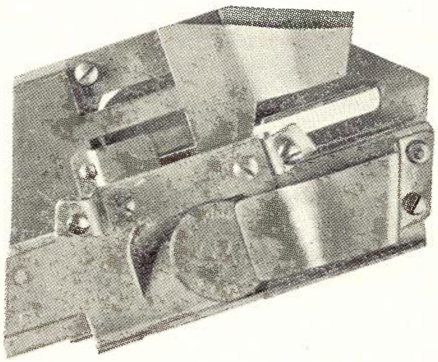


Fig. 4.—Coin Guides and Gauges.

After passing the gauges, the coins strike a signal gong and then fall into a swinging coin container which is mechanically controlled by two press buttons marked "A" and "B." These buttons are operated by the caller. The operation of button "A" moves the container to the left and deposits the coins in the coin tin, and the operation of button "B" moves the container to the right and returns the coins to the caller via the refund chute and receptacle.

The signal gongs mounted at the left of the coin guides are a telephone type bell and a coiled wire. A penny strikes the wire gong once, a sixpence strikes the bell gong once, and a shilling, by means of a double guide, strikes the bell twice. The wire gong emits a low note and the bell gong a high note. These "tones" are rendered audible to a telephonist by means of the coin signal transmitter which is mounted on a heavy "U" shaped spring inside the bell. The transmitter is of the button type familiar in C.B. No. 1 transmitters but is modified by having the usual mica diaphragm replaced by a thin ebonite diaphragm and the carbon chamber is tightly packed with carbon granules. The ebonite diaphragm carries a central ebonite stud which is held in close contact with the bell by the mounting spring, and by this means the transmitter is made to respond to the vibrations of the gongs. The gongs are rigidly fixed to the same mounting plate and this communicates the vibration of the wire gong to the bell and transmitter.

The transmitter is practically unresponsive to speech but to prevent the vibration of the case caused by the caller's voice being picked up by the transmitter it was found necessary to mechanically insulate the gong assembly from the rest of the mechanism by means of soft rubber pads.

The capacities of the three sections or compartments of the swinging coin container are 10 pennies, 8 sixpences, and 10 shillings, respectively. When the fee to be inserted by the caller contains more than eight coins of the same denomination, the standard procedure is for the telephonist to instruct the caller to insert eight only, then press button "A" before inserting the remainder.

The whole of the mechanism is hinged at the right hand side of the case and can be swung clear by simply pressing a latch, or the mechanism can be removed entirely by lifting it off the hinges which are of the pin and socket type. The electrical connections between the springsets on the mechanism and the terminals on the back of the case are made by means of a 16 point plug and jack of the automatic switch type.

Coin Tin.—The self-sealing coin tin shown in Figure 5 is constructed from No. 16 s.w.g. sheet steel with welded seams, the lid is of $\frac{1}{8}$ inch sheet steel, and the whole is given a sheradized finish. In the bottom of the coin tin a keyhole shaped hole is cut so that the coin compartment key can be inserted to assist in the withdrawal of the coin tin if necessary. Mounted on the lid is a spring operated shutter which automatically closes the coin entry aperture when the coin tin is drawn from its compartment. The shutter is retained in the open position by a toothed latch engaging a pawl screwed to the shutter, the latch being held against the pawl under the pressure of a spiral spring. The automatic closing of the shutter is accomplished by fitting a steel pin with a tapered point inside the coin compartment in such a position that it passes through a $\frac{1}{4}$ inch diameter hole in the lid when the coin tin is placed in position. The pin pushes the latch aside and out of contact with the pawl and at the same time allows just sufficient closing movement of the shutter to prevent the pawl re-engaging when the coin tin is withdrawn. When the shutter is fully closed it is locked by the latch and pawl.

Recently it has been necessary to add two additional details to the mechanism on the lid. These are marked 1 and 2 in Figure 5. The purpose of detail 1 is to hold the shutter in intimate contact with the lid when closed to prevent the egress of coins, usually sixpences, through a small space between the shutter and lid; and the purpose of detail 2 is to prevent the shutter closing on locked but empty tins through

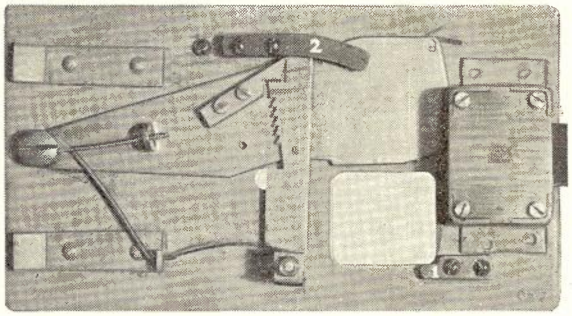


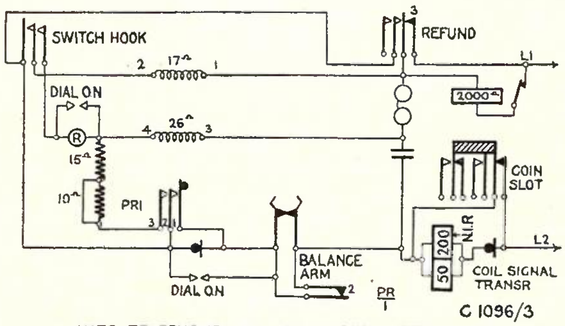
Fig. 5.—Lid of Self-Sealing Coin Tin.

the latch being jarred out of engagement with the pawl. Wherever the foregoing difficulties are experienced by coin tin collectors it is proposed that they should be met by adding the two extra fittings locally, and Drawing C.A. 1061 giving all necessary particulars has been issued for this purpose. Future supplies of coin tins will include the extra fittings or some arrangement serving the same purpose.

Operation and Circuits

Automatic Area—Local Call (Figure 6).—To originate a call the caller inserts two pennies in the "Penny" slot. The first coin operates the coin slot crank arm which operates the coin slot springset (1) by means of an ebonite stud fixed to the cam. The cam locks in position by the semi-circular slots in its periphery engaging a roller fitted to the end of a flat steel spring. Springset (1) removes a short circuit from the coin signal transmitter and polarized relay PR. The two pennies come to rest on the balance arm which extends across the bottom of the penny compartment of the swinging coin container. The balance arm, which is adjusted by a sliding weight to just operate with the weight of two well-worn pennies, operates springset (2) which removes a short circuit from the dial. The number can now be dialled. If the call is to an Automatic Exchange subscriber, the battery reversal, which takes place when the call is answered, operates the polarized relay. The PR. relay contacts short circuit the telephone transmitter and place a non-inductive resistance across the receiver to prevent its use as a transmitter. Upon hearing the called subscriber answer the caller depresses button "A." This action deposits the pennies in the coin tin and restores the coin slot crank arm to normal. The PR. relay and coin signal transmitter are again short circuited by springset (1) and the relay in falling back removes the short circuit from the telephone transmitter and allows the call to proceed. If the call had been to a Manual Exchange subscriber, the battery reversal takes place when the called subscriber answers or when the telephonist rings the called subscriber according to the type of exchange or circuit arrangements. The polarized relay is included in the circuit to enable the caller to speak to Manual Exchange or "Service" telephonists. If this was not necessary the function of the PR. relay could be performed by the coin slot springset (1) which operates when the first coin is inserted and restores when button "A" is depressed.

If the call is ineffective the caller depresses button "B" and the pennies are refunded. Button "B" also operates the refund springset (3) which opens the line circuit and allows the automatic switches to release. To ensure that the switches have ample time to release the refund springset is held operated for seven seconds by an escapement mechanism which is adjusted by means of a pendulum bob. The further functions of the refund springset will be explained later.



AUTO TELEPHONE AND MULTI-COIN ATTACHMENT

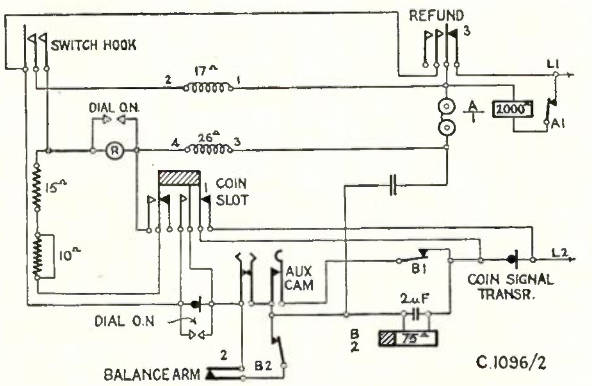
Fig. 6.

Automatic Area—Trunk or Phonogram Call.—The caller inserts two pennies as on a local call and dials the special number allotted (B 077, Sydney; M 077, Melbourne). If the call is for trunk service, the trunk operator obtains the number of the P.T. cabinet from the caller, takes particulars of the call and instructs the caller to press button "B" to recover the two pennies and wait outside the cabinet for the call to mature. When the call matures, the trunk telephonist dials the P.T. switch number and, after ascertaining that the correct caller answers, the telephonist instructs the caller to insert the fee in the correct slots. The telephonist checks the fee inserted by means of the tones developed by the coin signal transmitter. When satisfied that the correct fee has been inserted, the caller is instructed to press button "A." This deposits the coins and the call proceeds as for a local call. If the caller presses button "B" the coins will be refunded and springset (3) operated. Reference to Figure 6 shows that this springset also introduces the self-interrupting 2000 ohm relay A into the circuit. The buzzer action of relay A transmits a tone to line which is heard by the trunk telephonist and a seven seconds clearing signal is received on the supervisory lamp. These signals warn the telephonist that the wrong button has been depressed and the caller is instructed to redeposit the fee. The refund springset also short circuits the switch hook of the telephone so that the caller cannot mask the buzzer tone by temporarily operating the switch hook. Phonogram calls are similarly treated, except that when the caller asks for "telegrams" the call is reverted immediately after the refund button is depressed by the caller, and the call is routed to phonograms over special junctions.

The battery reversal for the operation of the polarized relay on reverted calls to the public telephone is obtained by reversing the normal wires to the final selector bank contacts.

The relays PR. and A and the 15 + 10 ohm non-inductive resistance are standard serial items and are supplied separately to the multi coin attachment.

R.A.X. Area (Figure 7).—Local calls from a multi coin attachment connected to an R.A.X.



AUTO TELEPHONE AND MULTI-COIN ATTACHMENT.

Fig. 7.—Circuit Diagram: Public Telephone Multi-Coin Attachment. Two-Button Type—R.A.X. Area.

are made in exactly the same way as when connected to an Automatic Exchange in the metropolitan area. The circuit operation is different, however, as the functions performed by the polarized relay in Figure 6 are performed by the coin slot springset. Trunk or Phonogram calls are lodged with the telephonist at an R.A.X. parent exchange. Trunks to these are grouped on the "O" level and are reached by dialling 01, 04, etc., depending on the number of trunks in each group: the selection of an idle trunk in each group is automatic as in P.B.X. groups.

To enable a parent exchange to be called without the "pre-payment" of twopence, the telephone is fitted with a special dial having an auxiliary cam which operates when "0" is dialled. The special dial is known as Dial No. 11, and differs from Dial No. 10 only in the provision of the auxiliary cam. The cam removes the short circuit from relay B which operates in series with the line.

Contact B1 opens the auxiliary cam circuit to prevent the relay being again short circuited when the cam springs close on the dial returning to normal. Contact B2 removes the short circuit from the dial and allows the "0" and subsequent impulses to be dialled. The relay remains operated during dialling due to its slow release feature. The remainder of the circuit functions are the same as given for Figure 6 except that, as previously mentioned, the coin slot springset is arranged to short circuit the telephone transmitter and shunt the receiver with the non-inductive resistance.

It is unnecessary to revert Trunk and Phonogram calls unless demand service cannot be given, as there is no polarized relay in the circuit and the circuit arrangements of the R.A.X. provide for a special indication to the parent exchange telephonist when calls are originated from a public telephone fitted with a multi coin attachment.

It will be observed that a multi coin attachment connected to an R.A.X. works on the "prepayment" principle for Local calls but the "postpayment" principle for Trunk calls.

The Dial No. 11 and the 75 ohm slow release relay are standard items.

Magneto Area—Local and Trunk Calls.—The circuit arrangements for this type of service is shown in Figure 8. The exchange is rung in the normal way and for Local or Trunk calls the caller is requested to insert the appropriate fee which is checked in by the aid of the coin signal transmitter and deposited by the "A" button. If the refund button "B" is depressed, the 30 ohm self-interrupting relay A is brought into circuit. The A relay is operated from the speak-

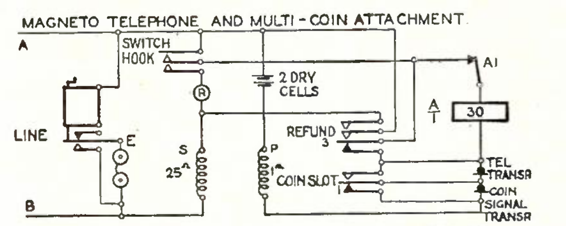


Fig. 8.—Circuit Diagram: Public Telephone Multi-Coin Attachment. Two-Button Type—Magneto Area.

ing battery and develops a tone in the primary circuit which is induced in the line circuit by the secondary winding of the induction coil. The refund springset (3) also short circuits the local receiver and switch hook. Trunk calls are only reverted where demand service cannot be given.

C.B. Manual Exchange Area.—Up to the present, with one exception, there are no multi coin attachments connected to C.B. exchanges in Australia and no standard circuits have been issued; if necessary, however, it is proposed to provide service on a "post-payment" basis exactly the same as for the Magneto area. C.B. "prepayment" working involves alterations to the line circuit at the exchange and the provision of special cord circuits. The advantages of "prepayment" working do not justify these alterations, particularly in view of the small number of installations which might be required in the few remaining C.B. areas in the Commonwealth.

Multi Coin Attachments—One Button Type.—This type of attachment was previously purchased for use in Magneto areas and a few are in use in each State. The type is not now standard and no further purchases will be made. In this type the "A" button is replaced by an A.C. relay operated by ringing current from the exchange. The depositing of the coins is under the control of the telephonist who operates a special ringing key.

A Cailho circuit is required for the operation of the depositing relay. This requirement led to the abandonment of the one button type of attachment as it is often necessary, in order to provide continuous service, to night switch the public telephone to a distant continuously staffed exchange via a minor Trunk line. In many cases where the installation of a multi coin attachment was justified, it was found that a Cailho circuit could not be made available and the proposals had to be abandoned or deferred. Furthermore the utilization of the Cailho circuit for the public telephone presented a serious obstacle to the rearrangement of available Trunk line circuits when additional channels became necessary. A further disadvantage of the one button type is that it requires a special ringing key to be fitted on the exchange switchboard.

The standardization of the two button type of attachment for all purposes has distinct advantages, not the least of which is that the public need only become familiar with the manipulation of one type. As the use of multi coin attachments becomes more widespread this consideration should yield tangible results.

PRIVATE AUTOMATIC BRANCH EXCHANGE EQUIPMENT—UNIT TYPE

A. R. Gourley, A.M.I.E.(Aust.)

To meet the needs of subscribers with services of up to eight both-way exchange and fifty extension lines, a new series of P.A.B.X.'s has been developed. The following facilities are provided:—

(i.) Extension to extension calls dialled direct.

(ii.) Calls outgoing to the public exchange dialled direct by prefixing "Y" to the directory number.

(iii.) Any extension may be barred direct access to the public exchange, in which case calls may be routed through the associated manual switchboard.

(iv.) Calls incoming from the public exchange are received on a cordless type manual switchboard and routed to extensions by the use of key sender equipment. If the extension is busy, the call is completed automatically as soon as it becomes disengaged.

(v.) Through clearing and automatic release on exchange calls. The exchange equipment is held busy until both calling and called terminations are free.

(vi.) All exchange lines are night switched to pre-determined extensions, but when the lines are free, any extension not barred may call the exchange.

(vii.) Extensions call the manual switchboard by dialling 9.

(viii.) A busy extension may be offered an exchange call; a warning tone is provided to advise the extension that the telephonist is across the line.

(ix.) On exchange calls, the telephonist may speak to either the exchange or extension without the other party hearing.

(x.) Outgoing exchange calls may be set up by the telephonist and reverted to any extension.

(xi.) Automatic call back and transfer of exchange calls. If an extension telephone is fitted with a non-locking press button (which when depressed grounds one side of the line) an exchange call may be held and information obtained from any other extension by dialling the relative number. Alternatively, the exchange call may be transferred to the extension number dialled without calling the manual switchboard.

Two sizes are available, the designations and capacities being:—

Type "C"—4 both-way exchange and 25 extension lines.

Type "CA"—8 both-way exchange and 50 extension lines.

The type "C" is the basic unit and is equipped and wired for:—

25 extension line circuits.
4 link circuits for local calls.
4 exchange line circuits.
1 level "9" information circuit.
1 call back and automatic transfer circuit.
1 ringing and tone equipment.

The type "CA" equipment is comprised of a type "C" unit plus an extension unit equipped with:—

25 extension line circuits.
4 link circuits.
4 exchange line circuits.

The type "CA" P.A.B.X., therefore, consists of two groups, each of 25 lines, each group being served by four link circuits. The exchange and level 9 circuits available to all extensions. The units are completely enclosed with dustproof covers and are wired ready for installation. Figs. 1 and 2 shows front and rear views of a type "CA" equipment with covers removed. In Fig. 1, the extension line and cut off and the miscellaneous relays are mounted at the top of the units. On each unit the link line finders are mounted on the shelf below the relays, whilst the next lower shelf is equipped with the ex-

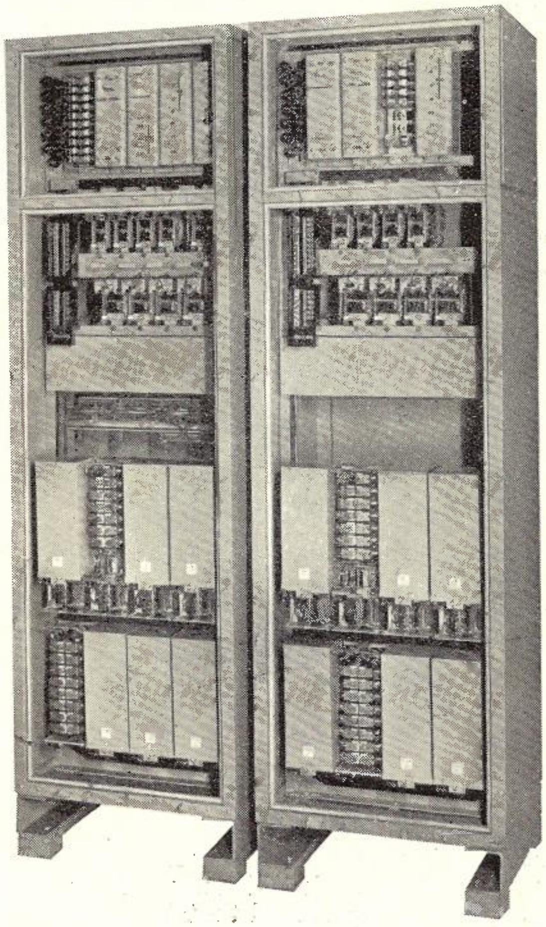


Fig. 1.—Type CA P.A.B.X., front view.

change line finders. A fuse panel is associated with each of these shelves. The ringing and tone pulse switches are mounted adjacent to the link finders on the type "C" unit only. The type 2000 final selectors and exchange line relay sets are mounted on the lower shelves on the unit. In Figure 2, the shelf on the type "C" unit is

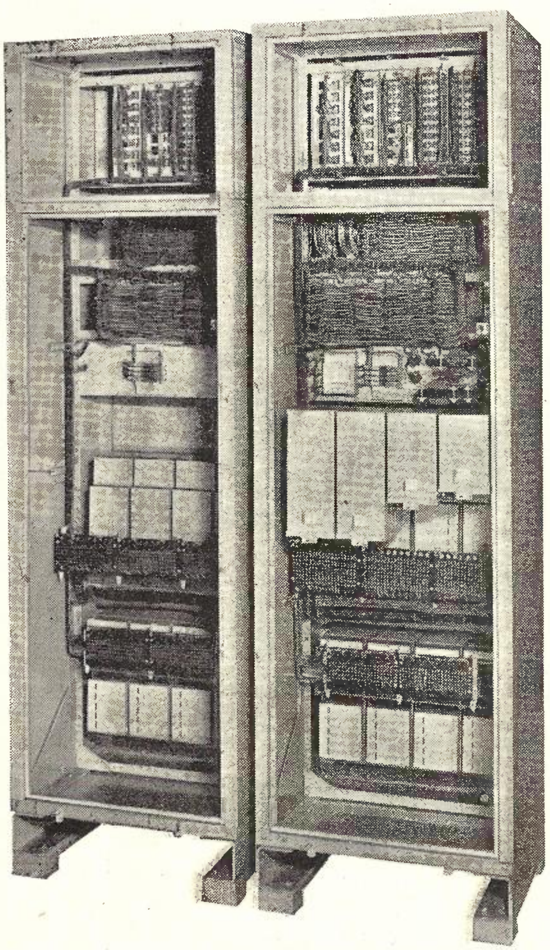


Fig. 2.—Type CA P.A.B.X., rear view.

equipped with relay sets for the attendant's circuit, ringing tone and alarm circuits, level 9 circuit and call back and automatic transfer circuit. It will be observed that the terminal strips and bank wiring are accessible. The line and cut off relays are of the B.P.O. 600 type, whilst all other relays are of the B.P.O. 3000 type. The extension line finders on each unit are 25 point non-homing uniselectors, whilst the exchange and level "9" finders are 50 point non-homing uniselectors. The extension line finders are tied directly to 100 outlet bi-motional switches of the B.P.O. 2000 type. For "out" exchange and for level "9" calls, the 25 point finders and final selectors are in circuit only until an exchange or level "9" finder locates the calling extension line. On incoming exchange calls, the exchange finders are positioned under the control of storage relays in response to the operation of the digit keys on the manual switchboard.

The manual switchboard is enclosed in a pressed steel cabinet suitable for table mounting and is shown in Fig. 3. All relay sets are mounted on the unit, the key and lamp wiring being terminated in the terminal box depicted on the right of Fig. 3. The switchboard keys control the exchange lines and miscellaneous facilities, there is one key per two exchange lines. One

Fig. 3.—Manual Switchboard.

lamp is associated with each exchange line and is used for both calling and supervision. The digit keys 1-0 on the lower portion of the unit are used for setting up calls to extensions, whilst the dial is for "out" calls to the exchange. The same board is used for both 25 and 50 line equipments.

The trunking scheme is shown in Fig. 4. The upper figure listed adjacent to each group denotes the number of switches provided for a 25 line equipment, whilst the lower figures relate to a 50 line equipment. The numbering scheme is:—

Extensions (25 line), 20-44.
Extensions (50 line), 20-69.
Information, "9."
Exchange, "0."

The units are designed to work on a nominal voltage of 48 volts, but will function satisfactorily over a range of from 44-56 volts. Where the commercial power supply is A.C. a rectifier and single battery of 24 cells are provided; the rectifier functioning as described in Telecommunication Journal, Vol. 1, No. 1, Page 20. In a D.C. supply area, 25 cell duplicate batteries, with automatic changeover equipment, are provided. This circuit was described in Telecommunication Journal, Vol. 1, No. 3, Page 99.

These units can be adapted readily to function in conjunction with Automatic, C.B. or Magneto public exchanges, but for other than connection to an automatic exchange with standard ringing, it is necessary to effect minor circuit changes which are not described in this article.

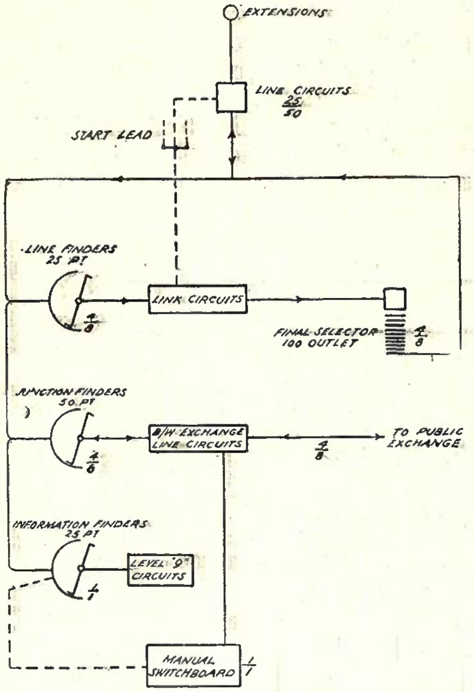


Fig. 4.—Trunking Scheme.

The operating procedure and main features of the circuits of the switches and relay sets are described hereunder.

Extension Line Circuit, Figure 5

When a call is initiated, line relay L operates over the loop, earths the start lead and applies a 200 ohm test potential to the H.F. contact of the finder banks. When a free finder seizes the line, a 6 ohm earth is connected to the H.F. lead to hold line relay L and operate cutoff relay K in series. Battery to the extension is fed from the finder circuit.

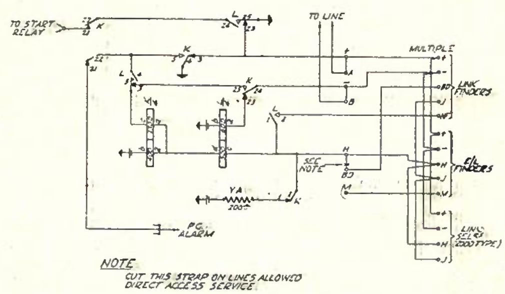


Fig. 5.—Extension Line Circuit.

Incoming calls operate relays L and K by an earth over the H lead.

If an extension line is short circuited, it is locked up in the line circuit. As described later, the link circuit is forcibly released and earth is removed from the lower windings of L and K. Relay L releases but K holds over the extension loop through back contacts of L and so applies earth to the P.G. alarm circuit to the manual board.

Link Circuit—Figure 6

By a study of this circuit, it will be apparent that the special features of the B.P.O. type 2000 final selector have been incorporated therein. These features were described in Mr. W. A. Phillips' article on "The B.P.O. Type 2000 Line Finder System," Telecommunication Journal, Vol. 1, No. 3, Page 114. The impulsing relay A operates from earth on the start lead from the line relays. Relay A operates B which closes circuits for starting the ringing and tone equipment, the line finder magnet and test relay FT. All disengaged finders hunt for the calling line. On the first finder reaching the marked HF bank contact, FT operates to the 200 ohm test potential, opens the driving magnet circuit and operates relay K. Relay FT contacts 2.3 short circuit the high resistance winding of FT to busy the calling line to other finders. Relay K in the line circuit (Fig. 5) operates and opens the start circuit to other links. The operation of K (Fig. 6) breaks the start lead to this switch and extends the calling line to relay A which holds over the extension loop. K also provides dial tone which is induced in a balanced circuit via N3.4 and the 500 ohm winding of D. K contacts 23.24 provide an earth over normal springs NR to the home contact on the vertical bank of the selector to operate relay C on its high resistance winding. Relay C prepares the impulsing circuit for the vertical magnet.

Local Call.—On receipt of dial tone, the extension dials and the first digit is taken on the V.M. which steps under the control of relay A. On the first step, the 1000 ohm winding of C is disconnected but, during impulsing, C holds on its low resistance winding in series with the V.M. On completion of the first digit, C releases and extends relay E to the vertical bank. The normal springs N, operate on the first vertical step and remove dial tone from D 500.

Relay E operates and switches the impulsing circuit from the vertical to the rotary magnet and re-operates relay C which provides a locking circuit for E via contacts 1.2.

When the second digit is dialled, Rotary Normal Springs NR operate on the first rotary step and open circuit the high resistance winding of C. During impulsing, relay C remains operated in series with the R.M. On completion of the digit, C releases and opens the holding circuit for E. During the slow release of E, an earth is extended from the 300 ohm winding of H to the H wiper of the selector.

Called Extension Free. If the called extension is free, H operates to the 200 ohm test potential on the H lead (See Fig. 5) and locks to K 21.22

(Fig. 6). When H operates, a full earth is connected to the H wiper and holds the called extension's line and cutoff relays. H switches the positive and negative leads to ringing via contacts of relay F, and on the release of E, ringing is applied to the called extension line and ringing tone furnished the calling extension via D.500. When the called extension answers, ringing relay F operates over the loop and locks over contacts of K and H. Relay F extends the line to battery feed relay D which operates and the connection is completed.

"Z" pulse will short circuit relay K and forcibly release the connection. The selector is restored to normal on the release of B and H when R is energized over its interrupter contacts to earth via the release signal. R drives the switch off the last bank contact and it then restores to normal under the control of the shaft restore spring. If the switch sticks with R operated, the release alarm functions.

Level "9" Calls.—On the first digit, the vertical magnet operates as described and when relay C releases, an earth through relay G is extended

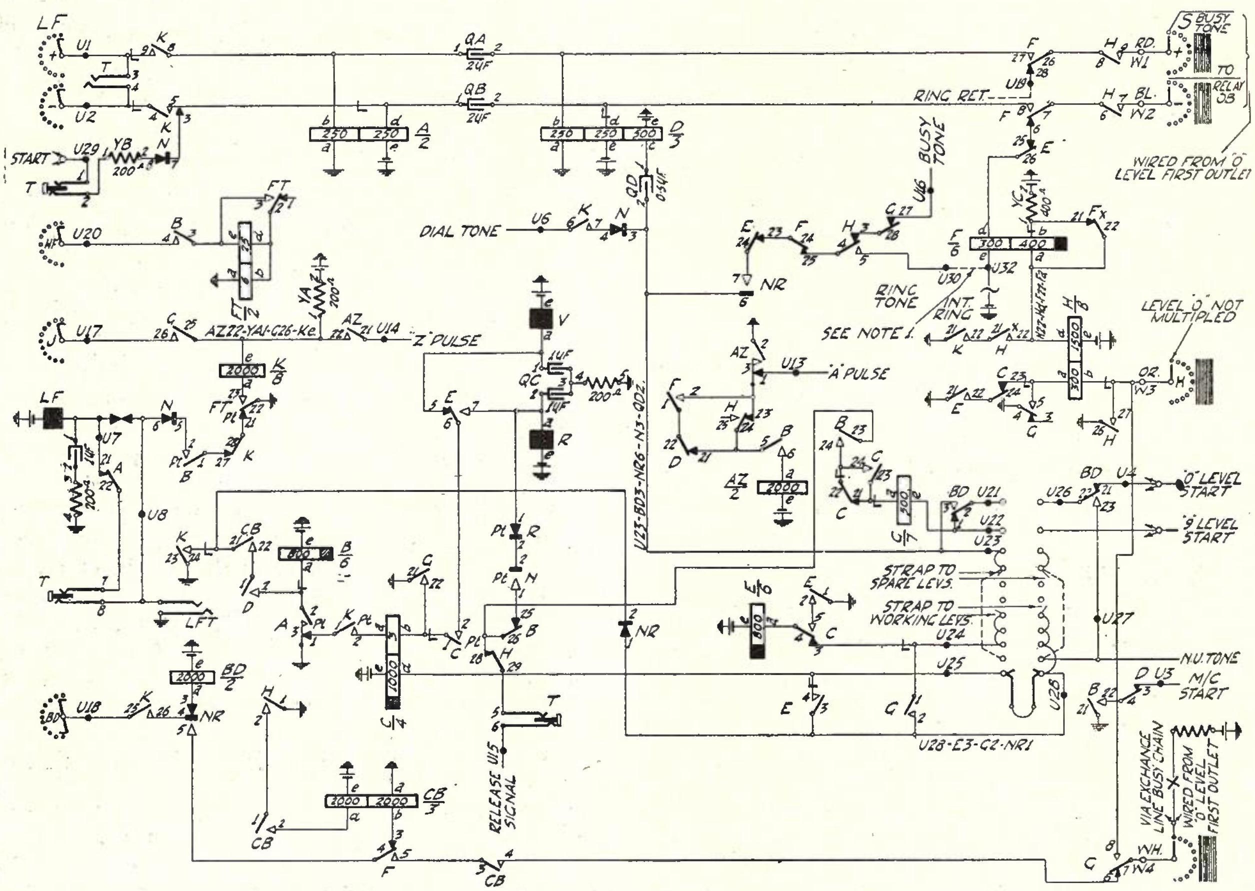


Fig. 6.—Link Circuit.

Called Extension Busy.—If the called extension is engaged H cannot operate and on the release of E, the busy tone circuit is completed via D500.

Release.—Calling party release is provided. On the calling party replacing the receiver, relay A releases and releases B, FT and K which releases H, F and D. The called extension is released from the connection and thrown on his line circuit as a P.G. until such time as he replaces the receiver. If the called party clears and the calling party does not, a circuit is extended via D 21.22 to relay AZ which will operate on the "A" pulse from the ringing equipment to prepare a circuit for the "Z" pulse to relay K. If the caller fails to clear in another 30 seconds, the to the level 9 start. Provided the "O" level is not engaged, G operates in series with the start relay (not shown) and connects 200 ohm test potential to the "J" wiper of the link finder whilst the start circuit starts the idle level 9 finder hunting for the calling line. When the level 9 finder locates the line, it takes over the call by connecting a low resistance earth to the J lead, short circuiting relay K and so releasing the link circuit.

Level "O" Call.—To gain exchange access, "O" is dialled and the operation to the end of the first digit is as described. When C releases, G operates to the "O" level start, provided the level 9 start is free. The "O" level finders search, the calling extension is taken and the link circuit released as for a level 9 call. If a barred extension dials "O," relay BD which is operated from the BD wiper, removes G from the "O" level start and applies NU tone.

Call Back. — The operation of relay CB is covered in the description of the call back circuit.

All Finders Busy.—No dial tone. Extension clears and calls later.

All Exchange Lines Busy.—Busy signal from operation of O.B. relay (not shown) operated from chain contacts wired from the "O" level, first outlet.

ing line and operates relays CA, CB and Z, as well as opening the lamp circuit. Relay CA switches the exchange lines through to the operator's set and ringing is tripped by retard IL (Fig. 9). To extend the call to an extension, the wanted number is set up on the digit keys (see Fig. 9) and an earth is extended from the operator's circuit over the D wire to operate the JF. magnet. When the finder reaches the marked line, the magnet circuit is broken (See Fig. 9) and an earth from the operator's circuit over the RR lead operates relays RR and CL in series. As the hold circuit of R is opened, R releases.

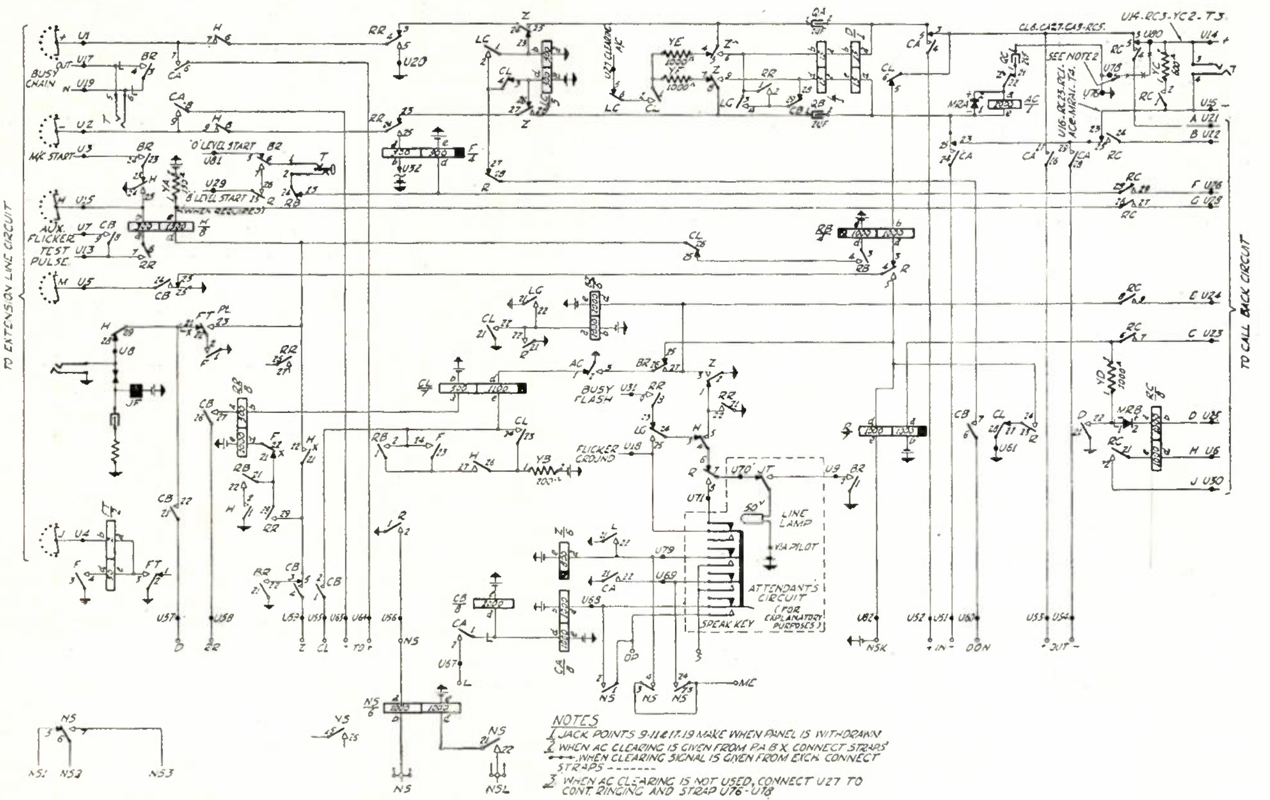


Fig. 7.—Exchange Line Circuit.

Level "9" Busy. — Under this condition, the switch camps on the circuit, and the waiting call lamp glows on the manual switchboard. When the circuit is clear, the call is switched through as explained.

Exchange Line Circuit (Fig. 7) Incoming Call. —When the exchange line is seized, relay RB operates from the positive line to earth to busy the line by opening the "O" level start and so guard against the silent ringing period. Ringing current from the main exchange operates relay AC to operate relay R which locks up to CL 27.28 and applies flicker ground to flash the line lamp on the manual switchboard. Relay BR is also operated. The operator answers by throwing the speak key associated with the calling line RR completes a test circuit for the 300 ohm winding of H to the line finder H lead.

Called Extension Free.—H operates to the 200 ohm test battery in the line circuit (Fig. 5) and locks to the "Z" lead. H puts a full earth on the wiper to hold the called extension's line and cut off relays and switches the line to ringing via contacts of RR and ringing relay F. When H operates the exchange line lamp glows steadily and the operator may withdraw from the circuit by releasing the speak key, thus releasing relays CA and CB. Relay Z is held operated by relay L which is operated over the exchange line loop via contacts of RR and CB. Relay CL is held from the back contacts of AC and RR locks to the front contacts of BR over break springs of F.

Called Extension Answers.—On the extension answering, relay F operates over the extension loop and breaks the circuit for RR which releases and switches the extension through to the exchange. Relay L is now held over the loop and speaking battery is fed from the exchange. Relay F releases.

Extension Clears.—The circuit is under the control of the extension which gives a clear to the exchange when the receiver is restored. Relay L releases and releases Z but the circuit is not cleared until the calling subscriber clears. Clearing A/C is sent over the back contacts of LG, front of CL, back contacts of Z, condensers QA, QB to the exchange. So long as the positive and negative lines are connected to a balanced feed at the exchange, this simplexed A/C will have no effect on relay AC but when the calling subscriber clears and the line is restored to the line circuit, the unbalance will cause relay AC to operate, release relay CL which, in turn, releases BR and H and removes clearing A/C from the line.

While clearing A/C is on the line, the supervisory lamp is alight from the back contacts of Z and operated contacts of H. If the operator notices a circuit remains in this condition for some time, she should challenge and release it by the operation of the speak and release keys on the switchboard. The operation of the release key breaks the hold circuit of H and releases the extension but the exchange line start circuit is open at BR 5.6.7 until the calling subscriber clears.

Called Extension Engaged.—If the called extension is engaged, relay H will not operate (200 ohm test battery in line circuit disconnected) and the supervisory lamp will flash over front contacts of RR, back contacts of LG, H and R. The circuit is so designed that the switch will "Camp on busy." The operator may withdraw from the circuit by releasing the speak key and permit the caller to wait. When the busy extension clears H will operate and the call proceeds as above. During "Camp on busy," a series of test pulses is provided to H via RR 6.7. When the call is switched through, the lamp glows steadily until the called extension answers.

Outgoing Call.—When the extension dials "O," the connecting circuit (Fig. 6) marks the J bank of the exchange line finders, and the "O" level start circuit operates relay F which closes a circuit for the JF magnet and for relay FT. The finder hunts under the control of FT which will operate to battery on the J wire from the local finder and open the JF magnet circuit. Relay FT operates relay H, switching the extension loop to relay LG. Relay FT also puts a low resistance earth on the J lead, shunting relay K (Fig. 6) and releasing the link.

Relay LG operates and closes a loop to the exchange through relays L and D. It also operates relay BR which opens the circuit of F. Relay L operates to the exchange battery and operates Z which switches the extension to the exchange line and releases LG. The call proceeds under the control of the extension; battery is fed from the exchange. Release is as described for an incoming call.

Busy Test.—The operator tests for busy lines by operating the JT key (Fig. 9). The JT relay (Fig. 9) operates and the supervisory lamp on busy lines will light to the BR contacts.

Trunk Offering. — The operator may offer a call to a busy extension by the operation of the trunk offering key in conjunction with an exchange line key. Contacts CA 6.7 and 8.9 bridge the operator's circuit across the extension line and a warning tone is applied to inform the extension that the conversation is being supervised.

Operator Calls Exchange.—After testing for busy lines, the operator throws the key of a free line, connecting the telephone circuit across the "in" line and the 400 ohm retard coil IL (Fig. 9) across the "out" line. Relays CA, CB, Z and BR operate as described above. The switchboard dial is used for exchange calls. When the first digit is dialled, as soon as the dial is off normal, LG operates from earth over the D.O.N. lead (See Fig. 9) and locks to LG1.2. Relay LG provides a hold for BR, prepares a loop for L and connects flicker ground to the supervisory lamp. Dialling proceeds and the call is completed. If required, the call can be reverted to any extension by the use of the digit keys as for an incoming call. If another call comes in whilst the operator is engaged on an out call, the out call can be held by restoring the exchange line key. Relays CA, CB and Z release but L operates and reoperates Z, holding the exchange line. Release is effected by depressing the release key (Fig. 9) with the exchange line key operated. Relay CL operates, and opens the hold circuit on LG which removes the hold on BR. When the exchange key is restored, all relays are restored to normal and the line is clear.

Night Switching.—On the M and M1 multiple, an extension is jumpered to the NS1 and 2 contacts of each exchange line. The night extension key on the manual board is operated. An incoming call operates relays AC and R which extends relay NS to the position circuit. NS operates and extends relays CA and CB to the position circuit, which then functions as for a call extended by the operator, the junction finder stepping to the extension line connected to the NS. 1 and 2 contacts. On the extension answering, relay NS releases, and in turn releases relays CA and CB and so extends the call to the extension.

Level 9 Circuit—Figure 8

Extension Calls Operator.—An earth on the start lead from the link circuit (Fig. 6) operates relay F over its 400 ohm winding. Relay F closes a circuit to the finder magnet and prepares a circuit for test relay FT. The finder hunts under the control of FT which operates to the test battery on the J bank: opens the magnet circuit and operates relay H. Relay H connects a guarding earth to the H bank and switches the extension lines to relay A which operates and closes the circuit of relay B. Relay B applies flicker ground to the line lamp. The operator answers by throwing the speak key, extension line circuit, connects the ring to line and provides a circuit for the line lamp to glow steadily. When the extension answers F operates and the extension is connected to the operator as for an incoming call. At the end of the conversation, the level 9 key is depressed to the RK position and the circuit restored to normal. If the called extension is engaged, relay H will not operate and the lamp flashes to "flash ground." The key is restored and RR held over RR21.22 to ground on RK. When the extension clears, H operates and the call proceeds as above.

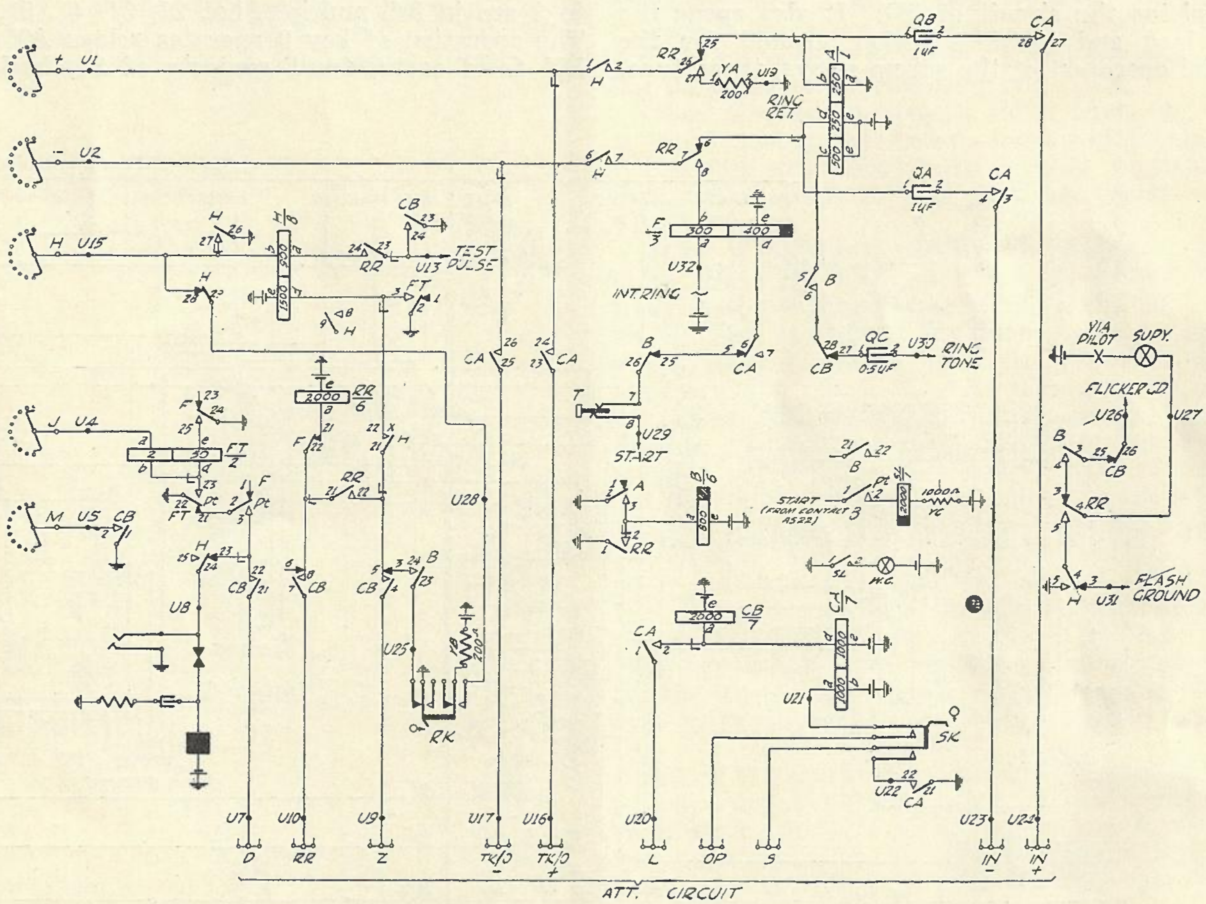


Fig. 8.—Level "9" Circuit.

thus operating relays CA and CB, switching the lines to the operator's set and opening the lamp circuit. Calls on this circuit cannot be extended. Release is effected by restoring the speak key.

Operator Calls Extension.—The speak key is thrown and the number set up on the digit keys. The finder is started by an earth on the D lead and when the marked extension is reached, relay RR operates over an earth on the RR lead. Relay RR operates B and prepares a circuit for ringing relay F. H operates as in the exchange line circuit, operates the L and K relays in the If it is desired to drop a call, the operation of the RK key clears relay H and the circuit is cleared.

Level 9 Circuit Engaged.—If the circuit is in use and another call comes in, relay SL operates from earth over the start lead and completes the circuit of the waiting call lamp. When the operator clears the call on the circuit, control relay AS (not shown) operates and the earth from the circuit held by the waiting call operates relay F and the waiting call is picked up as described under "Extension Calls Operator." Relay AS opens the circuit of SL and clears the waiting call lamp.

Attendant's Circuit—Figure 9

The operator is provided with a speak key per exchange line and level 9 circuit, together with digit keys for setting up calls to extensions and miscellaneous keys referred to later. The operator can only be connected to one circuit at a time.

Incoming Exchange Call.—The line lamp on an exchange circuit flashes and the operator throws the associated speak key operating relay CA (Fig. 7) over the OP lead and completing the circuit of Z (Fig. 7) and S (Fig. 9). Relay S earths the L lead operating CB (Fig. 7) and completes the circuit of SD. It also opens the NS lead and provides flicker ground for the initial operation of the set-up relays, these functions are for night switching only. Relay SD changes earth from the OP to the L lead and prepares a locking circuit for relay ME which is used only for night switching. When the speak key was operated, the attendant's set was placed across the "out" lines, and the incoming ring tripped by retard IL. speech is effected over the "in" lines and the circuit is prepared for the operation of the "set up" keys. The required extension number is, say, 33.

It is of interest to note the wiring on the M multiple of the exchange line finders. 20, 30, 40, 50 and 60 are individual leads, whereas digits 1 to 9 are in full multiple, i.e., 21, 31, 41, 51, 61. The operation of key 3 operates relays AX and BX from earth, front contacts of S1, back of NU, back of K, back of Z to the key. These relays lock up in series with relay Y over the same earth. The operation of Y changes over the digit key leads from the first to the second digits group. The operation of AX operated relay ST which provides an alternative path for holding NC (night switching only) prepares an earth for the D lead, prepares the RR lead and places the Z lead under the control of K 21.22. Relays AX and BX connect the marking potential to number 30 on the M bank of the exchange line finder via U3.

The second depression of key 3 operates relays AY and BY. Relay AY prepares a circuit for the marking potential YA 200, Q50 to BY4, and completes a circuit for relay Z. Relay BY prepares the marking circuit to 33 M bank via DY23-24.

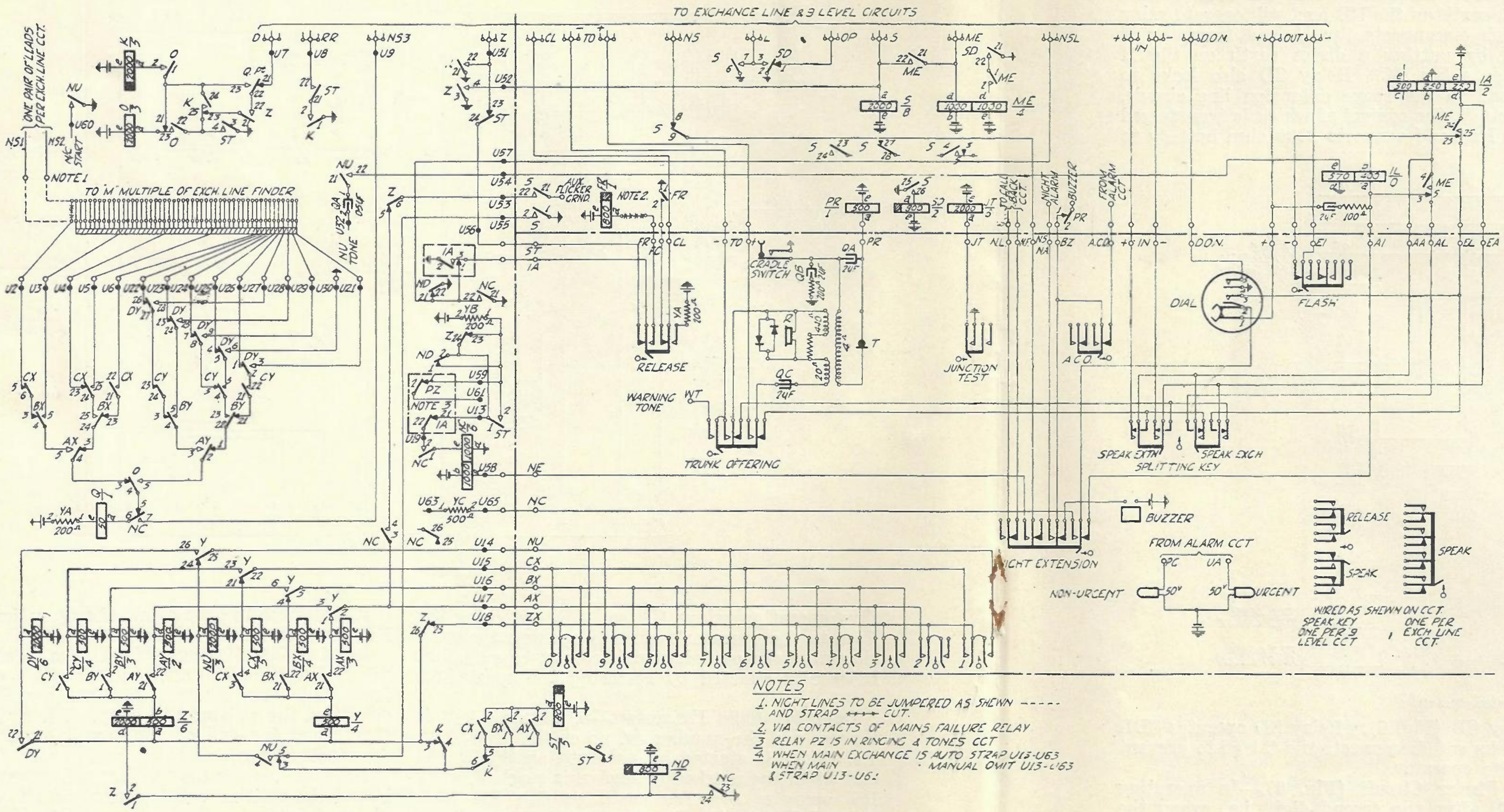


Fig. 9.—Attendant's Circuit.

Relay Z operating, earth from the front contacts of ST 3 and 4, back contacts of K and Q and front contacts of Z, is extended to the D lead, causing the L.F. magnet (Fig. 7) to operate to the mark extended by the first operation of the set up keys. The finder rotates to contact 30 and operates relay Q from earth on the M bank (See Fig. 7). Contacts Z 1.2, 5.6, and 23.24 are used only for night switching.

Relay Q operating, removes earth from the D lead, preventing further rotation of the exchange line finder and operates relay O which prepares a circuit for relay K, locks to ST 3.4, opens the circuit to relay Q at O3.4.5 and places marking potential on the M bank via U.23.

Relay Q releasing places earth again on the D lead, causing the finder magnet to rotate to the marked extension 33 and relay Q re-operates. Q.21.22.23 completes its holding circuit via ST.3.4.

Relay K operates, earths the RR lead, operating relays RR, CL and H (if the extension is free) in the exchange line circuit (Fig. 7). Relay H (Fig. 7) clears the extension line by operating relays L and K (Fig. 5). Relay K also open circuits relays Y, AX, BX, AY, BY and Z. Relay AY releases relay Q. Relay K also releases ST and earths the Z lead to hold relay H (Fig. 7). After the slow release of relay ST., relays O and K release. Ringing conditions are now set up and on seeing the line lamp glowing steadily, the operator restores the key. Relay S restores and releases CA and CB (Fig. 7). The call now goes through as explained in the description to Figure 7. It will be seen that, after the operation of relay K in the attendant's circuit, the set up relays are free, allowing other calls to be dealt with by the use of the set up keys.

Should the operator, by mistake, depress key 1, 7, 8, 9, 0 first, a circuit for relay NU is completed from earth, contacts of S, NU, K and Z, wrong first digit key, contacts of Y to NU. Relay NU locks and extends NU tone to the operator's set.

If the operator sets up the wrong number, providing the clear lamp glows, she can immediately reset to the correct extension by the operation of the correct push keys.

If the wanted extension is engaged, the supervisory lamp will flash, owing to relay H in the line circuit not operating.

The operator can restore the key as the circuit is designed to camp on busy lines. When the extension is free, relay H in the exchange line circuit, will operate over the test pulse circuit and the call will be extended. The busy flash will be replaced by a steady glow on the lamp.

When the extension clears from an exchange call, the lamp glows steadily until clearing A/C. clears the exchange line.

The set up of calls on the level 9 circuit is similar to that for exchange lines.

Night Service.—Calls are dealt with automatically. Relay NC operates to an incoming call and locks until the called extension answers or the call is forcibly released after a period of 40 seconds.

Relays S, SD and ME operate and extend relay IA to the extension side of the exchange line circuit. Relay IA operates as a trip relay to release the position circuit when the extension answers. Relay IA releases NC. Relay Q is extended to the NS 3 lead and operated contacts of NS in the exchange line circuit to the selected M bank contacts on the exchange line circuit. Relay Q operates relay K and relay RR in the exchange line circuit is operated over the RR lead to apply ringing to the extension line.

Call Back and Automatic Transfer Circuit—Figure 10

This circuit is common to all exchange lines and is connected by the RC relays shown in Fig. 7. Extensions with telephones equipped with an earthing key can hold "in" or "out" exchange calls whilst making a local call and, if required, transfer such calls direct to another extension.

Extension Originates a Call Back.—The non-locking earthing key is depressed once and so causes an unbalance in the exchange line circuit to operate relay D (Fig. 7). Relay D closes a circuit for relay RC (Fig. 7) to operate via the back contact of MC and lock over the H and J leads from earth on the E lead to battery via MC which, in operating, opens the D lead and prevents the operation of further RC relays. RC places a 600 ohm hold on the exchange line and extends the extension line via relay DR to a spare extension line circuit.

Relay DR operates as long as the earthing key is depressed and prevents the operation of relay DC. The extension loop operates the spare extension line relay and causes an idle local finder to pick up the line as described under Figure 6. Earth over the H lead from the finder operates relay K (Fig. 10). When DR releases, DC operates to prepare a circuit for PR and open the circuit for SD from M 22.23. The extension now dials the local number. When the second digit is dialled, earth on the BD lead will operate relay SD., which disconnects the H lead from the E lead and by putting a direct earth on the H lead, holds relay RC. Relay SD also locks to the H lead to the spare extension line circuit, disconnects K, the control of which is transferred to the E lead and connects 2000 ohm battery to hold relay CB (Fig. 6). Relay SD operates SDD which locks and disconnects the C lead to prevent calling the operator.

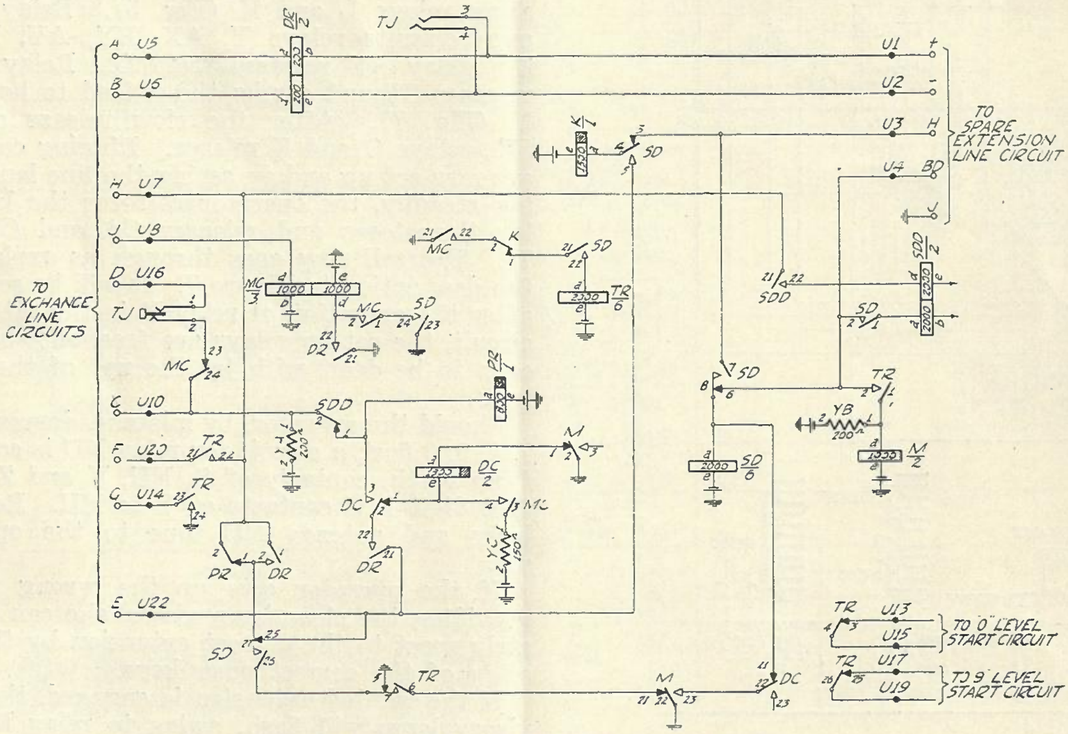


Fig. 10.—Call Back and Auto. Transfer Circuit.

Local Finder Circuit (Fig. 6).—In operating relay CB, after the second digit, i.e., when the NR Springs operate, CB 1.2. provide a hold for CB whilst 3.4 switch the BD wiper, (local finder) to the W wiper (final selector side), 21.22 prepares a circuit for relay B to provide for called party release.

Extension Returns to Exchange Call.—The key on the telephone is again depressed and DR operates to operate PR from earth on the E lead. Relay PR transfers the control of relay RC to the front contact of DR. As soon as the key is released, DR releases and RC will release during the slow release of PR. The release of RC will release the local finder circuit and the exchange line circuit will be reconnected.

Extension Makes Transfer. — The extension making the call back replaces the receiver and relays L and Z (Fig. 7) release, disconnecting earth from the E lead and releasing relay K (Fig. 10). As the operation of the CB relay in the link circuit converts the switch to called party release, SD in the call back circuit remains operated. When K releases, relay TR operates and completes a circuit for M to connect 200 ohm test potential to the waiting extension BD (W4.) bank contact. Relay TR opens the start circuit to levels 9 and 0 in the exchange line circuit, thus reserving the multiple exclusively for the call back circuit during the transfer process. It also extends a holding earth for Relay RC to the M relay contacts, operates relay F (Fig. 7) by earth on the F lead, extends earth on the G lead to force the release of relay H (Fig. 7).

Relay F (Fig. 7) operating, prepares circuits for the JF magnet, and relays FT, RR and CL. Relay H (Fig. 7) releasing opens the positive and negative lines, and completes the machine start and JF magnet circuit. The finder steps and FT operates to the marked J bank contact thus opening the JF magnet drive circuit. Relay FT. 21.22.23 contacts re-operate H, when the call back circuit releases and with the extension loop operating relay LG which, in turn operates L and Z, the exchange line circuit is connected to the second extension.

Releasing Call Back Circuit.—When the marked extension is found earth from relay FT (Fig. 7) operates relay M (Fig. 10) which opens the circuit to relay DC. This relay releases, removes the earth holding relay RC (Fig. 7) and earths the local H lead during the release of DC, thus forcing the release of the local link by releasing relays FT and K (Fig. 5).

Extension Calls Operator.—The earthing key is depressed twice in succession. On the first operation, DC operates as described previously. The second operation without dialling, i.e., prior to the operation of SDD extends earth to the C lead. This causes relay R in the exchange line circuit to operate and the line lamp flashes until the operator answers. At the same time, PR is operated and releases the call back circuit as described previously.

Ringing, Tone and Alarm Circuits—Figure 11

This equipment provides:—

(1) Continuous ringing current.

(2) Interrupted ringing current and ring tone (standard).

(3) Interrupted ringing current 0.75 sec on, 0.75 sec. off to distinguish between an exchange and a local call.

(4) Dial, Busy, and N.U. Tones.

(5) Warning tone for trunk offering.

(6) Busy flash for supervisory lamps.

Machine Start.—The equipment is controlled by relay MS which operates when either of the following relays are energized:—NU, Attendant's Circuit; B, link circuit; BR, exchange line circuit; OB, all exchange lines engaged relay via chain contacts of BR; P, pilot lamp relay in ringing equipment and by any extension calling a line on dead number equipment.

Time Pulse.—Relay MS operates pulse relays X, Y, Z. These relays operate and release in turn and generate pulses to step switch RP at a speed of 5 steps per second, this switch takes 5 sec. per half revolution. Once per half revolution of RP; switch TP is stepped via contacts Z 21.22. Switch TP steps once per 5 seconds and since the "A" and "Z" pulse wires are separated by 12 contacts, the delay between these pulses is approximately 60 seconds.

Ringing Supply is provided by transformer TRA and vibrator RV; the standard interruptions are effected by relay RE which is energized via the bank strappings of RP2. The ringing pulse switch functions as follows:—

Bank RP1 provides busy tone interruptions, etc., via relay XB.

Bank RP3 controls the auxiliary flicker ground to operate relay H in the exchange line circuit for the manual board line lamps.

Bank RP4 controls test pulses to H relays in the exchange and level 9 circuits when camped on busy lines; it is applied every 2.5 seconds.

Bank RP5 controls relay MI to provide clearing A/C to exchange lines. The commercial supply is stepped down to about 40 Volts.

The Time Pulse Switch, banks are wired for the following:—

Bank TP1. controls the Z pulses which are used to shunt relay K in the link circuits 1-4 and the "A" pulses for relay AZ in the link circuits 1-4.

Bank TP2 controls link circuits 5-8.

Bank TP3 controls the operation of relay PZ which operates every 40 sec. Its contacts 1-2 are shown in the Attendant's circuit. They are in the holding circuit of relay NC serving the purpose of releasing NC when a night switched extension does not answer.

The P.G. Alarm is provided by relay PGA., which is of the thermostat type and has an operating lag of 10-15 seconds.

The Dead Number Circuit enables NU tone to be given if a dead number is dialled. Resistance YC provides potential to operate the test relay, ring is tripped by relay MS and resistance YH, and NU tone applied to line. Dead lines must be strapped to the dead number circuit on the unit.

Clearing of Exchange Lines.—If the commercial supply fails relay MF will release and prepare a circuit for relay FR in the Attendant's circuit. The exchange lines are then cleared manually by the operation of the release key in the Attendant's circuit.

Acknowledgments

The equipment described was manufactured by Messrs. Standard Telephones and Cables Ltd., London.

The author is indebted to Mr. J. Linton for his keen personal interest and for work performed on these equipments.

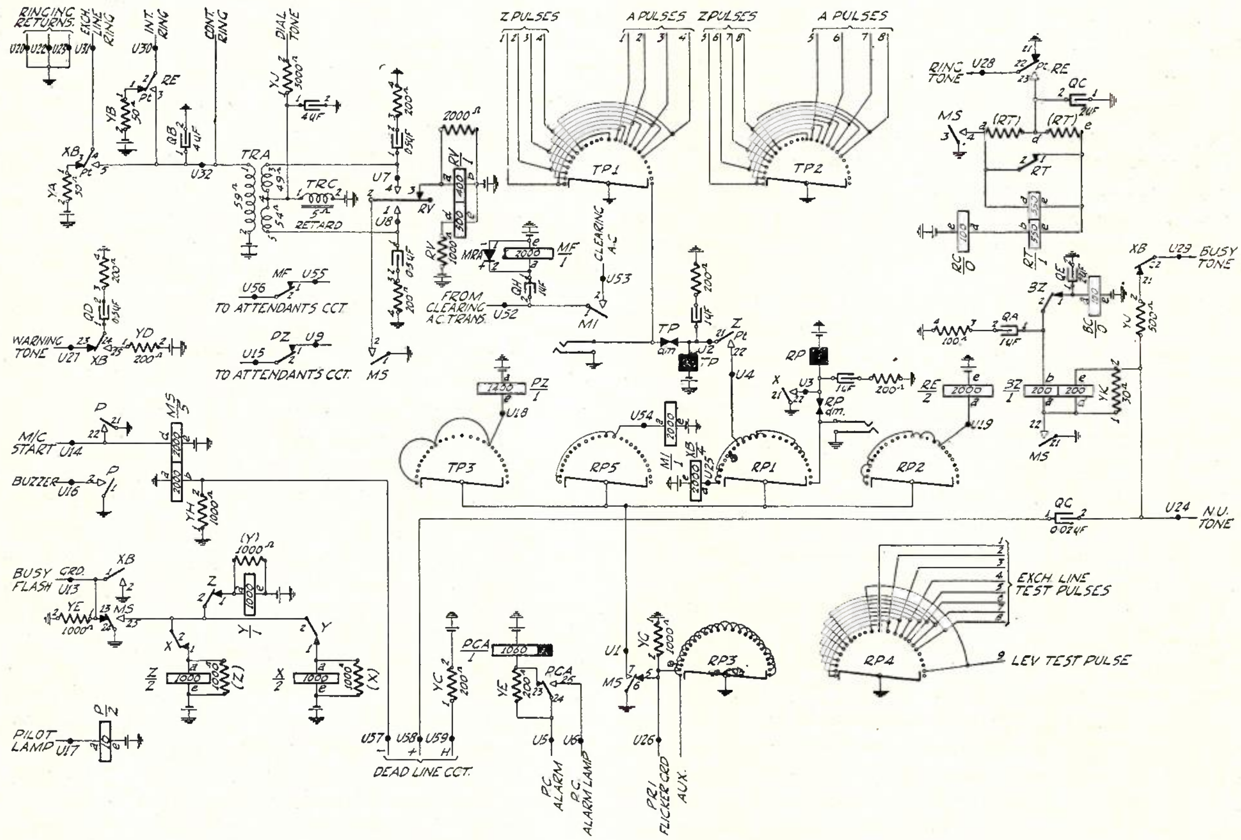


Fig. 11.—Ring, Tone and Alarm Circuits.

Cabling Of Melbourne City West Exchange

L. Paddock

As a large proportion of labour costs in an automatic exchange installation is expended in running and terminating cables, care must be taken to design a layout which tends to general simplicity, freedom from congestion, and which reduces to a minimum the distance between terminal points and avoids crossovers on main runs. At City West, the equipment layout sets a standard of simplicity, which, supported by the generous use of wide runways, allows separate space assignment for each cabling item by short direct routes.

The routing of what may be termed a basic call, i.e., a call between subscribers, connected to the same exchange, is shown in Fig. 1, and

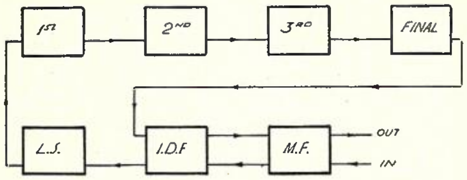


Fig. 1.

from this, the most desirable position of each main equipment group with respect to other groups may be gauged. A clear conception of

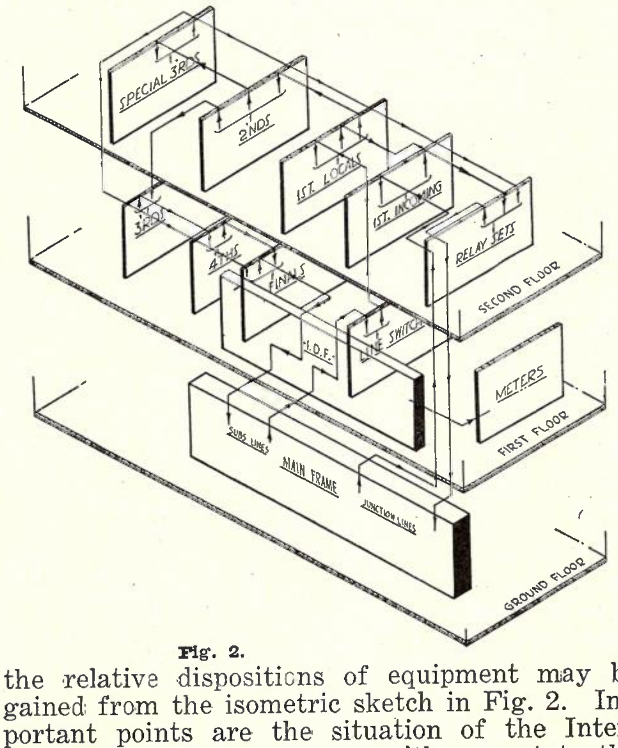


Fig. 2.

the relative dispositions of equipment may be gained from the isometric sketch in Fig. 2. Important points are the situation of the Intermediate Distributing Frame with respect to the Main Distributing Frame, the location of subscribers' Uniselectors and Final Selectors in respect to the I.D.F., and the relation of each rank of selectors in respect to the next rank in any call set up. In each instance, the distance between cabling points has been kept to a minimum. As will be noted, the I.D.F. is situated on the first floor and runs parallel to and almost above the M.D.F. situated on the ground floor. The M.D.F. is placed directly over the jointing chamber, the ceiling of which is 20 ft. above the tunnel floor level. The frame provides for the termination of 300 pairs per vertical on the line side and 250 pairs at the equipment side, and at the foot of each vertical an opening is provided for a 300 pair S. & C. L.C. cable to pass to the jointing chamber where four such cables are jointed to each distribution cable, these being 1200 pair P.I.L.C. Star Quad.

Cabling M.D.F.—Although difficulty is sometimes experienced in handling 300 pair Silk and Cotton Insulated Cables, owing to the stiffening which results from the wax impregnation, its use in this instance was entirely satisfactory, as the only set required was that necessary to taper the S. & C. L.C. cables to the paper insulated cables. Ample space was provided for this and each set of four S. & C. L.C. cables was formed up on a template so that the tapering of each set is identical and provides a neat appearance in the jointing chamber.

Between the M.D.F. and I.D.F., cables are carried in a number of small groups, each of which comprises eight cables which, for P.B.X. lines, are of 153 wires, and for Regular lines, 102 wires. In the case of P.B.X. lines, the private wire is carried to the M.D.F. for the purpose of busying faulty lines. To provide a run for these cables, suitable openings were formed in the pouring of the first floor, so that between each alternate pair of verticals on the I.D.F., an opening 7 in. x 4 in. is available to pass cables on runways between the frames in a series of small groups, so arranged that cables terminate on the M.D.F. strips at verticals near to the drop from the first floor. Fig. 3 is a view looking to the ceiling of the ground floor and shows the subscribers' cables feeding from the M.D.F. through openings beneath the I.D.F. Meter cables are shown to the left of the photograph. These also feed from the I.D.F. through the openings to a runway which carries them to a point beneath the meter racks located on the first floor. Here the cables rise on a runway to feed the racks.

Cable Runways.—Figure 3 also illustrates a new type of cable rack ironwork which was used throughout the installation. Sections are as-

This article was the subject of a lecture before the Postal Electrical Society of Victoria on 11th April, 1938.

sembled as required from stock items and the simplicity of the arrangement is demonstrated by the fact that the whole of the cable runways

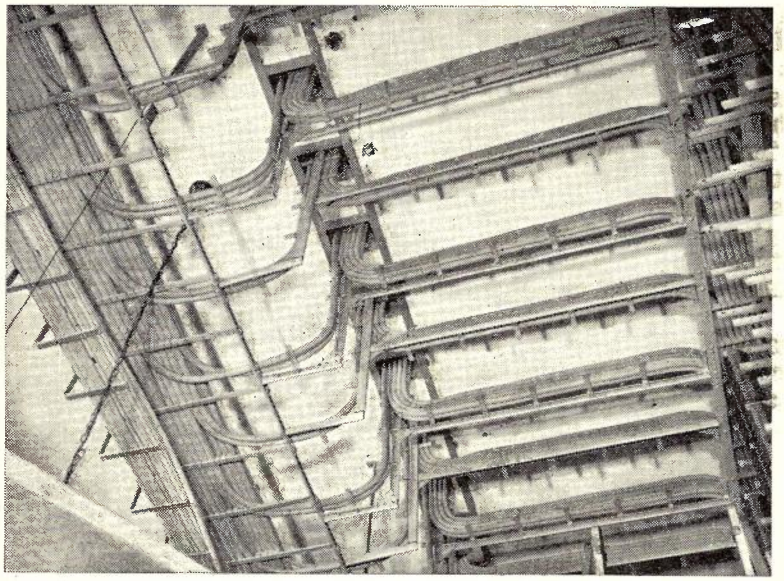


Fig. 3.

were erected with the aid of only a hack saw, screwdriver, one small spanner and the occasional use of a drillstock.

All parts are standard and are built up as required. The side rails are drawn from 14 gauge mild steel in oval section 1½ ins. x ½ in. and somewhat resemble oval conduit, but that the seam is open about ¾ in., the open face being normally the outside of the rail. Slats are available in several lengths and are of similar section to the rails, but are smaller, being only 1 in. x ⅜ in. Each end of a slat is returned about 1½ ins. and drilled to pass an "O" BA mounting screw which clamps the slat to the rail by engaging with a small ready tapped cast slug, sufficient of which are inserted from the end of the main members to mount the required slats. Slats may be re-spaced, reduced or increased in number if necessary when cabling proceeds to provide for dropping cables to lower levels or down apparatus racks. The slugs are cast in strips of 10 and are broken off as required. Short straight sections of "tyre" section are used to form all bends, drops and angles.

Cabling I.D.F.—As M.D.F. and meter cables approach the I.D.F. from the lower end of uprights, the space above the frame is available for cables from final selectors and subscribers' uniselectors. Three levels of runways are provided for cabling above the I.D.F., the lower and middle tiers are formed by the I.D.F. ironwork and the upper one is at rack level. Main cable runs which feed along the upper tier are subdivided to smaller groups which pass through to the middle tier to be further subdivided and fed down the uprights. Fig. 4 shows a portion of the I.D.F. in which several of the points mentioned are illustrated. Verticals 19 to 34 are

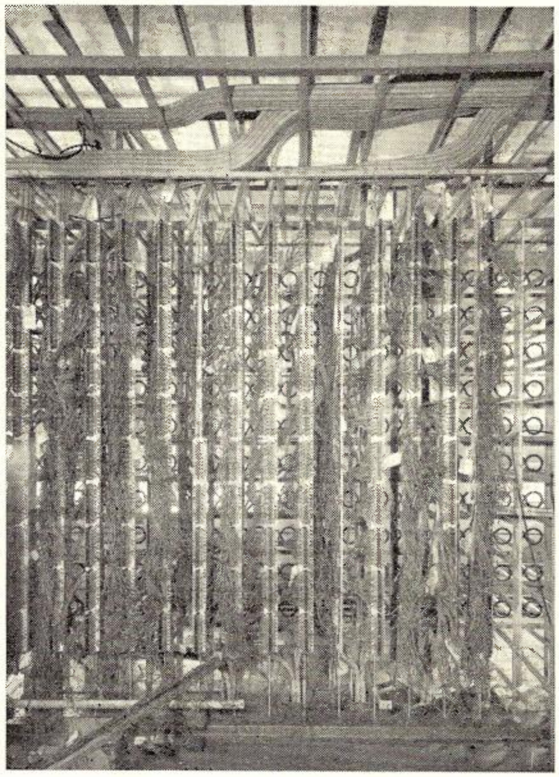
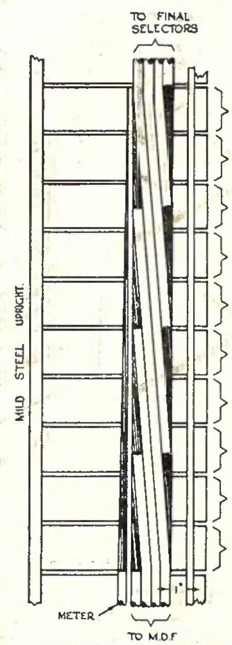


Fig. 4.

shown in Fig. 4, No. 19, to the left of the photograph.

An elevation of the cabling on a representative upright is shown in Fig. 5. Each cable form provides for 50 lines and covers 2½ terminal strips. The cables to Final Selectors are nearest the terminal strips, the skinners feeding straight to fanning strips.



I.D.F CABLING OF UPRIGHT
FIG. 5.

Behind the final selector cables are the M.D.F. cables, the skinners from which pass at the rear of the final selector cables to the strips. Next to the M.D.F. cables is the meter cable, the form for which covers 10 terminal strips (200 lines) and the skinners from which pass at the back of the M.D.F. and final selector cables to the terminal strips. The forms are prevented from contacting with ironwork by the use of "Leatheroid" or thin sheet fibre guards.

Trunk Distributing Frames. — In all cabling work, it is important that reservations be made for future cabling to the full allotment anticipated, both as regards extensions of equipment and trunking, but consideration should also be given to the desirability of running isolated cables to meet future requirements rather than leave them for future insertion. This is necessary as it may not be possible at all points on a run to provide space for growth in the proper location, as the cross sections of runs change as the runs proceed, so that the feed off to racks is corrected.

As the capacity of a T.D.F. is 1200 incoming junctions as many as 60 cables may feed to one of these frames. In several instances frames have been filled and in all other cases, space has

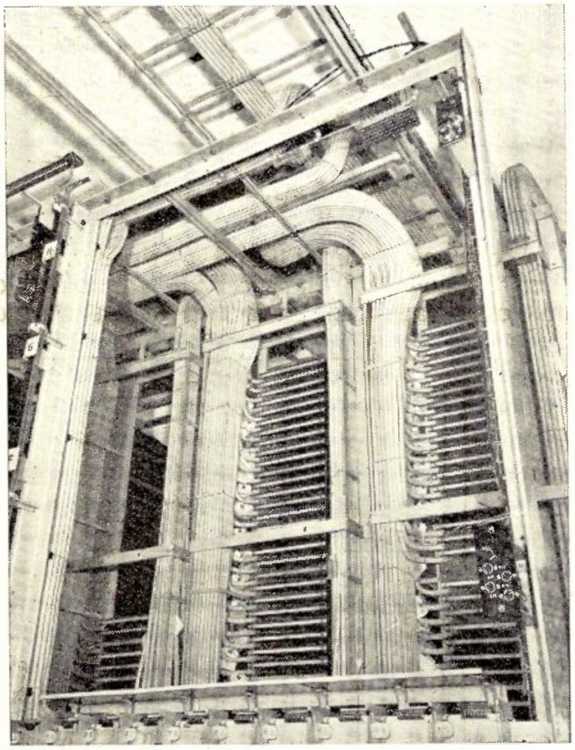
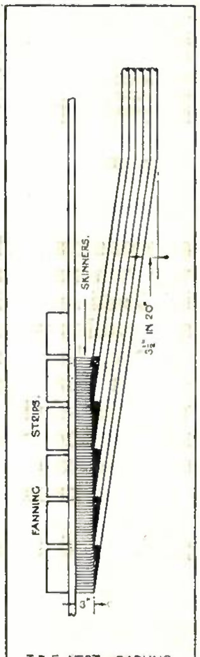


Fig. 6.

been reserved on cable runs for growth to the full allotment on racks for the various levels. In Fig. 6 is shown a suite of T.D.F.'s serving trunks from third selector levels to P.B.X. final selectors. It will be appreciated that cables must be assembled in sequential order at the T.D.F., but it has been found necessary to vary the method of feeding to the incoming junction terminal strips. This is clearly visible in the illustration where one group of cables is seen to feed from the right side of the form, while others feed from the rear. In each case, however, the sequential order is maintained.

Outgoing cables from T.D.F.'s present a difficulty in terminating, as the form of two 63 wire cables spread over only 6 ins. is somewhat stumpy. A skinner of 3 ins. or so behind the fanning strip is desirable as six wires pass through each hole and congestion results if the skinners are too short. The stumpy forms also tend to prevent skinners being even in length if cables are brought straight down the upright. The Method employed is shown in Fig. 7, the cables being set at an angle to the fanning strips to bring the forms into line.



T.D.F. VERT. CABLING
FIG. 7.

Cabling at Switch Racks.— As cables are assembled in sequential order at T.D.F.'s, re-arrangement is often necessary to ensure proper feed at the switch racks. To do this, it is sometimes necessary, for reasons of appearance, to re-arrange the lay of cables as the run proceeds and so avoid leaving behind the evidence of obvious re-arrangement. In general, cables approaching switch racks have been arranged on the runways so that they fall on the near side of the racks in correct positions with respect to the turn out to shelves. Where it was not possible to do this, cables were, of course, taken to the far side of the rack for proper feed to the shelves. This was also done on occasions to somewhat equalize the number of cables falling to each side of a rack. Fig. 8 shows sketches of various cabling details on switch racks and also includes one of cabling terminated on the test jack of a plate of 100 meters of the 100 type.

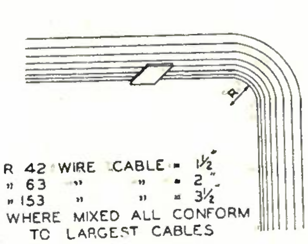


Fig. 8A.

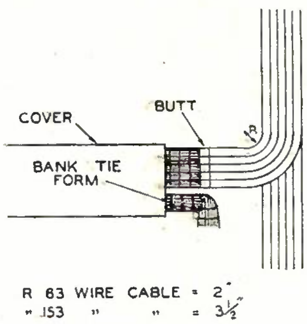


Fig. 8B.

It will be noted that all cabling at switch racks requires sharper bends than are customary in other types of equipment. The radii given in sketch (a) are typical of those usually adopted, but it will be understood that where cables of mixed sizes required treatment, the radius of the largest cables at that section set the standard worked to. Where a number of cables are taken out from bank levels as in Fig. 8b, they

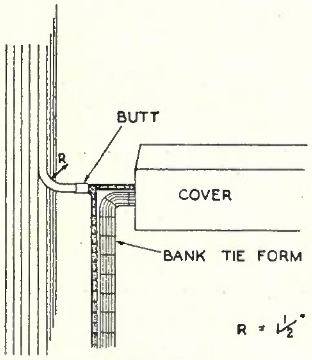


Fig. 8C.

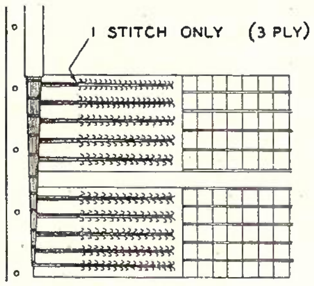


Fig. 8D.

are stitched as shown until approaching the terminal strip beneath the cover where they merge into one large form for distribution. Fig. 8c shows a method of treating shelf cables which usually split over two shelves. Here, the butt is made in line with the cable form for bank ties. The shelf cable feed to the lower shelf is carried to the lower shelf adjacent to the main form and well clear of the braided cable run.

The method of forming the meter cable is shown in Fig. 8d.

Typical Rack Cabling.—In Figs. 9A and B are

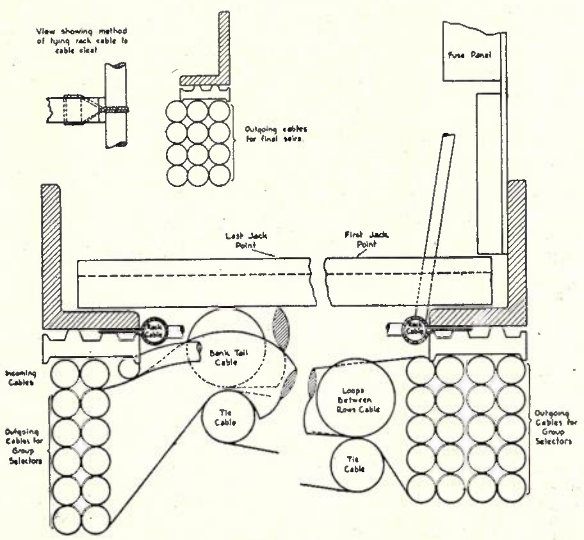


Fig. 9A.

shown a plan and side elevation of equipment cabling and wiring on selector and relay set shelves (2000 type equipment).

Also of interest are the standard terminations at present observed at various terminal points shown in Fig. 10. It should be observed that while I.D.F. terminations run in the order Private, positive, negative from the front of the strip, the order in the case of T.D.F.'s is Private, negative, positive.

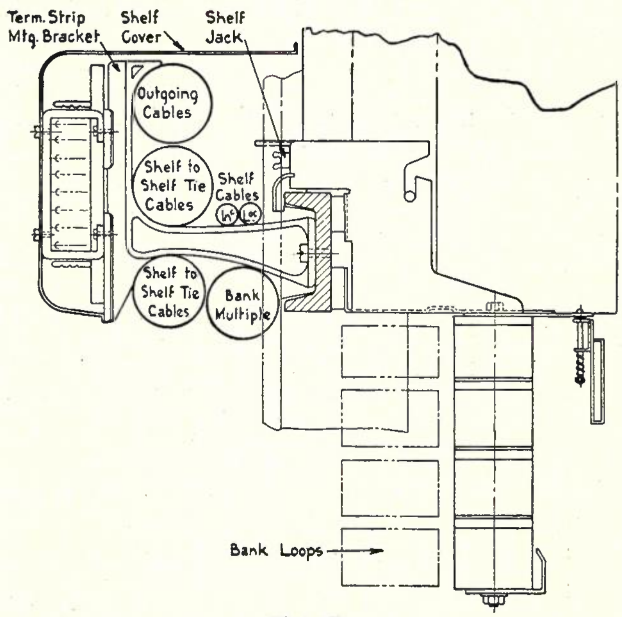


Fig. 9B.

In conclusion, might I add a warning note that when setting out the position for main cable runs over racks, at least two inches should be

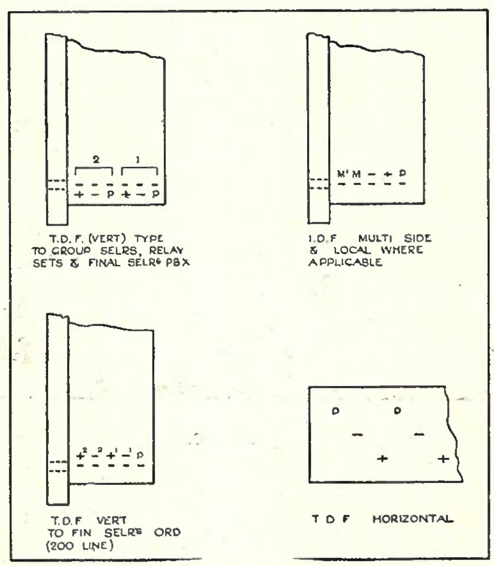


Fig. 10.

reserved next the top angle iron framework for miscellaneous cables such as spare level cables; Tone commons, Routiners, and traffic recording equipment.

CABLE JOINTING. PART 3

G. O. Newton

This is the third of a series of articles on the various operations performed by a Cable Jointer. Previous articles dealt with the methods of numbering, jointing and terminating cable pairs.

CHECKING AND TESTING JOINTED CABLE

On completion of the jointing of a cable, and at intermediate stages in the case of the larger and more important installations, it is necessary to check the jointing and test the cable to ascertain whether there are any faulty pairs. During such tests the cable pairs are also tagged for purposes of ready identification. The desirable frequency of these checks and tests will be indicated in the next section.

They should be so arranged that tests are made for the following:—

(i.) Correctness of jointing, i.e., freedom from split or transposed pairs or quads, etc.

(ii.) Continuity of all conductors.

(iii.) Freedom from earths, shorts and contacts.

Testing Equipment.—For the purpose of conducting the tests, use can be made of either two simple buzzers (or trembler bells) with sufficient cells at one end to obtain a full strength buzz at each end of the section of cable under test, or of two detectors with sufficient cells to give a substantial deflection of the needle at each end. These should be connected up, using the sheathing as a return, in the manner shown in Figure 13. Normally the buzzer (or bell) is preferable since the aural signal is more readily recognized

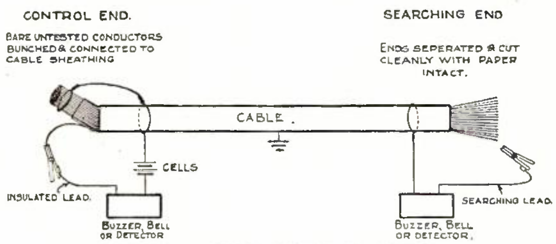


FIG. 13. METHOD OF TESTING OUT COMPLETED SECTION OF CABLE

and obviates operators having to shift their gaze backwards and forwards between the cable and the detector although the quantitative signal given by the latter is often advantageous. In addition to these arrangements, a means of communication is usually necessary. For this purpose, headphones and breast transmitters are to be preferred since they leave the hands continuously free for other operations with a consequential saving in time. For the connecting circuit one wire of the last pair or quad in the cable (or all wires of the pair or quad in parallel) with the sheathing as a return, is usually the most suitable.

Preparation of Cable for Testing.—The first operation before connecting up the testing apparatus will be to strip the paper off the ends of each conductor for an inch or two at the control end, bunch them together with bare wire, with the exception of the wire required for the speaking circuit and the first wire to be tested, and connect them to the sheathing. At the other test point (except where it is a distributing frame or box, etc.) the conductor ends should be cut cleanly with the paper intact and kept clear of each other and earthed objects.

Procedure.—The operator at the control end will then connect his lead to the first wire to be tested, i.e., the A leg of the No. 1 pair of the cable, leaving all others connected to earth via the sheathing, and advise the officer at the searching end to start. The latter should then pick out the A leg of No. 1 pair at his end and touch his lead to it. If jointing is correct and there are no faults, both buzzers (or detectors) will then operate. A suitable "all clear" signal when the buzzers or detectors operate is for the control officer to give three beats by removing and reconnecting his clip to the conductor, and for the searching officer to return it by a double beat. It is unwise to signal by single beats since they may be caused by accidental contacts. On receipt of the latter signal, the control officer will advise the searcher "O.K.," and proceed to the testing of the other wire of the pair and conductors of subsequent pairs in their correct rotation order.

If no signal results when the searching officer contacts with what is the A leg of the first pair at his end by counting, he should try further adjacent wires to ascertain whether the trouble is due to conductors being jointed in incorrect order. The continued absence of a signal then indicates either an open circuit fault in the conductor or insufficient battery or a fault in the testing circuit. If, when the testing equipment and wiring have been examined and tested and/or the battery increased, no signal is obtained, the wire together with the mate forming the pair, should be reconnected to the bunched wires for the time being and the next proceeded with. When the remaining wires of the cable have been tested, the wires on which no signals were received should be re-tested, and where no results are obtained on this occasion, it can be assumed that they are faulty.

As wires are identified, the correct number tags should be placed on the A leg of each pair at each end (unless one end is connected to an M.D.F. or cable box, etc.), and the two legs of the pair twisted together and set aside clear of the untested wires.

The presence of the last type of fault (earth, short or contact) is indicated by a continuous buzz (or deflection of the needle in the case of a detector) as soon as the faulty wire is touched at the battery end and prior to the searching officer connecting to it. In such a case the untested wires should first be disconnected from earth by the control officer, and if the signal continues, the conductor is earthed. If the signal ceases, there is a contact fault, and the other wire or wires should be identified by reconnecting the untested conductors to earth until the signal reappears. This identification will be facilitated by initially testing with groups of conductors, and having identified the group, then proceeding to the identification of the single conductors by a system of repeated halving of the group. Having identified the contacting wires, the control officer should connect them to his buzzer or detector to permit of them being identified at the other end. The possibility of the contact or earth fault being caused at the searching end, or of more than two conductors being in contact, should not be overlooked. Where any difficulty is encountered in dealing with apparently faulty conductors, it will be found expedient to reconnect them, together with the mate wires, to earth and test them fully at the end of the check, as has been suggested for conductors on which no signals are received.

The idea of dealing with one wire at a time is to ensure correct differentiation of the A and B wires to meet those cases where reversals of wires must be avoided (See Part 2.). In those cases where one end of the cable under test terminates on a distributing frame, box or pillar, and especially where there is evidence that some of the pairs have not been jointed in correct order, it is usually preferable for the searching to be done at this point, since the operator can more readily run his lead up and down the terminating tags than the officer at the other end can connect his lead to the ends of the conductors in turn. In such cases the officer at the distributing frame, box or pillar will indicate the numbers of the tags which are to be placed on the pairs as they are tested, since the record cable pair numbers are obtained from such points.

As an alternative to the use of buzzers or detectors, use can be made of magneto bells and ringing current obtained from the exchange over a spare pair, but the buzzer (not the type of test set which gives a continuous signal) is considered the simplest and most suitable arrangement for most occasions. When a detector is used (since the signal is quantitative), any variation of the normal deflection of the needle is another indication of a faulty condition. For example, a deflection below normal on an identified wire indicates the presence of high resistance joints unless there are loose connections on the test equipment or between it and the conductor. As far as possible, number tags should correspond with or indicate the order of the record cable pair numbers, and in such cases should normally be left on the conductors when jointed, so that pairs can be readily identified on future occasions.

Testing without Identification. — Complete testing-out of cable with identification and tagging of pairs requires two operators, but occasions may arise where a single operator may desire to test cable for faults without complete identification, and in such cases the arrangement shown in Figure 14 can be used. When one

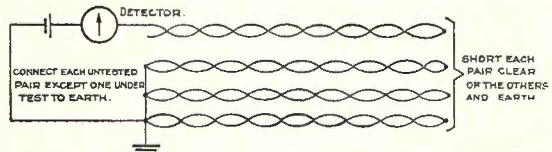


FIG. 14 METHOD OF TESTING OUT CABLE WITHOUT COMPLETE IDENTIFICATION OF PAIRS.

wire of the pair under test is connected to the detector and the other held clear, no deflection indicates that it is clear of a contact or earth, and that the pair is not split. If a deflection is obtained it is necessary to test further with a view to determining the nature of the trouble by freeing the ends of the other conductors from earth. If the deflection still remains, the pair is earthed. If the deflection ceases, it is a contact or a split pair, and conductors should then be reconnected to earth until the contacting wire or wires or the correct second leg of the pair, as the case may be, is found. Again a process of repeated halving of the group found to contain the required wire will facilitate this identification. The latter class of fault is proved by substitution for the wire which has previously been taken as the correct one, and if no deflection is then obtained, it is a case of split pair. Having tested the pair clear of contact or earth, the free end of the second leg of the pair is then connected to earth to prove continuity. If, however, a larger deflection than normal is obtained, the pair is short circuit. A deflection less than normal indicates high resistance joints or imperfect connections. A buzzer can be used in lieu of a detector, but in this case a test cannot be obtained for short circuit pairs or high resistance joints. It is advisable also in this instance to place on one side pairs which have been tested as O.K., and to reconnect faulty pairs to earth and test them once again at the end of the operation. This method of testing can be used for the identification of a single pair or of a number of pairs as a group by only shorting the required pair or pairs at the far end and earthing the others. Except when dealing with single pairs at a time, it does not indicate when pairs have been transposed in jointing or manufacture. Operators are also likely to be led astray if any of the pairs are short circuit within the section of cable under test.

High Resistance and Low Insulation Defects.—The foregoing tests are not completely effective for defects of a high resistance nature or for defective insulation between conductors or between conductors and earth. Where detectors have been used for testing, evidence of high conductor resistance due to imperfect joints will be given by a reduced deflection of the needle, but in other cases, when necessary, this class of defect must be tested for with such equipment as an ohmmeter, continuity tester, etc. Usually, however, on subscribers' cable, where the jointing has been completed by dependable workmen, the necessity to test for high conductor resistance does not arise, and in such cases an insulation test with a megger suffices. Except in the case of very minor installations, insulation tests should be applied to the completed cable, and in the case of the longer and more important installations, similar tests should be made at intermediate stages.

The method of performing this test which is the simplest and which is sufficiently effective for all practical purposes is to divide the conductors into four groups at the testing end, taking care that the ends of all conductors at the far end are insulated clear of each other. In the case of twin cable the four groups would be the A legs of odd pairs, B legs of odd pairs, A legs of even pairs and B legs of even pairs, whilst in the case of star quad cable, the A, B, C and D legs of each quad would be arranged in separate groups. Each group as a whole is then tested in turn against the others connected

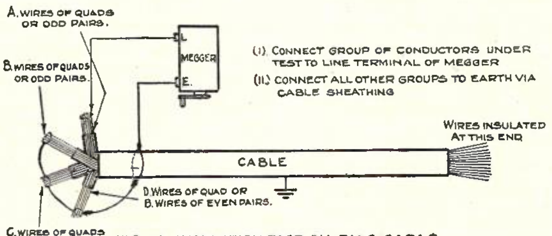


FIG. 15. INSULATION TEST ON P.I.L.C. CABLE
IF i = READING ON MEGGER IN MEGOHMS
n = NUMBER OF CONDUCTORS IN GROUP UNDER TEST
d = LENGTH OF A SINGLE CONDUCTOR IN MILES.
INSULATION RESISTANCE OF CABLE IN MEGOHMS PER MILE = ind

to earth via the sheathing, as shown in Figure 15. If the cable is a 400 pair, is one mile long, and the reading obtained on the Megger, which should be a 500 Volt one, is 15 megohms, then the insulation per mile is 3000 megohms. The insulation standard required of subscribers' cable when delivered from the factory is 5000 megohms per mile of conductor, and proper care should be taken during an installation to ensure that the insulation of the completely jointed cable is kept as close as possible to this figure. In no case should it be allowed to fall below half this figure. If any low insulation or other faults are revealed by the test, action should be taken to determine the extent and location of the defect with a view to the rectification of the faulty condition. Where the low insulation is general and no defect in the sheathing or plumbing can be traced it will be due either to some defect at the terminations or to the ingress of a certain amount of moisture during jointing. The latter defect can usually be remedied without difficulty by desiccation of the cable. Where a defect in the sheathing or plumbing is located, local drying out by the application of heat will usually rectify the insulation, but in some cases it may be found that desiccation over two or more lengths of cable is also necessary. Where only a portion of the pairs are affected, a knowledge of their numbers will often assist to decide the location of the trouble. For example, if an insulation test on, say, a 400 pair cable reveals that only 50 pairs, none of which are in the outer layer, are affected, and if the cables have been jointed correctly, it is fairly certain that the trouble will be found either in a 50 pair branch cable which contains these pairs or in a larger cable where all or a portion of them are in the outer layer.

Application of the Use of Cable Pair Numbering to Cable Installations

The application of the principles already set out will probably be more readily understood by discussing the two simple cable schemes shown in Figures 16 (a) and (b). Figure 16 (a)

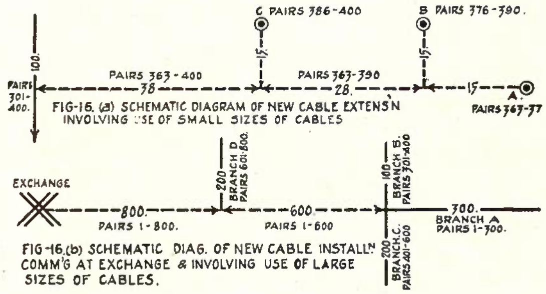


FIG-16. (a) SCHEMATIC DIAGRAM OF NEW CABLE EXTENS'N INVOLVING USE OF SMALL SIZES OF CABLES

FIG-16.(b) SCHEMATIC DIAG. OF NEW CABLE INSTALL'N COMM'G AT EXCHANGE & INVOLVING USE OF LARGE SIZES OF CABLES.

shows a schematic layout of an installation involving small sizes of cable such as may be installed in a locality where it is desired to serve three blocks of flats with ultimate possibilities of about 12 lines each. In this case it is being assumed that the new cable will be connected to an existing 100 pair cable which is connected to cable pairs with record Nos. 301-400. The record numbers of the cable pairs to which it is desired that the cable terminal boxes be connected are shown in Figure 16 (a). The required ordered relation between the record and the rotation cable pair numbers is set out in Table No. 5.

TABLE NO. 5

Record Cable Pair Numbers	Rotation Cable Pair Numbers 15 pair Cable to Box A	B	C	28 pair Cable	38 pair Cable
363-375	1-13	-	-	1-13	1-13
376-377	14-15	1-2	-	14-15	14-15
378-385	-	3-10	-	16-23	16-23
386-390	-	11-15	1-5	24-28	24-28
391-400	-	-	6-15	-	29-38

The first operation should be to complete all straight joints, including the connections of the cable to the cable terminal boxes A, B and C. This latter operation should be done so that the rotation cable pair numbers of each 15 pair cable correspond with the numbers of the terminal tags in the cable terminal box to which it connects.

The next operation is the connection of the 15 pair cables serving boxes A and B to the 28 pair cable in accordance with the arrangement indicated in Figure 16 (a) and Table 5. Box A will be connected to the first 15 pairs (rotation pair numbers), so that pairs 14 and 15 of the 15 pair cable to Box A will be connected to the same pairs in the 28 pair cable as pairs 1 and 2 of Box B. In the next operation the pairs of the 28 pair cable are jointed in rotation to pairs 1-28 (in rotation) and the 15 pair to Box C to pairs 24-38 (in rotation) of the 38 pair cable. In this case pairs 24-28 in the 28 pair cable and pairs 1-5 in the 15 pair cable to Box C are connected in order to the same pairs in the 38 pair cable. If now the jointing is tested out by ringing or buzzing from each pair of terminals in each of the cable terminal boxes (in the order of their numbers) to the end of the 38 pair cable where it is to be jointed to the 100 pair cable, Box A should appear (as

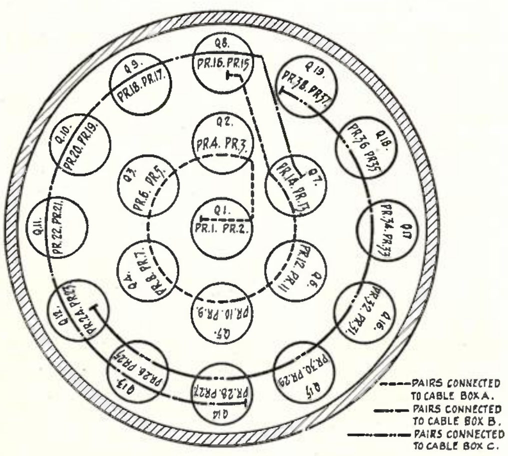


FIG. 17. SHOWING ARRANGEMENT OF PAIRS AT END OF 38 PAIR CABLE (SEE FIG-16a) & PAIRS CONNECTED TO EACH CABLE BOX.

shown in Figure 17) in the order of the rotation pair numbers on pairs 1-15, Box B on pairs 14 to 28 and Box C on pairs 24-38, the counting in the 38 pair cable being carried out in an anti-clockwise direction.

In an installation such as this, where small sizes of cable of comparatively short length are involved, normally any testing and numbering of pairs should not be necessary until the whole of the cable is jointed ready for connecting to the working cable. In the case of an inexperienced cable jointer, however, it is advisable that a certain amount of intermediate checking of his jointing be performed, especially where multiple jointing is involved, until he acquires confidence in his ability to do accurate work, after which he should gradually wean himself of any testing out, except for the final overall check. In this case the final overall check should, if possible, be made before the joint between the 38 pair and 28 pair cables is closed. Should any errors or faults arise, this will allow of the pairs affected being examined and tested at this point before it is closed. Having tested out the new work, the pairs required in the 100 pair cable should be identified from the M.D.F. and the 38 pair cable connected to these in order of record cable pair numbers. If the 100 pair cable has been jointed correctly these should be identical with the cable pairs numbered 63-100 in rotation.

Figure 16 (b) is a schematic layout of a proposed new 800, 600 pair cable installation commencing at an exchange and to which a number of existing branch cables will be transferred from existing main cables which require relief.

Unlike the case in Figure 16 (a), when dealing with long sections of cable, especially of the larger sizes, the practice of performing jointing without any testing out till the final joint is about to be made is not at all advisable, owing to the difficulty and expense of locating and clearing faults and to the possibility of a large number of these accumulating. Jointing of cables such as these should therefore be checked at reasonable intervals, having regard to the experience and reliability of the jointers, the importance, size and length of the cable, the availability of spare pairs and any knowledge of defects in manufacture. Where there is doubt in regard to the necessary extent of the checking, the initial stages of the work should be checked at very short intervals, and the extent of subsequent checking decided by the results so obtained.

Before proceeding with the jointing, therefore, it is first necessary to decide on the number and location of the test points. One of these should be the first suitable joint beyond the exchange and the remainder should as far as possible include joints in which it may be necessary to perform identification work in the future. After this, action should be taken to proceed with the initial operations which should include the connection of the S.I.L.C. cable to the M.D.F. and the completion of the joint between the S.I.L.C.

and P.I.L.C. cables beneath the M.D.F. On completion of these and intermediate joints (if any) to the first test point, the cable should be tested out from the M.D.F. and the pairs tagged at the first test point with record cable pair numbers. If this test out is completed before finally sealing the joint between the S.I.L.C. and P.I.L.C. cables, it will permit of any faults in this joint being readily corrected, but where pairs have only been jointed out of correct rotation and are not otherwise faulty it will usually be preferable to avoid interfering with the joint too much and to adjust them at the joint to be made at the point to which they are being tested.

Having in mind the requirement that record and rotation cable pair numbers should be kept in line, and the desirability of facilitating the localisation and clearance of any faulty pairs or the substitution of spare pairs where faulty pairs cannot be readily cleared, the most suitable arrangement in regard to the remainder of the work is to proceed with the intermediate joints between test points, and when the section between the first two test points is completed, to complete the joint at the first test point by connecting pairs on the side away from the exchange in order of rotation cable pair numbers to pairs on the exchange side in order of the tag numbers (= record cable pair numbers). The cable should then be tested out from the M.D.F. to the second test point and the pairs again tagged at this point with the record cable pair numbers. To facilitate attention to faults, it is preferable that the testing be done, where possible, before permanently closing the joint at the first test point. If jointing is continued in this manner, it ensures that record and rotation cable pair numbers are brought back into line whenever they get out of phase through mistakes in jointing, and that the number of each tag placed on a cable pair always coincides with the record cable pair number.

Another method which is more suited to new installations which do not terminate at one end on an M.D.F. or other cross-connecting device is to test out and number each section between test points after it is jointed, and then joint pairs at test points with corresponding tag numbers, making a final overall check from the M.D.F. to the end of the cable on completion of all jointing. This arrangement facilitates action in connection with faults within each section, but has disadvantages that:—

(i.) An extra check is involved.

(ii.) Errors made in the checking and placing of tags on one section, or in the jointing at any test point may result in pairs being placed out of correct order over several sections. In such cases tag numbers will not correspond with record cable pair numbers in all cases.

(iii.) Faults introduced at test points are not brought under notice until the final overall check.

(iv.) Double tagging at test points is involved, necessitating the removal of one lot as jointing proceeds.

In this case the idea of bringing record cable pair numbers into line with rotation cable pair numbers at each test point in cases where pairs have not been jointed in correct order will be achieved if the numbering of pairs is controlled by the order of the rotation cable pair numbers at the exchange end of the section.

With cable of good manufacture and with accurate jointing, the final check from the M.D.F. to the end of the 800 pair cable should indicate that the record cable pair numbers correspond with the rotation cable pair numbers. After completing intermediate joints on the first section of 600 pair cable and identifying the 200 pair branch to be connected at this point, the 600 pair cable should be jointed in rotation to the pairs with record numbers 1-600 in the 800 pair cable and the 200 pair in order of its record pair numbers to record pairs 601-800, after which testing and jointing should proceed along the 600 pair cable as for the 800 pair. At the end of the 600 pair cable each cable should be jointed according to its record pair numbers to the pairs of the 600 pair in accordance with the multipling indicated in the diagram and in the order of the record pair numbers. Again, if manufacture and jointing have been accurate the record cable pair numbers should correspond with rotation cable pair numbers in each case.

If all jointing work is performed accurately in accordance with the principles indicated, it will be seen that normally cable pairs according to their record pair numbers will always be found in sequence in a definite portion of each cable in which they appear by counting in rotation. For example, assuming all star quad cable in the installation shown in Figure 16 (b), pairs with record cable pair numbers 363-400 should appear in rotation in the 8th layer of the 800 pair, and partly in the 7th and partly in the 8th layer in the 600 pair, and should correspond to cable pairs numbered 63-100 in rotation order in the outer layer of the 100 pair (See Table 3, Part I.). The result of this will be that identification work is greatly facilitated, since the required pairs can first be obtained by counting and then very quickly checked from the M.D.F. without having to search through the whole or a large portion of the cable pairs. The work of checking jointing is also facilitated, since the operator at the searching end is enabled to deal quickly with pairs in order instead of having to search over a number of pairs each time the buzzer or other signal arrangement is connected at the control end. An ordered arrangement of cable pairs will also simplify operations in connection with cable faults.

ANSWERS TO EXAMINATION PAPERS

The answers to examination papers are not claimed to be thoroughly exhaustive and correct. 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. 2107.—MECHANIC GRADE 2.—TELEPHONE INSTALLATION AND MAINTENANCE

M. A. MACKEY, B.Sc. (Hons.)

Section A

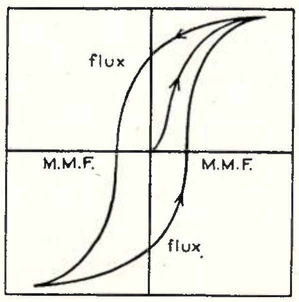
Q. 1.—Define the following:—

(a) Reluctance;
(b) Hysteresis;
(c) Potential Difference;
(d) Eddy Currents.

A.—(a) Reluctance is that property of a magnetic circuit which determines the amount of flux produced by a certain magnetomotive force. It is analogous to resistance in an electric circuit and therefore is sometimes called the magnetic resistance of the circuit. For each portion of the magnetic circuit, the reluctance is directly proportional to the length and inversely proportional to the cross-sectional area and the permeability, i.e.:—

Reluctance = Length / Cross-section area × permeability and Magnetic Flux = Magnetomotive Force / Reluctance.

(b) Hysteresis is the lagging of the magnetic flux produced behind the magnetomotive force (or Magnetising force) producing it; i.e., if we take a completely unmagnetised piece of material capable of being magnetised and apply a magnetising force until magnetic saturation is obtained and then reduce the force to zero again it will be found that the flux is not zero (i.e., residual magnetism) and force in the reverse direction will have to be applied and attain a definite value before the previous flux is quite removed. If then we increase this force until magnetic saturation is obtained and then reduce it to zero once again we will find a flux remaining, and a force in the same direction as the first will need to be applied to remove it. A complete cycle of magnetisation therefore gives a graph of the following formation which is known as the "Hysteresis Loop."



(c) Potential Difference is the measure of the volts used in driving a current between two points of a circuit connected to the output terminals of a source of electromotive force. It determines the direction in which current will flow. It is represented numerically by the amount of energy transformed when a standard unit quantity of electricity passes. This standard unit is one coulomb and if as the result of the passage of this quantity the energy transformed is one joule then the P.D. between the points under consideration is one volt. In terms of current and resistance the P.D. between any two points is one volt if the current flowing is one ampere when the resistance is one ohm.

(d) Eddy Currents are internal currents, circulating locally, set up in a solid mass of metal due to a change in the disposition of the lines of force from a magnetic field. Such an effect is set up for example in the iron core of a generator armature, and the currents tend to flow at right angles to the field and at right angles to the direction of movement, i.e., parallel to the shaft. A similar effect is obtained in a stationary solid mass of metal which is being cut by the lines of force of a magnetic field varying in intensity, for example, in the slug on a relay when the field in the core is building up or dying away. To reduce the effects of eddy currents, where desired, lamination is resorted to, i.e., the solid mass of metal is replaced by thin plates or sheets of the metal assembled together to the same cross-sectional area.

Q. 2.—A battery of 50 volts is joined in series with a resistance of 4960 ohms and a relay of 200 ohms. A resistance R is in parallel with the relay. What is the resistance of R if the current through the relay is two milliamperes?

A.—The P.D. over the relay is from Ohms law:—

P.D. = C × R
= 2/1000 amps. × 200
= $\frac{2}{5}$ = 0.4 volt.

Assuming the battery to have no internal resistance the P.D. over the 4960 ohms resistance is 49.6 volts. Then from Ohms law the current flowing is:—

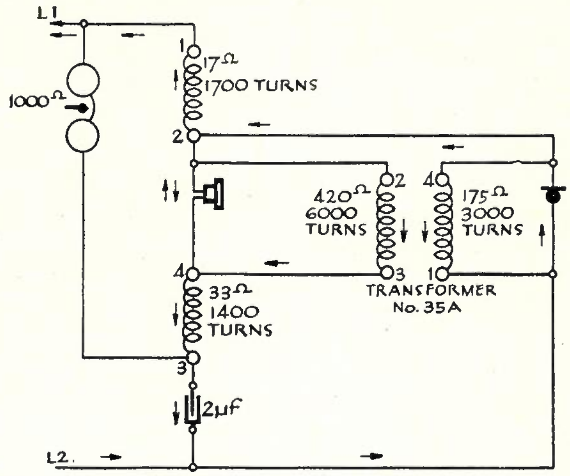
C = P.D. / Resistance = 49.6 / 4960 = 1/100 amps.
= 10 milliamperes.

The total current flowing in the circuit is therefore 10 milliamperes and therefore this current splits between the relay and its shunt resistance. The current through the relay is 2 milliamperes so the current through the shunt is 8 milliamperes, i.e., 8/1000 = .008 amps. So the resistance of the shunt from Ohms law is:—

Resistance = P.D. / Current = 0.4 / .008
= 50 ohms.

Q. 3.—What advantages are obtained by reducing sidetone in a telephone circuit? Explain a method to obtain this effect.

A.—Sidetone is the reproduction in the receiver of sounds picked up by the local transmitter. Besides the speaker's voice it includes room noises and other unwanted sounds. Sidetone affects both transmission and reception. If the apparent loudness of the speaker's voice, heard by him in the receiver, is greater than that heard normally by him through the air path, it causes him to lower his voice, resulting in a loss in transmitted power. Incoming speech is also masked in the receiver by the room noises picked up by the listener's transmitter and introduced into the receiver, as sidetone. Reducing sidetone, therefore, causes the speaker to talk with normal loudness, thus increasing the transmitted power and, is equivalent to muffling the transmitter during reception. Sidetone in a telephone circuit is reduced by the use of an anti-sidetone coil which is a two winding transformer connected in the circuit so that the primary winding parallels the transmitter and the secondary winding parallels the receiver. The arrangement is as follows:—



If the resistance of the transmitter is reduced by a sound impinging on its diaphragm, the potential difference at the terminals of the telephone is reduced, and as in the ordinary C.B. telephone the consequent induced current in the induction coil secondary winding and the current in the same winding due to the condenser discharge assist as will be seen by the directional arrows shown. Across the primary of the anti-sidetone transformer the P.D. is reduced and a consequent reduction of flux in the core occurs with the resultant effect in the secondary of a current in the direction indicated by the arrow. The induced E.M.F. in the receiver circuit due to the anti-sidetone transformer will be seen to be in opposition to those due to the secondary of the induction coil and the partial discharge of the condenser.

The direction of the induced E.M.F. in the secondary of the anti-sidetone transformer is additive as regards the line circuit, to the induced E.M.F. in the secondary of the induction coil, thereby securing an even greater booster effect than occurs in the ordinary C.B. instrument. (Editor's Note.—See also Journal No. 6, p. 265.)

Q. 4.—(a) What is the metal generally used in a relay core and why is it preferred to other metals?

(b) What other metals may be associated with the core and what is the effect of each?

A.—(a) Soft Iron is the metal generally used in a relay core. It is preferred to other metals because it has high permeability, high specific resistance, and low retentivity. The high permeability enables the maximum pull on the armature to be obtained with a small current and the high specific resistance reduces eddy currents in the core. Low retentivity means least effect due to residual magnetism.

(b) Other metals which may be associated with the core of a relay are Nickel and Copper. Nickel may be directly associated with the iron either as an alloy to give a nickel-iron or nickel-steel alloy core, or indirectly as a nickel-iron sleeve or several concentric sleeves over the core. The effect of the addition of nickel to the core is to give high impedance due to the fact that the permeability and the specific resistance are both increased. The increased specific resistance means a higher electrical resistance to eddy currents. The use of the nickel-iron in the form of sleeves is due to the fact that eddy currents are confined to the skin of the core nearest to the winding and also because the sleeve or sleeves will be less saturated by the normal D.C. flux giving even higher permeability. An example of a relay requiring high impedance is the impulsing relay in a bi-motional switch which is also the battery feed relay and thus is a bridge across the transmission circuit. The proportion of nickel for a relay with a nickel-iron core is approximately 50 per cent. Use of a lower proportion of nickel, i.e., approximately 26 per cent. produces a relay with operating and releasing lags about two-thirds of their original value.

Copper may be associated with a relay core either as a slug at the heel end, a slug at the armature end, or a sleeve over the core. The slug is equivalent to a short circuited winding having one turn of extremely low resistance and by the laws of induction the effect is (1) to reduce the impedance of the main winding; and (2) to oppose by means of the induced current in the slug (eddy current) any change of flux in the part of the core it surrounds. A slug on the heel end of a relay has little effect on the operation of a relay. The main flux between the core and the armature is immediately operative and in addition the reduced electrical inductance allows a faster growth of current in the coil. On disconnecting the current, however, the slug current tends to maintain the flux above the releasing value and so we get a slow releasing relay. A slug on the armature end holds back the building up of the flux from core to armature and causes slow operation of the relay. Again the effect of the slug is to prolong the flux when the operating current dies away and a slow release is produced. A copper sleeve also acts as a short circuited single turn but as it does not completely shield the armature end of the winding has only a small effect on the operating lag but delays the collapse of the flux and gives slow release as for a heel end slug.

Q. 5.—What would be the effect of continuing to apply the charging current after a secondary battery has reached the fully charged condition? What tests are necessary to determine when a battery is fully charged.

A.—The effect of unduly extending the charge of a secondary battery is waste of current and electrolyte and under certain conditions damage to the plates. When the plates are fully charged the electrical energy applied must be dissipated in some other way. This other way is electrolysis of the water in the electrolyte, i.e., the water is split up into its constituent parts hydrogen and oxygen visible as countless gas bubbles. This gassing occurs normally during the charging of a battery and the loss is made good by the addition of distilled water but when the charging is prolonged it becomes violent and excessive spraying occurs, i.e., electrolyte is carried off with the gas bubbles and thus a loss of acid and consequent lowering of the specific gravity occurs. This must be compensated for by the addition of acid. Again shedding of the active material of the plates becomes excessive if the plates are charged too much or at too high a rate. The violent gassing produces a scrubbing action on the plates and is a big factor in causing this disintegration. The tests necessary to determine when a battery is fully charged are Voltage and Specific Gravity. The voltage per cell should be 2.55 to 2.65 volts. Age affects the charged voltage of a secondary battery and a reading as low as 2.4 volts per cell may be satisfactory for a battery of appreciable age. The specific gravity (read by means of a hydrometer) of the pilot cell should be within 5 points of the reading attained on the previous overcharge, i.e., if it was 1.215 at the end of the previous overcharge, it should be 1.210 for the regular charge. It should be uniform in all cells and constant. In addition inspection of cells provides valuable indication. Both positive and negative plates should be gassing freely but not violently, and the positive and negative plates should be a rich chocolate and light grey respectively.

Section B

Q. 1.—Explain the following features associated with the standard telephone dial:—

(a) How are the impulses generated?

(b) Why are shunt springs associated with the dial necessary?

(c) State the speed and ratio of make to break of the impulses delivered by a dial in correct adjustment.

(d) How is the speed maintained constant?

A.—(a) The subscriber's loop includes the impulse springs of the dial and is completed through the impulsing relay at the exchange. During the rotation of the dial off normal the impulse springs are unaffected as the impulse springs lever is prevented from operating by the "slipping cam." The rotation off normal winds up a clock spring which returns the plate to normal, when the finger tip is withdrawn from the hole in the finger plate. For a period equivalent to two impulses, generation of impulses is still prevented by the slipping cam but thereafter the impulse lever is free to drop between the teeth of the impulse wheel as this rotates beneath the lever. The lever when on top of a tooth or on the periphery of the slipping cam maintains the impulse springs closed, but when it falls into a cavity between two teeth of the impulse wheel it permits the impulse springs to open. Thus the cavity corresponds to the break, and the tooth to the make period of the impulse. Impulses corresponding to the digit selected are transmitted as successive teeth and associated cavities pass beneath the impulse lever. The impulse wheel is rotated by the rotation of the finger plate since it is associated with that member through the medium of the main spindle.

(b) Two pairs of make springs are associated with the dial, which springs are known as shunt springs since one pair is used to short circuit the receiver, and the other to short circuit the transmitter from the time the dial is turned off-normal till it returns to normal. As the dial impulse springs open during impulsing then the current variations in the transmitter or line circuit would cause corresponding current variations in the receiver circuit of the telephone which would cause loud clicks in the ear of the person using the telephone if the pair of springs short circuiting the receiver during this period were not present. In order to maintain constant characteristics for the dialled impulses from a telephone it is essential that the dialling circuit shall not be subject to avoidable changes in resistance. One path of variable resistance in the dialling circuit is the transmitter and consequently to eliminate any possible effect on dialling from this cause, the transmitter is short circuited during dialling by the second pair of shunt springs.

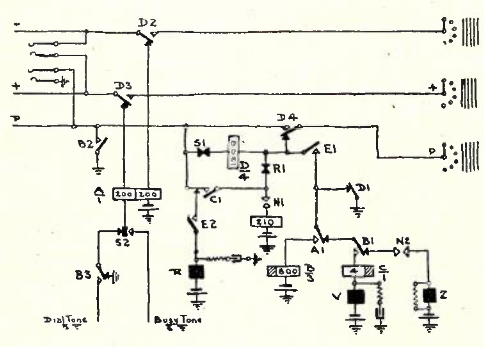
(c) The speed of a dial in correct adjustment is 10 impulses per second. The ratio of make to break is 1 is to 2.

(d) The speed of a dial during impulsing is maintained constant by the action of a governor which is geared to the main spindle through the medium of the star wheel assembly.

Q. 2.—Figure 1 is the circuit of a group selector. Explain the operation.

A.—Seizure.—When the switch is seized by the preceding switch the subscriber's loop is extended to the group selector, relay A operates current flowing from earth via contacts B3 normal, S2 normal, left hand 200Ω winding relay A, contacts D3 normal, subscriber loop, contacts D2 normal, right-hand 200Ω winding of relay A to earthed battery. Relay A operates, and contact A1 then completes an operating circuit for relay B, from earth via contacts D1 normal, A1 operated, relay B to earthed battery. Relay B operates, contacts B1 operated prepare a circuit for the vertical magnet (V) and relay C in series, which circuit, however, is still open at contacts A1 operated. Contacts B2 operated earth the private to hold the preceding switches operated and to busy the connection to any other searching switch. Contact B3 operated connects Dial Tone to the calling party's line.

Impulsing.—The switch is now ready to receive dialled impulses. Relay B, which is shown slugged, is a slow release relay and consequently will not release until approximately 300 milliseconds after its circuit is opened by the release of relay A, i.e., it will not open during the break period of an impulse which is only 66⅔ milliseconds. Relay A, however, releases for the break period of each impulse dialled by the subscriber and so during the "break" period of the first impulse contacts A1 releasing complete a circuit for the vertical magnet and relay C. This circuit is from earth via contacts D1 normal, A1 released, B1 operated, relay C and the vertical magnet to earthed battery. Relay C and the vertical magnet operate, and the switch shaft is stepped upwards to the first level. For the "make" period of the impulse contacts A1 complete the circuit of relay B and open that of C and V.



Relay C is also slugged and will not release for the operated period of A during a train of impulses. During this first vertical step the vertical off normal spring sets, N1 and N2 are operated by the upward movement of the shaft. N2 prepares a circuit for the release magnet which circuit is, however, still maintained open by contacts B1 operated. Contacts N1 close a circuit for relay E from earth via B2 operated, C1 operated, N1 operated, relay E to earthed battery. E operates and E1 closes an alternative circuit for relay E from earth via D1 normal, E1 operated, R1 normal, N1 operated relay E to earthed battery. E2 prepares a circuit for the rotary magnet which circuit, however, is still held open by contacts C1 operated. Further impulses of the digit train received by the switch cause the vertical magnet to function once for each impulse, until the shaft is stepped to the level corresponding to the digit dialled.

Searching.—At the conclusion of the impulse train relay A holds relay B operated, and contacts A1 thus hold open the circuit of relay C and the vertical magnet. After its slow release period relay C releases and contacts C1 releasing close a circuit for the rotary magnet from earth via contacts B2 operated, C1 released, E2 operated and the rotary magnet to earthed battery. The rotary magnet operates and rotates the switch shaft to move the wipers to the first contact of the level selected.

The operation of the rotary magnet opens the rotary interrupter springset R1, thus operating the alternative circuit of relay E. The original operating circuit of E was previously opened by the release of contacts C1. Relay E releases. Contacts E1 open the circuit of relay E and further contacts E2 open the circuit of rotary magnet which releases closing contacts R1. If the first contact in the level is busy that contact of the private bank will be earthed and the earth will thus be connected over the private wiper and private normal via contacts D4 to one side of relay D the opposite side of which is also earthed via springset S1 normal and contacts B2 operated. Relay D, therefore, is short circuited and cannot operate. The earth via the private and D4 is however extended via R1 normal and N1 operated to relay E and earthed battery and E re-operates, which again closes a circuit for itself and the rotary magnet and the switch steps to the second contact of the level. As before R1 opens the circuit of E and E2 opens that of R and the switch then tests the second contact as before. If this is busy D still cannot operate and the switch steps again.

Test in to a free line.—The process is repeated till an idle contact is found, when there will be no earth on the private. Then relay D is not short circuited and we have a circuit from earth via B2 operated, S1 normal, relay D, springset R1 normal, contacts N1 operated and relay E to battery and earth. Relay E does not receive sufficient current to operate when thus coupled in series with relay D. Relay D, however, operates, contact D1 opens to control the release magnet circuit, contacts D2 and D3 operate to switch through the negative and positive wires to the relative wipers, contact D4 extends the private wire through to the private wiper.

Relay A is released when contacts D2 and D3 operate, and contacts A1 then open the circuit of relay B, which in turn releases after the expiration of its slow release period. Contacts A1 and B1 prepare the release magnet circuit which however is held open by contact D1 operated. Contact B2 releases earth from the private wire, but before this, earth has been connected to this wire from the switch ahead via D4 operated which earth holds relay D and the preceding switches operated, contact B3 has no function at this stage. Relay D is the only relay operated in the switch at this stage.

Release.—When the conversation is finished and the calling subscriber hangs up, earth is removed from the private wire and so relay D releases. Contact D1 completes the release magnet circuit from earth via contacts D1 normal, contacts A1 normal, contacts B1 normal, N2 operated and the release magnet to earthed battery. The release magnet is energised permitting the switch to restore, rotarily out of the bank and then return vertically to normal under the action of gravity. Just before the shaft reaches normal in its vertical descent, the shaft movement opens the vertical off-normal springs. N1 has no function at this stage, but contacts N2 open the release magnet circuit, and all parts of the circuit are then back to normal.

Q. 3.—Figure 1 shows one terminal of a composite circuit used for providing simultaneous telephone and telegraph facilities over trunk lines. Describe the functions of each component in the circuit.

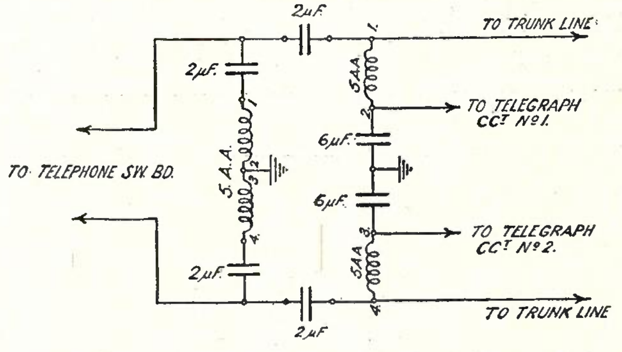
A.—The standard composite set as such a terminal is called, enables each wire of the metallic circuit telephone trunk line to be used as a telegraph circuit also. Briefly the circuit shown covers:—

(a) A high pass filter; and

(b) A low pass filter.

The two filters are parallel connected on the line side so that the high pass filter contains 4 - 2 Mf condensers and a 5.A.A. retard, centre tapped to earth. The low pass filter consists of 5.A.A. retard with one winding in series with one telegraph circuit and the other winding in series with the second telegraph circuit while connected in leak to each telegraph circuit is a 6 mf earthed condenser.

The function of the high pass filter is to transmit currents of all frequencies in excess of approximately 80 cycles, and to by-pass from the telephone termination frequencies of a lower order. The function of the



low pass filter is to pass current of any frequency below approximately 80 cycles but to choke back frequencies of a higher order from the telegraph terminations.

In the low pass filter combinations the retard coils choke back currents of high frequency while the condensers act as a by-pass to earth for higher frequency currents passing through the retard coil windings but unsuitable to the telegraph equipment.

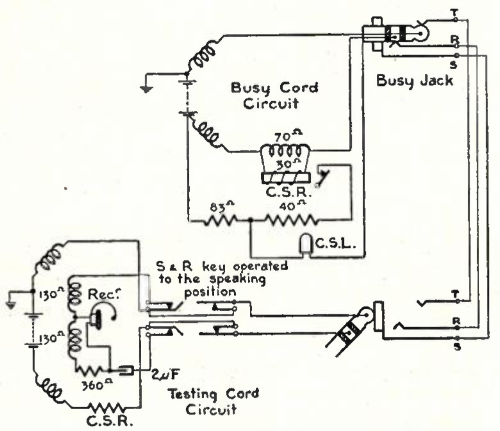
In the high pass filter the lower the frequency of the currents the less is the impedance offered to a by-pass to earth, through the retard coils, and as the frequency increases so does the impedance of the coil windings and the less is the tendency for the current to by-pass to earth. Thus in the high pass filter the high frequency speech currents only suffer slight loss due to the bridge across the circuit of the retard coil condenser arrangement being of high impedance to them.

Telegraph currents (i.e., interrupted direct currents) however of frequencies below 80 cycles are by-passed to earth through the filter and do not affect the telephone apparatus. In the low pass filter the low frequency telegraph currents meet little opposition due to impedance and the earthed condensers offer high opposition to such currents being by-passed to earth: To high frequency speech currents, however, high impedance is offered by the retard coil windings and low opposition to leakage of such currents to earth by the condensers.

Q. 4.—Explain how the engaged test is provided on any manual multiple switchboard with which you are familiar. Illustrate your answer with diagrams.

A.—On a manual multiple switchboard a subscriber is called from a jack in the multiple field appropriate to his line. In a large exchange there are several appearances of the multiple and in each appearance there will be one jack appropriate to a particular line. Such jacks are multiplied together, i.e., the sleeves are commoned, the tip springs are commoned and the ring springs are commoned. A C.B. manual "A" position switchboard arrangement has been taken. The engaged test functions when an operator tests a jack in the multiple field and the line concerned is busy through being plugged up at one of the other multiple jacks. The condition is then as shown.

The sleeve of a disengaged subscriber's jack in the multiple field is connected to earth through the cut-off relay, i.e., it is at earth potential. Then when a telephonist tests for engaged she does so by touching the tip of a calling plug on the sleeve of the appropriate jack in the multiple field within her reach, the speaking key of the cord circuit she is using being operated. The condenser as will be seen from the circuit is charged to the potential of the cord circuit battery, the earth potential being on the tip side. If the line is disengaged no interference with the con-



denser potential occurs as the tip of the testing plug meets earth potential on the sleeve of the jack tested. When, however, the line is busy then at the busy jack the normal earth potential is replaced by a battery potential, applied over the sleeve of the cord circuit. This altered potential is simultaneously applied by means of the multiple wiring to the sleeve of each other jack associated with the line in question, so the tip of a testing plug applied to the sleeve of one of these other jacks now meets this battery potential. The result is an alteration in the potential of the condenser in the testing telephonist's receiver circuit. The condenser discharges partially, the discharge path being through the receiver, and results in a click in the receiver, which click is an indication to the telephonist that the line is engaged.

Q. 5.—(i.) Considering a P.B.X. group of say four lines connected to an automatic exchange, what occurs when:—

(a) The number dialled is the first line of the group and is busy;

(b) The number dialled is the second line of the group and is not busy;

(c) The number dialled is the second line of the group and is busy?

(ii.) Explain why condition (c) is necessary.

A.—The nature of the question indicates that a different switch action takes place when the number dialled is the first of the group and is busy, or is the second of the group and is busy. For a P.B.X. group of lines only the first number is listed in the directory as the main call number. The remaining numbers are referred to only for an entry such as the following:— "After hours call . . ." In other words, numbers other than the first are only listed for night or after hours switching.

(i.) A P.B.X. final selector with night switching facilities has two private banks and a second private wiper P_1. Then for:—

(a) After the vertical and rotary action of the switch under the control of the dialled impulses has moved the switch wipers to the bank contacts corresponding to the line dialled and as the line is busy the P wiper finds earth on the private bank contact and the busy relay operates. The first line of the group is marked by battery on the contact of the second private bank and operates a P.B.X. test relay over the P_1 wiper. This relay locks up and closes a new interacting circuit for the rotary magnet. The switch steps to the next line of the group, and searches over the group for the first free line.

(b) If the number dialled is the second line of the group, the normal vertical and rotary action under the control of the dialled impulses steps the switch wipers to the corresponding bank contacts and as the line is not busy, the normal test relay operates to switch the wipers through in the normal manner and ringing is applied to the wanted line. As the contact on the P_1 bank has no battery connected the P.B.X. test relay does not operate.

(c) If, however, the called No. 2 line is busy, since the P and P_1 bank contacts are strapped for all lines in the group except the first and last, earth will be connected to each of these contacts and the busy relay operates as in case (a) of this answer. The wiper stepping relay now, however, is short-circuited by the earth on P private bank contact, and the switch cannot step on. Busy tone is then given to the calling subscriber.

(ii.) Condition (c) is necessary as after hours' entry in the directory indicates the particular number which will be attended when the other lines are unattended. Automatic rotary stepping to subsequent numbers which will be unattended therefore is not required when the number called is other than that of the first line in the group.

EXAMINATION No. 2106.—ENGINEER. NATURAL SCIENCE.

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

Q. 1.—(a) From first principles find the differential coefficient of $y = \frac{1}{x^3}$

(b) Find y in terms of x given that—

$$\frac{dy}{dx} = \sin x$$

and that $y = 2$ when $x = \frac{\pi}{3}$

A.—

(a) In general if $y = f(x)$

$$\text{then } \frac{dy}{dx} = \lim_{h \to o} \frac{f(x+h) - f(x)}{h}$$

But in this case $y = 1/x^3$

$$\text{hence } \frac{dy}{dx} = \lim_{h \to o} \frac{1/(x+h)^3 - 1/x^3}{h}$$

$$= \lim_{h \to o} \frac{x^3 - (x+h)^3}{h.x^3.(x+h)^3}$$

$$= \lim_{h \to o} \frac{-3x^2h - 3xh^2 - h^3}{h.x^3.(x+h)^3}$$

$$= \lim_{h \to o} \frac{-3x^2 - 3xh - h^2}{3x^3\ (x+h)^3}$$

$$= \frac{-3x^2 - o - o}{x^3\ (x+o)^3}$$

$$= -3/x^4$$

(b) Since $\frac{dy}{dx} = \sin x$

therefore $y = -\cos x + C.$ (by integration)

But when $y = 2,\ x = \pi/3$

hence $2 = -\cos \pi/3 + C.$

$= -0.5 + C.$

i.e., $C. = +2.5$

thus $y = -\cos x + 2.5$

Q. 2.—The metal of a certain iron boiler weighs 15,000 kilograms and contains 10,000 kilograms of water. Calculate the mechanical equivalent of the heat which must be supplied to raise the temperature of the water in the boiler from 20°C. to 170°C. The specific heat of iron may be taken as 0.1, and 1 calorie as equal to 4.2×10^7 erg.

A.—

If m = mass (grams)

S = specific heat (cals/gm/degree C.)

$T_2 - T_1$ = change in temperature (degrees C.)

then Heat $= H = m.S(T_2 - T_1)$ calories

$\therefore$ Heat to Boiler $= 15{,}000 \times 10^3 \times 0.1 \times (170 - 20)$

$= 1.5 \times 10^6 \times 150$ cals.

$= 225 \times 10^6$ cals. . . . . (i)

and Heat to Water $= 10{,}000 \times 10^3 \times 1 \times (170 - 20)$

$= 10 \times 10^6 \times 150$ cals.

$= 1500 \times 10^6$ cals. . . . . (ii)

$\therefore$ Total Heat supplied $= 1725 \times 10^6$ cals. (adding i and ii)

$= 1725 \times 10^6 \times 4.2 \times 10^7$ ergs

$= 7245 \times 10^{13}$ ergs

$= 7.245 \times 10^{16}$ ergs

Q. 3.—(a) What are the names and symbols used for the reciprocals of resistance, reactance and impedance?

(b) With the use of reciprocals derive the values of inductance L_2 in parallel with resistance R_2 which are equivalent to inductance L_1 in series with resistance R_1 at a frequency such that $\omega = 2\pi f$.

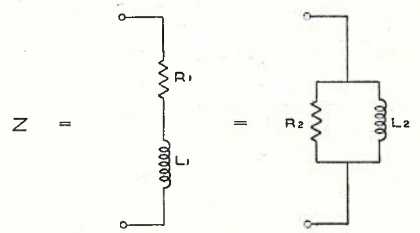
A.—(a)—

Quantity	Symbol	Reciprocal	Symbol
Resistance	R	Conductance	G
Reactance	X	Susceptance	B
Impedance	Z	Admittance	Y

(b) In the "parallel" case we have:

$Y = G - jB$

i.e., $1/Z = 1/R_2 - j/\omega L_2$ . . . . . (i)



In the "series" case we have:

$Z = R + jX$

i.e., $Z = R_1 + j\omega L_1$

$\therefore 1/Z = 1/(R_1 + j\omega L_1)$

$= (R_1 - j\omega L_1)/\ (R_1^2 + \omega^2 L_1^2)$

$= R_1/(R_1^2 + \omega^2 L_1^2) - j\omega L_1/\ (R_1^2 + \omega^2 L_1^2)$ . . . . . (ii)

Since the expressions (i) and (ii) are identical, we may equate their real and imaginary parts.

thus $1/R_2 = R_1/(R_1^2 + \omega^2 L_1^2)$

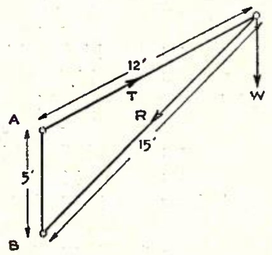
and $1/\omega L_2 = \omega L_1/(R_1^2 + \omega^2 L_1^2)$

giving $R_2 = (R_1^2 + \omega^2 L_1^2)/R_1$

and $L_2 = (R_1^2 + \omega^2 L_1^2)/\omega^2 L_1$

Q. 4.—In a common jib crane, the jib is 15 feet long and the tie rod is 12 feet long. The tie rod proceeds from the tip of the jib to a point on the vertical crane-post 5 feet above the point where the foot of the jib

meets the crane-post. If a weight of 6 tons be hung from the tip of the jib, find the tension in the tie rod and the reaction in the jib.



A.—The weight W, the reaction R, and the tension T act in the directions shown in Figure 1.

Since there are three, and only three, forces which act either along or parallel to the sides of a triangle, we have that each force is proportional to its corresponding side.

$$\text{Thus } W/AB = R/BC = T/CA$$
$$\text{i.e., } 6/5 = R/15 = T/12$$
$$\text{hence } R = 15 \times 6/5 = 18 \text{ tons wt.}$$
$$\text{and } T = 12 \times 6/5 = 14.4 \text{ tons wt.}$$

Q. 5.—If $A + B + C = 180°$ prove that—

(a)—

$$\cos A + \cos B + \cos C = 1 + 4 \sin \frac{A}{2} \sin \frac{B}{2} \sin \frac{C}{2}$$

(b)—

$$\tan A + \tan B + \tan C = \tan A \tan B \tan C.$$

A.—

(a) Since $A + B + C = 180°$

$\therefore \quad B + C = 180° - A$

$\therefore \quad \frac{1}{2}(B + C) = 90° - \frac{1}{2}A$

$\therefore \quad \cos \frac{1}{2}(B + C) = \sin \frac{1}{2}A$

Proof.

L.H.S. $= \cos A + \cos B + \cos C$

$= 1 - 2 \sin^2 \frac{1}{2}A + 2 \cos \frac{1}{2}(B + C) \cos \frac{1}{2}(B - C)$

$= 1 - 2 \sin \frac{1}{2}A \cos \frac{1}{2}(B + C) + 2 \sin \frac{1}{2}A \cos \frac{1}{2}(B - C)$

$= 1 + 2 \sin \frac{1}{2}A [- \cos \frac{1}{2}(B + C) + \cos \frac{1}{2}(B - C)]$

$= 1 + 2 \sin \frac{1}{2}A \; 2 \sin \frac{1}{2} B \sin \frac{1}{2} C$

$= 1 + 4 \sin \frac{1}{2}A \sin \frac{1}{2}B \sin \frac{1}{2}C$

= R.H.S.

(b) Since $A + B + C = 180°$

$\therefore \quad A + B = 180° - C$

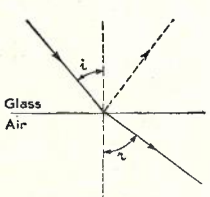
$\therefore \quad \tan (A + B) = -\tan C$

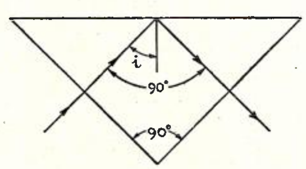
$$\therefore \quad \frac{\tan A + \tan B}{1 - \tan A \tan B} = -\tan C$$

$\therefore \quad \tan A + \tan B = -\tan C + \tan A \tan B \tan C$

$\therefore \quad \tan A + \tan B + \tan C = \tan A \tan B \tan C$

Q. 6.—Derive the relation between the critical angle and the refractive index of a substance. Calculate the lowest refractive index for the glass of a right-angled





prism used as a total reflector to turn a ray of light through 90°.

A.—In this case the direction of the light ray is from glass to air.

Let i = angle of incidence,

r = angle of refraction,

and u = refractive index of glass with reference to air,

then $1/u$ = refractive index of air with reference to glass.

$$= \frac{\sin i}{\sin r}$$

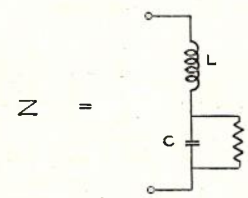
The light ray is always partially reflected and when the angle of refraction just becomes 90° then the refracted ray vanishes and the light ray is totally reflected. The angle of incidence then becomes the critical angle (i_c)—

$$\text{Thus } 1/u = \frac{\sin i_c}{\sin 90°} = \sin i_c$$

Since the ray is just totally reflected and turned through an angle of 90°—

$$i_c = \tfrac{1}{2} \times 90° = 45°$$
$$\therefore \quad 1/u = \sin 45° = 1/\sqrt{2}$$
$$\therefore \quad u = \sqrt{2} = 1.414$$

Q. 7.—A pure inductance L is in series with a mesh consisting of a capacitance C shunted by a resistance R, the whole forming a two-terminal, three-element net-



work of impedance Z. Derive the value of L that will make the impedance of the network become a pure resistance of value—

$$Z = \frac{R}{1 + \omega^2 C^2 R^2}$$

A.—The three-element network is as shown, in which we have—

$$Z_L = j\omega L, \; Z_R = R, \; Z_c = 1/j\omega C$$

$$\text{Hence } Z = Z_L + Z_R \,||\, Z_C$$
$$= Z_L + 1/(1/Z_R + 1/Z_C)$$
$$= Z_L + Z_R Z_C/(Z_R + Z_C)$$
$$= j\omega L + \frac{R \times 1/j\omega C}{R + 1/j\omega C}$$
$$= j\omega L + \frac{R}{1 + j\omega CR}$$
$$= j\omega L + \frac{R(1 - j\omega CR)}{1 + \omega^2 C^2 R^2}$$
$$= \frac{R}{1 + \omega^2 C^2 R^2} + j\omega L - \frac{j\omega CR^2}{1 + \omega^2 C^2 R^2}$$

Thus Z is a pure resistance of value $\dfrac{R}{1 + \omega^2 C^2 R^2}$

if the imaginary part of Z is zero.

$$\text{i.e., if } \omega L - \frac{\omega c R^2}{1 + \omega^2 C^2 R^2} = 0$$

$$\text{i.e., if } L = \frac{CR^2}{1 + \omega^2 C^2 R^2}$$

Q. 8.—(a) In an inductor wound with insulated wire on an air-core former for use at radio-frequencies of the order of 1,000 kc/s, and mounted remotely from surrounding objects, name four of the principal factors that are responsible for the observed losses.

(b) Calculate the figure of merit or "gain" of an inductor operating in a tuned circuit and tuned to a frequency of 1,000 kc/s, given that it has an inductance of 160μH and an effective resistance of 6.28 ohms.

A.—(a) The names of four of the main loss factors are—

(1) d.c. resistance,
(2) proximity effect,
(3) skin effect,
(4) dielectric loss.

(b) If pulsatance $= \omega = 2\pi f$ (rads/sec.)
inductance $=$ L (henries)
resistance $=$ R (ohms).

$$\text{Then } Q = \frac{\omega L}{R} = \text{Figure of Merit}$$

$$= \frac{2\pi \times 1000 \times 10^{3} \times 160 \times 10^{-6}}{6.28}$$

$$= \frac{6.28 \times 160}{6.28}$$

$$= 160.$$

Q. 9.—What weight of zinc is required to produce 100 litres of hydrogen at normal temperature and pressure? It is given that the atomic weight of zinc is 65 and that 22.4 litres of hydrogen at N.T.P. weighs 2 grammes.

A.—A chemical equation symbolizing the process is—

$$Zn + H_2SO_4 \rightarrow H_2 + ZnSO_4$$

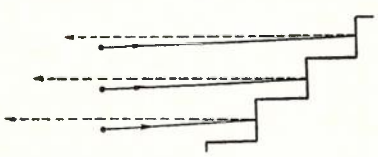
Molecular wt of Zn $= 65$
and molecular wt of $H_2 = 2 \times 1 = 2$
hence 65 gms of Zn produces 2 gms of H_2
ie., 65 gms of Zn produces 22.4 litres of H_2 at N.T.P.

i.e., $\frac{65 \times 100}{22.4}$ gms of Zn produces 100 litres of H_2

$$\text{i.e., amount of Zn required} = \frac{65 \times 100}{22.4} \text{ gms}$$

$$= 290.2 \text{ gms.}$$

Q. 10.— A sharp tap is sounded in front of a regular flight of stairs and a musical note is heard by an observer situated near the source of original sound. Given that the width of the treads of the stairs is 30



cm. and that the velocity of sound is 330 m.sec.$^{-1}$, calculate the pitch of the musical note heard.

A.—The sound made by the sharp tap will be reflected by the vertical portions of the steps as shown in Fig. 1, and consequently the series of echoes will be heard by the observer as a note whose frequency is numerically equal to the number of echoes per second.

s $=$ distance interval between echoes
$= 2 \times 30 = 60$ cm.
v $=$ velocity of sound
$= 33,000$ cm/sec.

$\therefore$ t $=$ time interval between echoes

$$= \frac{s}{v} = \frac{60}{33,000} \text{ secs.}$$

$\therefore$ f $=$ frequency of note

$$= \frac{1}{t} = \frac{33,000}{60} = 550 \text{ cycles/sec.}$$

Q. 11.—In a three-phase three-wire system prove that the power can be measured by the use of two wattmeters connected with their current coils in two of the phases and their potential circuits from these two phases, respectively, to the third phase. Show the wattmeter connections that should be used.

A.—

If i_1, i_2, i_3 are the instantaneous line currents
and e_1, e_2, e_3 are the instantaneous line potentials
then w $=$ instantaneous power
$= e_1i_1 + e_2i_2 + e_3i_3$
and $o = i_1 + i_2 + i_3$
Let e_x be the potential of any pt. x.
Then $o = e_x(i_1 + i_2 + i_3)$
hence $w = e_1i_1 + e_2i_2 + e_3i_3 - e_x(i_1 + i_2 + i_3)$
$= (e_1 - e_x)i_1 + (e_2 - e_x)i_2 + (e_3 - e_x)i_3$.

Now wattmeters when their readings are corrected for

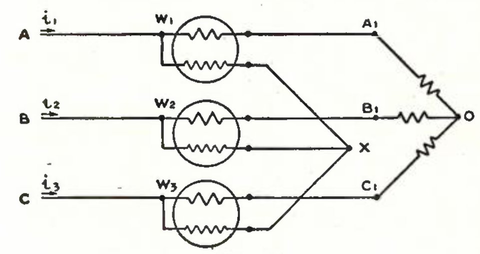


Fig. 1.

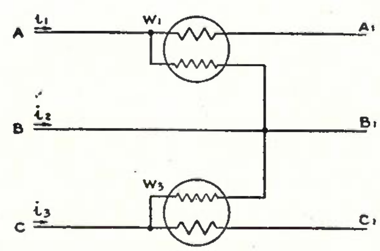


Fig. 2.

coil and resistance losses measure average power. Hence if three wattmeters are connected as shown in Fig. 1 then the total power will be the algebraic sum of the three individual wattmeter readings.

If the pt. x coincides with the second line
then $e_x = e_2$
and $w = (e_1 - e_2)i_1 + 0 + (e_3 - e_2)i_3$.

Hence if two wattmeters are connected as shown in Fig. 2 with the pt. x in the second line, then the total power will be the algebraic sum of the two wattmeter readings.

Q. 12.—A weight of 1,000 kilogrammes has to be pulled up a smooth inclined plane which rises 3 units for every 5 units of length measured along the inclined surface. Neglecting friction, find the smallest force, in dynes, which is capable of doing this (a) when the force acts parallel to the base; (b) when it acts parallel to the inclined surface. (g $=$ 980 cm.sec.$^{-2}$).

A.—(a) In all cases $\sin A = 3/5 = .6$

$\therefore \cos A = 4/5 = .8$

The forces act on the body as shown.

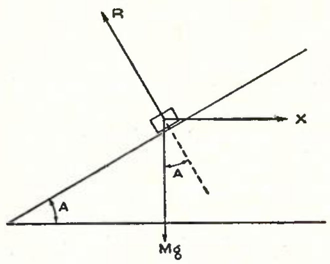


Fig. 1.

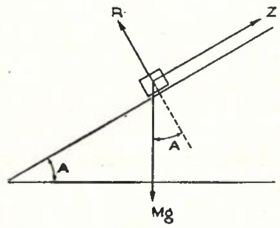


Fig. 2.

Resolving at right angles and parallel to the slope of plane, we have—

$$R = Mg \cos A + X \sin A$$

and $X \cos A = Mg \sin A$

$$\therefore X = Mg \sin A / \cos A$$

$$= \frac{1000 \times 10^3 \times 980 \times .6}{0.8}$$

$$= 735 \times 10^6 \text{ dynes.}$$

(b) Again resolving at right angles and parallel to the slope of plane, we have—

$$R = Mg \cos A$$

and $Z = Mg \sin A$

$$\therefore Z = 1000 \times 10^3 \times 980 \times .6$$

$$= 588 \times 10^6 \text{ dynes.}$$

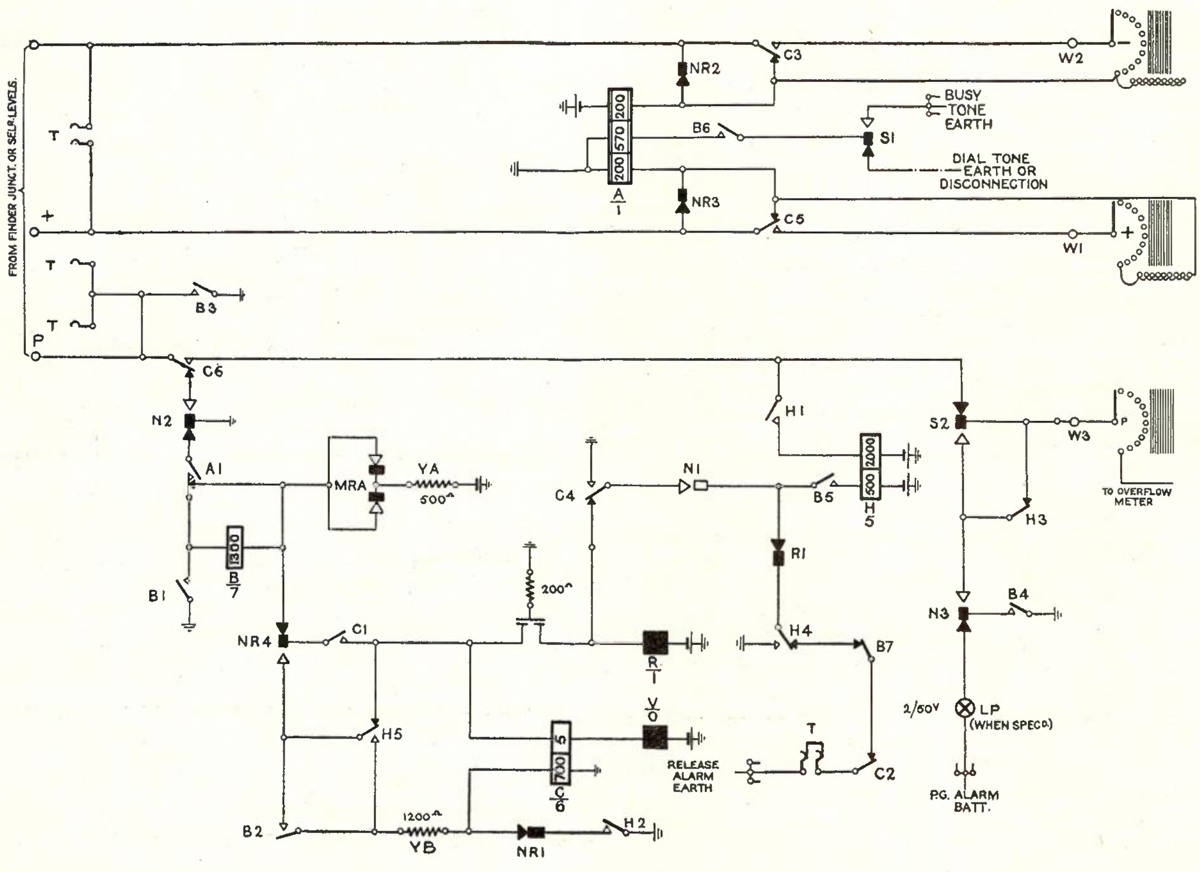
EXAMINATION NO. 2106.—ENGINEER—TELEPHONE EQUIPMENT

D. F. BURNARD, B.E.

Q. 1.—Give a schematic circuit diagram of a step by step, two motion group selector, 100 outlet, of modern type. Explain the operation of this selector.

A.—Fig. 1 is the circuit of a 2000 type group selector 100 outlet. The operation is as follows:—

Seizure.—When the circuit is seized by the preceding switch and the loop is extended over the positive and negative wires to operate Relay A over its 200/200 ohm windings, the only contact, A1, of relay A, closes the circuit to operate relay B via the rectifiers MRA and the 500 ohm resistance, YA. Contact B3 earths the incoming private wire to mark the switch engaged. Contact B4 earths the PG alarm circuit which will give the alarm unless the switch is moved off normal within a specified period. The dial tone circuit is closed by contact B6 over the 3rd winding of the impulse relay, the dial tone being induced through the 200/200 ohm winding of Relay A to the



line. Contact B2 closes a circuit for the pre-operation of relay C via circuit from earth, 700 ohm winding of Relay C, 1200 ohm resistance YB, contact B2, Back Contact of H5, 5 ohm winding of relay C, vertical magnet V to battery. Relays A, B and C are now operated and the switch is ready to receive a train of impulses from the subscriber's dial.

Impulsing. — When A relay releases on the first break of the dial, the back of contact A1 short circuits relay B to make it slow to release and this short circuit also allows the operation of the vertical magnet from earth at contact B1, back contacts A1 and NR4 and contacts C1 through C relay 5 ohm winding to vertical magnet and battery. The successive impulses of the train operate V and step the wipers in accordance with the digits dialled. The vertical off normal springs marked N are operated on the first vertical step and N1 closes a circuit for the 500 ohm winding of H relay over the make contacts C4 and B5. Contact H5 opens the circuit of the 700 ohm winding of relay C but the closure of contact H2 places a short circuit on this winding of relay C to make it slow to release so that during impulsing this relay is retained operated by the vertical magnet circuit through the 5 ohm winding.

Search.—When the impulsing train is completed, A relay is held operated and the holding circuit of relay C is no longer closed so that after the slow release period Relay C releases. The energizing circuit of relay C has been opened at contact H5. When C relay releases a circuit is closed for the rotary magnet from the back contact of C4, contacts N1, R1 and front contact of H4. When the rotary magnet is energized the R1 contact is operated and when the switch moves off the normal rotary position the NR spring contacts are operated. The NR springs remain operated until the switch releases, but contact R1 operates only when the rotary magnet is energized. Contact R1 which moves on the toggle principle self interrupts the circuit of the rotary magnet to give the rotary stepping of the wipers.

Action on Busy Lines.—Busy outlets will be marked by an earth on the P wiper and such an earth will complete the circuit for the 2000 ohm winding of relay H over its contact H1 to maintain that relay operated. The circuit of the 500 ohm winding on which the relay was initially operated is open at contact R1 on each rotary step, therefore H is retained only so long as there is an earth on the private wiper.

The earth on the private bank contact retains relay H over its 2000 ohm winding and contact H4 retains the operating circuit of the rotary magnet so that the self-interrupting drive continues until the circuit is opened by the release of contact H4. If all outlets are engaged the wipers are driven to the eleventh contact when the S switch springs operate. The circuit of H relay is opened at contact S2 and relay H releases. Relay C re-operates via the back of contact H5 but relay A is held by the extension of the bank wiring from the 11th contact to the 200/200 ohm windings of the relay. Relay B is, therefore, held operated and busy tone is substituted for dialling tone on the 570 ohm winding of relay A. An earth is extended to the overflow meter.

Switching on Free Outlet.—When the switch steps to a free trunk the absence of earth over the P wiper will allow H to release and over the back of contact H5 the circuit for relay C is again closed over both its 5 and 700 ohm windings. The operation of relay C prevents further switching by opening the circuit of the rotary magnet at the back of contact C4. A circuit is closed for the re-operation of relay H over the front of contact C4. H relay will then be locked via its 2000 ohm winding, contacts H1 and S2 to earth on the P wire of the next switch as soon as the subscriber's loop is extended through to it. The closure of contacts C3 and C5 switches the positive and negative wires through to the next switch and disconnects the A relay from the line (contacts NR2 and NR3 are already open). The releasing of contact A1 short circuits the B relay which releases slowly. B5 will open the 500 ohm winding of relay H, but not before H has locked to the earth over the succeeding switch. C relay is held operated over the vertical magnet, its 5 ohm winding, and over the front of contacts C1, NR4, H5, YB1200 ohms, 700 ohms winding of C to earth. Relays C and H are held operated until the switch is released.

Releasing.—With all lines busy, on receiving the busy signal the calling subscriber replaces the receiver, releasing relay A which, in turn, releases relays B and C. With contact N1 operated but all relays released a circuit is provided for the self-operation of the rotary magnet over the release alarm earth and the switch is driven off the eleventh contact when it drops to normal vertical position and restores to rotary normal. The release action after a successful call is similar. When the loop is broken the earth on the private bank contact is opened and relay H releases followed by relay C so that all relays restore to normal and the self interrupting drive is connected as given previously.

Q. 2.—On final selectors in an automatic exchange, for handling traffic to private branch exchanges, what features are incorporated in addition to those of an ordinary final selector:—

(a) To serve not more than ten exchange lines per P.B.X.

(b) To serve more than 10 lines, but not more than 50 lines per P.B.X.?

Assume a typical case each for (a) and (b) and discuss briefly the method of switch operation. Give assumed numbers suitable for your typical cases in a 6 figure exchange say the "F" exchange.

A.—(a) The significance of the division into the two sizes of groups of exchange lines is that by the provision of search over a full level of a final selector, 10 outlets can be allotted to one P.B.X. subscriber. The first number only is dialled, and there are facilities for testing each line and stepping the wipers as necessary until a free exchange line is found. Busy tone is returned to the calling subscriber only if all lines are busy. To provide these facilities, an additional bank contact is required for each line so that in the case of the 100 outlet final selector, an additional 100 point bank is required, and in the case of the 200 outlet switch, two additional 100 point banks are required. Additional wipers are, of course, required to correspond with the additional banks. To the first line of the P.B.X. group on the additional (P2) bank, battery is connected via 200 ohm resistance. To the last line of the group earth is connected, whilst the bank contacts of intermediate lines are left open.

To illustrate the above points, assume that the P.B.X.

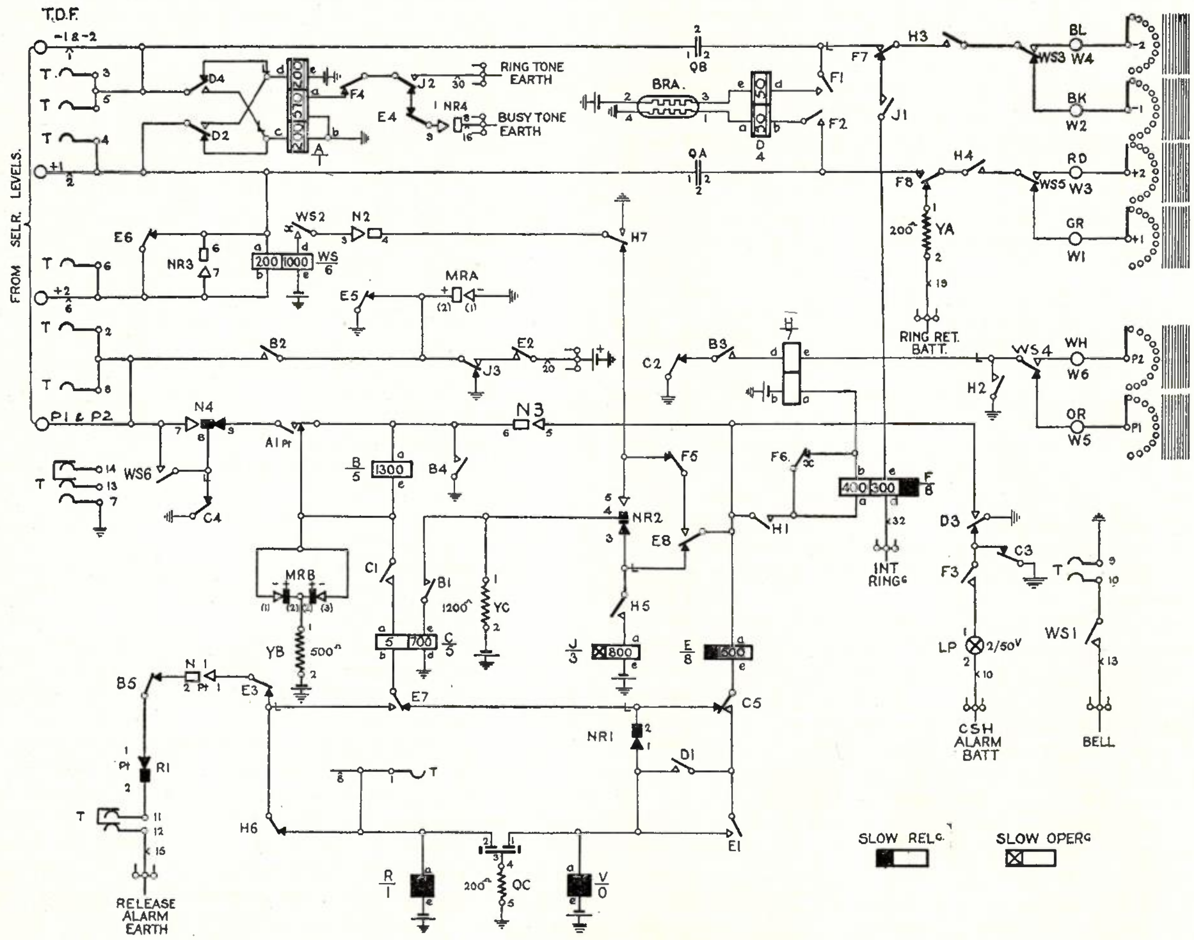
subscriber whose telephone number as advertised in the Directory is FW 4561 (10 lines).

The final selector seized is one of a group served by the 4th selectors of the 500 and 600 group (assuming 200 outlet switches). The operation of the switch is similar to that of the ordinary final selector for vertical stepping by the penultimate digit, and the digit 1 of the rotary stepping, so that the wipers will be on the first contact of the 6th level. The wiper switching relay which determines whether the 500 or 600 group is to be selected will not be operated for this call as it comes from an odd 4th selector group. To the outlet on which the wipers are standing battery will be connected through 200 ohms to the P2 bank contact. If this is engaged the rotary magnet interacting circuit will be reconnected, and the wipers stepped on to the next contact. Each outlet will be tested in turn, and when a free line in encountered the test-in relay will operate, which opens the rotary magnet circuit, and connects the wipers through to the P.B.X. line. The usual circuits for ringing and ringing tone, and for metering are operated in the ordinary manner. If all the lines in the group are engaged, the wipers will eventually step to the last outlet which corresponds to the number FW 4560 where earth is connected to the P2 contact which operates the busy relay which breaks the driving circuit of the rotary magnet and connects busy tone to the calling subscriber. The P.B.X. final selector requires two additional relays to those normally fitted on the ordinary final selector.

(b) When there are more than 10 exchange lines to serve a P.B.X. some special arrangements are made to provide for search over more than the 10 contacts, in a switch level. In Brisbane where Siemens equipment is used, special final selectors are employed which search over a level, release to rotary normal, step up one and search over the next level, and so on to the number of contacts in the group. In the 2000 type equipment, it is the practice for large services to avoid this search over a large group of lines, and, to obtain an equal traffic distribution by suitable trunking from 4th selectors. A particular case will best explain the method used:—

Suppose a P.B.X. subscriber has 50 "in" exchange lines (i.e., "in" with respect to the subscriber). The number allotted to this subscriber may be FW 4510.

The 5th level of the 4th selectors serves 100 lines normally. In this case 50 of these are taken by one subscriber. The outlets from the 5th levels are graded and trunked to final selectors, but the trunking is arranged in five groups, so that there will be five groups of final selectors, the number of final selector switches in each group depending on the traffic. The



Ques. 3, Fig. 1.

first level is multipled within each group of final selectors, that is, each group serves 10 exchange lines. It should be noted that the final digit "0" is ineffective, and is absorbed by the final selector. The rotary action is quite automatic, and continues until a free outlet is found on the 1st level. Each group in this case is wired to serve 10 different exchange lines. So that it depends on which 4th selector is seized by the incoming call as to which group of 10 lines is available to the calling subscriber.

In some city exchanges, a different method is used for serving large P.B.X.'s. The outlets from special 4th selectors are graded, and feed ringing repeaters. Final selectors are not used, hence a description of this method is not within the scope of this question.

Q. 3.—What is the switch represented by figure 1? Explain the circuit operation.

A.—The circuit shown is for a 200 outlet Final Selector of the 2000 type, using positive battery metering, and last party release.

Operation:

Seizure: The subscriber's loop brought forward by the previous selectors operates relay A, via contacts D2 and D4. Relay B then operates from battery via resistance YB 500 ohms, metal rectifiers MRB, 1300 ohm winding of B, A1, N4 and C4 to earth. The closure of contact B2 places an earth on the incoming private wire to guard the switch from intrusion. B4 provides an alternative earth for the B relay, and B1 closes a circuit for the operation of relay C over its 700 ohm winding and the 1200 ohm resistance YC. Although a circuit is closed from battery via V, NR1, E7, the 5 ohm winding of relay C, C1, B relay, A1, N4 and C4 to earth, the vertical magnet does not operate in series with the 1300 ohm winding of B relay.

With relays A, B and C operated, the switch is ready to receive the penultimate train of impulses from the sub's dial.

Action Under Control of Dial:

(a) **Vertical Stepping:** At each impulse, the subscriber's loop is broken and relay A releases. As its contact A1 restores to normal it short circuits B relay and allows V to operate to earth via B4.

Relay B is made slow to release by this short circuit and so remains operated. The wipers are lifted vertically by the vertical magnet to the level corresponding to the digit dialled.

At the first vertical step, the off-normal springs N operate and remain operated until the switch restores to normal. N3 short-circuits the 700 ohms winding of relay C via NR2, E8, N3 and B4 to earth, thus making it slow to release.

It is, however, retained, operated throughout dialling by the impulse circuit through its 5 ohm winding.

At the completion of the vertical stepping, relay C releases. Relay E then operates from battery via V, NR1, back of C5, E relay 1500 ohms, N3 and B4 to earth. Relay E removes the short circuit across the 700 ohm winding of relay C at contact E8 and allows C relay to re-operate. Contact E7 changes over the impulsing circuit from the vertical magnet V to the rotary magnet R.

For 200 outlet finals, the trunking from the 4th or 3rd selectors is arranged so that two levels serve one group of final selectors. There are two sets of banks on the final selector, and the one used by a particular call is determined by relay WS. The operation or non-operation of relay WS is determined by whether the final selector is reached from an odd or an even level of the preceding selectors.

Now, when contact E6 operates, a short cricuit is removed from the 200 ohm winding of relay WS. If the incoming call is from an even level, the subscriber's loop will be over wires —2 and +2. If from an odd level it will be over —1 and +1. In the former case, relay WS will now operate. In the latter case relay WS is unaffected now and throughout the call.

Assuming the former case for purposes of this description, relay WS operates from sub's loop over wires +2 and —2 and in series with relay A. Contact WS2 locks relay WS from battery via the 1000 ohm winding of WS, WS2, N2, H7, F5, E8, N3 and B4 to earth. Contacts WS3, WS4, WS5 transfer the circuit to the wipers corresponding to the second set of banks.

(b) **Rotary Stepping:** The switch is ready to receive the final train of impulses with relays A, B, C, E and WS operated.

The circuit for the rotary magnet is from battery via R, H6, E7 the 5 ohm winding of relay C, C1, A1, B4 to earth. The wipers are stepped around by the impulsing of A1, and at the first rotary step NR springs are operated. NR2 shorts the 700 ohm winding of relay C via NR2, F5, E8, N3 and B4 so that it is slow releasing, but is held over the 5 ohm winding until the end of the dialling.

Called Subscriber Available

Relay C releases. The circuit of relay E is then opened at the front of contact C5. Relay E releases and at contact E8 removes the short circuit over the 700 ohm winding of relay C, and allows Relay C to re-operate, but the short period during which C2 is back, gives relay H a chance to operate from the battery on the P wire and the P wiper if the called line is free.

This battery is given via the K relay in the subscriber's line circuit. Relay H immediately operates and locks itself on its 400 ohm winding from battery via F6, H1, N3 and B4 to earth. H5 operates relay J from battery via H5, E8, N3, B4 to earth. Ringing current is sent to the called sub via resistance YA 200 ohms, F8, H4, WS5, wiper, sub's line, WS3, H3, F7, J1 and 300 ohm winding of relay F. J2 feeds ringing tone to the 3rd winding of relay A, which induces the tone in the line windings and so to the calling subscriber. Relay C re-operates as a result of relay E releasing.

Relays A, B, C, WS, H and J are operated when dialling has just been completed, and the subscriber is available.

Called Subscriber Answers

When the subscriber answers, his loop puts 50v DC which is superimposed on the ringing current, through the 300 ohm winding of relay F. Relay F operates. Contact F6 opens and relay F is held operated by its 400 ohm winding being in series with the 400 ohm winding of relay H. F7 and F8 disconnect the ringing current from the line and also open the circuit for the 300 ohm winding of F relay, but F6 is designed to open before F7 and F8 operate, thus ensuring that F relay holds operated. F4 disconnects the ringing tone, F1 and F2 close the circuit for relay D from battery via barretters BRA, 50 ohm winding of D relay, F1, F7, H3, WS3, subscriber's line, WS5, H4, F8, F2, 50 ohm winding of D relay to earth. Relay D operates, reverses the polarity of the battery feed to the calling subscriber at D2 and D4, connects a holding earth to P wire at D3 and re-operates relay E at D1.

Relay E operates and contact E8 opens the circuit of relay J which is slow releasing. E2 closes a circuit for a positive battery impulse to the P wire for metering. The pulse is interrupted when J releases.

Conversation proceeds with relays A, B, C, D, E, F, H, and WS operated.

Called Subscriber Engaged

Returning to the stage where RM is driving under the control of the final train of impulses, relay C is ready to release at the end of impulsing and relays B and E are operated. A is held operated at end of impulses, then relay C drops out and releases relay E.

Relay C re-operates, but relay H has not operated in the short period of the release of relay C because the P wiper found earth on the P wire (the sub being engaged). Busy tone is fed via NR4, E4, J2, F4 to the 3rd winding of relay A, and is induced on to the line. This condition is maintained until the calling subscriber hangs up. Relays A, B and C then release, and the rotary magnet drives through the release circuit as described previously.

Release

When the called party hangs up relays D and E release and the C.S.H. alarm circuit is closed to start the timing circuit.

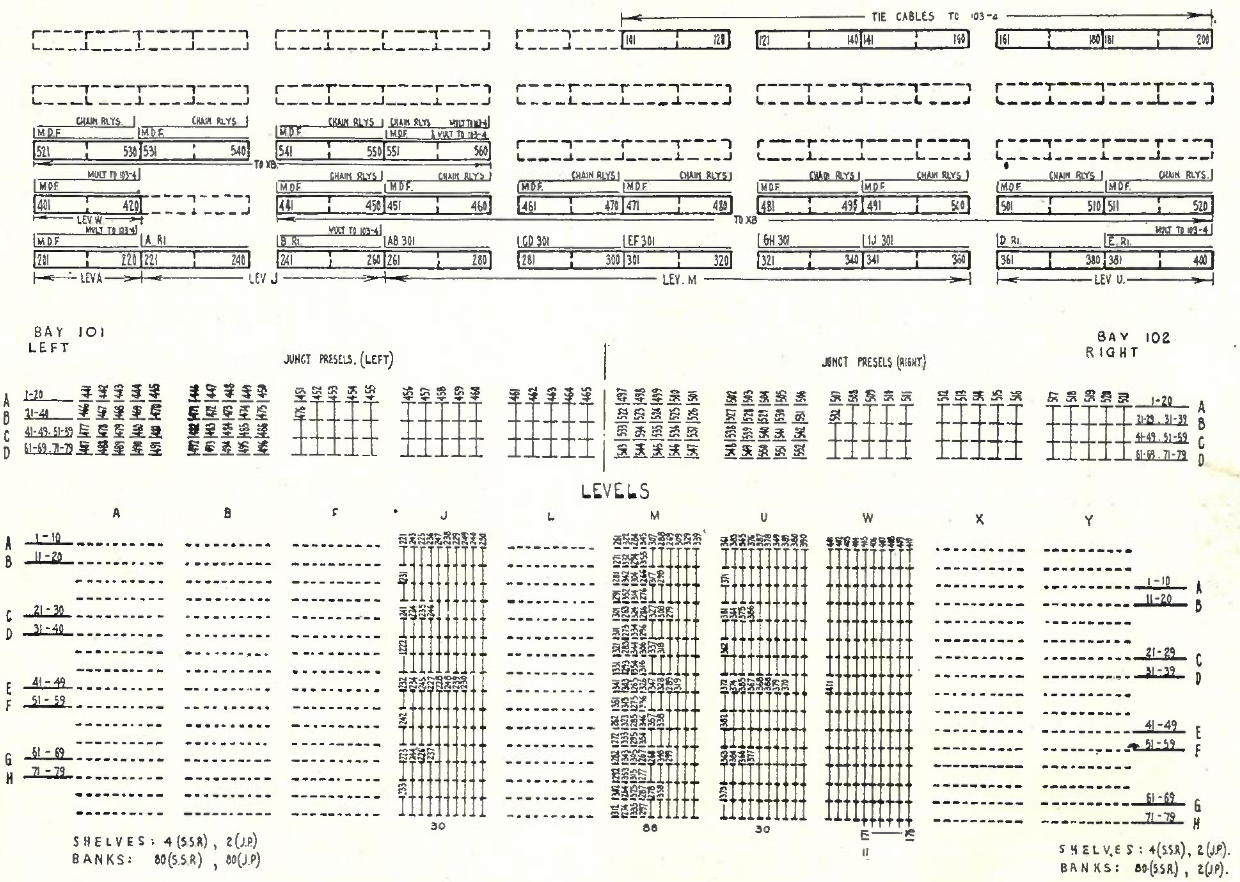
When the calling party hangs up with the called party still connected relays A, B, C release in order. C.S.H. alarm is again given via C3 and F3.

When both subs. have hung up, a release circuit is given and R drives the wipers off the bank level. The release circuit is from battery via R, H6, E3, N1, B5, R1 to earth. The drive is self-interrupted at R1 contacts.

The switch drops off the bank and restores to normal.

Q. 4.—(a) Define "traffic unit," "grade of service" and "grading."

(b) The figure is a copy of one of the diagrams furnished to an installer. What does it represent? Explain it and, if you so desire, criticize it.



A.—(a) **Traffic Unit:** The number of switches required in an automatic telephone exchange depends on the number of calls and the length of calls going through, i.e., depends on the telephone traffic. For the calculation of switch quantities, a suitable unit is necessary, and the "traffic unit" is used. If one call last 1 hour, then 1 T.U. (traffic unit) has passed. If 20 calls, with an average length of 1/20 hour (3 minutes) each pass, then 1 T.U. has passed.

If C = number of calls, and T = Average duration of the calls in hours, then $A = \text{traffic units} = C \times T$.

Grade of Service.—The number of traffic units which originate during any one hour varies with the hour chosen. There is usually a well defined busy period of the day, when the traffic is at a maximum. It is necessary to provide switches to carry the traffic of the "Busy Hour," i.e., the hour over which the greatest amount of traffic originates. However, as calls originate spasmodically, it is not economical to provide enough switches to take all the calls that may arrive at any one instant. Enough switches are provided so that on the average, 1 in 200, or 1 in 500, or 1 in 1000 calls are lost, according to the "Grade of Service" desired. "Grade of Service" may be defined as the allowable loss of calls during the busy hour, and may be applied to a particular group of switches or to the whole exchange. Some loss of calls is necessary for economic reasons.

Grading.—Grading is the method of connecting the outlets from a particular level of a selector, for example, to switches in the succeeding rank of selectors, so that the first outlets have undivided access to following switches, while the later outlets are multipled with the corresponding outlets of several other switches. The later the choice the greater the number of outlets which are multipled.

(b) The figure represents the trunking and grading out from Switching Selector Repeater banks, and junction preselectors, on a Trunk board formed by Bay 101 and Bay 102. The top half of the diagram represents the terminal strips mounted at the top of the Trunk Distributing Frame which forms one end of the trunk board. The bottom half of the diagram should be divided for description purposes. The larger bottom division (that portion under word "Levels") form the bottom part of the Trunk Distributing Frame. The smaller top division, that portion between word "Levels" and dividing line across the diagram, represents the grading of the outlets from the junction preselectors mounted on this trunk board. This grading is done by utilizing the vacant portion of the grading frame.

The trunk board represented is the first of the S.S.R. boards, as indicated by the Bay numbering. The designation Bay 101 indicates S.S.R.'s or 1st Selectors. Bay 204 would indicate 2nd Selectors, 4th Bay. Bay 302 would indicate 3rd selectors, 2nd Bay.

In this diagram, it is seen that no tie cables come in but the cables are taken out from the R.H.S. half of top row of terminal strips to Bays 103-4. On the next trunk board, these would terminate on the L.H.S. half of the top row of terminal strips which in this board are vacant.

On the left side of this trunk board, there are two shelves of junction preselectors, capacity 40 switches per shelf, and four shelves of switching selector repeaters, capacity 20 switches per shelf. On the right hand side, similarly. The shelves are not fully equipped with switches. It is seen that four junction preselectors are missing on the L.H.S. (Nos. 50, 60, 70 and 80) and six are missing on the right side (Nos. 30, 40, 50, 60, 70 and 80), while a similar number of switching selector repeaters is missing also.

A mistake in the designation might be pointed out here. On the right side, bottom corner of diagram.

Banks: '80 (S.S.R.) 2 (J.P.) should be Banks 80 S.S.R. 80 J.P.

The switching selector repeater banks are multipled in sets of 10, i.e., there are two cables per shelf. Each of these cables is terminated horizontally on the grading frame. Cable A serving half of the first shelf holding switches 1-10 on the L.S. is terminated on the top row of the grading diagram under word "Levels." Cables from both sides are similarly brought in and terminated, the 10 outlets for each level are clearly indicated. One stroke represents the three wires +, —, and P.

It is seen that no traffic goes through the S.S.R. banks on levels A, B, F, L, X or Y, but levels J. M. U, and W are in use. The outlets are graded and the terminals on the strips above to which each outlet is jumpered is numbered on the contact. For example, the first outlet of the J level of all the switches on the first shelf (i.e., switches 1-20) is jumpered to terminal number 221, which is also marked on the terminal strip. It is seen on the bottom strip on the left side of the diagram. Then the last choices or outlets of all the switches on both sides of the board are commoned together and jumpered to terminal number 250, which is not marked on the terminal strip at top of board but will obviously be the 10th contact along in the 2nd strip of the bottom row, counting from the left. The number of outlets for each level is indicated at the bottom of each grading, e.g., there are 30 outlets from the J level, 88 from the M, 30 from the U and 11 from the W.

Considering the terminal strips, it is seen that the diagram is more or less an elevation of the end of the trunk board; this applies to the grading frame also. The diagram indicates where the strips are connected. The top side of each terminal strip is cabled and the cable is taken away as indicated. For example, considering the bottom left side terminal strip, it is seen that contacts 201 to 220 are cabled to the M.D.F. and also multipled to the next trunk board, Bays 103-104, via tie cables. Terminals Nos. 221-240 are cabled to Shelf A of the repeater board. Other strips are cabled as follows:—

Terminals 281-300 are cabled to 3rd selectors, Shelf CD on trunk board 301, i.e., the first trunk board of the 3rd Selectors.

Terminals 441-450 are cabled to the M.D.F. and also to the chain relays.

The multiples to trunk board 103-4 go to terminals 101-200 first, whence tie cables are taken.

The middle section of the diagram shows the grading of the junction preselector outlets. The banks of switches 1-20 on L.S. are multiplied and terminated on the top 25 contacts horizontally on the diagram. Similarly, the Right Side, but the gradings of the two groups are kept separate.

The explanation of this section is similar to that given for the grading of S.S.R. outlets.

It should be remembered that one junction preselector is associated with each S.S.R. and that the traffic through the junction preselectors does not go through the S.S.R. banks. In this particular case, the main exchange of the group is XB. The local exchange is XM, while direct trunking is provided to other branch exchanges, XJ, XU and XW, from this exchange. Level A is apparently being reserved for a small automatic branch exchange, similar to that served by the "W" level. Only a few junctions are required in both these cases, hence the traffic is not taken through O.G.S. switches (on repeater shelves) as on levels J and U. It is taken straight to the M.D.F.

The outlets from terminals 441-560, to which the junction preselectors are jumpered, go direct to the M.D.F., i.e., to junctions to the main exchange. There is nothing connected on the B level of the S.S.R.'s, the traffic goes to the incoming 2nds at the main exchange.

A further point is that the last six outlets of the W level are multipled to Bays 103-104, via a tie cable which is connected to terminals 171-176 on the terminal strip. The traffic to XW exchange is obviously very low and the last six outlets are being shared by 103-104 trunk board also.

There is very little adverse criticism that can be offered in regard to this diagram except for the mistake in the number of junction preselector banks shown on the right side of the board (it should be 80 instead of 2).

Q. 5.—(a) A group of selectors, observed for 10 busy hours, carried an average of 20 T.U. The total number of calls lost was 12. Taking average holding time as two minutes, what was the grade of service?

(b) Explain how you would have carried out observations on these selectors by visual methods.

A.—(a) Total T.U. = 10 × 20 = 200 = A.

Average holding time = 2 mins. = $.0\dot{3}$ = T.

∴ No. of successful calls = $200/.0\dot{3}$ = 6,000.
Calls lost = 12 ∴ total originating calls = 6,012.
∴ Grade of Service = 12/6012 = 1/501,
i.e., Say 1 in 500.

(b) The average number of calls in progress at any one moment is numerically equal to the traffic flow measured in traffic units. This would form the basis of a visual method of determining the grade of service in this group of selectors.

Illustration of this Method: In the above group, there are, say, 34 switches. One or two mechanics begin observations on these four shelves of switches. At 10 a.m., say, they examine the shelves and find 25 switches in use.

At 10.2 a.m. they re-examine and find 22 in use.

At 10.4 a.m. they re-examine and find 13 in use.

And so on, at two-minute intervals until 11 a.m. They then find the average number of switches engaged at any one moment by totalling the number of switches engaged at each reading and dividing by 30. The average figure will be 20. They then know that this group of 34 switches is carrying 20 traffic units. From curves which are available, they find that the grade of service being given under these conditions is approximately 1 in 500.

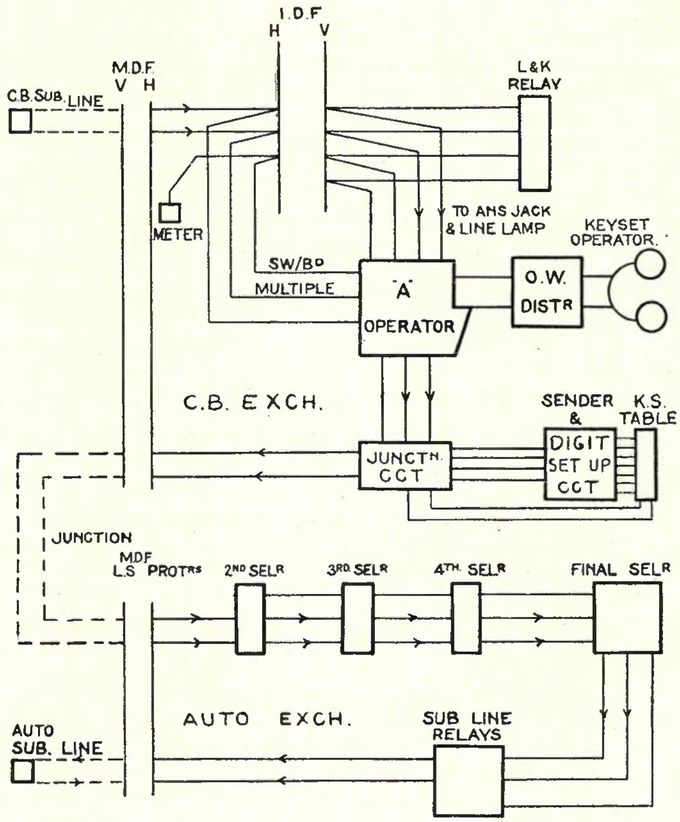
Q. 6.—(a) In a large city central exchange, there are 8000 lines connected to a C.B. multiple switchboard, and key senders are installed. Show by block schematic diagram the links in a call to a 6-figure automatic subscriber.

(b) If a general complaint of "No Progress" is made, what would be your course of investigation?

(c) What maintenance precautions do you consider necessary for successful operation of the key sender apparatus?

A.—(b) A "No Progress" fault is one which occurs somewhere in the stage following the allotting of a junction by the key sender operator. It thus excludes possible order wire troubles. A general complaint means that the fault is in some equipment common to a number of calling subscribers. Assuming that the power supply is correct, first examine the impulse machines. If there is nothing obviously wrong here, test the weight and speed of the impulses being delivered. In Melbourne Central Exchange, one impulse machine serves two keyboards, i.e., six senders. Therefore, unless the fault is already known to be in one group, one sender on every alternate board should be tested.

If impulse machines are correct, a sender must be out of order. In this case the A operator would soon notice it and the particular keyboard would be known. The particular sender would then be examined. There



is no other equipment common to more than one junction, therefore the fault causing "No Progress" would be found in an impulse machine or in a sender circuit.

(c) Daily maintenance tests on all the equipment associated with the key senders are essential. There are two routine tests that will ensure satisfactory service:

(1) Each of the three senders on each table is connected, in turn, to a portable test set. This test set contains relays adjusted to operate only from impulses of correct weight and speed, and lamp supervision shows that the digits set up are sent out correctly.

Ten (10) successive calls are then sent out for each sender, each call testing one digit. (A digit key is operated five times to correspond to one call). Five flickers on the particular lamp on the test set indicate that the sender circuit, the digit set up circuit and the impulse machines are correct. The supervision on each call is observed and the correct operation of each key is noted.

(2) The junction test is done from each sender on each table on each junction. The digits O8. are set up and sent. A returned tone shows that the junction circuit is correct and the supervision on the junctions is noted.

(To be continued.)

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