THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

VOL. 29 OCTOBER, 1936 PART 3.

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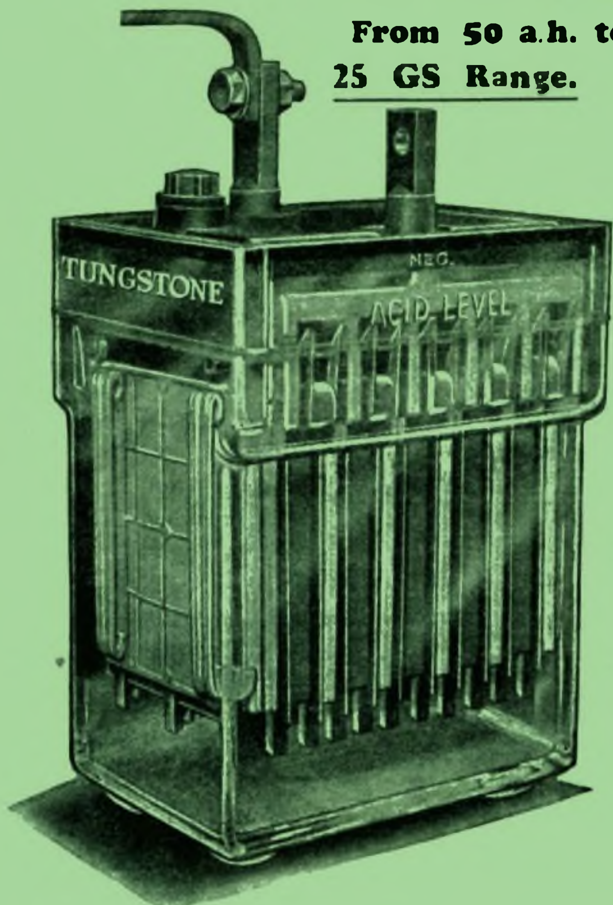

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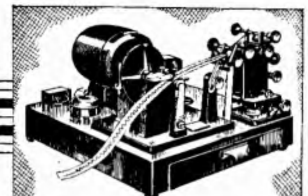

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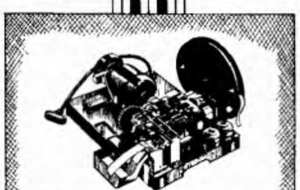

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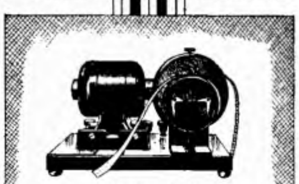

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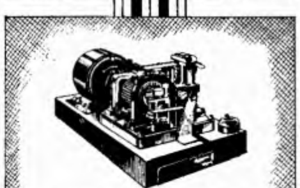

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TELEPHONE KIOSK No. 6.

THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

Vol. XXIX October, 1936 Part 3

Kiosks

By F. J. JUDD

A brief review of the earliest types of telephone kiosks is given and the new Jubilee Kiosk described

Introduction.

IT may come as a surprise to many to be reminded that the now well known and extremely useful telephone kiosk is a comparatively recent innovation as apart from a very small number provided by the National Telephone Company, the first kiosks, constructed in wood, were not introduced until 1912 and then only in very limited quantities.

In 1913 concrete construction was first mooted, but it was not until 1918 that serious consideration was given to this form of manufacture. In 1921 kiosks modelled to the same design as the wood structure made their appearance.

In view of present day activities in connexion with the provision of kiosks it may be of interest to note that in 1918 it was considered undesirable, owing to the supposed reasons of misuse and theft, to provide kiosks unless there were no alternative.

Kiosks, Nos. 1, 2 and 4.

The original type of kiosk, known as Kiosk No. 1 (Fig. 1), left much to be desired from an appearance point of view and when it was realized in 1927 that the kiosk had come to stay and increase in number, the eminent architect, Sir Giles Gilbert Scott, R.A., was commissioned to furnish a new design, resulting in the introduction of the cast iron kiosk No. 2 (Fig. 2) now so well known in the Metropolitan area and perhaps to a somewhat lesser degree in the larger provincial cities.

A telephone kiosk combined with a stamp-selling machine, known as kiosk No. 4 (Fig. 4) designed on the general lines of kiosk No. 2, but of more generous dimensions, has been provided to meet special circumstances, and 50 such structures are at the present time in existence, but further provision of this class of kiosk is not being made.

The Concrete Kiosk.

Owing to the high initial cost of kiosks No. 2 it was decided to give further attention to the possibilities of improving the appearance of the concrete type structure and in 1929 kiosk No. 3 (Fig. 3), again to a design by Sir Giles Gilbert Scott, made its appearance and was adopted for general use in urban districts, the cast iron model No. 2 being utilized as the standard for the Metropolitan area and for a limited number of sites possessing outstanding architectural interest in other localities.

The scheme of decoration was given close attention and the designer finally recommended the well-known light portland (Clipsham) stone with window and door frames in Post Office red.

Experience has proved that concrete generally is difficult to obtain in standard quality and in spite of every precaution being taken by the periodical testing of samples of cement and aggregate, difficulties arise in the form of disintegration and scaling, etc., and such troubles are difficult to deal with efficiently and economically.

The handling and transport of concrete kiosks which, in spite of care in design and construction, are inherently fragile, presents difficult features and these disadvantages, coupled with the ever-present problems associated with the necessity for maintaining a satisfactory appearance, have finally led to the abandonment of concrete and the adoption of cast iron as the one standard for future provision.

The Jubilee Kiosk.

The new kiosk No. 6 (Fig. 5), perhaps already better known as the Jubilee Kiosk, has been designed by Sir Gilbert Scott and has been approved by the Royal Fine Arts Commission. The policy of substantially increasing the number of telephone kiosks in rural areas has rendered it highly desirable to give careful consideration to the choice of a decorative scheme that will ensure adequate advertising value to the telephone service, and the choice of colour somewhat naturally falls to the familiar Post Office red. This colour, although not without objections from some quarters on æsthetic grounds has nevertheless received the approval of the Royal Fine Arts Commission and this approval is supported by the Councils for the Preservation of Rural England, Wales and Soctland, thus placing the Post Office in a particularly strong position to justify the choice made.

Kiosk No. 6, as would be expected from the source of architectural design, presents particularly fine proportions and simple, dignified lines. The over-all dimensions are:—Height, 8 ft. 4 in.; width, 3 ft. 0¼ in.; depth, 3 ft. 0¼ in., with a door height of 6 ft. 5¼ in. A modernistic touch, not over-emphasized, is introduced by the horizontal glazing scheme and this feature furnishes a remarkably free view from the inside of the kiosk.

Fig. 1.—Kiosk No. 1.

Fig. 2—Kiosk No. 2.

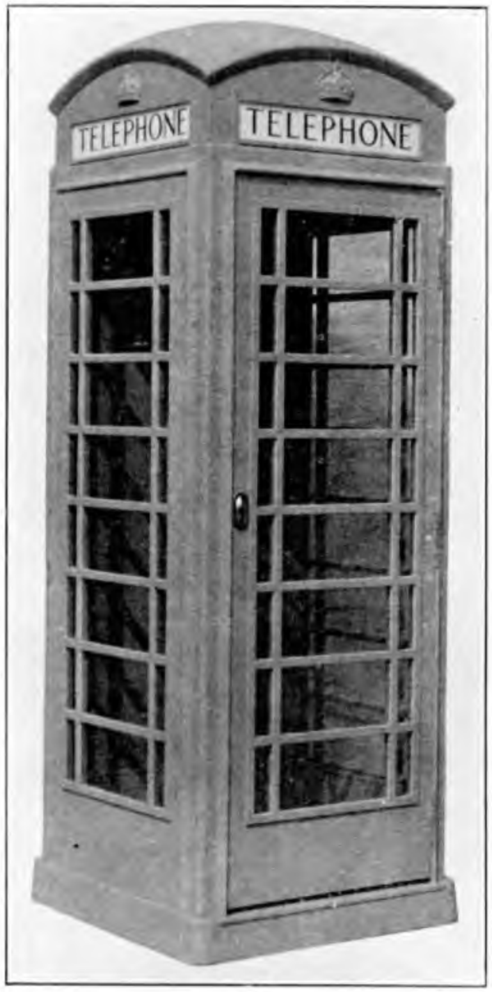


Fig. 5—Jubilee Kiosk.

Fig. 3—Kiosk No. 3.

Fig. 4—Kiosk No. 4.

The kiosk comprises 18 cast iron parts consisting of:—

1 cill frame;
2 corner pillars prepared for door and side;
2 corner pillars prepared for side and back;
1 transom rail for top of door;
1 transom rail for back;
2 transom rails for sides;
2 crown panels for front and back;
2 crown panels for sides;
1 dome top.
2 side panels prepared for glazing;
1 solid back panel;
1 glazing frame for door.

There are also 24 large and 48 small glazing frame beads.

The kiosks are all best tough grey cast iron thoroughly cleansed and dressed, and considerable care is taken to ensure that all joints are carefully faced and fitted and all screw holes are accurately drilled to template. Every kiosk has to be completely erected on the contractors' premises, the glazing completed with 26 oz. glass, the door hung and restraining straps fitted. After approval by the Department's testing officer the kiosks are dismantled and held pending demand. The door of the kiosk is constructed in teak and the total weight of the structure without apparatus is $13\frac{1}{2}$ cwt.

A new form of door-closing spring is provided giving, by oil check action, a strong, rapid movement for travel up to approximately 1 inch of the closed position, the final movement being entirely without shock.

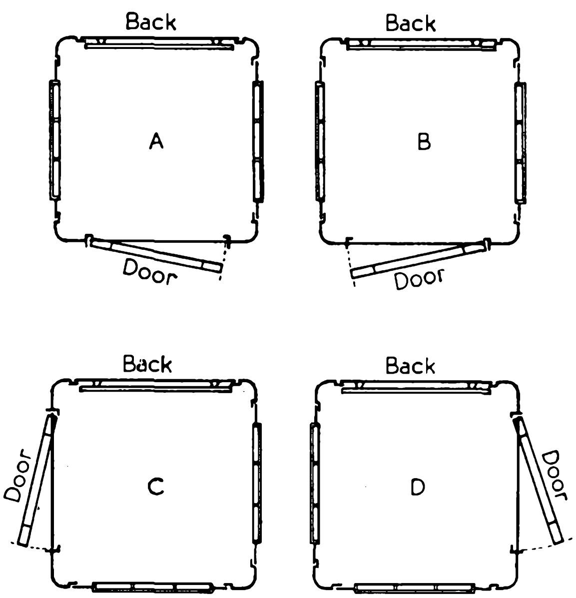


Fig. 6—Four Types of Kiosk No. 6.

To suit all locations the kiosks are made in four types, a, b, c and d as shown in Fig. **6**. The glass "Telephone" signs are normally fitted on all four panels, but where the back or side panel is situated against a wall or building of greater height than the kiosk, clear glass is fitted in the panel adjacent to the obstruction in lieu of the special "Telephone" sign.

Elongated holes are provided in the unglazed panel of the kiosk for leading-in telephone and electric light wires, but where it is essential to adopt an overhead lead-in for the telephone service a special bracket has been designed for this purpose.

Erection.

The erection of a cast-iron kiosk calls for considerable care to ensure uninterrupted progress of the work, and the following brief details of the operations may be of interest:—

It is desirable that the erection should be arranged to ensure that the work, including filling the cill frame with concrete, can be completed in one day.

(a) The cill frame complete with levelling screws is placed in position and corner pillars secured by screws.
(b) Back and side panels are then placed in position similarly secured.
(c) The four transom rails are secured to the top of the corner pillars and side panels.
(d) The crown panels are fitted.
(e) The dome top is fitted.
(f) The door is hung together with the restraining straps and door closing spring.

As the above processes are carried out all joints are lead painted and served with putty and all screws gradually tightened, surplus putty which exudes from the joints being removed. After hanging the door the vertical alignment of the kiosk is tested and final adjustments made. The cill frame is then filled with concrete and finished with a granolithic surface with slight fall towards the door.

Conclusion.

The telephone apparatus used in connexion with the No. 6 kiosk has been dealt with in detail in another article,[1] and it is suggested that the combination of what must be considered one of the best telephone kiosks in existence and the finely finished, well-balanced equipment with its attractive and serviceable layout, should leave little to be desired by the call office using public. At the same time all concerned in Post Office activities will have reason to feel some satisfaction in the introduction of such high standard equipment.

[1] Call Offices. W. A. Collett, *P.O.E.E.J.*, Vol. 29, page 178.

Call Offices

W. A. COLLETT

A description is given of the modern developments in the design of call office equipment and circuits.

Introduction.

THE general term, Call Office, covers all installations at which originated calls are paid for by the caller at the time the connexion is set up. The call office may or may not be equipped with a coin box. The latter type consists of a simple telephone of the microtelephone type, the call being obtained and the fee collected and recorded by the attendant. The disadvantage of this type of call office, in so far as it is available for public use only during the hours that the attendant is present, is recognized and the erection of call office kiosks, affording continuous service, either in addition to or in replacement of the existing arrangements is proceeding rapidly. By the end of this year the large schemes for the extension of the public call office service, now in progress throughout the country, should be completed, and by then the inhabitants of even the smallest hamlet in Great Britain, will, by means of its call office kiosk, be able to enjoy the same facilities afforded by the telephone as the inhabitants of the large cities.

Passing from the simplest type of installation, that of the kiosk on the quiet village green in the remote corners of the country, where the traffic carried may not average one call per week, the range extends to the very large suites of call office cabinets in the metropolis, which during the busy hours of the day provide some of the most heavily worked circuits on the whole telephone network.

The nature of the traffic carried varies from the usual everyday personal or business call to the extremely important emergency call in respect of fire, police and ambulance services. The public call office is still the principal and in many cases the only means of speedy access to these vital services, and it is found that as between the busy call office and one comparatively isolated and little used, the latter carries by far the greater proportion of calls of an emergency nature; also, the latter class of call office carries a far greater proportion of calls originated by persons unused to handling a telephone.

From the foregoing it will be appreciated that the process of establishing a normal call from a call office should demand as little as possible in the way of additional operating on the part of the caller to that which would normally be required for a similar call from a subscriber's installation and less, if possible, for emergency calls. Although development of call office equipment has by no means reached finality, the desired conditions are reasonably met in the new call office equipment.

In addition to the service aspect, it is recognized that a call office kiosk or cabinet, in presenting a high standard in so far as appearance is concerned, is one of the best possible publicity mediums, by virtue of the fact that it is the main point of contact between the telephone service and the non-subscriber. The call office equipment has therefore been redesigned and a new wallboard of exceptionally pleasing appearance introduced. These developments in equipment and layout, combined with the Jubilee kiosk[1] designed by Sir Giles Gilbert Scott, constitute a very definite step in the improvement of the appearance of public call offices.

New Layout arrangements for Public Call Offices.

The new wallboard, which is illustrated in Fig. 1, is designed in the modern black and silver style, being constructed of bakelite-faced plywood with stainless steel fittings. Bakelite-faced plywood, a laminated board or plywood to which is cemented a facing of thin bakelite sheet, is a comparatively new material and, except in so far as it has been used in some examples of modern shopfitting, this is perhaps the first time it has been introduced as a utility item for general use on a large scale. Bearing in mind the rough treatment which the call office equipment has to withstand at times, and the com-

FIG. 1.—WALLBOARD ASSEMBLY.

[1] Kiosks. F. J. Judd. *P.O.E.E.J.*, Vol. 29, page 175.

paratively exposed conditions of a kiosk subjected to the extremes of temperature and humidity throughout the seasons, this material will undoubtedly be subjected to very exacting tests and it will be interesting to note how it stands up to the demands made upon it.

The complete wallboard is in two parts. The upper part carries the instruction card in the frame on the left, the tariff card in the frame on the right, a publicity notice in the frame at the top centre, a mirror in the centre and the emergency call notice with, in the case of the manual (CB) system, the emergency calling button in the frame at the bottom centre. All these frames are made of stainless steel and in view of their special construction will be dealt with in greater detail later.

The lower part of the wallboard carries a receptacle on the left, in which callers may temporarily deposit parcels and a receptacle on the right to hold the directories. The back of this part of the wallboard and the sides of the two receptacles are of ebonized wood. The bottoms of the two receptacles have the words PARCELS and DIRECTORIES respectively embossed thereon. The top of each receptacle is of bakelite-faced plywood with a nosing of stainless steel. A stainless steel fitment in which a caller may rest a pipe or cigarette, with an open grille through which the ash can fall is let into the top of the parcels receptacle and a hook to support an umbrella is fixed to the underside of the bottom of the directory receptacle.

In order that the joint between the upper and lower parts of the wallboard should be as unobtrusive as possible it is arranged that this is behind, and about half an inch below, the top of the receptacles and coin box. An accurate joint is ensured by means of a tongue on the upper part which fits into a corresponding groove on the lower part; lateral movement of the two parts is prevented by a dowel in the centre of the tongue and groove.

The coin box is fitted in the centre of the wallboard, the top being level with the top of the two receptacles, forming in effect a shelf across the whole width of the kiosk. This shelf is at such a height that the top of the directories receptacle can conveniently be used by the caller as a writing desk.

The telephone, which is of the microtelephone type, is secured to the top of the parcels receptacle in the following manner. The base, which is without the usual four rubber feet, is first screwed to the shelf through four suitably placed holes. The body of the microtelephone is then screwed to the base by means of two trapped screws in the base, access to these screws being gained by two clear holes in the shelf. It will be appreciated that for maintenance purposes it is not necessary to remove the base; the body of the microtelephone is readily removed from the base by releasing the two trapped screws.

Apart from the lead-covered leading-in cable, the cord from the telephone is the only wiring passing behind the wallboard. This cord is of the tough rubber covered type and, in view of the past difficulties experienced in some localities due to low insulation, it is considered that this arrangement is a marked improvement and should materially assist in maintenance.

In order to provide an adequate safeguard against theft and as breakages are not anticipated to be frequent, the frame carrying the mirror has been secured by screws passing completely through the wallboard and nutted at the rear. The other frames have been specially designed with a view to affording the easiest possible means for the replacement of the various notices consistent with a reasonable safeguard against interference by unauthorized persons. An important point which has received careful consideration in the design of these frames is the prevention, so far as possible, of the entry of dirt and damp, which was more or less inevitable with the old type wood frames with the opening at the top. The construction of these frames is illustrated in Fig. 2.

(a) and (b) are two strips of channel brass which are screwed to the wallboard horizontally, (a) at the top and (b) at the bottom levels of the frame. The notice, glass and pasteboard backing sheet slide into these channels from the side. Over the whole of the foregoing assembly is placed a stainless steel cover in the form of a surround. It will be seen that this surround has two dowels riveted to the inside of the top edge which register with two holes in the top of the channel (a). The surround is first hung on the top channel and then pressed home over the bottom channel. In so doing the two projections on the bottom edge of the surround engage and lock on the steel spring catch in the bottom channel. This catch is in fact a double catch in so far as it is fixed at its centre with both ends free, each engaging independently with the relative pin in the surround. Two small holes are provided in the bottom of the surround to afford access for the release of the spring catch. It will be appreciated that the provision of a double catch, both sides of which must be operated together to release the surround, materially reduces the risk of unauthorized interference with the notice. To facilitate the removal of the surround, the key

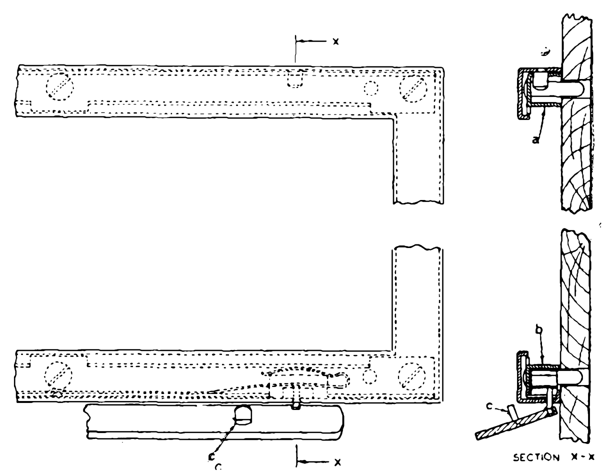


Fig. 2.—Construction of Notice Frame.

shown at the bottom has been introduced. This key, made of mild steel, has two pins which register with the corresponding holes in the bottom of the surround. An upward pressure with this tool will release both sides of the spring catch and easing the surround forward enables it to be readily removed. In order to safeguard against the risk of scratching the surface of the wallboard when using this tool the two projections (c) are provided. These projections engage on the front of the surround and thus the back edge of the tool is kept clear of the wallboard.

To change a notice card, the surround is first removed as indicated above and the card bent forward and withdrawn. To fit a new glass, it is necessary to unscrew and remove the top channel.

The special emergency notice for manual (CB) systems is by virtue of the information it conveys, required to be displayed in a prominent position and, in addition, in as close proximity to the emergency press button as possible; to meet these requirements the label has been designed to surround the press button.

This arrangement precludes the use of any form of protective covering and the notice must therefore be of a durable nature. The use of the more usual forms of engraved notice with coloured filling suffers from the disadvantage of discolouration and falling out of the filling and recourse has therefore been made to a comparatively new material. The material chosen is laminated bakelite having a black upper surface on a white base. The lettering appears white on a black background by engraving completely through the black upper surface to the white base below.

The notice has a hole in the centre through which passes the barrel of the press button and to enhance further the appearance of the assembly the brass flange of the press button is covered with a stainless steel cap.

In the design of the new wallboard endeavour has been made to obscure, as far as possible, all items of equipment with which the caller is not directly concerned. The apparatus usually mounted in the bell set and the auxilliary apparatus required for prepayment coin box working on the manual (CB) system and certain U.A.X. systems is now mounted inside the coin-box. (These items will be dealt with in greater detail later). There are, however, two items, the protector, and the local speaking battery for CBS systems, which are not readily adaptable for mounting in this manner. The protector, when required, will be screwed to the right and near to the top inside the parcels receptacle. As this item is already in a black material and harmonizes reasonably well with the general appearance of the layout, no further covering is considered necessary. The local speaking battery must, of course, be protected against interference and at the same time it must be unobtrusive. These two factors have been met by mounting the battery at the rear of the parcels receptacle behind an ebonized wood partition. The battery normally consists of two dry cells type DR2, but where transmission requirements necessitate it, i.e., for long lines, etc., three cells are provided. The receptacle accommodates two cells in the normal upright position but when three cells are used, they must be placed on their sides, one above the other. Since the bottom of this receptacle is metal covered a rubber mat is provided on which to stand the battery in order to ensure adequate insulation.

Coin-Boxes.

The multi-coin box, which permits the insertion of fees up to any amount, thereby enabling a caller to make toll and trunk calls without the assistance of an attendant, is the standard for all coin box installations. With the exception of a few call office suites where trans-continental and trans-Atlantic calls involving very large fees are handled, and some special suites such as those serving stock exchanges, where special operating procedure is required due to the nature of the business transacted, the services of an attendant have been abolished.

The multi-coin box is available in two types, the prepayment coin box which is the standard for use on automatic and manual (CB) systems, and the postpayment coin box which is the standard on all local battery systems.

With prepayment working on an automatic system the insertion of two pennies in the coin box, in advance, enables the caller to dial any number within the local fee area and the call is completed automatically without the assistance of the telephonist. Toll and trunk calls are obtainable via the manual board telephonist by dialling " O." No money is inserted before dialling " O," the whole of the fee for these calls being inserted at the request of and under the supervision of the telephonist. Emergency calls are also obtained by dialling "O" but no charge is, of course, made in respect of these calls.

On the manual (CB) system it is necessary to insert two pennies to call the exchange for all calls except emergency calls. Emergency calls are obtained by pressing the special emergency call button which causes a distinctive calling signal to be displayed on the exchange switchboard. All calls are completed manually, the telephonist checking the insertion of the additional fee required for toll and trunk calls.

On local battery systems, prepayment working offers no advantage over postpayment working. Any small saving which might be effected in operating costs would not compensate for the provision of the more complicated and expensive prepayment box. In postpayment working, it is not necessary to insert any portion of the fee in order to call the exchange, the whole fee being inserted at the request of and under the supervision of the telephonist after she has obtained the wanted party and is holding that party in readiness to complete the connexion.

As previously stated the apparatus normally mounted in the bell set and such auxiliary apparatus as is required for manual (C.B.) and certain U.A.X. systems, are now mounted at the back of the mechanism compartment of the coin box.

To effect this modification four new bell sets have been introduced, for

(a) automatic systems (other than U.A.X.'s Nos. 5 and 6).
(b) U.A.X. Nos. 5 and 6 systems.
(c) C.B. exchanges.
(d) C.B.S. exchanges.

Each of these units is completely self contained and inter-changeable, utilizing the same mild steel mounting plate. The bell set required for use in C.B. areas is shown in Fig. 3. This feature of inter-changeability is of particular value at the time of the conversion of the exchange system of working. As an instance, the conversion from manual (C.B.) to automatic working can be made by the substitution of the C.B. bell set by the automatic bell set and the provision of a dial.

It will be observed that three key hole slots are provided in the mounting plate and these are so placed as to engage with three screws in the back panel of the coin box used for mounting the unit.

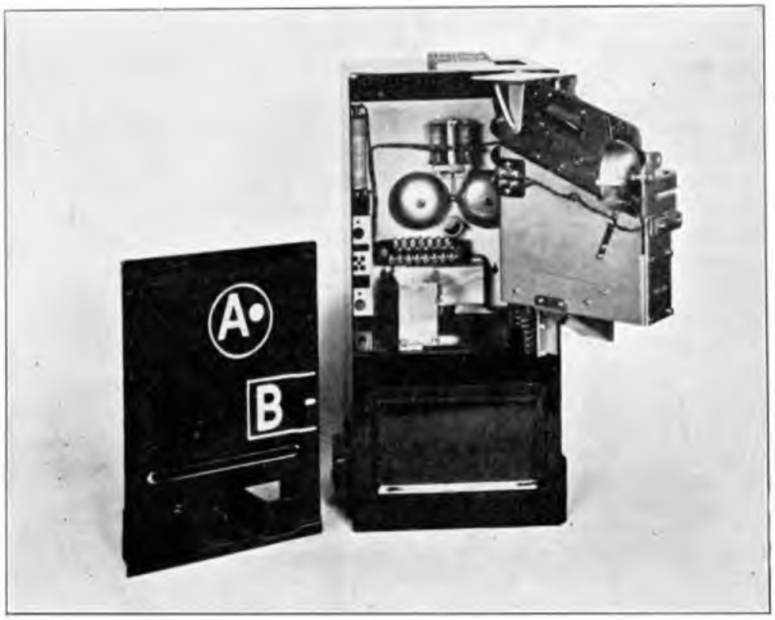


Fig. 4.—Prepayment Multi-Coin Box.

Fig. 4 shows the prepayment multi-coin box as used on public call offices in automatic and manual (C.B.) areas; the bell set shown mounted at the rear of the coin box is that used for automatic systems other than U.A.X.'s Nos. 5 and 6. In this coin box, as in all coin boxes used on public call offices, the cash is withdrawn by means of a sliding plate in the bottom of the cash receptacle. This plate is secured by means of a combination lock let into a recess on the left-hand side of the box.

Fig. 3.—Bell Set for Manual C.B. System.

In the corresponding coin box for use on subscribers' circuits the cash receptacle is in the form of a drawer. This arrangement is necessary as the coin box is often required to be secured to the top of a desk or table. The drawer is secured by means of a padlock.

The postpayment multi-coin box used on C.B.S. 1, 2 and 3 systems is generally similar. Only one bells set is used, the necessary circuit modifications being made on the connexion strip.

Prepayment Mechanism (Fig. 5.)

On the top of the mechanism is a plate having three slots through which coins are inserted.

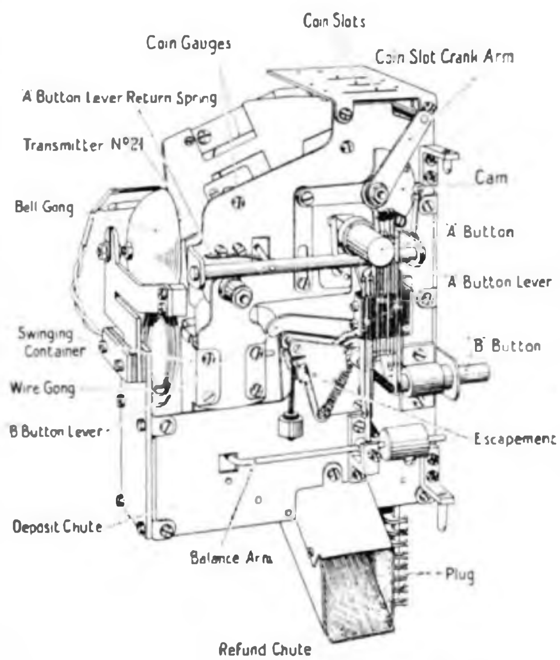


Fig. 5.—Prepayment Mechanism.

These slots are just large enough to permit the insertion of a penny, a sixpence and a shilling respectively. Coins larger than the correct denomination or mis-shapen coins cannot be inserted and in order to guard against wear, with consequent variation in the gauging, this plate is made of tool steel.

Each of the slots is situated over an inclined coin guide which carries a gauge to check against coins smaller than the correct denomination. To illustrate the action of these gauges the penny guide and gauge are shown in detail in Fig. 6 It will be observed that the guide is inclined in two directions, the inclination downwards causes the coin to roll past the gauge and the tilt backwards ensures that the coin, which is given an initial inclination by the tilting plate at the top of the guide, is bound to make contact with the gauge. The aperture formed by the gauge is the minimum acceptable diameter of the particular coin concerned; acceptable coins will,

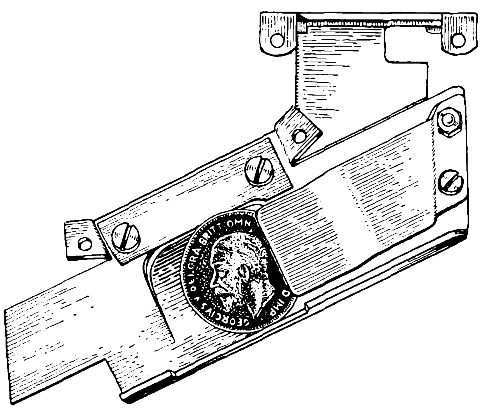


Fig. 6.—Penny Guide and Gauge.

therefore, be supported past the gauge, whereas smaller coins will fall through. Rejected coins, that is coins which have fallen through the gauge, are returned to the caller via the refund chute on the front of the coin box.

Directly below the coin slots is a crank arm. The first coin inserted operates this arm which causes a cam to rotate and operate spring assembly No. 1. The cam is retained in the operated position by a flat steel spring furnished with a roller engaging in a recess in its periphery.

At a short distance from the end of the coin guides are fixed the gongs which, in conjunction with the coin box transmitter, transmit distinctive sounds to the telephonist to permit a check of such additional fees as may be required for toll and trunk calls. The distance between the gongs and the coin guides is slightly greater than the diameter of the coins and they will, therefore, fall past the gongs. The momentum gained in rolling down the inclined guide, however, ensures the coins striking the gongs before falling.

The coin box transmitter is a simple microphone button modified for this particular purpose by substituting a thin ebonite diaphragm in place of the usual mica diaphragm and packing the granule chamber full and tight with carbon granules. The button is thereby made practically unresponsive to speech, functioning only in response to mechanical vibration. The button is fixed inside the bell gong used to transmit the silver signals; a sixpence strikes the bell once on the bottom edge, a shilling, by means of a double guide, is caused to strike the bell gong twice, first on the top edge and then on the bottom edge.

Alongside the bell gong and at the end of the " penny " guide is fixed a wire gong; each penny inserted strikes this wire gong once. This wire gong is rigidly fixed to the same mounting as the bell gong and the vibrations of the former are transmitted to the coin box transmitter by vibration of the mounting. As the bell gong emits a high-pitched note and the wire gong a low-pitched note, distinctive signals in the form of one high-pitched note for a sixpence, two high-pitched notes for a shilling and one low-pitched note for a penny are transmitted to the telephonist.

It will be noted that the whole of the gong assembly is mechanically insulated from the remainder of the coin box. This course is necessary in order to guard against the voice of the caller being picked up by the coin box transmitter. In the early types of prepayment coin box it was found that a conversation of a reasonable commercial standard could, in some circumstances, be carried on even with the telephone transmitter short-circuited. It was at one time thought that this was due to the caller's voice reaching the coin box transmitter via the refund chute. Exhaustive tests, however, proved that the real cause was the vibration of the casework, in response to the caller's voice, being transmitted to the coin box transmitter, the response of the coin box transmitter to direct sound pressure being practically negligible. The obvious remedy was to insulate the gong assembly mechanically and it is, therefore, now mounted on pads of soft rubber with rubber collets and washers on the fixing screws.

Each coin after striking its respective gong falls down the swinging container and comes to rest on the balance arm.

The balance arm performs two functions, the first of which is to check the correctness of the initial fee, i.e., 2d., for local calls. To do this it is adjusted by means of the sliding weight so that it will just operate with the weight of two well worn pennies. The second function of the balance arm is to support all coins inserted and to hold them in suspense until the fee is deposited and conversation with the called party is established by depression of button A or the call abandoned and the fee refunded by depression of button B. The operation of the balance arm operates spring assembly No. 2.

The "A" button operates the A button lever which restores spring assembly No. 1 and also causes the swinging container to swing to the left over the deposit chute. In so doing all coins held in suspense are tipped off the balance arm and caused to fall through into the cash compartment. The release of the coins from the balance arm allows it to return to its normal position, thereby restoring spring assembly No. 2.

The depression of the "B" button operates the B button lever which causes the swinging container to swing to the right, and all coins held in suspense are caused to fall into the refund chute and are returned to the caller. The release of the coins from the balance arm allows it, as before, to return to its normal position and to restore spring assembly No. 2. The B button lever also operates the portion of the A button lever which restores spring assembly No. 1.

In addition to the foregoing, the "B" button operates spring assembly No. 3. The restoration of this spring assembly is controlled by the escapement mechanism which, by means of a pendulum bob, is adjusted to restore in approximately seven seconds.

Post-payment Mechanism. (Fig. **7.**)

With this simple coin box it is necessary only to check each coin inserted and indicate to the telephonist the denomination of each coin accepted. Accepted coins fall direct into the cash compartment, rejected coins being returned to the caller via the refund chute.

The coin slots, guides, gauges, gongs and coin box transmitter are precisely the same as and perform similar functions to those in the prepayment box.

The coin slot crank arm is, however, directly engaged with the change-over spring assembly and escapement mechanism. As each coin is inserted it engages the coin slot crank arm which, in turn, operates the change-over spring assembly. The spring assembly returns to normal under control of the escapement mechanism in 1½ to 2 seconds.

To enable the postpayment coin box to be used in conjunction with the new wallboard, and also in order to accommodate the bell set inside the coin box, it has been necessary to make use of the large outer case, as used for the prepayment box. In fitting the postpayment mechanism, which is smaller than the prepayment mechanism, in the large case, a gap is left between the coin chute and the aperture through which coins are deposited in the cash compartment. A coin chute extension, to bridge this gap, has therefore been introduced and this is screwed to the mechanism in the manner shown in Fig. **7.** Although the top fixing lug on the postpayment mechanism is in the same relative position as the top lug on the prepayment box, the positions of the bottom lugs do not correspond. The bottom lug on the postpayment box is, however, in the same relative position as the "B" button on the prepayment box and as the aperture for the "B" button in the casework needs to be covered, it has been possible to introduce a simple fitment which serves both as a means of blocking the "B" button aperture and also as a support for the bottom lug on the postpayment mechanism.

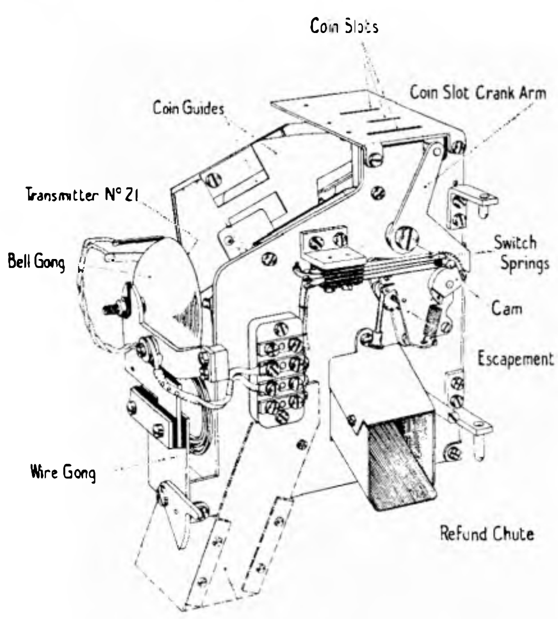


Fig. **7.**—Postpayment Mechanism.

Fraud Preventive Devices.

It is a well known fact that a receiver will function very satisfactorily as a transmitter and advantage has sometimes been taken of this fact to avoid the deposit of the calling fee. It is difficult to degrade the transmitter effect of the receiver without also degrading its performance as a receiver but after exhaustive tests it has been found that a 200 ohm non-inductive shunt placed across the receiver while the money is in suspense effectively bars the use of the receiver as a transmitter for average line conditions, although its fraud preventive value decreases on very short lines.

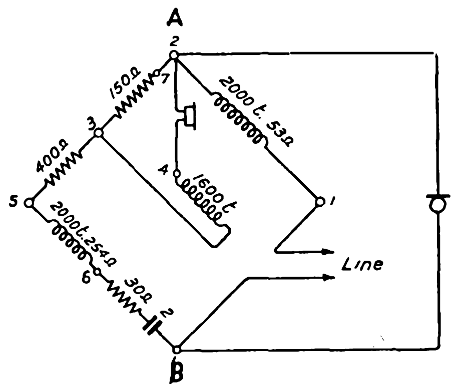
One very important factor which must not be overlooked in fraud preventive devices is the relation between the possible loss in revenue due to perpetration of the fraud and the cost of providing a preventive device. A preventive device has been developed for every known type of fraud, but the relation between the losses and the cost of the device does not always warrant the expense, or the resultant complication of the mechanism or circuit, which would result from its inclusion.

Transmission Circuits.

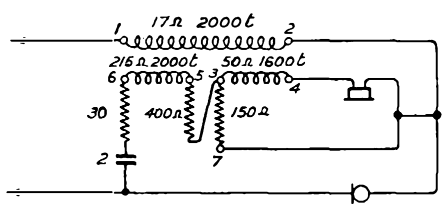
The transmission circuit for automatic and manual (C.B.) systems employs the new arrangement for the suppression of side-tone, which is of even greater importance in call offices than in subscribers' stations in view of the noisy situations in which many call offices have to be placed. Very often the more desirable the site for a call office both from the viewpoint of meeting the public need and from its revenue earning capacity, the more serious is the effect of extraneous noise, and the provision of some form of side-tone suppression becomes a necessity if satisfactory working is to be maintained.

A comprehensive explanation of the new anti-side-tone arrangement would be somewhat complicated and would need to be dealt with mathematically and this is perhaps outside the scope of an article of this nature. A simple, non-mathematical, explanation can, however, be arrived at if the essential portions of the circuit only are considered in the form of a "bridge," as indicated in Fig. **8a.**

Both the inductive and non-inductive windings are wound on the same core; the complete item being known as the anti-side-tone induction coil. In Fig. 8a the resistance shown against each winding is its A.C. resistance at 800 c.p.s. Fig. 8b, which shows the coil in its conventional form, should enable the " bridge " to be readily comprehended when considering the complete circuits dealt with later; in this figure the resistance shown against each winding is its D.C. resistance. Referring to Fig. 8a and considering the transmitter as a generator of alternating current, the current generated will divide at the points A B between the two paths 2-3-5-6-two μF condenser and 2-1-line. If the impedances of the two paths are identical the currents will be



(*a*) THEORETICAL CIRCUIT.



(*b*) PRACTICAL CIRCUIT.

FIG. 8.—ANTI-SIDE-TONE TELEPHONE CIRCUIT.

equal and in phase—and as the two 2,000t windings are in opposition—no E.M.F. will be induced in the 1,600t winding. However, as the line impedance varies considerably, the currents in the two 2,000t windings will not be exactly equal, or in phase, and some degree of side-tone will persist. In order therefore to effect a further reduction, the lower end of the 1,600t winding is tapped to a point 3 and the P.D. developed across the resistance 2-3 will cause a current to flow in the receiver path. The current flowing in the receiver path due to the P.D. across 2.3 and the current induced in the 1,600t winding by the out-of-balance conditions of the bridge will oppose each other and it is assumed, with the particular values used in the design of this coil, that these two currents will be as nearly as possible equal and opposite, thereby reducing the side-tone to a minimum. The function of the condenser in the " bridge " is to ensure that the current flowing in the path 2-3-5-6 has a negative angle. This factor, bearing in mind that with very few exceptions the current from line has a negative angle, is essential in order to ensure that the current in each arm of the " bridge " shall be in phase.

As regards the reception of speech incoming from line, the received current, ignoring the shunting effect of the transmitter which is small and has little effect on the overall performance, will take the path 1-2-3-5-6. In this direction the two 2,000t windings assist each other in inducing an E.M.F. in the 1,600t winding. The path for the receiver and the 1,600t winding is completed *via* the non-inductive winding 2-3; the two currents in the winding 2-3 due to the current received from line and the induced current through the 1,600t winding are in the same direction.

The following table shows the number of db's reduction in side tone when using the anti-side-tone induction coil as compared with the telephone No. 162, each being connected to similar lines of various types.

Junction.	Local Line.			
	Type.		Resistance.	
		350 ohms.	176 ohms.	80 ohms.
		db	db	db
Non-reactive Z_0= 600 ohms.	non-reactive	– 9	–11	–11
	10 lb. cable	– 3	–12	–10
	20 lb. cable	– 3	– 7	–13
20 lb. cable	non-reactive	–12	– 9	–10
	10 lb. cable	– 1	.0	– 7
	20 lb. cable	– 3	– 4	– 5

Tests under working conditions, with average amounts of noise picked up by the transmitter, show that the reduced side tone effects an improvement in reception compared with a telephone No. 162, equivalent to a reduction in line attenuation of about 3 db. There is also the psychological factor, in so far as the reduced side-tone causes the speaker to speak more loudly, which results in a further improvement amounting to 2 to 3 db.

The transmission circuit arrangements for the local battery systems employ the normal three-winding induction coil which can be considered as an auto-transformer, the three windings being arranged to match as nearly as possible the impedances of the line, receiver and transmitter respectively. No attempt is made in this arrangement to effect suppression of side-tone; the need for such a device is however recognized and will, no doubt, be incorporated later when the development work now proceeding is completed.

CIRCUIT OPERATION.

Automatic System. (*Fig.* 9)

To originate a local call the user removes the microtelephone and inserts two pennies in the " Penny " slot. The insertion of the first coin causes the crank-arm to operate spring assembly (1).

(1)A serves to shunt the receiver with a 200-ohm resistor, thereby degrading the receiver to such an extent as to prevent its misuse as a transmitter when the call has matured.

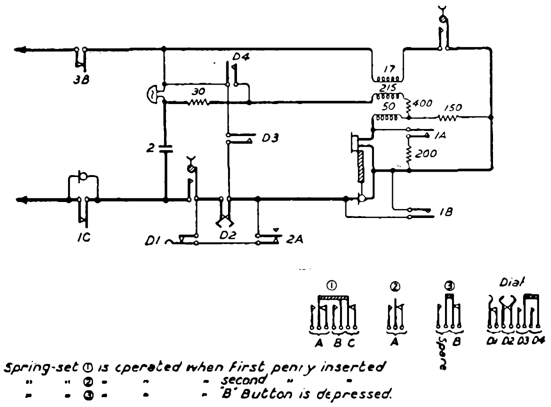


FIG. 9.—PREPAYMENT CIRCUIT, AUTO SYSTEM.

(1)B short-circuits the transmitter to ensure that transmission is not possible until the springset has been restored to normal, i.e., by operation of the "A" button.

(1)C opens the circuit of the coin-box transmitter to enable the operator to check the denomination of coins should the caller desire a trunk or toll call.

The second penny—by its added weight—operates the balance arm and effects the change-over of spring assembly (2).

(2)A removes a short-circuit from the dial impulsing springs to allow dialling to proceed.

The caller proceeds to dial the required number, and while the dial is off-normal contacts D3 and D4 close.

D3 short-circuits the telephone circuit.

D4 short-circuits the bell *via* the 30-ohm resistor to avoid bell tinkling.

In addition, D3 and D4 complete a spark quench circuit for the dial impulsing springs by connecting the 2 μF condenser and 30-ohm resistor across D2.

On hearing the wanted subscriber answer the caller will depress button A to deposit the calling fee. This action allows springsets (1) and (2) to return to normal, thus restoring the circuit for transmission purposes to the equivalent of a subscriber's standard termination.

Ineffective Calls.—When a call cannot be completed, e.g., line engaged, the caller will, on receiving busy tone, depress button B to recover the suspended coins; this action will restore spring assemblies (1) and (2) and operate spring assembly (3), which is held in the operated position for approximately 7 seconds by the action of a mechanical escapement; during this period a disconnexion of the line at 3B allows the exchange apparatus to restore to normal.

" Deposit-free " Calls.—A call to the manual board operator for inquiries, etc., may be made by dialling " O " without the insertion of coins.

Due to the special cam provided on dials fitted in call offices, the spring set D1 is operated when the dial is fully rotated (i.e., when dialling "O"), thereby removing the short-circuit across D2. In these circumstances the precautionary measures taken by arranging the operation of spring sets (1) and (2) are unnecessary.

With some U.A.X.'s which employ the standard auto circuit, the numbering scheme is such that calls outside the unit fee area are obtained by dialling a level other than " O " and a special cam fitted to the dial of call office circuits permits the operation of the dial auxiliary springs (D1) on the dialling of any predetermined number.

C.B. (Manual) System. (Fig. **10.**)

As in automatic areas the subscriber removes the microtelephone and inserts two pennies to effect **a** call.

The first penny operates the crank arm, which, in turn, operates spring assembly (1).

(1)A shunts the receiver thus avoiding its misuse as a transmitter.

(1)B prepares the " calling " earth circuit.

(1)C removes a short-circuit across relay T and the coin box transmitter.

The additional weight of the second penny on the balance arm effects the operation of spring set (2).

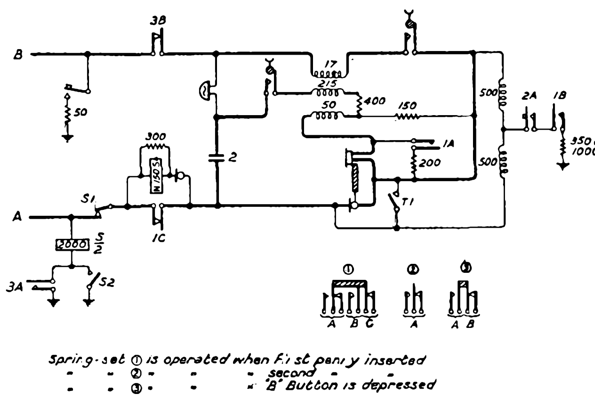


FIG. 10.—PREPAYMENT CIRCUIT, MANUAL C.B. SYSTEM.

(2)A completes the calling earth circuit (which was prepared by 1B) and applies earth *via* the bridging coil to the A and B lines.

The B line earth serves to operate relay LR at the exchange. Relay X will not operate in series with relay LR due to the presence of a resistor in the earth connexion at (1)B.

*LR*1 *via* X1 completes a circuit for the calling lamp.

The operator inserts the answering plug of the call office cord circuit (Fig. **11**) into the answering jack, thereby operating relay CO from battery on the cord circuit plug sleeve. CO1 serves no purpose; CO2 disconnects the circuit of relay LR and thereby breaks the calling lamp circuit. Relay LA operates from the telephone loop to battery *via* RA and at LA1 completes a shunt across the answering lamp to effect supervision. (The polarized relay T at the call office will not operate to battery on the B line.)

The earth condition on the line applied by the coin box spring sets still persists, but due to the combined resistance of the bridging coil and resistor (in earth lead) relay LA is not affected by this condition.

The operator throws the cord circuit speak key to ascertain the number required by the caller; at this stage the " out of balance " condition which would exist had the calling earth been applied to the B line only, is avoided by the balancing earth on the A line. It is, primarily, for this purpose that the calling earth is connected to both lines.

Having ascertained the number required the operator completes the connexion by inserting the calling plug into the multiple jack. Relay SA operates to earth *via* the wanted subscriber's CO relay.

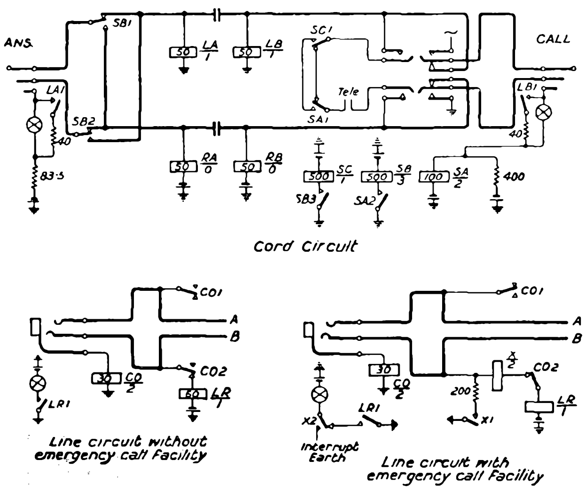


FIG. 11.—CORD AND LINE CIRCUIT, MANUAL C.B. SYSTEM.

SA1 disconnects the operator's telephone circuit.

SA2 completes a circuit for relay SB.

Relay SB operates.

SB1 and SB2 change over to reverse the direction of current flowing around the telephone loop.

SB3 completes a circuit for relay SC.

SC1 completes the operator's telephone circuit which was disconnected on the operation of SA1. The disconnexion of the operator's circuit during the operation of relay SB avoids the reception of a distressing click which would be given in the operator's receiver by the momentary disconnexion and reconnexion on the answering side of the transmission bridge, caused by the operation of contact units SB1 and SB2. The operation of relay T at the call office is effected by the reversal of current from the cord circuit, and T1 short-circuits the caller's transmitter.

The operator rings the wanted subscriber in the usual way and the latter, on answering, is heard by the caller. The calling subscriber, however, cannot reply due to the transmitter being short-circuited by the operated contact of the relay T. As stated on the instruction card, conversation is made possible by depressing button A; this action serves to deposit the suspended coins into the cash-box and, in addition, to restore to normal the spring-sets (1) and (2).

(1)A removes the 200-ohm shunt from the receiver to restore this part of the circuit to normal.

(1)B and (2) A remove the calling earth from the A and B lines.

(1)C short-circuits relay T and the coin-box transmitter.

Relay T releases and at T1 removes the short-circuit from across the transmitter, thus completing the restoration of the circuit to normal.

Ineffective Calls.—When a call cannot be completed the caller will depress button B to recover the suspended coins, thus restoring spring sets (1) and (2) to normal and operating—for approximately **7** seconds—spring assembly (3).

(3)A completes a circuit to allow the operation of relay S from battery of the cord circuit over the A line.

(3)B disconnects the B line thereby releasing relay LA to give a clear to the operator on the answering supervisory lamp.

Relay S operates.

S1 disconnects the A line from the telephone circuit.

S2 completes a locking circuit for relay S to make this circuit independent of the "seven second" operated 3A.

Relay S remains operated until the operator withdraws the cord circuit plug from the jack to restore the circuit to normal.

Emergency Calls.—Certain calls from public call offices, e.g., fire, etc., are permitted free of charge. In this case it is not necessary for the caller to insert coins; the call may be made by depression of the emergency button. It is essential that the operator should be able to discriminate between this type of call and an ordinary call, in order that fraudulent use of the circuit may be avoided. For this reason relay X is connected in the calling circuit in series with relay LR. Operation of the call office emergency button connects a low resistance (50-ohm) calling earth to the B line to operate relays X and LR.

X1 completes a locking circuit for relay X dependent on CO2.

X2 connects the calling lamp to an interrupted earth to give a flashing signal. LR1 is rendered ineffective by the operation of X2.

Units Automatic Nos. 5 *and* 6. (*Fig.* **12**)

The circuit conditions of these exchanges are such that it is necessary to dial two digits to gain access

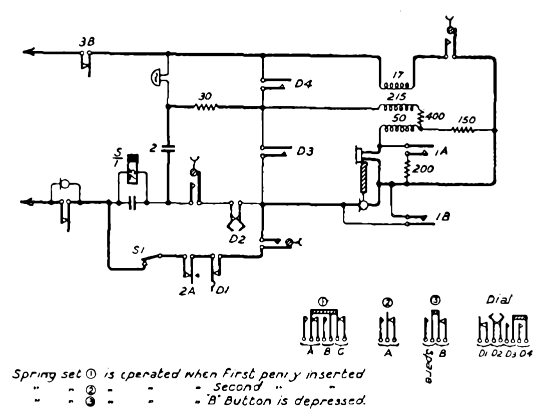


FIG. 12.—PREPAYMENT CIRCUIT, U.A.X.'s 5 and 6.

to the parent exchange and for this reason it is necessary to depart from the standard automatic circuit. For local calls, the circuit operation is identical with that of the automatic circuit; for calls outside the U.A.X. area, however, it is necessary to employ a relay to allow the transmission of a second impulse train.

The caller wishing to make a call over a junction dials the appropriate number as given on the instruction card, and operates, on the first digit, the auxiliary springs D1. This contact unit removes a short-circuit from the impulsing springs D2 and

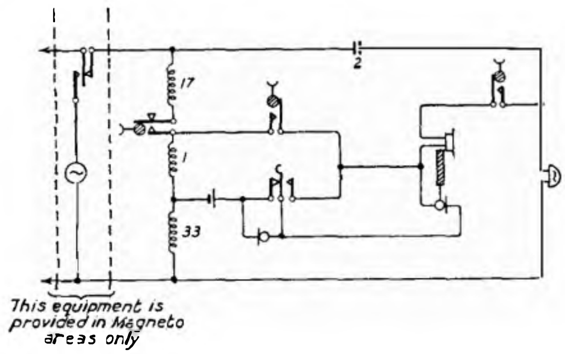


FIG. 13.—POSTPAYMENT CIRCUIT, C.B.S. 2 AND 3 AND MAGNETO SYSTEMS.

relay S. Relay S operates and, due to its slow release feature, remains operated during impulsing. While the dial is off-normal, the circuit for this relay, which operates from the U.A.X. battery, is completed *via* the off-normal springs D3 and I4; on return of the dial to normal the relay holds *via* the telephone loop. S1 operates to allow of the continued operation of relay S when the second digit to be dialled is numerically less than the first digit, i.e., when D1 will not be operated.

The fee necessary for the junction call is deposited under the direction and supervision of the operator.

Local Battery Areas.

The circuit arrangements for C.B.S. No. 2 and 3 and Magneto (**Fig. 13**), and C.B.S. No. 1 (Fig. **14**)

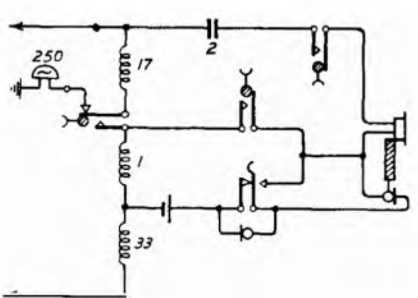


FIG. 14.—POSTPAYMENT CIRCUIT, C.B.S.1. SYSTEM.

are identical with those of a subscriber's direct exchange line with the exception that arrangements are made for the telephone transmitter to be put out of service and replaced by the coin box transmitter as each coin is inserted in the coin box.

All coin box fees in these areas are collected under the supervision of the telephonist; the action of inserting coins causes the crank-arm to operate the change-over spring-set which opens the circuit of the coin box transmitter and short-circuits the transmitter of the microtelephone. With the coin box used in these areas the coins are not held in suspense, but pass direct into the cash box. The necessity of coin control buttons, i.e., buttons A and B, does therefore not arise.

P.M.B.X. or P.A.B.X. Extension with Coin Box. (Fig. **15**.)

For these extensions a post-payment coin box (as used in local battery areas) is provided, and the circuit is arranged as for an ordinary extension with the exception that the insertion of coins effects the opening of the coin box transmitter circuit to permit the collection of coins under the direction and supervision of the P.M.B.X. or P.A.B.X. operator.

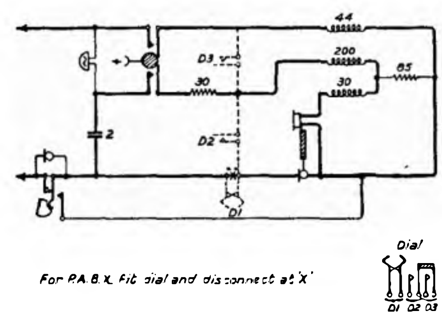


FIG. 15.—POSTPAYMENT CIRCUIT, P.B.X. EXTENSION, ALL SYSTEMS.

Reverted Calls.

Coin box circuits on all systems are closed with the normal bell arrangement in the disengaged condition to permit the acceptance by callers of "reverted calls." On reverted calls the caller answers and inserts the fee under the direction and supervision of the telephonist.

Conclusion.

Reference has been made in this article mainly to public call offices on direct exchange lines, but coin boxes are also provided on subscribers' circuits. The new wallboard is not fitted and the coin box differs slightly from the call office type having a drawer instead of the bottom opening for the collection of cash. In addition a large number of different arrangement is available for subscribers' plan number extensions with coin box. Space will not permit of these being described in detail but generally the aim in each arrangement is to provide the usual coin box facilities in addition to the normal facilities applicable to the particular plan number. In order to make the coin box service more attractive to subscribers, new types of coin box are in process of development and will probably form the subject of a further article at a later date.

Traffic and Delay Formulæ

G. S. BERKELEY, A.M.I.E.E., Whitworth Prize.

The author gives details of the methods and results of artificial traffic tests employed to determine the degree of accuracy of the various formulae evolved by mathematicians for estimating traffic delays. The case examined is that in which the holding time is constant and a call waits for a free line if a busy condition is encountered. The author also shows how the various mathematical formulae relating are best evaluated.

(1) Introduction.

CONSIDERABLE thought has been devoted during the last few years to the mathematical determination of the delays attendant on automatic telephone systems in which a call that arrives when all trunks in a full-availability group are engaged is not lost, but is held and delayed until a trunk becomes free.

There are two main problems to be considered in these systems. First, when the holding times t of the calls follow the exponential law $e^{-\frac{t}{T}}$, where T represents the average holding time of all the calls. Under this law, the majority of the calls have durations near the average, and fewer and fewer have longer and longer durations. All authorities who have investigated this problem, and made the same assumptions, have arrived at the same formulæ for calculating (*a*) the proportion of calls delayed, (*b*) the proportion of calls delayed beyond intervals of time t, and (*c*) the average delays : the formulæ[1] in question have already appeared in this Journal. As the durations of calls circulating in a local telephone network obey, more or less, the exponential law, the formulæ mentioned can be applied with some accuracy to groups of trunks in a system in which, instead of a busy signal being passed back to a calling subscriber when all the trunks in a group are engaged, the call is merely held until a circuit becomes free, and then passed forward.

This article forms the subject of the other main problem to be considered in a system with delay or " waiting " arrangements; it is where the calls are subjected to constant durations, *i.e.*, each call occupies a trunk for the same length of time. If a switch is delayed in obtaining a free trunk in a particular group, the searching switch will have a holding time equal to the duration of the delay plus the normal holding time of the trunk, but the trunk itself when seized will be occupied for its normal duration only, unless, of course, congestion is experienced at the next switching stage. The effective solution of this problem has presented some difficulty; Crommelin,[2] Erlang, Fry, Molina, Pleijel, Pollaczek, and others have, however, derived useful formulæ, each investigator making his own assumptions. Full reference to the works of these authorities, with the exception of that of Pleijel's, mentioned below,[3] are contained in Crommelin's articles.

Although calls of constant durations may not be met with frequently in telephony, the condition does arise where holding times do not follow the exponential law, but are practically constant : especially is this so where common equipment, such as allotters serving line finders, is installed.

The formulæ developed by the aforementioned experts differ to some extent according to the various assumptions made, and as it appeared that Crommelin's and Pollaczek's formulæ were the most satisfactory solutions, a series of " Artificial Traffic Records " were carried out with a view to discovering the deviation of theory from test results.

The assumptions embodied in Crommelin's work are outlined in the next section, and the need for assuming a variation of traffic from busy hour to busy hour is emphasized in Section 3.

From the results of the tests shown in Section 5, it will be gathered that the adoption of Crommelin's method of working and certain of Pollaczek's formulæ will be justified in practice.

Previously, the various formulæ have been stated without showing, in sufficient detail, the steps in their evaluation; this omission is now rectified in Section 6.

The last section deals with the relative efficiencies of small and large groups of trunks.

(2) Assumptions Underlying Crommelin's Formulæ.

The assumptions made in solving problems in probability generally have a very definite bearing on the results, and care must always be taken to visualize the implications of the assumptions before forming opinions on the solutions. Hence, the assumptions underlying Crommelin's Theory will be stated in detail, the symbols used having the same significance as in Crommelin's articles.

1. *Full-availability conditions are given to a limited number of trunks n.*
2. *The average traffic in traffic units y, is less than the number of trunks.* (Pollaczek has evolved formulæ relating to the more unusual condition in which y is approximately equal to n, and also greater than n.)
3. *The effective holding time of every call is the same and is equal to T.*

[1] " Solution of some Problems in the Theory of Probabilities of Significance in Automatic Telephone Exchanges," by A. K. Erlang, *P.O.E.E. Journal*, Vol. 10, p. 189.

[2] " Delay Probability Formulæ when the Holding Times are Constant," *P.O.E.E. Journal*, April, 1932, and " Delay Probability Formulæ," *P.O.E.E. Journal*, January, 1934. Both articles by C. D. Crommelin.

[3] " On the Calculation of Delays in an Automatic Telephone System," by Stig Ekelöf. Ericsson Review, 1930, Nos. 7 & 8. Ekelöf presents Pleijel's formulæ with calculations and graphs.

4. *A call delayed owing to congestion is not released, but is held until a trunk becomes free, the trunk then being held for the full holding time T.*
5. *The traffic originates from an infinite number of subscribers or sources.* It is thus implied that the traffic is of a pure chance character.
6. *The average number of call originations per holding time is y.* That is, it is not assumed that the number of calls per hour is constant, but that the traffic in individual hours may vary around the average.
7. *Delayed calls are served in the order in which they originate.* In the majority of systems no arrangement is provided to ensure that delayed calls are served in the sequence of their arrival. In practice, if the calls are not dealt with in the order of their origination, there might be a tendency for a greater proportion of calls to be delayed longer than theory would lead one to expect, and fewer calls for shorter times. The average delay on all calls, and the average delay on those calls delayed will, however, not be affected by this assumption.
8. *Statistical equilibrium conditions exist.* This assumes that, no matter when the system is examined, the probability of finding it in any specified condition is always the same. For this condition to hold, the traffic must be maintained around the average level, and accordingly, only the busy-hour traffic can be considered. Moreover, it is implied that, if a large number of busy hours is considered, the traffic is not above or below the average level continuously for long periods.

(3) Busy Hour Variation of Traffic.

As is well known, it is usually assumed that during the busy hour calls occur in accordance with the laws of chance, or pure chance; a definition of pure chance traffic is as follows :—

> " Pure chance traffic is traffic such that a call is as likely to originate at any one moment as at any other. This carries with it the implication that the number of subscribers or other sources from which calls originate is infinite."

In addition to the number of calls simultaneously in progress during the busy hour varying from moment to moment, the busy hour on any one group often occurs at different times on different days. Usually, however, the busy hour occurs between the hours of 9 a.m. and 12 noon, but there is no guarantee that it will occur during one specified hour, although it might be predicted with a fair amount of certainty that it will happen during a specified period of $1\frac{1}{2}$-2 hours.

An important factor which must be taken into account in theoretical studies is the fluctuation of traffic from busy hour to busy hour since, in practice, wide variations occur around the average. For instance, a group of trunks may handle 10 traffic units when averaged over a large number of busy hours, but during one or two busy hours (excluding days on which are known special events) the traffic may fall to 5 T.U. or rise to 15 T.U. On larger groups with 100 T.U. average busy hour traffic, the percentage variations will be less, but may be as large as $\pm 20\%$ occasionally.

Fig. 1 illustrates typical variations of busy hour traffic. This curve shows the actual traffic recorded

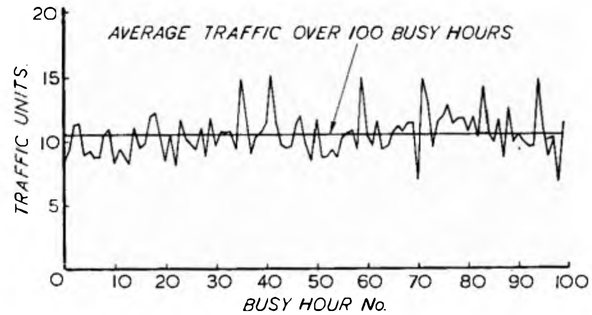


Fig. 1.—Typical Variation in Busy Hour Traffic.

during the busiest hour on one small group of 1st selectors on each of 100 days, excluding Sundays and special days such as Bank Holidays, etc. Over these 100 hours the arithmetic average of the traffic was 10.466 T.U.; the lowest busy hour traffic was 6.72 T.U. and the highest 15.27 T.U. Referring to this graph it will be apparent that the practice of taking traffic measurements over more than one day so as to obtain a fairly reliable average is fully justified.

The traffic recorded during the 100 hours is illustrated in another form by curve A of Fig. 2. Here

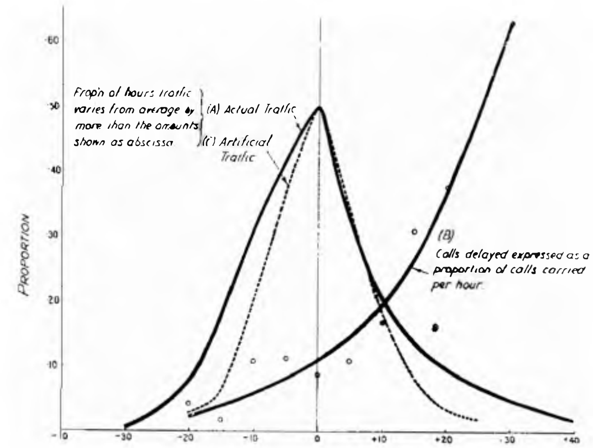


Fig. 2.

is shown the proportion of hours in which the traffic varied by more than $\pm 5\%$, $\pm 10\%$, $\pm 15\%$, etc., from the average traffic of 10.466 T.U. For example, it can be seen from the curve that during a proportion of 0.05, *i.e.*, 5 hours out of 100, the traffic was more than 25% above the average, and for a proportion of 0.02, *i.e.*, 2 hours out of 100, the traffic was more than 25% below the average.

As a general rule an Administration adopts a grade of service which, over a large number of busy hours, allows a specified proportion of calls to fail at any one stage owing to an insufficiency of switching plant. The proportion of calls failing increases during individual hours at a greater rate as the traffic increases beyond the average (see curve B of Fig. **2**). This curve shows the proportion of calls delayed on a group of 20 trunks when the traffic in individual hours varies around the average. The results were obtained from one of the tests mentioned in Section **5**. It will be appreciated that, on an average, the proportion of calls failing per hour will be much more when the traffic is 10% above the average than when the traffic is 10% below the average, since a straight line law is not followed. It logically follows that, on an average, more calls will fail overall if the busy hour traffic varies uniformly above and below the average, than if the traffic were equal to the average during every hour.

Any attempt to make tests by artificial means must then allow for the variation of traffic in the several busy hours, because results obtained by assuming a constant number of calls per hour would be misleading. A method of arriving at a varying number of calls per hour for the purposes of artificial traffic tests is indicated in the next section, and the frequency-distribution curve for the calls so obtained in one set of 100 hours is reproduced in Fig. **2**, curve C. This curve relates to an average of 120 calls per hour and, notwithstanding the fact that it does not follow exactly curve A, which was obtained from actual records, it possesses, to a large extent, the same characteristics : it would naturally be expected that the tests made artificially would approximate fairly closely to actual practical conditions.

(4) Preparation and Method of carrying out Artificial Traffic Records.

By the term " Artificial Traffic Record " is meant the process whereby the origination times of calls are found by an artificial means and the calls are deemed to occupy, for some predetermined holding time, imaginary trunks according to the arrangement under test.

As already mentioned, the traffic or number of calls fluctuates from busy hour to busy hour and, in addition, the time of arrival of calls during each hour is dictated by chance. The first step in preparing an artificial traffic record is to fix arbitrarily the number of hours over which the record shall extend. For purposes of illustration let it be assumed that it is desired to test a group of 10 trunks handling an average of 6.0 T.U. over 100 hours, the duration per call being 3.0 minutes (0.05 hours). The average number of calls per hour is 6.0/0.05 = 120, and 12,000 calls will accordingly need to be distributed over 100 hours in such a manner that the average number per hour is 120.

The telephone directory has proved a useful source for obtaining chance figures, and the method instituted some years ago for obtaining data necessary for making artificial traffic records is outlined below.

The directory was examined in alphabetical order and the 10's digit of the first subscriber's number was paired with the 10's digit of the next subscriber's number; by pairing the 10's digits of the next two subscribers' numbers and so on, some thousands of 2-digit numbers were obtained. These numbers were set down in the order of occurrence, all combinations of 2-digit numbers from 00 to 99 being obtained in a pure chance order. Causes tending to upset the pure chance requirement were, of course, excluded.

Considering now the 100-hour test with 12,000 calls : the 100 individual hours would be allotted numbers 00-99, and a group of 12,000 2-digit numbers obtained in the above manner would be examined, and the number of times 00 appeared in the 12,000 numbers would be taken as representing the number of calls arriving in the 00 hour, say 109 calls. Similarly, the number of calls arising in the 01, 02, 03, etc., hours would be ascertained. The frequency-distribution of 100 hours with an average of 120 calls per hour obtained by this means is illustrated by curve C of Fig. **2**.

Having determined the number of calls in each hour, it would then be necessary to determine the originating time of the calls within each hour. Each hour would be considered to be divided into 100 equal parts numbered 00-99. Taking again hour 00, the particular 1/100th part of the hour in which each of the 109 calls originated would be found by taking a new block of 109 consecutive 2-digit pure chance numbers, and assuming that the calls occurred in the 1/100th parts of the hour as indicated by the chance numbers. The 109 numbers would then be arranged in correct numerical sequence; the first three arranged in order of magnitude, for instance, might be 00, 03, and 07. In a similar manner the originating times of each call to the 1/100th part of the hour, in all hours of the test could be found. In order to simulate practical conditions, it is necessary to subdivide each 1/100th part of the hour into 100 parts, so obtaining the originating times to 1/10,000th parts of the hour, thereby avoiding the unreal position of too many calls originating at the same instant. This further sub-division would be effected with the aid of another block of chance numbers. For example, in respect of hour 00, another group of 109 consecutive 2-digit numbers taken in order of occurrence would be combined with the 109 2-digit numbers already obtained which represent the particular 100th part of the hour in which each call originated. Supposing that the first three numbers of this new block were 47, 23, and 82 respectively, they would be arranged alongside the 2-digit numbers representing the arrival times to 1/100th parts of the hour (00, 03, and 07) so giving 0047, 0323, and 0782 as the times of arrival of the first three calls in this hour to 1/10,000th parts of the hour. The remainder of this hour and the other hours would be dealt with similarly, and having determined the origination times of all the calls the record would be commenced.

Considering the first three calls in hour 00 which originate at times 0047, 0323, and 0782, the first call would seize Trunk No. 1 at 0047 and hold it for the normal holding time of 05 hours, *i.e.*, until

0047 + 05 = 0547. (For convenience, the decimal points are omitted when dealing with times in artificial traffic records.) The second call occurring at 0123 would arrive while Trunk No. 1 was engaged, so the call would pass to Trunk No. 2 and occupy it until 0323 + 05 = 0823. By the time the next call arrives, Trunk No. 1 would be free, so the third call would occupy Trunk No. 1 until 0782 + 05 = 1382. By treating each call individually in this way, and assuming that a call arriving when all trunks are engaged is held until a trunk becomes free, when the call is passed forward, irrespective of the trunk number becoming free, it is possible to obtain information which it is reasonable to expect would line up with conditions met with in practice, if the delayed calls were served in the order of their origination. This method of testing artificially has been applied to the delay case of constant holding times with various numbers of trunks and loadings with the result shown in the next section.

(5) Results of Artificial Traffic Records made on Delay Case.

Artificial traffic records as outlined in the previous section have been made on 1, 5, 8, and 20 trunks, the holding time being different in each instance. Each record covered a minimum of 50 hours in order that results as reliable as practicable could be obtained over as great a range of t as possible. It was assumed that delayed calls were served in the order in which they originated.

The average traffic per trunk, the proportion of calls delayed, and the proportions of calls delayed more than certain multiples of the holding time, are shown in Table I, together with the theoretical values as determined by Crommelin for comparison. It should be noted that the majority of the theoretical values shown were obtained by reading from Crommelin's curves proportions delayed for certain fixed times for each number of trunks, 1, 5, etc., for varying values of traffic. From this series of curves, the proportions delayed appropriate to the average traffic in the records were then found by interpolation. The theoretical values shown for the proportions of calls delayed, and the proportions delayed on one trunk up to one holding time were, however, calculated.

It will be seen that the theoretical proportions of calls delayed agree very well with the results of the artificial records with the exception of the record on eight trunks.

As regards the proportions delayed more than t holding times, it will be observed that there is good agreement up to one holding time, *i.e.*, $t = 1.0$, in the record on one trunk, and generally good agreement up to $t = 0.5$ in the other records.

A clearer conception of the variations between theory and the records may be gained from Figs. **3**

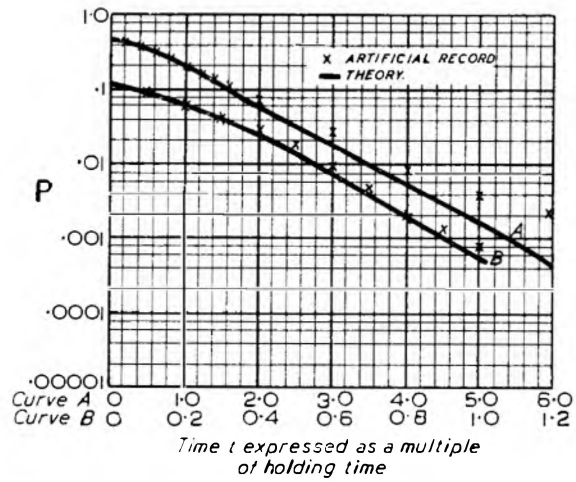


Fig. **3**.—Probability P for a Delay exceeding t Holding Times when (A) 1 Trunk handles 0.5128 T.U.; (B) 5 Trunks handle 2.50 T.U.

Table I.

No. of Trunks.		Traffic per Trunk (T.U.).	Proportion of calls delayed.	Proportion of calls delayed more than time t expressed as a multiple of the average holding time :—															Holding time assumed in hours.
				0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2.0	3.0	4.0	5.0	6.0	
1	Artificial Record...	.5128	.517	.49	.46	.44	.41	.38	.34	.31	.27	.23	.20	.072	.023	.0084	.0039	.0022	.01
	Theory ...	.5128	.5128	.49	.46	.43	.40	.37	.34	.30	.27	.23	.19	.057	.0167	.0051	.0016	.00044	—
5	Artificial Record...	.5000	.1135	.088	.066	.042	.027	.016	.0092	.0044	.0020	.0012	.00080						.05
	Theory ...	.5000	.1105	.09	.061	.041	.025	.013	.0079	.0040	.0020	.0010	.00050						—
8	Artificial Record...	.6353	.1945	.138	.090	.057	.033	.017	.0076	.0044	.0032	.0025	.0012						.10
	Theory ...	.6353	.1502	.112	.074	.044	.023	.012	.0062	.0032	.0016	.0008	.00038						—
20	Artificial Record...	.7625	.1442	.069	.031	.016	.0082	.0031	.00068										.13
	Theory ...	.7625	.1628	.086	.036	.014	.0054	.0019	.0007										—

and **4**. The curves show the theoretical proportions delayed more than t holding times, whereas the proportions found from the records are indicated by the crosses.

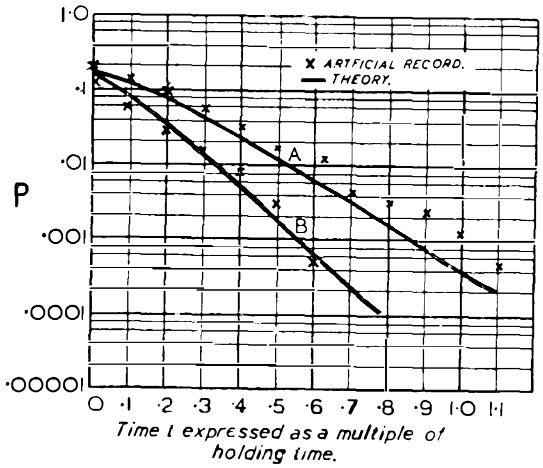


FIG. **4**.—PROBABILITY P FOR A DELAY EXCEEDING t HOLDING TIMES WHEN (A) 8 TRUNKS HANDLE 5.08 T.U.; (B) 20 TRUNKS HANDLE 15.25 T.U.

number of calls delayed beyond this time, except in the record on one trunk.

As in practice it is very seldom necessary to know the proportion of calls delayed more than 0.5 holding times, it is clear from these records that the theoretical method and results as presented by Crommelin will apply with some accuracy.

For determining the proportion of calls delayed and the average delay, Pollaczek's formulæ are very useful, the amount of work involved in evaluation being less than that required by Crommelin's method. It is of interest to compare the results obtained by using their respective methods, and at the same time the values given by Molina's formula. Molina advanced his solution to the constant holding time case as approximate only, but his formulæ were found very helpful for several years owing to their simplicity of evaluation.

Table II shows the calculated proportions of calls delayed by employing Crommelin's, Pollaczek's, and Molina's formulæ, from which it will be seen that there is good agreement between the first two and the records, but Molina's formula gives results consistently higher.

The calculated average delays using Molina's and Pollaczek's formulæ are also shown in Table II. The delays shown for Crommelin have been determined by graphical means, the squares between the P(> t) curve and the axes, when drawn on ordinary graph paper, being counted. With the exception of the record on 8 trunks, the theoretical values as found from Crommelin's graphical method and Pollaczek's formula agree fairly well with the records, but the results obtained from Molina's formula are again on the high side.

TABLE II.

No. of Trunks.	Average traffic per trunk. (T.U.).	Proportion of calls delayed more than zero.				Average delay.			
		Artificial Record.	Crommelin.	Pollaczek.	Molina.	Artificial Record.	Crommelin.	Pollaczek.	Molina.
1	.5128	.5170	.5128	.5128	.5128	.5650	.5180	.5263	.7961
5	.5000	.1135	.1105	.1213	.1304	.0315	.0297	0327	.0441
8	.6353	.1945	.1502	.1647	.1797	0433	.0329	.0341	.0554
20	.7625	.1442	.1628	.1633	.1814	.0190	.0216	.0214	.0364

Curve A in Fig. **4**, which shows the result of the test on 8 trunks, indicates that the record gives higher losses all along the line, but the character of the theoretical curve is preserved. The reason is, no doubt, due to the occurrence of two or three abnormal hours in the record, and in all probability if the test had been continued over a longer period the results would have been more in line with theory. Moreover, as close agreement was obtained in the records on 5 and 20 trunks it is reasonable to suppose that theory would line up on intermediate groups of trunks.

The curves indicate that the proportion of calls delayed more than t holding times will, in general, be more than the theoretical values, the percentage errors in theory becoming larger as the delay time increases. The principal reason for this increasing divergence is apparently due to the approximate method of obtaining some of the fundamental factors in the formula; further mention of this point is made in Section 6. It should perhaps be made clear that too much reliance must not be placed on the results of the records applying to delay periods of more than 0.5 to 0.6 holding times, owing to the relatively small

(6) EVALUATION OF FORMULÆ.

Usually the steps required to be taken in evaluating the apparently formidable formulæ associated with traffic problems are not given in sufficient detail, and this practice does otherwise than stimulate an interest in the art of trunking. This section is, therefore, devoted to an explanation of the method of evaluating the more important formulæ appertaining to the delay case with constant holding times.

In all the formulæ quoted y represents the average busy hour traffic in traffic units on the group, and n the number of trunks.

(A) *Proportion of Calls Delayed.*

It is first necessary to obtain the proportion of calls not delayed at all, and the formula obtained in the first instance by Pollaczek and later confirmed by Crommelin may be written :—

$$\log_e [P(=0)] = -\sum_{w=1}^{\infty} \frac{e^{-wy}}{w} \sum_{u=wn}^{\infty} \frac{(wy)^u}{u!} \qquad \ldots\ldots\ldots\ldots(1)$$

Assume that it is required to find the proportion of calls delayed when 2.5 T.U. is handled on a delay basis on 5 trunks : substituting $n = 5$ and $w = 1$, $w = 2$, $w = 3$, etc., successively in (1), the following series of expressions are obtained :—

Considering still a group of 5 trunks handling 2.5 T.U., the calls being of 3.0 minutes duration, and supposing it is required to know the proportion of calls delayed more than 3.0 minutes or one holding time, *i.e.*, $t = 1.0$, the first step is to determine the value of the a_v where :—

$$a_v = \frac{1 + y + \frac{y^2}{2!} + \ldots\ldots \frac{y^v}{v!}}{1 + y + \frac{y^2}{2!} + \ldots\ldots \frac{y^{n-1}}{(n-1)!} + \frac{y^{n-1}}{(n-1)!} \cdot \frac{y}{n-y}}$$

$$= \frac{1 + y + \frac{y^2}{2!} + \ldots\ldots \frac{y^v}{v!}}{13.5694} \qquad \ldots\ldots\ldots\ldots(3)$$

$$\text{When } w = 1, \quad p_1 = -e^{-y}\left(\frac{y^5}{5!} + \frac{y^6}{6!} + \ldots\ldots\right) = -.108822$$

$$\text{,,} \quad w = 2, \quad p_2 = -\frac{e^{-2y}}{2}\left(\frac{(2y)^{10}}{10!} + \frac{(2y)^{11}}{11!} + \ldots\ldots\right) = -.015914$$

$$\text{,,} \quad w = 3, \quad p_3 = -\frac{e^{-3y}}{3}\left(\frac{(3y)^{15}}{15!} + \frac{(3y)^{16}}{16!} + \ldots\ldots\right) = -.003420$$

$$\text{,,} \quad w = 4, \quad p_4 = -\frac{e^{-4y}}{4}\left(\frac{(4y)^{20}}{20!} + \frac{(4y)^{21}}{21!} + \ldots\ldots\right) = -.000863$$

$$\text{,,} \quad w = 5, \quad p_5 = -\frac{e^{-5y}}{5}\left(\frac{(5y)^{25}}{25!} + \frac{(5y)^{26}}{26!} + \ldots\ldots\right) = -.000239$$

$$\text{,,} \quad w = 6, \quad p_6 = -\frac{e^{-6y}}{6}\left(\frac{(6y)^{30}}{30!} + \frac{(6y)^{31}}{31!} + \ldots\ldots\right) = -.000069$$

Total -0.129327

The figures on the right hand side have been obtained by substituting $y = 2.5$ in each expression. For this particular traffic and number of trunks, the values may be found practically direct from Karl Pearson's tables of the Poisson function. Greater accuracy, if desired, could be secured by taking higher values of w.

Now $\log_e [P(=0)] = p_1 + p_2 + p_3 + \ldots\ldots p_6 = -0.129327$, from which $P(=0) = 0.87869$, *i.e.*, the proportion of calls not delayed is 0·87869 or 87·869%. Hence the proportion of calls delayed is $1 - P(=0) = 1 - 0.87869 = 0.12131$ or 12.131%.

(Bi) *Proportion of Calls Delayed More than Time t expressed as a Multiple of the Holding Time T.*

Adopting Crommelin's method, the formula may be written :—

$$P(>t) = \sum_{v=0}^{n-1} a_v \left[\frac{\{y(1-t)\}^{(1+T)n+n-1-v}}{\{(1+T)n+n-1-v\}!} \cdot e^{-y(1-t)} + \frac{\{y(2-t)\}^{(2+T)n+n-1-v}}{\{(2+T)n+n-1-v\}!} \cdot e^{-y(2-t)} + \frac{\{y(3-t)\}^{(3+T)n+n-1-v}}{\{(3+T)n+n-1-v\}!} \cdot e^{-y(3-t)} + \ldots\ldots \right] \ldots(2)$$

if $y = 2.5$ and $n = 5$ is substituted in the denominator. The values of a_v from $v = 0$ to $v = n - 1$ thus become :

$$a_0 = \frac{1}{13.569} = .07369$$

$$a_1 = \frac{1 + 2.5}{13.569} = .2579$$

$$a_2 = \frac{1 + 2.5 + \frac{2.5^2}{2!}}{13.569} = .4882$$

$$a_3 = \frac{1 + 2.5 + \frac{2.5^2}{2!} + \frac{2.5^3}{3!}}{13.569} = .6801$$

$$a_4 = \frac{1 + 2.5 + \frac{2.5^2}{2!} + \frac{2.5^3}{3!} + \frac{2.5^4}{4!}}{13.569} = .8001$$

It is now necessary to calculate the values of the series within the brackets in (2) for $v = 0$ to $v = n - 1$.

Since the proportion of calls delayed for more than 1.0 holding time is needed, T = 0 and t = 1.0 must be substituted in the expression. If, however, the proportion of calls delayed more than 4.5 minutes is required, *i.e.*, 4.5/3.0 = 1.5 holding times, T = 1 and t = 0.5 should be inserted in the formula.

Inserting T = 0, t = 1.0, and v = 0, 1, 2, etc., up to $v = n - 1$ successively in (2) :

$$\text{When } v=0,\quad {}^{0}p = \frac{\{y(2-1)\}^{3n-1}}{(3n-1)\,!} \cdot e^{-y(2-1)} + \frac{\{y(3-1)\}^{4n-1}}{(4n-1)\,!} \cdot e^{-y(3-1)} + \ldots\ldots$$

$${}^{1}p = \frac{\{y(2-1)\}^{3n-2}}{(3n-2)\,!} \cdot e^{-y(2-1)} + \frac{\{y(3-1)\}^{4n-2}}{(4n-2)\,!} \cdot e^{-y(3-1)} + \ldots\ldots$$

.... etc., etc., up to ....

$$v=4,\quad {}^{4}p = \frac{\{y(2-1)\}^{3n-5}}{(3n-5)\,!} \cdot e^{-y(2-1)} + \frac{\{(y(3-1)\}^{4n-5}}{(4n-5)\,!} \cdot e^{-y(3-1)} + \ldots\ldots$$

Substituting y = 2.5 and n = 5 in each of these expressions results in the following values :

$${}^{0}p = .000003$$
$${}^{1}p = .000011$$
$${}^{2}p = .000030$$
$${}^{3}p = .000140$$
$${}^{4}p = .000485$$

The proportion of calls delayed more than one holding time is represented by the products of the respective a's and p's, whence

$$\begin{aligned} P(>t) &= .07369 \times .000003 + .2579 \times .000011 \\ &\quad + .4882 \times .00003 + .6801 \times .00014 \\ &\quad + 8.001 \times .000485 \\ &= .0005009 \end{aligned}$$

That is, the proportion of calls delayed for more than 1.0 holding time is 0.0005 or 0.05% which may be verified by referring to Curve B of Fig. **3**.

Crommelin pointed out that his method of obtaining the a's (formula 3) was approximate only, the value of a_{n-1} invariably being smaller than the correct figure which is difficult to determine readily. It would appear that the a_{n-1} term becomes more important as the delay time increases, and as lower values than the true ones are given, it may be expected that by using the approximate method, the theoretical proportions of calls delayed will become less accurate with an increase in delay time, but, as remarked by Crommelin, there is less need for extreme accuracy when dealing with very small proportions of calls delayed.

(Bii) *Asymptotic Formula.*

For large values of t, the limits of application of which have been outlined in Crommelin's second article, the proportion of calls delayed more than time t_1 may be determined from the simple asymptotic formula :—

$$P(>t_1) = P(>t_2) \cdot e^{-y(r_0-1)(t_1-t_2)} \ldots\ldots\ldots\ldots\ldots (4)$$

when the proportion of calls delayed more than time t_2 is known.

In this formula, the values of r_0 represent the real roots of the equation $\alpha e^{-\alpha} = \alpha_1 e^{-\alpha_1}$ divided by the average traffic per trunk $\alpha = \frac{y}{n}$. The values of r_0 as determined from Erlang's Table[4] are shown in Table III below.

TABLE III.

Average traffic per trunk in T.U. α	Values of r_0
0.0	∞
0.1	37.149500
0.2	14.301995
0.3	7.881893
0.4	5.046965
0.5	3.512862
0.6	2.579009
0.7	1.964960
0.8	1.538553
0.9	1.230162
1.0	1.000000

An example of the use of this formula follows.

Suppose that the proportion of calls delayed more than t_1 = 0.8 holding times is required when 16.0 T.U. is handled on 20 trunks, and the proportion of calls delayed more than t_2 = 0.3 holding times is known—0.026 as determined from Crommelin's curves.[5] The average traffic per trunk is $\frac{y}{n} = \frac{16}{20}$ = 0.8, and the corresponding value of r_0 as found from Table III is 1.538553. Substituting in equation (4) :—

$$\begin{aligned} P(>t_1) &= 0.026 \times e^{-16(1.538553-1)(0.8-0.3)} \\ &= 0.00035. \end{aligned}$$

This value may be verified by reference to the above mentioned curve in Crommelin's article.

(C) *Average Delay on All Calls.*

Pollaczek's formula for determining the average delay on all calls is :—

$$M = \sum_{w=1}^{\infty} e^{-wy} \left\{ \sum_{u=wn}^{\infty} \frac{(wy)^u}{u\,!} - \frac{n}{y} \sum_{u=wn+1}^{\infty} \frac{(wy)^u}{u\,!} \right\} \ldots\ldots\ldots (5)$$

Taking again the case of 5 trunks loaded with 2.5 T.U., with calls having a duration of 3.0 minutes, the average delay is found by inserting n = 5 and w = 1, 2, 3, etc., in (5) in the following manner :—

[4] Révue Générale de l'Electricité : 21st Aug., 1926, p. 278.

[5] *P.O.E.E. Journal*, Jan., 1934, p. 270, Fig. 8.

$$\text{When } w = 1, \quad m_1 = e^{-y}\left\{\frac{y^5}{5!} + \frac{y^6}{6!} + \ldots\ldots\ldots - \frac{n}{y}\left(\frac{y^6}{6!} + \frac{y^7}{7!} + \ldots\ldots\right)\right\} = .026801$$

$$,, \quad w = 2, \quad m_2 = e^{-2y}\left\{\frac{(2y)^{10}}{10!} + \frac{(2y)^{11}}{11!} + \ldots\ldots - \frac{n}{y}\left(\frac{(2y)^{11}}{11!} + \frac{(2y)^{12}}{12!} + \ldots\ldots\right)\right\} = .004439$$

$$\text{Similarly} \quad m_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots = .001044$$

$$m_4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots = .000278$$

$$\text{and when } w = 5, \quad m_5 = e^{-5y}\left\{\frac{(5y)^{25}}{25!} + \frac{(5y)^{26}}{26!} + \ldots\ldots - \frac{n}{y}\left(\frac{(5y)^{26}}{26!} + \frac{(5y)^{27}}{27!} + \ldots\ldots\right)\right\} = .000089$$

Total 0.032651

The values on the right represent the computed values when $y = 2.5$ is inserted in the expressions. The aggregate, 0.032651 represents the average delay on all calls expressed as a multiple of the holding time, *i.e.*, the average delay per call is $0.032651 \times 3.0 = 0.097953$ minutes. To obtain the average delay on those calls delayed, it is only necessary to divide 0.097953 by the proportion of calls delayed, so giving $0.097953/0.1213 = 0.807$ minutes.

The average delays for 1-9 and 18 trunks, for various values of traffic up to 0.8 T.U. per trunk, have been calculated and shown in graphical form by Pollaczek.[6]

(7) Availability.

As in the usual lost call systems, the traffic capacity of groups of switches under delay arrangements is greatly influenced by the availability. This may clearly be illustrated by considering one switch carrying 0.5 T.U. Then, from Crommelin's curves,[7] the proportion of calls delayed is 0.5. If, however, two switches are provided and they are loaded to a total of 1.0 T.U., *i.e.*, an average of 0.5 T.U. each, it is found by referring to Fig. 3 of the same article, that the proportion of calls delayed is reduced to 0.22. Or, if the same proportion of calls were allowed to be delayed, *i.e.*, 0.5., the two trunks could be loaded to as much as 0.72 T.U. per trunk approximately, and the average delays would be as before. This improved service, or alternatively increased loading for the same grade of service, is due to the increase in availability, which will be apparent from the following consideration. If instead of 1.0 T.U. being offered always in the same direction, *i.e.*, to No. 1 switch first and then to No. 2 switch if the first is engaged, 0.5 T.U. is offered to No. 1 switch and 0.5 T.U. to No. 2 with overflow facilities from one to the other, it will be obvious that there will be times when No. 1 switch is not handling calls from its particular 0.5 T.U.; during these times No. 2 switch may be engaged when it is offered another call, in which circumstance the call passes to switch No. 1 which happens to be free, the call thus being accepted without delay. If the two switches were in separate groups the call arriving for switch No. 2 would, of course, have been delayed.

That the importance of the availability on the service, or the carrying capacity, is very marked cannot be gainsaid whether it be automatic or manual telephony under review. In ordinary local manual working, subscribers' answering equipments appear only once on the switchboard, but as more than one operator can reach any one calling line (team working) the availability is generally increased to three operators, and a satisfactory and economical service results. If, however, the answering equipments were ancillaried so that all operators were able to reach every line in the exchange—assuming that it were an economical and practical proposition—a better grade of service would result owing to the increased availability.

Conclusion.

Before concluding, I should like to express my thanks to Mr. V. R. Henderson for preparing the drawings incorporated in this article, and to Mr. H. W. Nelson for the arduous and somewhat onerous task of carrying out the artificial traffic records mentioned in the text.

[6] Telegraphen-und Fernsprech-Technik, March, 1930.

[7] *P.O.E.E. Journal*, Jan., 1934, p. 269, Fig. 2.

Portable Petrol Driven Rock Drills and Concrete Breaking Machines

J. J. EDWARDS, B.Sc. (Eng.), A.C.G.I., A.M.I.E.E.

The author describes a portable petrol driven drill which is suitable for excavation work in connexion with cable laying and pole erection.

Introduction.

THE need for a portable machine capable of excavating and drilling concrete and natural rocks has been felt for many years past by the Post Office Engineering Department and by nearly all other Public Utility Undertakings having mains to lay or poles to erect. The air compressor outfit feeding several pneumatic tools simultaneously has a field of its own that is but little impinged upon by the small portable machine, and on extensive excavation works requiring the continuous operation of power driven tools the pneumatic drive is still supreme. The portable unit finds its application on the short disconnected works which, so far as the Department is concerned, occur as road crossings and short trenching sections. This aspect has previously been considered in this Journal[1] and it has been shown that for such works as these the high transport costs and high standing charges of a compressed air outfit cannot be justified. Similarly such charges cannot be faced where the excavation of only a few pole holes in rock is required and the small portable machine provides an economic alternative to excavation by manual labour.

Equally as important as the constructional side is the maintenance aspect. There is a great and growing need for a cheap, portable mechanical tool to accelerate the work of breaking down concrete roads, etc., to enable underground cables to be reached in cases of breakdown. When each pair of conductors forms a single channel its speedy restoration in case of breakdown is important enough, but when a single pair may carry numerous carrier channels or form part of phantom circuits in addition to the purely physical circuits, the speedy repair of the circuit is vital.

Until 1933 there was no machine available to fulfil these requirements adequately although portable rammers had been adapted to perform simple cutting. At the Public Works Exhibition of 1933, however, the Warsop Portable Petrol Driven Concrete Breaker was demonstrated and it was at once apparent that this machine embodied all the features essential to the use of a small portable unit on Post Office work, viz., it was self contained, portable, reasonably cheap, and utilized a standard commercial prime mover unit, so faciltating maintenance.

The machine is made in two forms—

(a) a concrete breaking machine in which the chisel steel is given a purely percussive effect, and

(b) a rock drilling machine in which the drill steel receives both a percussive effect and a rotary motion,

and as the fundamental operating principle is the same in each case it will be convenient to describe the concrete breaking machine first and to deal with the rotary motion of the drill subsequently.

Concrete Breaker.

The motive power is supplied from a standard commercial two-stroke engine mounted in the head of the machine in an inverted position, *i.e.*, so that crank case is uppermost. Immediately beneath the engine cylinder is the hammer cylinder and beneath this the front end casing housing the drill steel shank, the whole being clamped together by draw bolts as shown in Fig. 1. Part of the aluminium casting has been removed in this figure to show the petrol tank and carburetter.

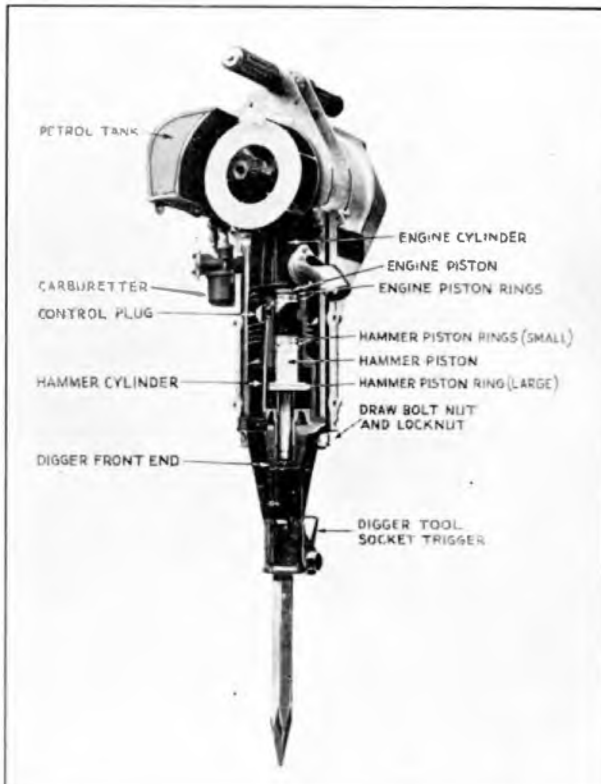


FIG. 1.—CONCRETE BREAKER.

The engine runs on a "petroil" (petrol-oil) mixture as in normal practice and is started by a crank handle, the ignition being by flywheel type magneto and a standard type of sparking plug, the latter being fitted at the lower end of the engine

[1] "Mechanical Ramming." Vol. 27, Part 1.

cylinder wall. A twist grip throttle control is embodied in one of the handles, the engine speed being adjustable between 1500 and 2000 r.p.m.

The cycle of operations is briefly as follows: The explosion of the petrol-air mixture in the engine cylinder causes the engine piston to travel upwards and the hammer piston downwards, the latter continuing till the end of the piston rod strikes on the top of the drill steel. On its upward stroke the engine piston in due course uncovers a bypass port—quite distinct from the main exhaust port—so allowing part of the exhaust gases to be by-passed to the under side of the hammer piston. The exhaust gas pressure acting on the larger diameter of the hammer piston raises the latter in readiness for the next explosion.

It should be noted that there is no metallic contact between the engine and hammer pistons, and that the force of the explosion is applied directly to the hammer piston. Thus the engine receives little wear, as it is practically running light and due to the petroil system of lubrication (wherein lubricating oil is mixed with the petrol in the tank) lubrication of both pistons is positive throughout. The control plug shown on the left of Fig. 1 has now replaced the control valve which was fitted on earlier machines, and is provided to enable the by-pass port to be cleaned free of carbon deposit. The cleaning is done with a short length of stiff wire, once a week being sufficiently often in normal circumstances.

Diamond pointed drill steels are normally supplied with each machine for general road and rock breaking work, and to facilitate the excavation of pole and stay holes these steels are supplied in sets, each set comprising 3 steels, 1′ 0″, 2′ 0″ and 3′ 0″ long. In addition, a flat chisel and a clay spade are supplied as standard with each machine supplied for Post Office purposes, the chisel for cutting tarmac and similar road surfaces, and the clay spade for trench excavation in heavy sticky soils.

Rock Drill.

The rock drill follows pneumatic tool practice in that the drill steel is given a rotary motion in addition to the percussive effect. The latter effect only is given in the concrete breaker.

Fig. 2 shows a sectional view of the rotational mechanism of the drill, and Figs. 3 and 4 show photographs of the separate parts and of the assembly of the same mechanism From these illustrations it will be seen that the spindle or rod of the hammer piston has a series of splines cut in it, each spline being vertical in its lower portion and helical in its upper portion; also that a rack wheel and drill chuck are assembled on the hammer piston shank and that each of these parts has grooves in its internal bore. The grooves in the rack wheel are helical and those in the drill chuck are straight, so that they mate with the corresponding splines on the piston rod shank. The rack wheel and drill chuck are restricted from vertical movement by their

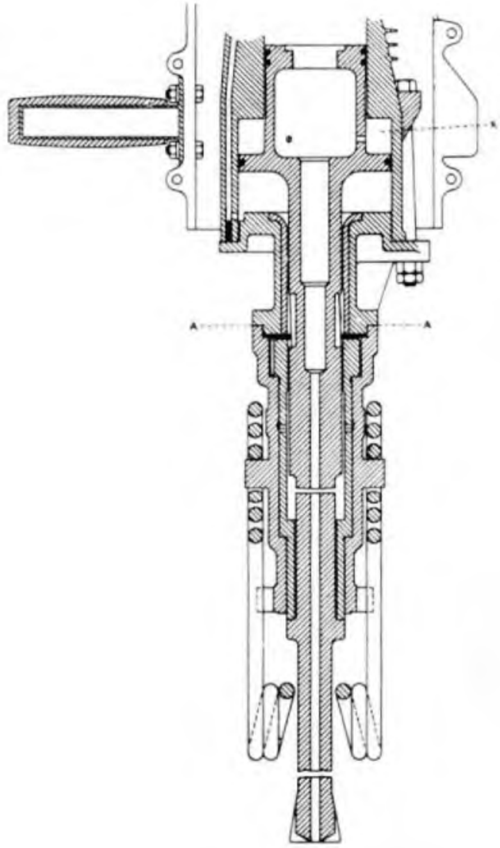


Fig. 2.—Sectional View of Rotational Mechanism.

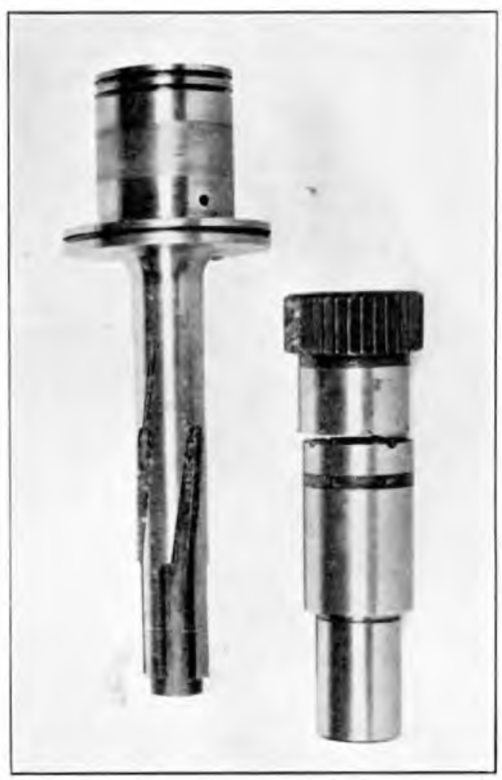


Fig. 3.—Rotational Mechanism Parts.

FIG. 4.—ROTATIONAL MECHANISM ASSEMBLY.

location in the casing and two spring loaded pawls are accommodated in the casing as shown in Fig. 5 and operate on the rack wheel teeth, permitting the rack wheel to rotate in one direction only. Thus when the force of the explosion drives the hammer piston down, the helical splines on the piston rod being engaged with those in the rack wheel cause the latter to revolve in an anti-clockwise direction (when viewed as in Fig. 5), and since the pawls permit rotation in this direction only the rack wheel revolves, but neither the piston rod nor the drill chuck does so.

When the hammer piston moves upward for its next stroke, however, the pawls prevent movement of the rack wheel in the clockwise direction, and consequently the hammer piston rod and drill chuck (which is kept in phase with the piston rod by the straight splines) must rotate in an anti-clockwise direction. So for each blow on the drill, the latter is given a rotary motion keeping it clear in the hole and preventing jamming.

This rotary movement would not by itself be enough to prevent binding and, as in the case of the compressed air tool, a blast of air is driven down the centre of the drill, and discharges from the side of the drill steel head. In the Warsop machine the blast of air is provided by the hammer piston, in its upward stroke, displacing the air in the space X (see Fig. 2) and forcing it to pass through the small holes in the body of the piston down the hollow centre of the drill steel. A fresh supply of air for the next blast is drawn in through a flap valve (not shown) by the next downward stroke of the hammer-piston.

This air blast is only effective when the hole being drilled does not exceed about 2′ 0″ in depth and to keep holes deeper than this clear, a supplementary air supply from a handpump is fed to the hollow drill steel by means of a flexible hose. This pump is supplied as a standard part of the equipment.

Drill Steels.

For ease in drilling deep holes for blasting of pole and stay excavations, successively longer steels are employed, the standard lengths being 1′ 0″, 2′ 6″ and 4′ 0″ below the collar. Under normal conditions and in the commoner rocks 4′ 0″ is about the maximum depth that can be reached with this machine using steels of successively smaller diameters as the hole is deepened to a final diameter of $1\frac{1}{8}$″, the starting drills in this case being $1\frac{3}{8}$″ and $1\frac{1}{4}$″ respectively.

The drill steel tips can be forged and sharpened into various forms to suit the class of rock to be met, single chisel and double chisel ends, four point and six point cross bits being quite common, the former types being used on the softer and coarser rocks and the cross point bits on the harder, stouter rocks. For general work and unless otherwise called for, the double chisel ended drill is being supplied as standard.

A type of drill that has a renewable working tip known as a "Rip-Bit" screwed to the shank, is being tried, more or less experimentally. It has the obvious advantage that a supply of Rip-Bits to fit a common set of drill shanks only need be carried instead of a variety of complete drills with the

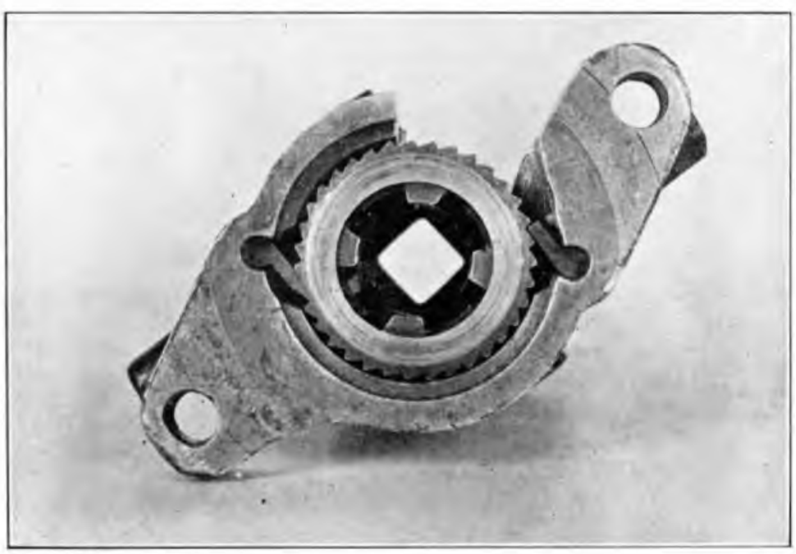


FIG. 5.—RACK WHEEL AND DRILL CHUCK. (PLAN ON AA, FIG. 2).

necessary spares, so saving considerably in weight. Although they have been found satisfactory for the easier rocks, they have not yet proved themselves on the tougher types and for these the solid steels are being used.

Experience.

The experience to date with machines of both types has, on the whole, been extremely satisfactory.

The concrete breakers have been largely used to break up roads for short lengths of trenching or to enable faults in underground cables laid under the roadway to be reached. On road trenching works the savings in labour costs are found to be from 55% to 85% according to the foundations, whereas in breaking up rocks savings varying from 35% to 75% according to the degree of hardness and coarseness of the rocks, are being obtained. In shale and laminated rocks the labour saving is of the order of 50%.

The concrete breaker has also been used for a variety of other purposes such as manhole demolition, clearance of duct obstructions, fitting of earth plates, excavation for buried joint boxes and excavation of pole holes where blasting methods cannot be employed. The excavation of pole holes is probably the most arduous of the jobs commonly encountered as the working space is very restricted. In these cases it is desirable to arrange for two men to take short spells at the operation of the machine while the remainder of the gang clear the hole of spoil between periods of machine operation. The same method is frequently found to be an advantage in trench excavation and other classes of work except that, in the majority of such cases, spoil clearing can be carried on almost continuously.

Experience with the rock drill has not been so extensive as with the concrete breaker and its main use has been on the excavation of pole and stay holes in rocky ground. Normally, blasting methods are employed, a small diameter hole being drilled, laid with blasting gelatine and fired. In one observed case a hole of this type $1\frac{1}{8}''$ final diameter was drilled to a depth of 3′ 6″ in flint in 25 minutes, and blasted out in a further 5 minutes.

In other cases a series of holes is drilled round the edge of the circle to be excavated and the rock is then broken in comparatively easily towards the centre.

In one or two cases difficulty has been reported due to the drill steel jamming, but this has been traced to the use of Rip-bits which have not given sufficient clearance over the diameter of the drill rod. It has been found that the drill rods supplied are " jumped " at the point where the rod is threaded to receive the Rip-bit with the result that there is practically no difference in the diameter of the rod at this point and that of the Rip-bit. The relative sizes of rod and Rip-bit are being adjusted to avoid this difficulty in future.

In the earlier machines the solid drill steels and Rip-bits were drilled with the exhaust holes for the air blast in the bottom of the drill, but in this position they were found to clog readily. In the later supplies, therefore, holes were drilled in the side of the drill rod about $1\frac{1}{2}''$ to 2″ from the end, but this also was not entirely satisfactory and the latest modification is to drill the air blast hole obliquely so as to emerge between the flutes of the Rip-bit. This alteration, together with the greater clearance provided, should eliminate jamming of the drill in normal holes. Jamming may, however, occur in wet holes in limestone and similar rocks and this can be avoided by feeding additional water to the drill hole.

It must, of course, be recognized that this portable machine driven by an engine of less than 1 h.p. rating cannot be regarded as equal to a compressed air tool where the motive power is rated at 12 B.H.P. or more. Despite the conversion and transmission losses incurred in the latter case, the power available at the tool is considerably greater than with the portable petrol driven unit. Although, therefore, there will be extremely hard and difficult rocks that cannot be dealt with by the Warsop machine, it is safe to say that the majority of materials met with on Post Office work will be adequately dealt with by this machine.

Silencing.

As mentioned earlier, the engine speed is controllable over a range of 1500-2000 r.p.m., but the best speed for normal continuous working is about 1800 r.p.m. As the engine is of the two-stroke type, there is an explosion every cycle and the drill steel receives 1800 blows per minute.

The noise issuing from one of these machines when used without a flexible hose connexion on the exhaust pipe has been found comparable with that issuing from a pneumatic tool, and a considerable reduction in the volume of noise is effected when the standard flexible exhaust hose is coupled to the machine. An independent silencer is also being fitted to machines now being supplied to reduce still further the noise from the exhaust.

Conclusion.

The running cost of either machine is estimated at 4d. per hour under normal working conditions, assuming a consumption of 2 pints of petroil mixture per hour, and this low cost coupled with reasonably low standing charges, small weight (78 lbs.) and consequent ease of transport, render the breaker in particular an extremely attractive proposition for use on small works and cable breakdowns. Being self-contained and unencumbered with hoses, its radius of action is unrestricted and its use is unlikely to meet with opposition in the most congested thoroughfares. Its continued success will bring a stage nearer the ideal of fully mechanized breakdown equipment located at strategic points to serve wide areas.

Construction Standards for Subscribers' Distribution in Suburban Areas

Colonel H. CARTER, T.D., B.Sc., A.R.C.Sc., M.I.E.E.

The article gives a brief historical summary of the development which has led to the present methods of local distribution in suburban areas and suggests lines of development more adapted to present day conditions.

Introduction.

RECENT reductions of tariff have led to a greatly accelerated development of subscribers' services. An important feature of this development is the fact that a large proportion of the new services comes from suburban private residences whose occupiers are lower on the income scale than has, in general, been the case hitherto. This circumstance, together with the intensive building development which is taking place in suburban areas present a rather different problem to the telephone development engineer from that with which, generally speaking, he has previously been faced in this country. The purpose of this article is to suggest that the time is ripe for a review of Post Office standard methods of distribution with a view to determining whether radical changes are necessary to meet the new conditions.

Development of Present Methods of Construction.

In making this review, it will be useful to survey, briefly, the development of the present methods. Complete overhead distribution, commencing from terminal poles near exchanges or from roof standards, was first adopted. So far as suburban areas are concerned, service was ultimately given to subscribers from spur pairs from small open wire routes or by overhouse wiring.

Leaving aside the question of the provision of direct underground distribution in the more congested areas, with which this review is not concerned, the next development was to give relief to congestion near the exchanges by means of underground cables to distribution poles. These distribution poles were usually poles of comparatively large capacity serving considerable areas by radial distribution, frequently overhouse, and were sometimes, in addition, the terminal poles of through routes. Alternatively, they were often, in effect, small terminal poles for through routes along suburban streets, the subscribers being fed by drop pairs of open wires.

The gradual increase in telephone density and the change in the character of suburban housing schemes has led to the abandonment of the large distribution pole.

The introduction of covered drop wire in recent years was a development from normal open wire methods designed to secure a cheaper form of "last span" which would be less liable to interruption.

The standard methods available for suburban distribution may be summarized as consisting of—

(a) Small open wire routes from terminal poles at the end of underground cables from the exchange, with open wire spur pairs to subscribers.
(b) Small or medium sized armed distribution poles distributing radially.
(c) Drop wire distribution poles distributing radially.

Many areas are served by combinations of these three methods.

Weak Points of Existing Methods of Construction.

At this point, it is desirable to emphasize the fact that the cross-arm which is designed to carry wires at right angles to the direction of the arm, to another pole, is being used for radial distribution. By judicious use of various well-known auxiliary fittings on the ends of the arms, this is quite possible, but the method has several obvious disadvantages. Apart from the difficulties frequently met with in securing the leading-off of a spur pair in the required direction, the single pair lead-covered pole-leads speedily become numerous and complicated. It is very difficult to keep them tidy and they are very liable to interruption by men working on the pole. A pole of this type at its worst can be very unsightly. Fairly heavy lines running along a street with frequent open wire spans, particularly when mixed open and drop wire distribution is employed, also suffer from the same objection.

Modern Requirements.

The rapid development of building estates in many of which considerable attention is given to architectural features renders it very necessary to pay attention to the question of amenities. The circumstances detailed in the introduction to this review lead to a practical certainty of a good telephone density being reached in these new estates within a short time, in contrast to the comparatively slow growth in existing built-up areas to which we have become accustomed. This is the essential difference between conditions at the present time and those existing a few years ago which render a review of Post Office methods so desirable.

With present methods of underground construction, it is difficult to justify economically, complete underground systems in suburban areas.

An estate, consisting of houses with wide frontages and large gardens, even if fully telephoned, is almost as difficult to serve underground economically as one with small houses and a poor telephone development, although the former is certainly the estate at which from the amenity point of view, underground distribution is most warranted. An estate with houses of medium size and frontage, where under present conditions a good development is to be obtained rapidly, is easier of treatment and represents a case in urgent need of attention.

It is very desirable that serious consideration should be given to the problem of devizing modified methods of distribution to meet these conditions. From the maintenance point of view, complete underground distribution is undoubtedly desirable. Efforts should therefore be made to secure a system of underground distribution which can be economically justified.

Obvious points to which attention must be directed to secure this end are:—

(1) A cheaper form of conduit than the present S.A duct for laying in the footways of suburban streets.

(2) As an alternative to (1) in favourable cases, protected cable might be laid without any form of conduit.

(3) A cheap and easily installed form of jointing box.

(4) The possibility of laying the cables in the footways before they are made up.

(5) Arranging the footway cabling in such a way that the footway is not disturbed when subscribers' connexions are to be made.

Until such time as a satisfactory form of construction has been evolved to meet these conditions, serious attention should be given to the appearance of overhead service lines in suburban areas. Where good development is anticipated, the through line with open wire drops should not be employed, service being given by radial distribution from distribution poles spaced at intervals of 80 to 100 yards. These poles should be no higher than is necessary to distribute the wires in an approximately horizontal plane. (This does not, of course, apply to a street of bungalow type houses.) To achieve this object 26ft. to 30ft. medium poles should be satisfactory. The capacity of the poles should not exceed 15 pairs. To overcome the objections to radial distribution from cross arms detailed above, arrangements have recently been made for the experimental trial on a large scale of a ring type pole head for open wire radial distribution. Photographs of such a pole viewed from a distance and as a close-up are given in Figs. **1** and **2**. It should be mentioned that the pole illustrated is too tall. These rings will accommodate twelve spindles No. 7 and are thus suitable for distributing from cables up to ten pairs. The additional holes give a degree of flexibility in arranging the radial spurs. Two rings may be used to serve from a 15 pair cable. This type of construction has advantages in three directions over present standard methods.

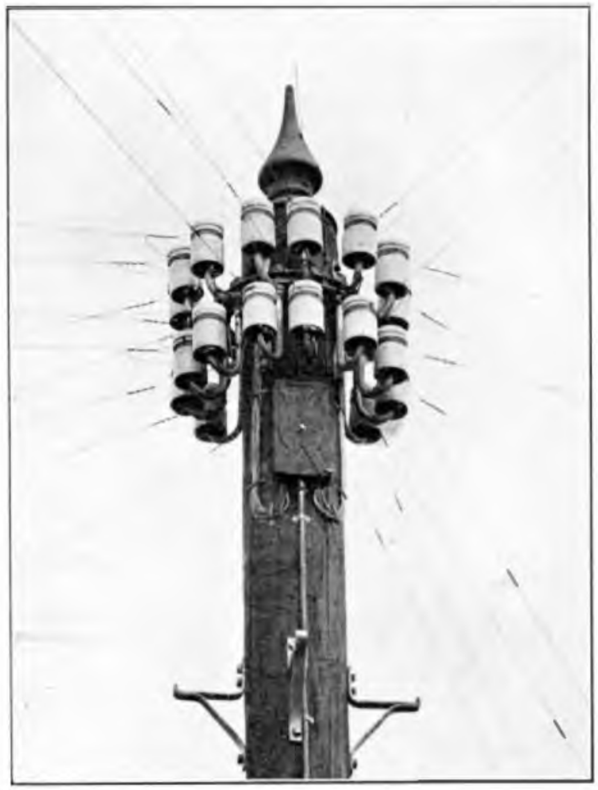


Fig. 2—Ring Type Pole Head.

Fig. 1—Pole with Ring Type Head

(1) It is less conspicuous and neater in appearance. It should therefore meet to some extent the objections of wayleave grantors to overhead distribution.

(2) The arrangement of the single pair pole leads is simpler than with the armed pole and the leads are less liable to disturbance by men working on the pole.

(3) All pairs must be led off in vertical formation and the elimination of flat or quarter twist pairs should considerably reduce the fault liability.

There are one or two disadvantages which can probably be overcome by a little forethought on the part of gang foremen.

(1) It is not possible to take two pairs to the same leading-in point. In some cases it may be possible to meet this by a wide separation of the termination on the subscribers' premises, or if there

is no objection to the use of drop wire, a drop wire pair may be run from both the upper and lower insulator of one of the No. 7 spindles to corresponding points on the subscribers' premises.

(2) If care is not exercised in choosing the hole in the ring as pairs are added, so as to leave some degree of flexibility, changes may be necessary if the development leads to unbalanced distribution.

It is not intended that this type of distribution should supersede drop wire, which has a useful field where no objections are raised to the greater visibility of the covered wires. To avoid wayleave difficulties, however, it is desirable to use drop wire with discretion.

Conclusion.

Some apology is necessary for an article which leaves unsolved the most difficult of the problems which it propounds. Recent experience of negotiations with public authorities and private wayleave grantors has led the author to the conclusion that there will be considerable obstacles in the way of telephone progress in this country if we attempt to meet the conditions of tomorrow with the methods of yesterday, and it seems advantageous to state the problem clearly at the outset, in order to enlist the widest possible interest and assistance in its solution.

Telegraph and Telephone Plant in the United Kingdom.

TELEPHONES AND WIRE MILEAGES. THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 30TH JUNE, 1936.

Number of Telephones owned and maintained by the Post Office	Overhead Wire Mileages				Engineering District	Underground Mileages			
	Telegraph	Trunk	Exchange*	Spare		Telegraph	Trunk	Exchange†	Spare
958,725	368	4,763	51,657	6,435	London	37,376	259,224	4,016,160	90,278
123,414	1,900	14,766	52,609	8,509	S. Eastern	6,028	107,992	398,603	45709
142,640	2,871	34,956	95,217	7,993	S. Western	25,305	79,537	314,470	97,538
98,937	3,448	38,019	83,563	13,024	Eastern	15,446	89,560	196,978	47,574
114,324	3,382	31,392	61,159	18,941	N. Midland	4,772	184,918	254,162	90,482
123,095	2,073	21,497	75,637	15,274	S. Midland	9,398	123,960	355,855	33,189
81,839	2,048	25,170	68,369	9,909	S. Wales	6,773	77,384	172,086	66,048
164,272	3,121	17,374	69,013	20,244	N. Wales	10,102	147,690	488,517	103,287
206,657	1,034	3,552	30,627	9,019	S. Lancs.	7,398	140,725	766,985	64,985
88,082	795	9,191	32,918	18,984	N. Western	6,021	98,381	268,986	76,007
34,095	2,964	11,556	15,382	1,127	N. Ireland	411	8,153	85,565	21,145
243,856	5,430	38,516	83,715	21,370	N.-E. Reg.	16,017	226,284	688,047	125,271
222,281	6,748	44,410	88,091	19,467	Scot. Reg.	12,502	183,410	487,086	126,297
2,602,217	36,182	295,162	807,957	170,296	Totals	157,549	1,727,218	8,493,500	987,810
2,563,835	46,316	302,363	781,162	165,079	Totals as at 31 March 1936	159,583	1,637,192	8,374,721	989,694

* Includes low gauge spare wires (*i.e.*, 40 lb. in open routes and 20 lb. or less in aerial cables).
† Includes all spare wires in local underground cables.

An Outline of the Principles of Atomic Physics

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III. Isotopes, Radioactivity and the Neutron

The third article of this series begins with a description of the Geiger counter. This is followed by a discussion of the existence of isotopes and the elementary facts of radioactivity. The article concludes with a description of the neutron and its significance.

The Geiger Counter.

WE concluded the previous article with a description of the Wilson cloud chamber and its use to enable a photograph to be taken of the trail of ions formed along the path of a rapidly moving particle. Mention must also be made of another device which is used for the detection of these rapidly moving particles and which is very useful either separately or in conjunction with a cloud chamber. The instrument in question is known as a Geiger counter and enables the passage of successive single particles to be recorded and counted. It consists of a small discharge tube filled with a gas at a pressure of a few millimetres of mercury and provided with suitable electrodes. It is found preferable that one electrode should consist of a cylinder and the other a wire forming the axis of the cylinder. The potential difference between the two electrodes is arranged to be just below the value at which a discharge will pass. If now a fast-moving particle enters the tube, the gas is ionized and a discharge current flows. By the use of valve amplifiers this discharge current can be amplified and made to operate a meter of the telephone type. The passage of successive particles across the discharge tube causes successive bursts of ionization current and successive operations of the meter. A device is thus available, by means of which the passage of individual particles may be counted and recorded. Alternatively the amplified current can be made to operate a recording galvanometer, and with suitably designed circuits the deflection may be arranged to be proportional to the ionization. By means of this arrangement a permanent record can be obtained of the passage of particles of different types and of different energies through the counter.

The use of Geiger counters has been specially valuable in the research into the nature of cosmic rays. These rays are streams of high energy particles which are continually reaching the earth and apparently originate in outer space.

Their passage across an experimental chamber is comparatively infrequent and in consequence difficulties have been encountered in obtaining Wilson cloud tracks of them owing to the very small chance of effecting the expansion at the right moment. By the use of a Geiger counter, the expansion may be effected automatically by the operation of the counter and a flashlight photograph taken at the same instant. In addition by the use of two counters, it may be arranged that the apparatus (meter or cloud chamber) shall only be operated by particles which pass through both counters, and hence experimental studies may be restricted to particles moving in a particular direction. This is known as the double coincidence method.

The Geiger counter provides further convincing evidence of the existence of separate particles in the various streams of energy encountered in experimental atomic physics.

Isotopes.

In the early part of the nineteenth century a hypothesis was put forward by Prout that all atoms consist of clusters of hydrogen atoms. The atom of the lightest element, hydrogen, was regarded as a unit from which all other atoms were built. This view arose because the atomic weights of the elements appeared to be integral multiples of the atomic weight of hydrogen. In later years, however, the improvement in the technique of experimental physical chemistry has shown definitely that this relationship is only approximate in most cases, and in some cases, for example that of chlorine, the atomic weight is 35.5 times that of hydrogen. Prout's hypothesis was therefore abandoned. It has now been discovered, however, that a chemically pure element invariably consists of a mixture of different sorts of atoms, identical in chemical properties but differing in atomic weight. These different sorts of atoms are known as " isotopes " and may be identified by means of the mass spectrograph. The atomic weight of each isotope is much more nearly an integral multiple of the atomic weight of hydrogen, the value measured by the methods of physical chemistry being a mean value of the atomic weights of the different isotopes. The fact that in many cases the mean value is nearly a whole number is due to the fact that there is generally one isotope present in much greater numbers than the others.

The question now arises as to whether Prout's hypothesis may be revived, whether in fact each atomic nucleus is made up of a number of protons, the nucleus of the lightest isotope of hydrogen. In order to answer this question it is necessary to examine any experimental evidence which may be available on the masses of various nuclei and also the charges carried by them.

The evidence provided by the mass spectrograph is that the masses of all nuclei are (except for very small divergencies) integral multiples of the mass of the proton. The nature of the small divergencies and their significance will be discussed at a later stage. The nearest integer to the value of the ratio between the mass of an atom and that of the proton is known as the mass number of the atom in question and may be denoted by the symbol M. The mass number is thus the approximate value of the atomic weight.

In order to distinguish between the different isotopes of an element, by means of symbols, it is convenient to write the chemical symbol for the element with the mass number as an upper affix. Thus the most prominent isotope of helium is written ^{4}He and the other isotopes ^{3}He and ^{5}He respectively.

Returning to the evidence regarding nuclear charge, we must consider some experiments made by Rutherford, Geiger and Marsden in 1913. By shooting alpha particles through a sheet of gold foil, and noting what proportion of the particles was deflected through a given angle, and then repeating the experiment with other metal foils, they were able to draw two conclusions.

(1) That the space occupied by an atom, except for a small massive nucleus is practically empty.

(2) That the nuclear charge has a definite value which may be calculated and is of the order of half the mass number.

These conclusions follow in the following manner. Firstly, since an alpha particle is several thousand times the mass of an electron, we may neglect the effect of the extra-nuclear electrons upon the incident alpha particles and attribute any deflection observed to the effect of the heavy nucleus.

Secondly, by applying the laws of dynamics to the observed deflections suffered by incident alpha particles of known energy, and assuming that the positively charged alpha particles and the positively charged nucleus repel one another in accordance with the well known inverse square law of electrostatics, we may calculate the value of the nuclear charge. We may also deduce that when alpha particles are turned back on their course by a head-on collision with a nucleus, their centres must have approached to within 10^{-12} cm. This value sets an upper limit to their linear dimensions, which are accordingly about 1/10,000 of the dimensions of an atom.

It will be profitable to digress for a short space in order to realize the significance of these conclusions as to atomic dimensions. Having set an upper limit to the size of the nucleus and knowing its mass we find that its density must be enormously high. If we suppose an atom of metal, say copper, to be magnified 10^{10} times it would be about 7 feet in diameter. The diameter of its electrons would be 0.0004 ins. and each would weigh about 2 lbs. The atomic nucleus would be just visible to the naked eye as a tiny speck, but its mass would be 100 tons. These figures help us to realize the enormous density of the proton and the relatively small space in which the mass of the atom is concentrated, most of the volume occupied by an atom being empty space. Earlier theories of the atom have likened the atom to the solar system; a central nucleus which is surrounded by planetary electrons revolving in definite orbits. This is a convenient picture in many ways, but present-day knowledge leads us to beware of being too dogmatic about defining the precise nature and position of the orbits of the electrons. It is more consistent with the known facts merely to consider the electrons as a cloud round the nucleus. What we can say, however, with some confidence, is that the central nucleus or sun of this imaginary solar system is exceedingly minute in proportion to the size of the planetary electrons and of the atom itself and that the particles are separated by much greater distances in comparison with their size than are the planets and sun of the astronomical solar system.

Returning to the evidence supplied by Rutherford's experiments as to the value of the nuclear charge, it has been found that the value of this charge for each atom is always an integral multiple of the value of the electronic charge, e, the integral value being known as the "Atomic number" and usually denoted by the symbol Z.

In passing it may be noted that since atoms are neutral the positive charge on the nucleus Ze must be equal to the total negative charge of the surrounding electrons. The atomic number Z must, therefore, be numerically equal to the number of electrons surrounding the nucleus and forming part of the atom. In symbolic notation the atomic number is usually written as a lower affix to the chemical symbol of an element. Thus the three isotopes of Helium are written respectively, $^{5}_{2}He$, $^{4}_{2}He$ and $^{3}_{2}He$. We are now in a better position to answer the question raised earlier, as to the probability of each nucleus consisting of protons. The facts established experimentally are:

(1) that the masses of all nuclei are (except for trifling divergences) integral multiples of the mass of the proton, and,

(2) that the positive charges on nuclei are exact integral multiples (Z times) of the charge of the proton.

If the mass number were equal to the atomic number we should have very strong evidence that the nuclei consisted entirely of protons, but actually the mass numbers are always greater than the atomic numbers except for the solitary case of hydrogen $^{1}_{1}H$, the nucleus of which is the proton itself. Indeed, there are two other isotopes both with atomic numbers equal to unity but with mass numbers 2 and 3 respectively. The isotope $^{2}_{1}H$ is known as "heavy hydrogen" and its nucleus is called the "deuteron." We note in passing the fact that an element is distinguished by a characteristic atomic number common to all the isotopes. The isotopes of an element possess the same atomic number but differ in mass number.

In order to convince ourselves more strongly that isotopes really exist, it is profitable to examine in detail some striking evidence regarding the existence of heavy hydrogen.

The difference between the atomic weight of hydrogen as determined by the well-known classical methods of physical chemistry and the value obtained by Aston by means of the mass spectrograph led a number of investigators to look for an isotope of hydrogen heavier than $^{1}_{1}H$. In 1932 spectographic evidence of the existence of a heavy isotope of hydrogen $^{2}_{1}H$ was obtained by Urey, Brickwedde and Murphy. The theory of optical spectra suggested that if a heavy isotope of hydrogen did exist its spectrum would be similar to that of hydrogen but with its lines displaced towards the violet. Theoretical consideration also suggested that if the heavy isotope existed its molecules should have different vapour pressures in the liquid state from the molecules of ordinary hydrogen. Urey, Brickwedde and Murphy carried out fractional distillation of liquid hydrogen and examined spectrographically the gas coming over in the last stage. These experiments revealed additional lines in the spectrum exactly corresponding to those calculated for an isotope of hydrogen of mass number 2.

The existence of a second isotope of hydrogen immediately raises the question of a second variety of the compound water. What we know as water will consist of a mixture of $^1_1H_2O$ and $^2_1H_2O$. The compound $^2_1H_2O$ has been called " heavy water " and will be present in ordinary water to the extent of about 1 part in 10,000. Washburn and Urey have discovered that heavy water is present in relatively large proportions in old electrolytic cells in which water has been electrolysed for long periods. It accordingly appears that the common isotope of hydrogen ^1_1H is more freely evolved during electrolysis than is heavy hydrogen ^2_1H, with the result that in an electrolytic cell the proportion of $^2_1H_2O$ in the liquid which remains unelectrolysed tends to increase continually. In 1933 Lewis and Macdonald developed a concentration method on these lines and were able to prepare water of density 1.11 containing over 90 per cent. of heavy water.

Element.	Atomic number Z.	Properties of Isotopes. Mass number M.	Symbol.	Mass on atomic weight. scale.
Hydrogen	1	1	^1_1H	1·0081
		2	^2_1H	2·0142
		3	^3_1H	3·0161
Helium ..	2	3	^3_2He	3·0171
		4	^4_2He	4·0034
		5	^5_2He	5·010
Lithium	3	6	^6_3Li	6·0162
		7	^7_3Li	7·0170
Beryllium	4	8	^8_4Be	8·007
		9	^9_4Be	9·0137
Boron ..	5	10	$^{10}_5B$	10·0144
		11	$^{11}_5B$	11·0111
Carbon	6	12	$^{12}_6C$	12·0032
		13	$^{13}_6C$	13·0069
Nitrogen	7	14	$^{14}_7N$	14·0076
		15	$^{15}_7N$	15·0053
Oxygen	8	16	$^{16}_8O$	16·0000
		17	$^{17}_8O$	17·0040
		18	$^{18}_8O$	18·01

TABLE SHOWING A FEW OF THE LIGHTER ELEMENTS AND THEIR ISOTOPES

The reality of the existence of heavy water confirms the existence of isotopes and is a very strong indication that the present development of atomic theory is proceeding along sound lines. In spite of the somewhat fantastic ideas involved and the remarkable consequences of assuming the truth of the modern atomic theory, the direct proof of the reality of a substance such as heavy water should reassure us that the new ideas are not entirely divorced from real facts.

The fact that the atomic number Z is apparently an exact integral multiple of the charge on the proton, whereas the mass number is only approximately so, does suggest very strongly that the atomic number Z is actually the number of protons in the nucleus, the balance of the mass being made up in a manner at present unknown. We may suppose, however, that the balance of mass is made up of particles each of which has approximately the same mass as a proton, but carries no charge. The existence of such a particle had already been contemplated by Rutherford as early as 1920, but it has until quite recently evaded all efforts to verify its existence. It was, however, identified by Chadwick in 1932, and has been called the " neutron."

As we are assuming that the nucleus contains neutrons, it appears that the obvious way to isolate them is to bombard the nucleus and see if neutrons can be knocked out. This is actually what has been done although at the time the experiments were first made the observers were not on the look out for neutrons, and did not appreciate at once what they had actually done.

Radioactivity.

Before passing on to the experiments which led to the discovery of the neutron, we must examine the elementary facts of the phenomenon of radioactivity, in which the nuclei of certain elements are observed to disintegrate spontaneously with the emission of charged particles. As early as 1896 Becquerel found that certain substances spontaneously emitted penetrating rays which would effect a photographic plate, cause fluorescence and would also ionize gases. This was followed by the discovery of the element radium by Madame Curie in 1898, and since that time numbers of radioactive elements have been discovered and their properties examined. Radioactive materials are observed to emit three distinct types of rays, known as alpha, beta and gamma rays respectively. Alpha rays are identified as streams of alpha particles, beta rays as very high energy electrons and gamma rays as high frequency photons. In emitting these rays the parent radioactive material is observed to change into a new element of atomic number two less than that of the parent. The atomic number of alpha particles being two, it would appear that the emitted alpha particles are ejected from the nucleus by this transformation and it is found that this assumption agrees with experimental observations. In many cases the new element formed is itself radioactive and the disintegration proceeds by

A Mobile Post Office

W. G. DUNK and C. F. MILLS

A recent innovation in Post Office services is a " Post Office on Wheels." It is designed to afford essential post office facilities at important open-air functions, such as exhibitions and sports meetings.

Introduction.

THE provision of telegraph, telephone and postal facilities at what are officially termed " special events " presents very interesting problems. Generally, for race meetings, etc., which occur at stated intervals, buildings are permanently wired for the telecommunication services, the apparatus being sent to the site before the meeting and recovered directly afterwards. The smaller event is, however, more difficult to cater for, especially in regard to telephone facilities, as telephone call offices which give reasonable sound qualities are not easily erected and dismantled. To meet these conditions it was decided to build a motor vehicle which would provide facilities for these services and thus reduce preliminary work to a minimum.

As a result of discussions between representatives of the Headquarters Departments concerned it was decided that the undermentioned facilities should be provided in a motor vehicle :—

(a) Telegraph—Acceptance of telegrams from the public and receipt of telegrams at the vehicle.

(b) Telephone—Trunk and local telephone service from two telephone cabinets built in the vehicle.

(c) Postal—Sale of stamps, acceptance of letters and parcels and registration of letters and packets.

Type of Vehicle.

After the services were decided consideration was given to the type of vehicle most suitable for the work, bearing in mind the many governing factors, e.g., limitation in size by the Road Traffic Act to overall length of 33 ft. and overall width of 7 ft. 6 in.; ability to manœuvre; economy in capital cost and in maintenance costs; maximum floor space; low floor position for the staff and the public telephone cabinets; convenient height for the counter and windows used by the public. With these factors in mind, it was decided that the most suitable vehicle would be the articulated type, i.e., with the tractive unit separate from the body portion, which would allow a vehicle to be produced of maximum length of 33 ft. This type of vehicle is easier to manœuvre than a rigid vehicle of the size required, a factor which is important in view of the certainty that the vehicle will be used at functions held in fields approached by narrow and twisting lanes and narrow gateways. A saving in cost was also effected, a rigid vehicle costing appreciably more.

The body of the vehicle, which is referred to as the trailer, had to house two telephone call offices and provide accommodation for three counter clerks with facilities to conduct telegraph and postal business, and provision for these had to be made in a body of maximum over-all horizontal dimensions of 22 ft. long by 7 ft. 6 ins. wide. The lay-out adopted is shown in Fig. **1**.

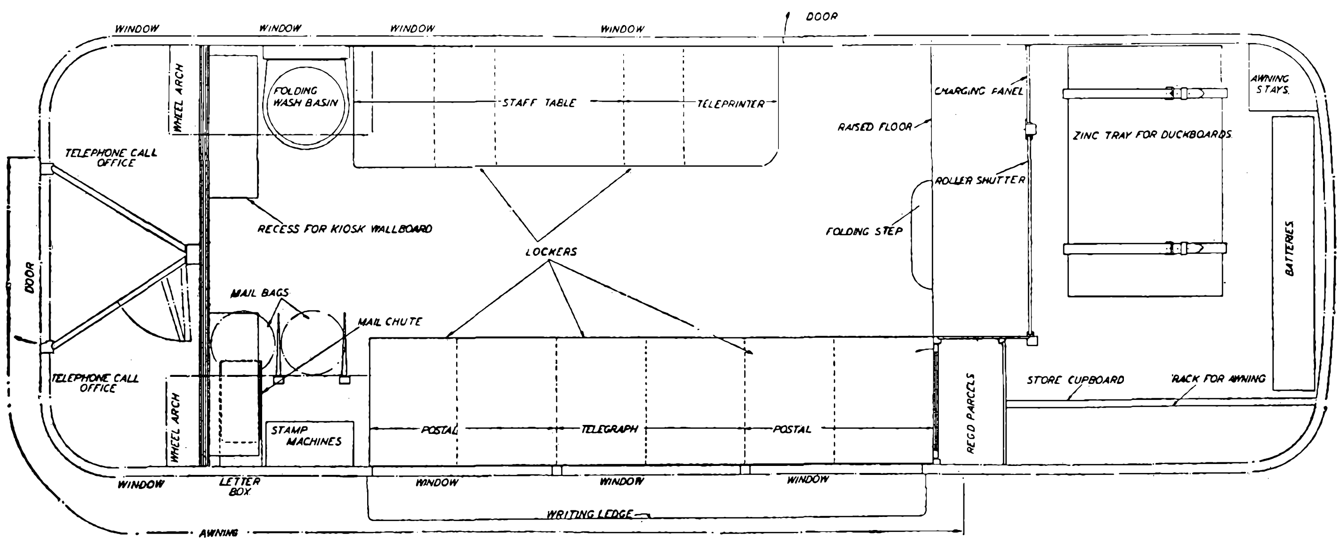

FIG. 1.—LAYOUT PLAN.

The window height was important as service to the public for postal and telegraph business had, of course, to be at a convenient height. A Brockhouse drop frame trailer was accordingly selected which enabled windows to be fitted 3 ft. 11 ins. from the ground. A floor height of 1 ft. 5 ins. was also obtained. The trailer is marketed by Messrs. J. Brockhouse & Co., Ltd., and is fitted with that firm's patent " Kwikfiks " attachment. This attachment allows the tractor, which is equipped with the other half of the coupling, to be linked up to the trailer by simply backing the former to the latter until the king-pin on the trailer engages with a hooked coupling on the tractor. The connexion is automatic and at the same time the brake on the trailer is coupled to a lever on the tractor. The "Post Office" body is built upon the trailer and its shape was designed on lines which are considered to be the most attractive and pleasing consistent with utility. (Fig. 2). It is partitioned into three compartments, the rearmost portion housing the telephone cabinets, the centre portion the office proper and the front what may be termed a store room. The three postal and telegraph counters are situated in the vehicle at the offside and accommodation for the teleprinter is provided on a counter at the nearside.

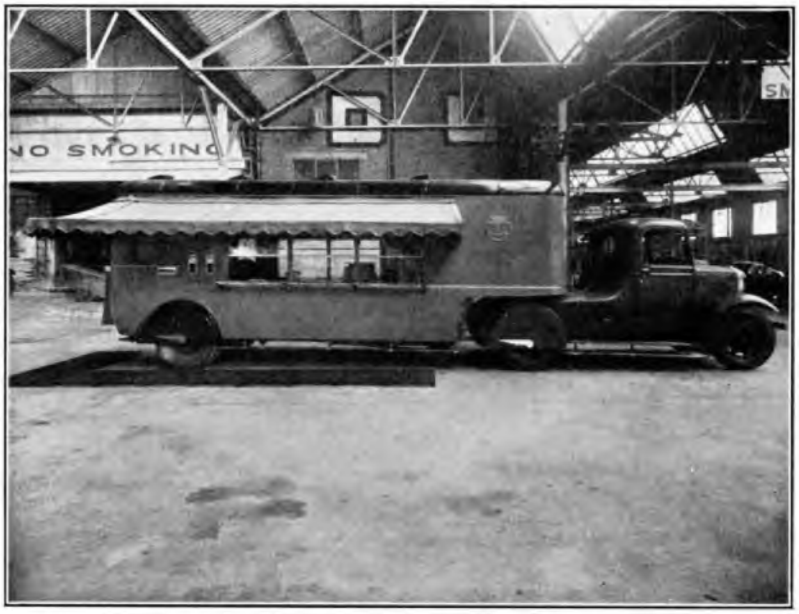

FIG. 2.—GENERAL VIEW OF TRACTOR AND TRAILER.

The two telephone cabinets are reached by a folding step—single tread—between the ground and the platform forming the floor of the cabinets. In order to facilitate entry and egress and to allow as much interior room as possible, access to each call office is by a two-sectioned folding door, set at an angle and hinged to a pillar fitted centrally on the partition which forms the backs of the cabinets. When the vehicle is not in use a rear door encloses the platform which gives the vehicle an orthodox rear view. This door, when the vehicle is "on duty," is fixed open with a door adjuster at an angle of 90° and the inside of the door thus exposed is fitted with a grip handle to assist entry of the public to the call offices. A similar handle is fitted just inside the shut pillar. The following notice is inscribed in Roman Trojan type engraved on black with cream lettering on the inside face of the door —"Public Telephones—Local and Trunk Services." The usual type of folding door is fitted to the cabinets and the construction generally follows that used for cabinets in public offices, thus allowing as large a measure of sound-proofing as possible.

The Call Offices.

The call office layout is that used in the new Jubilee kiosk, one minor modification having to be made to the offside call office to allow for the passage of the letter chute. This was effected by altering the directory pigeon-hole and in no way detracts from the appearance of the layout or lessens its utility.

To provide connexion with any type of exchange, Magneto, CBS Nos. 1, 2 and 3, CB, and automatic systems, including unit automatic exchanges, necessitated the design of a special circuit and to avoid change of instruments in the vehicle or provision of special plant at exchanges, postpayment coin boxes were necessary. This arrangement has certain traffic disadvantages as postpayment working in prepayment areas will sometimes be occasioned, but the Traffic Branch, viewing all considerations, did not anticipate any considerable difficulty in this direction as they will have due notice of the special event and sufficient time to prepare suitable instructions for the guidance of the operating staff.

In the circumstances in which the vehicle will be used it may be assumed that a considerable number of persons wishing to use the call office will require connexion to towns not in the immediate vicinity of the event, and to prepare comprehensive lists of charges for such calls and provide accommodation for them, would cause difficulty. Skeleton lists will therefore be prepared.

A special call office circuit was designed using a Telephone No. 196 LB fitted with a Dial Automatic No. SS 11 FA, three dry cells and a six point two-position switch for changing from loop to earth ringing. The latter connexion is required in CBS No. 1 areas only. In CB and CBS areas the operators' attention will be called by lifting the receiver and for magneto areas a generator is provided. In non-automatic areas the dial of the Telephone No. 196 LB is covered by a cap. The generator is housed in the coin-collecting box and when not in use the hole for the handle is covered by a screwed cap, the handle being stored in the battery compartment of the parcel receptacle. In automatic areas the attention of the operator is obtained by dialling 0 or the local two digit code. The disposition of the apparatus is shown in Fig. 3.

The call offices are connected to Protectors HC and F 2/2 mounted on a board immediately below the roof of the vehicle at the nearside of the trailer. From this board connexion to the telephone network will be made by Cable IR Aerial 8 pair/20, the cable passing through the side of the trailer. The entry is so arranged that rain will not enter. A third telephone circuit is provided for telephoning telegrams when the teleprinter is not in use or is temporarily out of service. This telephone connexion is paralleled to the public counter and can thus be used for service messages when required. It was not considered necessary to make special arrangements for direct connexion to underground cables.

Telegraph and Postal Equipment.

Telegraph service will normally be provided by Teleprinter No. 3A. Unit Auxiliary Apparatus No. 72

FIG. 3.—CALL OFFICE EQUIPMENT.

is used with the teleprinter and provides facilities for simplex, duplex and YQ workings. A pair of leads from the teleprinter position is brought to a Protector HC and F 2/2 on the terminal board on which are also mounted the telephone protectors and the line connexion is made here.

From the charging panel a lead is connected to the teleprinter position giving 110 volts. This is required for the motor drive. Across the 110-volt leads a potentiometer consisting of 4,000 + 4,000 ohms is connected, thus giving 55 + 55 volts positive and negative potentials from either side of the centre tap, and is used to provide the line and local currents.

Adjacent to the public counter (Fig. 4) are two stamp-selling machines (½d. and 1d.) and a letter chute. When the vehicle is not in use the stamp-selling machine mechanisms are removed and a shutter covered with aluminium sheet is inserted in the aperture and held in position by two Bloxwich spigot budget locks. A spring-loaded hinged louvre type of cover is fixed over the letter chute aperture and a temporary shutter is placed over this cover when the vehicle is " off duty." One end of the chute is attached to the posting box aperture and the chute continues to the mouth of a mail bag so that handling of postal packets is reduced to a minimum. When the vehicle is in use two mail bags are utilized; they are held on detachable hook arms similar to but smaller than those used in sorting offices. As previously stated one of these bags is under the letter chute and the other is for parcels.

As far as possible, having regard to the space limitations of the trailer, the drawer and shelf accommodation normally provided in Post Offices has been installed. This is an important feature as the postal and telegraph personnel will be drawn from the local staff, and as rush times may be expected, it was essential that the personnel should carry out their duties under conditions of accommodation as near normal as possible.

Stamps, cash, etc., will not be kept in the trailer when the staff is not on duty. The stock of stamps, cash, etc., will be handed over to the local postmaster for safe custody at the end of the day's business. It is the usual practice to keep this stock in metal deed boxes and racks at the backs of the three

FIG. 4.—REAR VIEW OF TRAILER.

knee-holes under the service counters have been provided to accommodate them during " office hours." Separate locked cupboards are provided for registered letters and parcels. These cupboards have framed doors with expanded metal fronts so that when the cupboards are being cleared, packages are not overlooked.

For the convenience of the public, a sloped writing ledge, in three pieces, but forming a continuous shelf, is fitted under the three public windows. The ledge is removable and is mounted on four detachable mild steel brackets which slide into brass brackets screwed to the side of the vehicle.

Staff amenities have not been overlooked. A wash-basin of the ship cabin tip-up type, purchased from Messrs. Beresford & Sons, Ltd., is installed, water being drawn from a tank of six gallons' capacity fitted near the roof and filled from inside the vehicle. An electric kettle is included and this is filled from a tap fitted in the feed pipe connecting the storage tank to the wash basin tap. A table is also provided with cupboard space for staff use. On the front of the partition which forms the back of the call offices is a luggage rack, similar to those fitted to modern motor coaches.

Seats for the staff are of the type used by phonogram operators, generally referred to as the "Tan-Sad" type. These chairs have been specially upholstered and finished to match the general internal colour scheme of the vehicle.

The public counters, teleprinter and staff table tops are constructed of plywood, covered with black bakelite and are edged with stainless steel. These tops were manufactured by Messrs. Tucker Armoured Plywood Co., Ltd.

Power Supplies.

Provision of electrical energy for the teleprinter and lighting of the vehicle presented a certain amount of difficulty. At first it was considered that a petrol or diesel engine-generator set, housed in the fore part of the vehicle, would be a suitable means, but examination of various charging sets revealed the fact that such a scheme was undesirable owing to lack of space, noise and vibration. It was ultimately decided to mount the generator on the tractor and to drive it from the engine of that unit by means of a power take-off from the gear-box, which is controlled by a lever in the floor of the cab. Although normally the generator will be used while the vehicle is stationary, it will be possible to charge the batteries while the vehicle is travelling.

The generator, a light weight, enclosed, ventilated, shunt compound machine producing 15 amperes at 98/150 volts, runs at 1,500 r.p.m. It is housed in the driver's cab on supports underneath the passenger's seat and is easily accessible.

The generator supplies current to charge two batteries of 54 cells at a normal charging rate of 3 amperes. The batteries were supplied by Messrs. The D. P. Battery Co., Ltd., being their MEZ traction type. Sealed ebonite containers are used and the cells are assembled in three hardwood crates each containing 18 cells.

The batteries are carried in the fore part of the vehicle on light section steel racks (Fig. 5). The two under trays are arranged to draw forward to allow for taking hydrometer tests and topping the cells when necessary. In order to facilitate this work the battery trays rest on rollers and when attention to batteries is required, detachable bracket arms affixed to the rack at the level of the bottom of the tray provide a support for the tray and battery.

The charging panel allows for the charging of the batteries separately or in parallel and also for the supply of current direct from the generator to the lighting circuit should this be necessary. As the space in the vehicle is limited iron-clad switch gear was provided. The charging panel was supplied by Messrs. The Power Equipment Co., Ltd.

Connexion between the generator and the charging panel is effected by a multi-core tough rubber type cable. Included in this cable is a pair of wires for the rear light of the trailer, current for which is supplied by the ordinary lighting dynamo on the tractor. The cable connectors are of the watertight plug and socket type.

For the guidance of the engineering staff, the necessary instructions, circuit diagrams, etc., have been bound into folders in duplicate. The instructions include circuit diagrams of the call-office circuit, charging panel connexions and instructions regarding the removal and packing of the stamp-selling machines. A set of call office instruction cards proper to each area will also be carried on the vehicle.

FIG. 5.—INTERIOR OF TRAILER LOOKING FORWARD.

Constructional Details of Trailer Body.

The framework of the body consists of 24 vertical pillars attached direct to the trailer chassis, each point of attachment being reinforced with a mild steel bracket. There are five horizontal body rails which are halved into the vertical pillars and reinforced where necessary with mild steel plates. At the rear these rails are equally spaced, but at the sides they are arranged to suit the service windows, the bottoms of which are 47 ins. from the ground. At the offside an additional rail was inserted 5 ins. below the cant rail to provide a cavity for the awning rail. Furthermore, on this side of the vehicle special framing was required for the stamp machines and letter box aperture. Also the nearside framing was reinforced to hold the auxiliary unit for the teleprinter. Twelve curved roof rails, five longitudinal and seven transverse, complete the main framing and these are checked into the cant rail.

In addition to the skeleton, framing for two partitions was necessary. The rear partition, which is fixed, isolates the telephone cabinets and the other divides the front portion of the body from the main compartment. A roller shutter has been provided in the latter.

Each of the outside doors is framed by two vertical pillars and five horizontal rails, the latter being mortised and tenoned into the former. All the framework is constructed of English ash.

The flooring consists of tongued and grooved deal boards 1 in. thick placed longitudinally. The normal construction of motor van bodies provides for crossbars, but the inclusion of such members in the body under review would have negatived to a certain extent the advantage of the low frame height. It was accordingly decided to dispense with them and bolt the boards direct to the trailer frame.

Panelling.

The vehicle is panelled externally with aluminium sheet 16 s.w.g., and the joints of the panels are covered with 1 in. × 3/16 in. half-round aluminium moulding. Panelling of the inside of the body is effected with birch plywood 3/16 in. thick on all flat surfaces and with aluminium sheet 16 s.w.g. on the curved surfaces and the under side of the roof. Insul Board, marketed by Messrs. G. D. Peters & Co., a proprietary material, has been provided in the walls of the telephone cabinets to obtain maximum sound proofing.

Windows.

The design of the three windows over the service counters on the off-side of the body presented some difficulty. Motor coach windows on the market are normally of the " half drop " or " side-sliding " types. The kind of windows required for the vehicle was a " half-lift " pattern, a type which did not appear to be marketed. It was therefore necessary to design and manufacture special windows. They are 36 ins. wide × 30 ins. high and are made of ¼ in. Triplex toughened glass. Behind each there is an inside pane 36 ins. wide × 12 ins. high, also of Triplex toughened glass, with a pigeon-hole cut from the bottom and in the centre. It is recognized that pigeon-holes have certain disadvantages but it was decided that they were essential in order to minimize draught through the windows and so cause as little inconvenience as possible by papers, etc., on the counters being disturbed. The outer glass extends over the full width and height of the window frame and lifts sufficiently to expose the pigeon-hole in the smaller pane. The small panes of glass in the two forward windows are fixed, but that in the rearmost window has been made to lift so that parcels may be passed through the window to the counter clerk. In order to promote easy operation of the windows they are fitted with a balance mechanism on the spring loaded roller principle. On the nearside there are four windows, two large and two small. The larger ones are fixed at the bottom but are provided with hinged louvre ventilators at the top. The two smaller ones are in the nearside telephone cabinet and over the wash basin respectively and are fitted with opaque glass.

Awnings.

Protection for the public from sun and rain is afforded by an awning over the service windows, which extends from a point 18″ forward of the foremost service window to the nearside of the rear door and is in four pieces, each being 4′ deep. Green " Willesden " canvas has been utilized for the awning and a scalloped and bound frill enhances its appearance. It is supported by eight removable stays, each 3′ 6″ long which are made of steel tubing, their free ends being linked together with steel tubes to which the bottom of the awning is attached. The awning supports are so designed that the awning can withstand the strongest wind. The recess or cavity which houses the awning rail is provided with a wooden cover which is placed into position when the awning is not in use.

Duckboards.

Six heavy duckboards 4′ × 2′ 6″ are available for use on wet or muddy ground. They are constructed of oak, treated with external solignum and are sufficient to cover the ground in front of the service windows and that round the offside rear corner to the door leading to the telephone cabinets.

Tractor.

The tractive unit is a standard Morris Commercial 3-ton " Leader Tractor " chassis with a four cylinder engine rated at 24.8 h.p. It is fitted with a specially designed cab to conform as far as possible with the lines of the trailer body but departure from the ideal was necessary owing to the appreciable clearance required for the rear and sides of the tractor when driving the vehicle along roads with acute bends. Such roads will frequently be met in the districts where the vehicle is used.

Decoration scheme and Ventilation.

The exterior colour of the trailor and tractor is generally " Post Office Red," British Standard colour No. 38 and cellulose finished. The roof of both units and the mudguards and cover plates are black. The " flying wing " ornaments on the cover plates of the rear wings are red. With a view to improving the attractiveness of the general appearance of the outside, the waist moulding on the trailer body is finished a golden colour. Gold leaf was considered for this moulding but for reasons of cost and durability it was decided to utilize anodized aluminium moulding for this purpose, as metal so treated is more durable and less prone to disfigurement than a gold finish. The " G.P.O." monogram, also in golden anodized aluminium, appears on each side of the trailer body, as well as on the rear door.

The mudguards or wings were designed to be in keeping with the general lines of the body. The rear ones on both the trailer and tractor follow a similar streamlined contour and are each fitted with a detachable cover plate with a " flying wing " ornament placed in a suitable position. It was essential that detachable cover plates be provided in order to secure accessibility to the wheels and tyres for replacement and repair purposes. The front wings of the tractor are the orthodox curved type. It was not possible to fit cover plates on these as it was necessary to allow for the turning lock of the front wheels.

The interior colour scheme is black and grey with most fittings chromium finished. This scheme creates an impression of spaciousness (Fig. 6). The roof and as much of the remainder of the interior as practicable is lined with grey Rexine, which is washable, uncovered parts being painted dove-grey. Dreadnought-grey linoleum covers the floor.

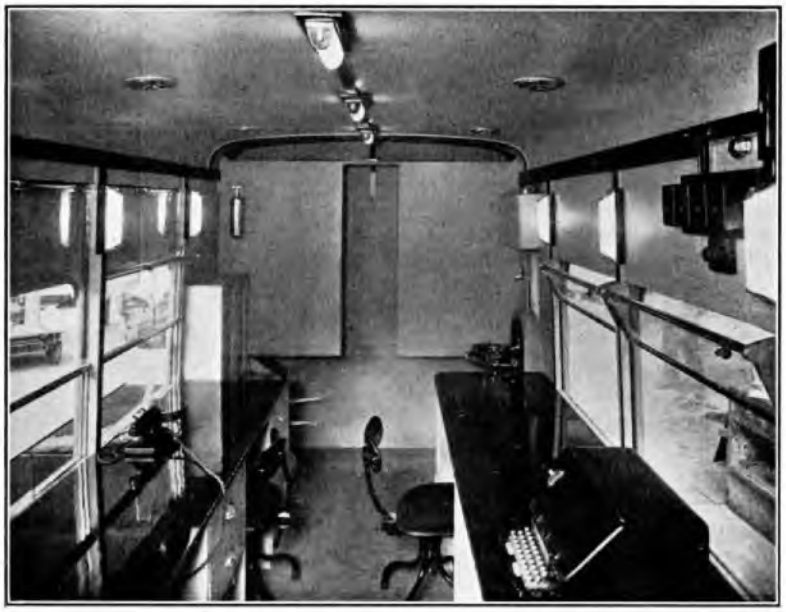

Fig. 6—Interior of Trailer Looking Towards the Rear.

Ten " Ashanco " ventilators are provided in the roof, one over each telephone cabinet, six equally spaced over the main body compartment and the other two over the forward portion. Each ventilator is fitted with a "hit-and-miss" grid so that air currents may be controlled when necessary. In addition the pigeon holes in the service windows and the open portion of the two large nearside windows afford adequate circulation of the air.

In order to minimize the heat inside the vehicle during hot weather the roof is lined with Alfol marketed by Messrs. Alfol Insulations, Ltd., a proprietory heat-resisting and insulating material. This is inserted between the outer covering and the inside lining of the roof.

For publicity purposes and in order to provide adequate and efficient illumination for the staff and to harmonize with the general decorative scheme special attention was paid to the type and position of the internal electric light fittings. In addition to eight " D " section roof lights in the main body similar fittings are affixed to the body pillars over the service and staff counters. The latter were considered necessary as the roof lights might cast shadows which would hamper the counter clerks in their duties. Furthermore, each counter is provided with a plug point for a table lamp, which might possibly be required, *e.g.*, by the teleprinter operator.

Locks.

To prevent the entry of unauthorized persons into the vehicle each door has been equipped, in addition to a slam lock, with two locks, one a Yale type and the other a Bloxwich spigot budget type. Similar type locks are fitted to the cab doors.

The internal locks are Yale pattern and a separate key combination is provided for each counter position. A padlock is provided to secure the roller shutter of the storage compartment.

Prevention of Fire.

Four Pyrene chromium plated fire extinguishers have been provided, three in the trailer and one in the tractor.

Miscellaneous Accessories.

The front or store compartment of the trailer has a higher floor level than that in the main body and is reached by a folding step. In addition to holding the batteries it is equipped with racks for the awning, awning stays, duckboards, writing ledges, tools, spare parts and accessories for the use of the staff responsible for the maintenance of the vehicle. The accessories include a broom, mop, cleaning rags, polishing cloths, a step ladder, a can for filling the water tank, a pail for emptying the waste tank and a plank for placing beneath the parking wheels of the trailer to prevent them from sinking into soft ground.

Registration.

For publicity reasons the Ministry of Transport was approached with the request that the registration index letters GPO should be allotted to the General Post Office for use on special publicity vehicles such as the Mobile Post Office. The Ministry agreed and this index mark has been allotted to the London County Council for the exclusive use of the Post Office. The registration number of the Mobile Post Office is accordingly GPO 1.

The vehicle was build by Messrs. Duple Bodies & Motors, Ltd., and thanks are due to this firm and the other contractors concerned for many helpful suggestions.

It will no doubt be appreciated that the vehicle is in the nature of an experiment and experience gained with its use will probably suggest modifications and improvements.

C.C.I.F. XIth Plenary Assembly, Copenhagen, June, 1936

F. E. A. MANNING, M.C., B.Sc. (Eng.), M.I.E.E., A.M.I.Mech.E., and P. B. FROST, B.Sc. (Eng.), M.I.E.E.

A brief resumé is given of the subjects discussed and decisions reached at the XIth Plenary Assembly of the C.C.I.F.

Introduction.

A PLENARY assembly of the C.C.I.F. was held in Copenhagen in June, 1936, and was attended by delegates from twenty-eight countries and seven international organizations. Some of the principal matters decided are given under the headings:—

(1) Operation and Tariffs.
(2) Transmission.
(3) Protection.

The full recommendations will be issued by the C.C.I.F. as a supplement to the "White Book," which was published after the Budapest (1934) Assembly as a complete record of the decisions on international telephony that had been agreed up to that time.

General Procedure.

The eleventh Plenary Assembly of the Comité Consultatif International Téléphonique was held at the invitation of the Danish Government in the magnificent Parliament House of Christiansborg Palace in Copenhagen. The twelve delegates from the British Post Office, under the leadership of the Engineer-in-Chief, Lt.-Colonel A. G. Lee, O.B.E., M.C., were most cordially entertained with true traditional Danish hospitality arranged by M. C. Mondrup, Director-General, and M. M. Gredsted, Director, of the Danish Administration. At the joint opening session, held on June 11th, M. Mondrup was elected President. It was decided to follow the usual practice of holding three consecutive sessions daily, each under a Vice-President, to deal with the three main groups of questions. Thus, if necessary, a delegate could attend any or every plenary session because no more than one plenary session was held simultaneously. Since, in general, several delegates were present from each country, this procedure left time for meetings of Commissions and Sub-Committees, dealing with particular aspects of the work, to be held during plenary sessions at which questions in another group were being studied. Colonel Lee (Great Britain) presided over sessions devoted to protection, Herr Höpfner (Germany) over those devoted to transmission, and M. Muri (Switzerland) over those devoted to operation and tariffs. At the closing session, on June 20th, in addition to formal ratification of the decisions reached and also approval of the issue of a supplement to the "Livre Blanc,"[1] the administrative recommendations made by a meeting of heads of delegations were adopted, together with the questions to be studied during the next few years. On the invitation of the governments of the countries concerned the following meetings have been arranged:—

Sixth and Seventh Commissions. (Operation and Tariffs)	Paris.	Sept., 1937.
XII Plenary Assembly. (Operation and Tariffs only)	Cairo.	Feb., 1938.
First to Fifth Commissions. (Technical)	Oslo.	June, 1938.
XIII Plenary Assembly. (All Groups)	Lisbon.	1940.

The list of delegates shows that about 160 delegates, accompanied by 50 ladies, attended the Plenary Assembly.

Operation and Tariffs.

The work of the Administrative Commissions is necessarily linked with that of the Technical Commissions and the opportunity was taken to discuss points of mutual interest. One of the most important questions being studied is the realization of a European trunk switching plan, and it was decided that a joint sub-commission of administrative and engineering experts should be constituted to further the project. The improvement of the facilities offered to broadcasting authorities was discussed and the procedure involved in providing and handing-over circuits was modified to facilitate provision at short notice. This step, combined with some reduction of the charges, should result in a wider use of the international music network. The cable maps and circuit lists issued by the Bureau of the International Telecommunications Union were discussed and future issues will embody modifications to make them more useful to all concerned. One of the principal modifications to the circuit lists will be the recording of any limitation by filters of the frequency bands transmitted, which will give the technical services a better picture of the quality of the circuit than has hitherto been obtainable. The remainder of the work under the heading of "Operation and Tariffs" has little engineering interest.

Transmission.

It was pointed out in an article on the London Meeting of the Technical Commissions of the C.C.I.F.[2] that the questions studied covered a very wide ground, and only a brief mention of the principal decisions is possible here.

The increasing use of radio circuits for international telephony has made necessary the specification of the more important characteristics of automatic volume regulators and anti-fading devices. The characteristics specified agree with existing British Post Office practice.

The closer relations of telephony and telegraphy and the introduction of international Telex working involve close collaboration with the C.C.I.T.[3] and some important decisions have been ratified. For international Telex working a frequency of 1,500 c.p.s. is standardized and the power at the trunk ex-

[1] Report of the X Plenary Assembly, Budapest, September, 1934.

[2] *P.O.E.E.J.*, Vol. 29, Part 1. April, 1936.

[3] Comité Consultatif International Télégraphique.

change is limited to a maximum of 5 milliwatts of steady current. Voice frequency ringers must be rendered insensitive to telegraph signals and echo suppressors must not cut off the "answer-back." The use of super-audio telegraph circuits will involve the bye-passing of echo suppressors and the limitation of repeater outputs to + 0.5 neper. Moreover, voltage limiters securing a maximum speech output of 4 volts at points of relative level + 0.5 neper are recommended. Maintenance procedure for circuits employed for super-audio and for voice-frequency telegraphy has been more clearly specified than hitherto. The precautions to be observed are now clearly laid down for the use of sub-audio telegraphy on telephone circuits, in order to protect personnel and equipment. For filters used on telephone circuits either for separating sub-audio and super-audio telegraphy from telephony or for monitoring, such characteristics as may affect the telephone or telegraph channels are now specified.

A mixed commission of the C.C.I.F. and U.I.R.[4] on which both the Post Office and the British Broadcasting Corporation are represented, is studying the importance of international broadcast circuits on which experimental work is being carried out. Some new setting-up and maintenance regulations are being introduced which are intended to reduce distortion and to ensure the reception by the broadcasting authorities of an adequate volume free from background noise. The C.C.I.F. Maintenance Sub-Commission has drawn up a list of long circuits frequently used for international broadcasts, which will be subjected to periodic tests by means of recording transmission measuring sets.

The constitution of international circuits is being profoundly influenced by the long distances now covered, by the extension of carrier working, and by the introduction of co-axial transmission systems. It is recommended that multi-channel systems of lightly loaded cables should use upper side band transmission with carrier frequencies integral multiples of 4,000 c.p.s. It is not yet possible to do more than exchange information on multi-channel systems on unloaded and on co-axial cables.

The limits of capacity unbalance at present included in the typical specification for underground cables are considered satisfactory for single channel working, but further study is necessary before the appropriate limits can be agreed for multi-channel working. Characteristics of loading coils have, however, been agreed for circuits permitting up to 3 carrier channels in addition to the voice frequency circuit. An agreed specification for repeater station cabling in close conformity with Post Office practice has been added to the typical specifications.

The extension of automatic telephony necessitates consideration of the operating tones (dialling, ringing and number engaged) used in Europe. Information is being exchanged and it is agreed that an attempt must be made to standardize the tones on the basis of interruptions to a basic frequency between 400 and 450 c.p.s. For voice-frequency dialling, frequencies of 600 and 750 c.p.s. are to be adopted, but, in the meantime, 500/20 c.p.s. ringing will continue in use.

The division of delay distortion between national and international links has been agreed for continental and inter-continental connexions, but a similar division of other characteristics such as propagation time, noise and cross-talk has not been completed. The maximum permissible cross-talk on long international circuits has hitherto been specified as 6.2 nepers, but this recommendation has provisionally been modified to 7.5 nepers between two complete terminal circuits in the same cable. Further study is being given to this question.

Modern conditions necessitate the use of terminal echo suppressors in many circuits, and the requirements to be met have been examined. Although further work is necessary, some useful additions to the existing documentation with regard to suppressors has been recorded.

Some preliminary technical work in connexion with a European trunk switching plan has been carried out, and the point has been reached at which detailed study of traffic requirements must proceed in parallel with further technical work, and, therefore, the mixed commission, already mentioned, has been constituted. Some provisional directives have been included in the recommendations concerning the constitution of transmission systems, and the first meeting of the mixed commission was held in Copenhagen at which a list of questions for study in the immediate future was drawn up. An article on some technical aspects of the problem will appear in a subsequent issue of this journal.

Although the use of message recording devices on telephone circuits is largely a matter for national decision, the employment of such apparatus on international circuits has already been mooted. A summary has been made of the essential technical requirements which must be fulfilled if satisfactory service is to be guaranteed. The use of "loud speaker telephones" which may comprise a loud speaker and a high quality microphone is also increasing and much information on the essential characteristics of such apparatus has been collected. Although it is still too early to draw up recommendations on the subject, attention is drawn to the directives followed in certain countries, and in particular to the importance of ensuring that loud speaker telephones shall be installed in suitable rooms reasonably free from room noise and reverberation.

When testing apparatus or systems at the SFERT[5] Laboratory in Paris or elsewhere it is frequently necessary to test in the presence of a certain amount of room noise. Unfortunately, it has not been found possible to standardize either sound meters or the reference zero to be used. An international acoustic conference will study the matter, but, in the meantime, the reference room noise of 50 decibels measured with the American instrument or 46 phons measured with the German instrument

[4] Union Internationale de Radiodiffusion.

[5] Système fondamental européen de référence pour la transmission téléphonique.

will be employed generally, though a higher value may be taken for certain tests. Some rules for the determination of the reference equivalent of side-tone from speech and room noise were established.

The SFERT Laboratory will continue to study the question of effective transmission by means of articulation tests on different arrangements of lines and apparatus and numerical data on different factors affecting transmission quality will be obtained. The details and characteristics of the test circuits and apparatus have been laid down, so that other laboratories can carry out experiments on the same lines as those envisaged for the SFERT Laboratory.

Protection and Corrosion.

Commission 1 deals with all problems arising from the co-existence of power lines and telecommunication lines and is therefore concerned with inductive interference due to the electric and electromagnetic fields caused respectively by the voltage and current of power lines. The effects upon telephone lines are to expose them to high induced longitudinal voltages, which may cause acoustic shock to telephone users and electric shock to linesmen, and to cause noise interference.

Commission 2 deals with corrosion of cable sheaths, whether from electrolytic action or from the chemical action of the ingredients of the soil and water. It studies the construction and operation of traction systems and such measures as are available for reducing the current passing from the rails to the earth by improvements on those systems and also the practices of drainage and the fitting of insulating gaps on the telephone cable sheaths.

It also studies methods of measurement of the current flowing to and from cable sheaths and the measurement of the potential differences between rails and cable sheaths and cable sheaths and earth with a view to ascertaining the degree of danger to which cables are exposed. The further study concerns all methods of protecting cable sheaths by the chemical formation of protective films on the lead or lead alloy as well as by protective wrappings of inert material. The problem of intercrystalline disintregation due to fatigue is also under close consideration, while a further study of possible inert substitutes for lead has been embarked upon.

Much of the experimental work required by the investigations of these two Commissions is carried out by the Comité Mixte International, a body comprising both C.C.I.F. members and representatives of all the chief power industries.

The continuance of close co-operation with the power industry was ensured at Copenhagen by joint meetings with representatives, at which the progress made towards the solution of the problems was fully reviewed.

The " Directives " or guiding principles for the establishment, along common routes, of power and telecommunication lines were originally drawn up in co-operation with representatives of the power industries, including the Conférence Internationale des Grands Réseaux Electriques, L'Union Internationale des Chemins de Fer, L'Union Internationale des Producteurs et Distributeurs d'Electricité and latterly the Commission Internationale Electrotechnique.

These " Directives " last amended in 1930 have been in need of complete revision for some time in order to take account of the progress which has been made and the second meeting of the Joint Revising Committee followed the C.C.I.F. meeting at Copenhagen and lasted three days. The general principles of the revision were established on agreed lines and the work of drafting the various chapters was apportioned among the members for completion at an early date.

The subjects considered included longitudinal induced voltage, the effects of earth wires run along power lines, the screening factors of cables, special types of telephone cable designed for a high screening factor, the effects upon telephone lines of transient conditions on power lines and all forms of electric railway, noise interference due to the operation of rectifiers and other types of plant, the conditions arising from earthed, multiple earthed and insulated power systems, including Petersen coil operation, the effects of the transformer connexions, protective devices against lightning and power risks, apparatus for the prevention of acoustic shock, the balance and transposition of telephone lines, the measurement of noise produced by power induction and its tolerable limits, the measurement of the liability of power plant and power lines to cause noise interference, the permissible proximity of parallel power and telephone lines, high voltage direct current transmission, etc.

On the corrosion side it was decided to prepare a pamphlet corresponding to the " Directives " to be called " Recommendations for the protection of cables against corrosion " which will embody such modified conclusions as have been retained from the chapters in the Livre Blanc, Tome II hitherto covering this subject.

The principles have been thoroughly discussed and revised and the work of drafting shared amongst members. The somewhat unfavourable attitude towards the use of drainage has been more particularly specified and limited in its application in view of the successful results achieved in America, Japan, Italy and elsewhere by the use of special types of non-return switches in some cases controlled by copper oxide rectifiers.

The advantages of the use of insulating gaps in telephone cable sheaths and the precautions necessary when this principle is applied will be more fully dealt with. The general characteristics of the materials used for protective coverings will be outlined, together with guiding principles for their partial use without the introduction of increased danger elsewhere.

Representatives of the traction industry, certain Corrosion Commissions and Cable Manufacturers have co-operated with the Telephone Administrations and operating companies, represented by the C.C.I.F. in the establishment of the general principles upon which the " Recommendations " will be based.

Automatic Teleprinter Switching

L. H. HARRIS, M.Sc., M.I.E.E.

Telegraphy is no longer an isolated branch of telecommunications engineering, and development can proceed on common ground with other branches to their mutual benefit. The early stages of an experimental examination of the problem of applying automatic telephone switching methods to public teleprinter circuits are described briefly in this article

Introduction.

The idea of applying automatic telephone switching methods and mechanisms to telegraphy has for some years exercised the minds of telecommunications engineers generally. In Germany development has been directed to the provision of automatic intercommunication between private teleprinter subscribers while in America automatic concentrators have been designed with a view to effecting operating economies. In the British Post Office a detailed survey is being made of the bigger problem of applying such methods to the Inland Public Telegraph Service.

A complete switching system would provide for the operator at any teleprinter office in the British Isles being able to dial any other office and so set up a telegraph circuit by automatically connecting together various intermediate telegraph links between the teleprinters concerned. Each telegraph office would have to deal only with traffic originating at or for delivery from that office and transit time and re-transmitting operations would be reduced to a minimum.

The economic value of such a scheme is dependent, to a large extent, on the relative costs of operating and of line plant and it is safe to say that, without the multi-channel voice frequency network which now practically covers the British Isles, switched methods could not reasonably be considered. The standardization of the teleprinter as the operating instrument is also an essential and already established factor.

The Voice Frequency Telegraph Network in Great Britain.

A plan of the voice frequency telegraph network is shown in Fig. **1** from which it will be seen that it is possible to set up a connexion between any of the main towns by the interconnexion of a few channels at intermediate points. This, together with comparatively short physical extensions on a two-way simplex basis, should enable practically the whole country to be brought within the scope of such a scheme.

It will be noticed that alternative routes (with corresponding alternative routing digits) would often be available, while, where more than one 18 channel system is provided, a further safeguard is obtainable by spreading the switching channels over the available systems.

So far as the actual transmission of the dialling impulses over a teleprinter network is concerned the problem is a comparatively simple one. Clearly a system which is primarily designed for the transmission of teleprinter signals of 20 milliseconds duration should be capable of transmitting dialling impulses of 33 milliseconds duration and this has been confirmed by tests.

For the sake of simplicity and speed a direct dialling system has been preferred and translation, such as is present in the director, avoided. Again, for the sake of convenience and speed (by reducing the number of dialled digits) and also to avoid circuitous routings between adjacent towns, an area numbering scheme rather than a common numbering scheme, has been considered advantageous.

In order to obtain a high grade of service on the main routes the system shown in Fig. **1** would need

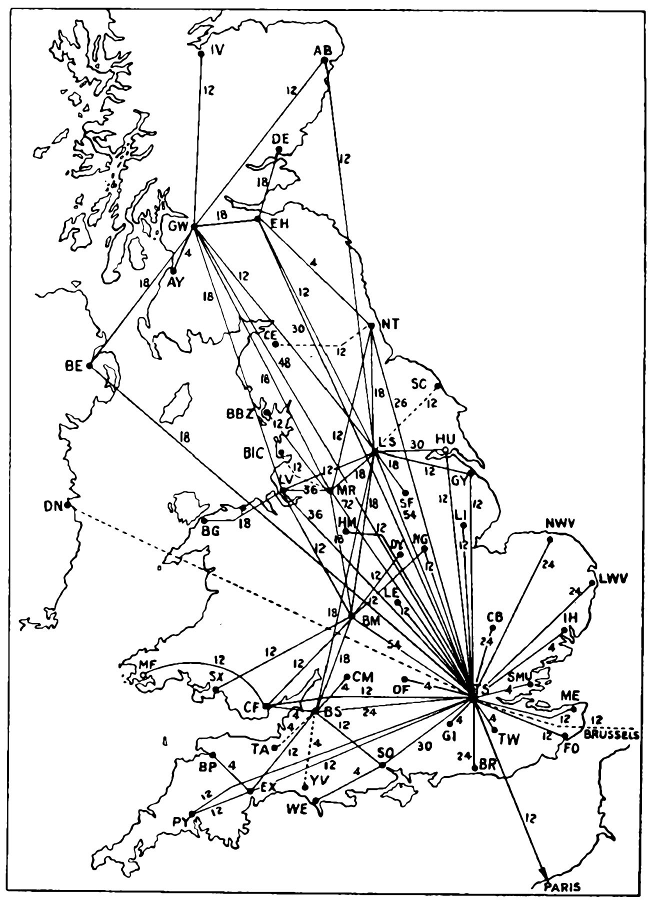

Fig. 1.—Multi-Channel Voice Frequency Telegraph Network.

intensifying, since under a switched system chance traffic replaces the queued traffic inherent in the present retransmitting system. The extension circuits to small telegraph offices would also have to be increased in number for the same reason and here, due to the small number of circuits to each office, it is more difficult to make provision for a high grade of service. On the other hand the overload capacity of small groups is higher than that of the large groups on the main routes, an important factor when considering peak traffic conditions.

In the examination of the grade of service aspect of switching, simplex operation has been assumed throughout, but duplex operation would be possible on any connexion if required by traffic pressure.

The Switching System.

In order that an originating operator may dispose of her traffic without re-dialling even if all the extension circuits of the required office are engaged an overflow facility has been designed whereby the call is passed to the normal suite of operators at the final switching centre for subsequent re-transmission. On a call to an office having a very small number of circuits this overflow facility only operates after a short " suspense " period during which the call waits for one of the extensions to become free. Only a very small percentage of the total traffic should make use of the overflow facility; the actual amount being a measure of the efficiency of the system.

In estimating the number of circuits required to provide a given grade of service an essential consideration is the average holding time per message. This depends on a number of operating and traffic considerations some of which, however, in turn depend on the engineering facilities provided. Thus the number of digits and the preferential use of the low digits affect the time involved in setting up a call; any delay in commencing to transmit by failure to realize that switching is completed, and delay in obtaining acknowledgment, add to the average holding time. The distribution arrangements whereby further messages for a circuit already set up are directed to the correct operating position may also have a bearing on this question.

So far as delay in commencing sending is concerned, the Research Branch has designed for fitting to teleprinters a special answer-back unit which transmits the code of the called office back to the originating station as soon as the circuit is complete. This answer-back unit differs from that on the No. 7 teleprinters in that it is operated on seizing the required extension circuit at the beginning of a call, by an electromagnet energized by the automatic switching apparatus, but is controlled subsequently from the keyboard at the other end of the line. No key movements or operations of any kind are necessary for the reception of a message and the calling operator can therefore proceed with the transmission as soon as the answer-back is received. At the end of the message this operator depresses her " who are you " key and obtains the answer-back again. This reception of the answer-back she would accept as an acknowledgment and clear the circuit. In the occasional event of a query arising a fresh call would be set up and the message checked up by reference to the serial number. These answer-back units were originated and designed for switching experiments, but have since been adopted and used in considerable quantities for the ancillary teleprinter equipments recently installed.

It will be seen from the above that messages may be received on a teleprinter without the intervention of an operator. For small out-offices, therefore, a lamp and bell signal has been designed which operates and locks on the operation of the answer-back unit. As the lamp remains alight until reset by the operator's depression of a push key, a definite indication is given that the teleprinter has been actuated since last attended, and that further attention should be given.

A distribution scheme under examination provides each operator at offices having a large number of positions with a set of keys marked with the codes of the offices to which her office is most frequently connected. At the beginning of a received or transmitted message the appropriate key is depressed, thereby lighting a labelled lamp at the distribution position. If there is a further message for that office the officer at the distribution position sees that a connexion already exists and determines by means of press keys the number of the connected operating position and also lights a hold lamp at that position. The message is then directed to that position and the hold lamp reset by the distributor when she delivers the message for transmission.

The voice frequency telegraph systems operate with tone transmitted in the idle condition and dialling, teleprinter and other signals consist, therefore, of interruptions to an otherwise continuous tone. The failure of a four wire circuit naturally interrupts this tone, and this fact can, to some extent, be arranged to busy faulty channels against incoming calls, and also to give audible warning of the failure. The circuit of the automatic apparatus is such that during the setting up of a call a short signal impulse preceding each train of dialled impulses is transmitted automatically by the successive relay sets as the call proceeds, in order to seize the next relay set and link and busy the circuit against other calls. Use is made of the " Off Normal " springs of the dial to avoid the provision and operation of a dialling key.

The clearing signal which is transmitted when the calling operator restores her key from the " send " position to normal, consists of two long adjacent impulses and has been chosen in preference to a long simple impulse to reduce the liability to a simultaneous accidental release of calls by the momentary interruption of a circuit or battery. In order to avoid as far as possible the critical timing of relays, the clearing signal is generated by an independent cam associated with the drive of the answer-back unit of the teleprinter, and is operated automatically on the restoration of the " send " key.

The busy signal consists of impulses at the rate of one per second, which produce on the calling teleprinter a distinctive series of clicks. Similarly provisional arrangements have been made for the calling operator to receive clicks at the rate of one per 6 seconds during the period of waiting on those calls in which the " suspense " facility is brought into operation.

Experimental Equipment.

The experimental equipment now under test comprises 22 teleprinter positions and associated switching equipment. The layout is shown in Fig. 2 and is designed to cover experimentally the conditions likely to be met in practice. That part of the equipment within the rectangle is situated in one room for convenience in testing, but that outside the rectangle has been made up for removal to the actual towns or offices indicated.

The equipment consists of (a) the teleprinter with special answer-back units, (b) one dialling set per teleprinter position, (c) one position relay set per position, (d) at the switching centre, one extension relay set per extension circuit including local positions, (e) one trunk relay set per V.F. channel termination, and (f) selectors.

Every opportunity has been taken in the design of the experimental equipment to make use of the most modern telephone switching apparatus and practices as far as applicable. Thus 3,000 type relays and 2,000 type selectors have been utilized throughout, but the two wires of the usual speech path in the selectors now become two double current telegraph paths; one for each direction. Further, in order to keep the telegraph conditions correct, leakage paths have been avoided completely by introducing telegraph type relays in series with the transmission paths for controlling the telephone type relays in the relay sets and selectors. The telegraph type relays are in the terminal relay equipments and repeat the dialling impulses into the selectors to avoid having to equip each selector with this type of relay.

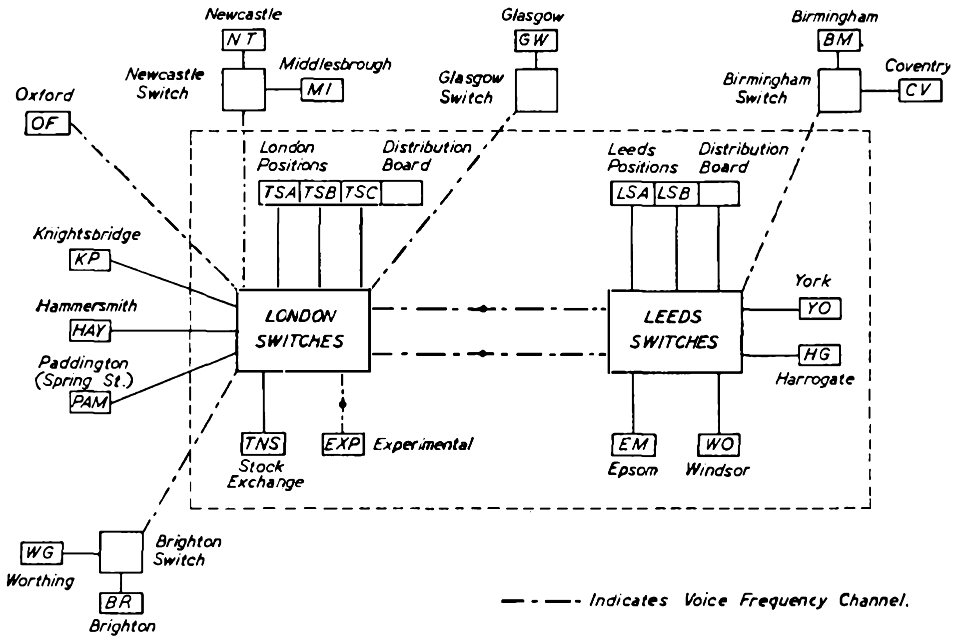

FIG. 2.—PLAN OF EXPERIMENTAL EQUIPMENT.

Conclusion.

The application of automatic teleprinter switching to the Telegraph Service is a most interesting and important technical development in the art of telecommunication. The above outline describes only the principles of the equipment so far developed. Much work remains to be done, and it is for this reason that detailed description has been omitted at this stage.

Anglo-Belgian and Anglo-French Cables

The St. Margarets-La Panne cable laid in 1932 failed on May 8th, due to damage by a ship's anchor. A length of 0.467 nautical miles of new cable was inserted and communication was restored on May 13th. This is the largest submarine paper core cable hitherto laid in the open sea; consequently the matter of repair is of particular interest.

The Anglo-French (1933) cable also became faulty on May 11th. The damage in this case was caused by the anchors of the French Lightship " Dyck," which had been moved to a position immediately over the cable. The fault was cleared on May 14th by H.M.T.S. " Monarch."

Carrier Telephony III

G. J. S. LITTLE, B.Sc., A.M.I.E.E.

In this third article of the series on Carrier Telephony, the author describes the principle of the negative feed-back amplifier, and its application to the 12 channel carrier system being installed between Bristol and Plymouth. A fundamental difference between near and distant-end crosstalk is also explained.

The Negative Feed-Back Repeater.

THE latest advances in carrier telephony are closely bound up with the development of the negative feed-back repeater. The negative feed-back principle has enabled repeaters to be designed which combine the high gains obtainable with screen grid and other multi-electrode valves with great stability of gain and low levels of harmonics —characteristics favouring the development of multi-channel systems for long distance circuits in cable. Although, as is often the case when an advance in technique comes about, several workers appear to have applied this principle independently of each other, there is little doubt that the realization of its inherent advantages came in full measure first to H. S. Black, of the Bell Telephone Laboratories.

The idea of " feed-back " is familiar as, for instance, in an amplifier in which unwanted capacities or inductive couplings may enable voltage from the output stage to find its way back to an earlier stage, causing the gain of the amplifier to be increased or decreased at certain frequencies according to the phase of the voltage fed back. Reaction in a radio receiver and the tendency of a two-wire repeater to become unstable if the impedances of the lines on either side of the repeater are not sufficiently well reproduced by the balances are other examples of " feed-back." If there were perfect equality between the lines and networks there would be no current returned to the input as the differential transformers would then be in a state of complete balance. In practice a fraction of the voltage is returned from the output to the input of the amplifier and even when the circuit is operating under conditions which are satisfactory for the transmission of speech the overall transmission equivalent of a trunk circuit may be affected to the extent of two or three decibels when subscribers with short exchange lines are connected at either end of a two-wire trunk circuit.

In this article it is not proposed to discuss the practical forms of the feed-back circuit as these have been described elsewhere,[1] and Fig. **1** is intended

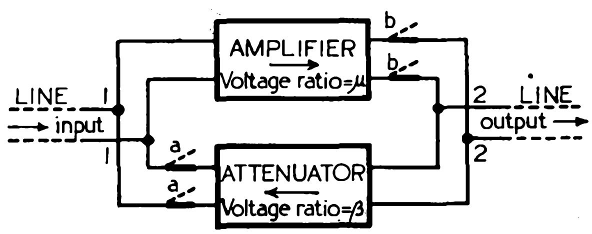

FIG. 1.—DIAGRAM TO ILLUSTRATE ACTION OF NEGATIVE FEED-BACK REPEATER.

only to assist in explaining some of the fundamental principles involved.

In Fig. **1** an amplifier and an attenuator are shown connected in " parallel " between two lines. If the switch aa is opened and a voltage V_1 is applied between terminals 11, let it be supposed that the corresponding amplified voltage at 22 is $V_1\mu$. (If, for example, the gain of the amplifier is 40 db, μ would be 100.) In a similar way if the switch aa is now closed and bb opened, and a voltage V is applied at 22 let the loss in the attenuator reduce the corresponding voltage at 11 to $V\beta$. (If, for example, the loss in the attenuator is 60 db, β would be 1/1000.)

With both switches closed, let a steady alternating voltage V_1 (representing a speech or carrier voltage) arrive over the line from the left at 11. A voltage $V_1\mu$ will appear at 22. This will give rise to a voltage $V_1\mu\beta$ at 11. It can be imagined that this voltage will in its turn be amplified to $V_1\mu^2\beta$ at 22, a corresponding voltage $V_1\mu^2\beta^2$ appearing at 11. If we take $\mu=100$ and $\beta=1/1000$, $\mu\beta$ will be 1/10, and although the total voltage at 11 is increased by the voltage returning after each successive "round trip" it is a decreasing geometric series which has a definite limit. The total voltage at 11 will be

$$V_1\left(1 + \mu\beta + (\mu\beta)^2 + (\mu\beta)^3 \ldots\ldots\right) = \frac{V_1}{1-\mu\beta}$$

Using the value $\mu\beta = \frac{1}{10}$ this becomes $V_1 \times \frac{10}{9}$

Similarly, the total voltage at 22 will be

$$V_2 = \mu V_1\left(1 + \mu\beta + (\mu\beta)^2 + (\mu\beta)^3 \ldots\ldots\right) = \frac{\mu V_1}{1-\mu\beta}$$

$$= 100V_1 \times \frac{10}{9}$$

The expression for the ratio between input voltage V_1 arriving from the line on the left and the total output voltage V_2 built up at 22 is

$$\frac{\text{Total output voltage}}{\text{Input voltage}} = \frac{V_2}{V_1} = \frac{\mu V_1}{1-\mu\beta} \times \frac{1}{V_1} = \frac{\mu}{1-\mu\beta}$$

and the effective gain of the repeater

$$= 20 \log_{10}\frac{\mu}{1-\mu\beta} \text{ decibels.}$$

Note that the ratio between the *total* voltage at the output and the *total* voltage at the input remains μ. In the particular case considered the resultant voltage at the input is increased by approximately 1 db, and this is amplified by 40 db, the inherent gain of the amplifier, so that the effective gain of the amplifier has been increased from 40 to 41 db due to feed-back.

If the gain of the amplifier and the loss in the attenuator expressed in decibels are exactly equal, for example $\mu=100$ and $\beta=1/100$, the voltage returning after the first round trip will be equal to the input voltage. That is, a circulating voltage would be maintained after the input voltage had ceased. The circuit is unstable and will " sing " under these conditions. (Note that the expressions for the total

[1] A New Feed-Back Repeater. Bast & Stielties. Vol. 28, pt. 3. Carrier System No. 4. Halsey & Millar. Vol. 29, pt. 3.

voltages at input and output become infinite when $\mu\beta = 1$.)

The combined action of the amplifier and the attenuator can be summed up by saying that the effect of closing the switch aa is to alter the voltages at all points in the circuit between 11 and 22 in the ratio $1/(1-\mu\beta)$.

So far there has been an implied assumption that the voltage returns after a round trip without change of phase. If, instead, the voltage returns directly out-of-phase the sign $\mu\beta$ is negative and $1/(1-\mu\beta)$ is to be replaced by $1/(1+\mu\beta)$. The gain of the amplifier is then reduced, instead of increased, by the action of the feed-back.

If a case is considered in which the round trip results in a gain instead of a loss the summation of the voltages contributed by successive round trips leads to the conclusion that the circuit must be unstable, irrespective of the phase change undergone by the voltage in each round trip, because it would appear that voltages at 11 and 22 would increase without limit. This conclusion, though it would have been challenged by few before the advent of the negative feed-back circuit, is not necessarily correct. Actually, provided that, at any frequency at which the voltage returns in phase, the round trip results in a loss, even though at other frequencies there may be a round trip gain, the circuit will be stable. The expressions which were found for the total voltage at the input and for the effective gain of the circuit are valid for all cases, provided the amplifier is stable. The expression for the effective gain can also be obtained from a simple equation, as follows:—

Referring to **Fig. 1**: let the voltage from the line on the left be V_1 and let the total voltage acting between terminals 22 when the circuit is **in equilibrium** be V_2. A voltage $V_2 \times \beta$ will be transmitted through the attenuator back to the input so that the total voltage at the input will be $V_1 + \beta V_2$. Owing to the amplification inherent in the amplifier the total voltage acting at the output must be μ times the total voltage acting at the input and the following equation must hold.—

$$V_2 = \mu(V_1 + \beta V_2)$$

Whence $V_2(1-\mu\beta) = \mu V_1$

and $V_2 = \frac{\mu V_1}{1-\mu\beta}$ and $\frac{V_2}{V_1} = \frac{\mu}{1-\mu\beta}$

This is the same expression as was found when considering the case of a round trip loss. If the symbols μ and β are treated as vectors, that is, if μ and β are understood to represent not only ratios but also the changes in phase which occur between the input and output terminals of the amplifier and of the attenuator, the expression holds within itself a statement of practically all the steady state characteristics of the feed-back amplifier. It will not, however, be possible to enlarge upon this aspect of the matter here.

The equation does not, of course, explain why the repeater remains stable. (The conditions governing stability involve the transient response of the system.)

In the negative feed-back repeater, as designed for multi-channel carrier systems, the inherent gain of the amplifier is usually about 30 db greater than the loss in the circuit connecting output and input, and in the middle part of the effective frequency range of the amplifier the voltage from the output is fed back to the input in opposing phase. The use of screen-grid and other multi-electrode valves makes practicable far higher amplifications than were feasible previously and three-stage feed-back repeaters can now be constructed with an inherent gain of 90 db which may be reduced to a working gain of 60 db by application of feed-back.

Nothing has so far been said of the advantages that accompany this apparently quixotic reduction in gain. These can perhaps be most conveniently illustrated by a numerical example based on the gains quoted above. The inherent gain of 90 db corresponds to $\mu = 31{,}600$ and there would be a loss of 60 db in the feed-back circuit, that is $\beta = -1/1{,}000$, the negative sign signifying the return of voltage out-of-phase. The ratio of output to input voltages for one round trip $= \mu\beta = -\frac{31{,}600}{1{,}000} = -31.6$. The round trip gain $= 20 \log_{10} 31.6$ db $= 30$ db.

The expression obtained previously for the effective gain expressed as a voltage ratio is $\mu/(1-\mu\beta)$. In the case under consideration $\mu\beta$ is large compared with 1. If $\mu\beta$ were made so large that the 1 could be neglected in the denominator, the net voltage gain ratio would be $\frac{\mu}{-\mu\beta} = -\frac{1}{\beta}$ This indicates that if the round trip gain ratio $\mu\beta$ can be made very large the effective gain of the repeater is determined by the loss in the feed-back circuit. Substituting the value $\mu = 31{,}600$ and $\beta = -1/1{,}000$ the voltage ratio is

$$\frac{\mu}{1-\mu\beta} = \frac{31{,}600}{1+31.6} = \frac{31{,}600}{32.6} = 970$$

and the gain is $20 \log_{10} 970 = 59.74$ db.

The difference between the net *gain* of the repeater and the *loss* in the feed-back circuit is thus no more than $60 - 59.74 = .26$ db. Suppose now that due to some reason, such as changes in operating voltages, the inherent gain of the amplifier increases by 2 db, μ is increased from 31,600 to 39,800 and $\mu\beta$ becomes 39.8. The net gain voltage ratio $= \frac{39{,}800}{1+39.8} = 976$ and the net gain of the repeater is 59.80 db. Although the inherent gain of the amplifier has changed by 2 db the gain of the feed-back repeater as a whole has only changed by .06 db or about 1/30 of the change in the inherent gain. The stability is increased in proportion to the round trip gain ratio. Thus the gain of a repeater with a large amount of feed-back is practically independent of changes in the filament and anode supply voltages and of changes in the characteristics of the valves.

In the previous article of this series mention was made of the interference between the channels of a multi-channel system which results when simultaneous amplification takes place in an amplifier, due to the harmonics generated. The level of harmonics generated in any particular amplifier is dependent chiefly on the power output from the amplifier and the harmonics can be considered as being generated in the last stage of amplification. In regard to a voltage applied at the input it has been shown that the effect of adding negative feed-back is to reduce the voltage acting at the input by an amount approximately equal to the round trip gain. This reduction takes place in regard to a voltage applied at any point in the amplifier circuit and such a reduction in the harmonic voltage occurs. In the example that has been taken the harmonics for a given power output will be at a level approximately 30 db. lower than when the amplifier is operated with the same power output but without feed-back. This lowering of harmonic levels is sufficient to enable the whole available power output of the repeater, up to the point at which grid current begins to flow, to be used without introducing undue interference between channels.

The principal advantages of negative feed-back repeaters as used in recent developments in carrier telephony can be summarized as follows:—

Gain-Frequency Curve. The gain in the working range is practically independent of the inherent gain of the amplifier provided there is a sufficient margin between the inherent gain and the loss in the feed-back circuit throughout the working range. In designing the amplifier it is unnecessary that the gain-frequency characteristics should be flat. The action of the feed-back circuit will bring the gain to the same level throughout the range.

Gain Stability. Normal changes in gain due to quite large supply voltage variations and changes in valve characteristics are practically eliminated. If supply voltages are regulated within reasonably close limits the gain is stabilized to an amazing degree. Long circuits with repeaters at close intervals, with high gains, become feasible as the total gain variation of all the repeaters remains small. The variation in attenuation of the lines due to changes in temperature constitutes a much more difficult problem in maintaining the stability of long circuits than the small changes in gain of such repeaters.

Power Handling Capacity. The reduction in the level of harmonics makes possible the use of comparatively low voltages and valves of normal type in amplifiers handling a large number of carrier channels simultaneously.

Near-end and Distant-end Cross-talk.

Turning now to the question of cables in relation to multi-channel systems, some observations on the subject of cross-talk are necessary.

The first trunk telephone circuits employing repeaters were two-wire circuits but the limitations of two-wire circuits led in course of time to the general adoption, for the more important trunks, of four-wire circuits in which separate pairs of wires are provided for the " go " and " return " directions of transmission. To minimize crosstalk between circuits in cables it has been usual to balance important cables in groups. In a typical case pairs in the centre of the cable might be used to provide four-wire " go " pairs and a group formed of the outside layer of pairs used to provide the four-wire " return " pairs. The intervening group of pairs would be more heavily loaded and would be used for two-wire circuits. The two-wire group screens the two four-wire groups from each other and enables a high degree of freedom from crosstalk between the " go " and " return " groups to be obtained.

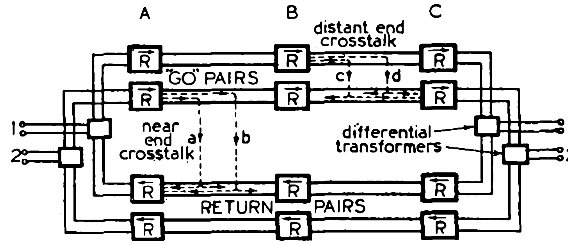

Fig. 2.—Near-End and Distant-End Crosstalk in a Four-Wire System.

Fig. 2 has been drawn to illustrate the differences between near-end and distant-end crosstalk. The figure represents two four-wire circuits with repeaters at stations A, B and C. Crosstalk between cable pairs is the resultant effect of a number of small transfers of energy which leaks across between the pairs at intervals. Two leakage paths between the "go" pair of circuit 2 and the "return" pair of circuit 1 are shown at a and b in the repeater section between A and B. On reaching the return pair of circuit 1 each leakage path divides, currents flowing towards A and also towards B. The currents flowing to B meet the output of the repeater and do not cause disturbance to circuit 1. The currents flowing to A reach the input of the repeater and after amplification are transmitted to the two-wire end of circuit 1. Thus between the "*go*" of one circuit and the "*return*" of another it is *near-end* crosstalk which causes disturbance.

In repeater section BC the paths of leakage currents between the "go" pairs of the two circuits are indicated at c and d. In this case it is the currents which, after leaking across, proceed towards C which will cause disturbance in circuit 2. Between pairs of two circuits which transmit in the *same* direction it is *distant-end* crosstalk which causes disturbance.

There is an important fundamental difference between these two types of crosstalk. Considering near-end crosstalk in repeater section AB, it will be seen that the path AaA is much shorter than the path AbA. Currents which leak across at b undergo a correspondingly greater phase change than those which leak across at a. Of the two distant-end crosstalk paths shown between B and C the total distance traversed in the cable is necessarily the same in both cases. The phase changes experienced due to transmission over the cable will consequently be the same. This circumstance renders distant-end crosstalk a markedly less complicated phenomenon than near-end crosstalk and distant-end crosstalk can be dealt with by means of networks connected between appropriate wires of the circuits concerned, though this method does not appear to have been applied to loaded cables other than experimentally.

The level diagram in Fig. 3 shows the variation in transmission level on the "go" and "return" pairs with respect to a voltage applied at the two-wire end of the circuit with assumed repeater section attenuations of 30 db. The levels at corresponding points on two "go" or two "return"

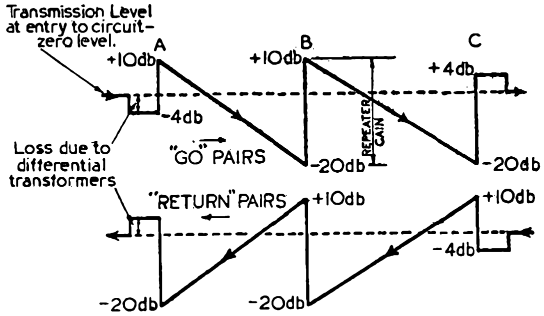

FIG. 3—LEVEL DIAGRAM OF A FOUR-WIRE CIRCUIT.

pairs are equal, but there is a difference of level between "go" and "return" pairs at the ends of each repeater section equal to the repeater section attenuation.

In fixing the degree of crosstalk that can be tolerated in a single repeater section it is necessary to take account of the following factors.

i. The differences in level of speech entering trunk circuits from different subscribers,
ii. the additive effect of crosstalk from all other circuits in the cable, and
iii. the effect of crosstalk in successive repeater sections.

For circuits of moderate length it is advisable that near-end crosstalk between any two circuits in a single repeater section shall not give rise to disturbance at the two-wire end that is not at least 65 db below the speech entering the disturbing circuit. If the repeater section attenuation is 30 db the near-end crosstalk must not be worse than 30 + 65 = 95 db. Such a value can be assured without undue difficulty for cables designed for operation at voice frequencies, but as the frequency band to be transmitted is extended difficulties increase. Pairs in the Liverpool-Glasgow cable are being specially lightly loaded at intervals of 1,000 yards to enable voice and four carrier circuits to be obtained with circuits worked on the four-wire principle. The band of frequencies used extends up to 16 kc.p.s. This probably represents a practical limit to what can be achieved with comparatively large groups of circuits without resorting to screens specially designed to be effective against electromagnetic as well as electrostatic couplings. It may be found practicable to work at higher frequencies if cables are designed with a few special pairs isolated from each other by quads transmitting lower frequencies.

The Bristol-Plymouth 12-Channel Carrier Scheme.

To make the most effective use of the possibilities of the negative feed-back repeater:—

(i) Repeater sections should have an attenuation of from 50 to 60 db. at the highest transmitted frequency. Compared with a system employing repeaters with lower gains, costs can be cheapened by reducing the gauge of conductor (or increasing the distance between repeaters) until the attenuation per section approaches the maximum repeater gain. (This is without taking account of crosstalk requirements.)

(ii) The system should be designed to transmit a band of frequencies to accommodate as many speech channels as the repeater is capable of amplifying simultaneously without undue interference between channels.

Each circuit requires a "go" and "return" channel each with an effective band width of, say, 2,600 c.p.s. With present technique where more than four or five channels are required on a pair of conductors a total band width of 4,000 c.p.s. per channel may be regarded as standard.

(iii) Crosstalk between cable pairs must be small enough to enable circuits to be obtained which will have adequate freedom from crosstalk.

The near-end crosstalk attenuation of each repeater section is required to be of the order of 60 + 65 = 125 db. or greater and without special interlayer screens this requirement can only be met by providing separate cables for "go" and "return" directions of transmission. The requirement in regard to the range of transmission cannot be met if pairs are coil-loaded unless the coils are inserted at much closer intervals than at present appears to be practicable. Cables for 12-channel systems in this country are therefore being provided without loading coils, separate cables for the two directions being drawn into a single duct.

The American Telephone and Telegraph Company were the pioneers of this type of system. An experimental system at Morristown was operated over a 25-mile length of specially constructed cable in which 18 gauge pairs for carrier (approximately 40 lbs. per mile) alternated with two 19 gauge quads (approximately 20 lbs. per mile) for voice circuits. Although separate cables were not provided for the two directions of transmission the trial was arranged to simulate this condition. A nine-channel carrier system was installed and all nine channels were amplified together in repeaters of feed-back type. Excellent results were obtained and the published description of the experiment served to inspire the development of similar systems elsewhere.[2]

A 12-channel carrier system between Bristol and Plymouth, a distance of 125 miles, is being installed by Messrs. Standard Telephones and Cables, Limited, who are responsible for the design of the cable and equipment. It is expected that the system will be in service by the end of this year. The "go" and "return" cables each comprise 19 pairs of 40 lb. conductors and repeater stations are spaced at distances of about 20 miles. At the middle of each repeater section a small building is being provided to accommodate networks for the reduction of distant-end crosstalk between the pairs within each of the cables.

Terminal equipments will be installed at Bristol

[2] "Carrier in Cable," by A. B. Clark and B. W. Kendall. Bell System Technical Journal, July, 1933.

and Plymouth to provide 36 Bristol-Plymouth circuits (three pairs in each cable) and 36 Bristol-Exeter and 36 Exeter-Plymouth circuits (three pairs in each cable), for which terminal equipment will be required also at Exeter.

The circuits provided will be practically indistinguishable from good quality four-wire circuits, audio frequencies up to 2,600 c.p.s. being effectively transmitted, thus meeting the international standard recently agreed by the C.C.I.F. at Copenhagen.

In the Morristown experiment balancing networks for the reduction of crosstalk consisted of condensers connected between appropriate wires to reduce electrostatic crosstalk and small air-core mutual inductances connected in series with the wires of the pairs concerned in such a way as to counteract electromagnetic crosstalk. A method which is somewhat less direct is to use combinations of resistances and condensers in place of mutual inductances, but it has the advantage that the connexion of the wires to the networks is simpler, and that the balancing elements are all connected in bridge. It is likely that this method will be more generally used in this country.

being 60 kc.p.s. The lower sideband only is transmitted, the carrier being suppressed. Approximate limits to the frequencies passed by the filters of the Bristol-Plymouth system are indicated in the diagram on the rectangles representing the filters. Fig. 5 shows the frequency allocation. An explanation of the reasons for not making use of frequencies below 12 kc.p.s. needs to be given.

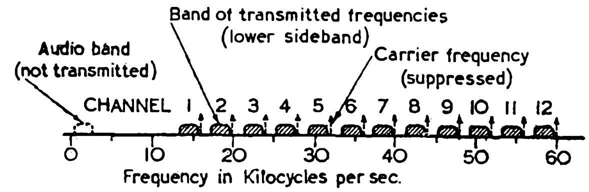

FIG. 5.—FREQUENCY ALLOCATION OF BRISTOL-PLYMOUTH 12-CHANNEL CARRIER SYSTEM.

Some of the principal difficulties encountered in designing a feed-back amplifier, such as control of phase shift and design of transformers, are governed jointly by the highest frequency to be transmitted and the ratio between the highest and the lowest frequencies to be transmitted.

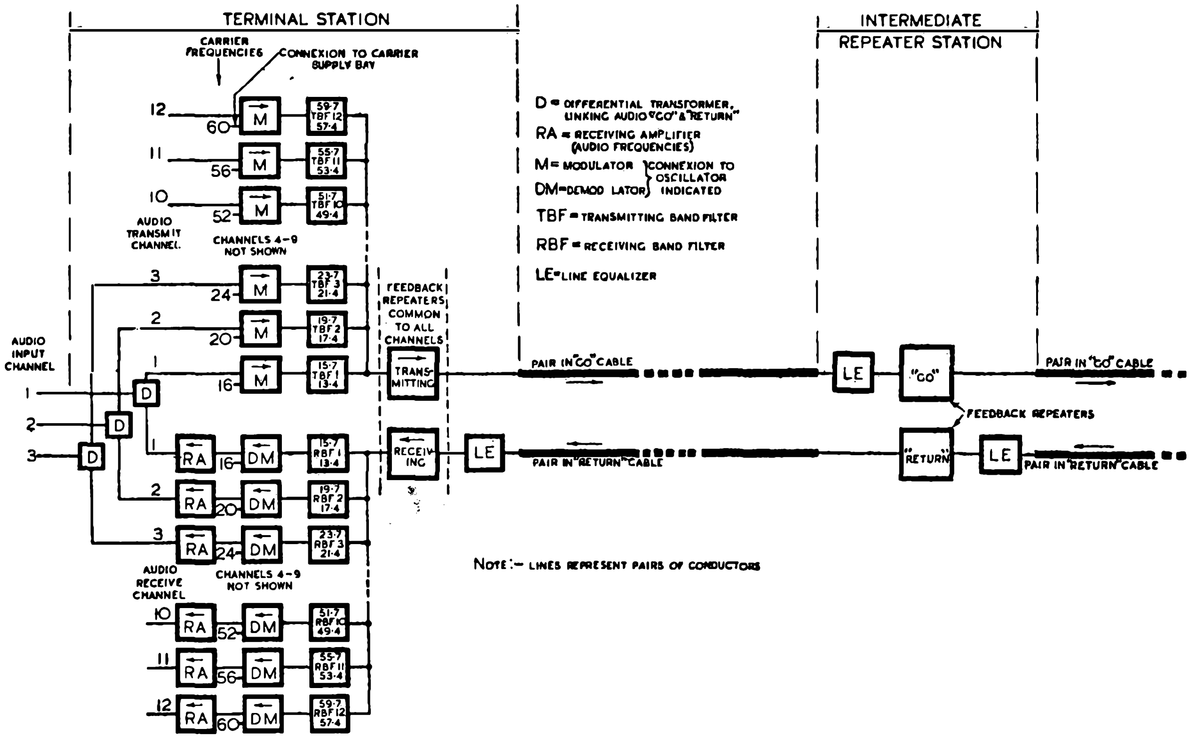

FIG. 4.—12 CHANNEL CARRIER SYSTEM—BLOCK SCHEMATIC OF EQUIPMENT AT A TERMINAL STATION AND AT AN INTERMEDIATE REPEATER STATION FOR ONE PAIR IN EACH CABLE

Fig. 4 is a block diagram which illustrates the arrangement of a multi-channel system for underground cables, and it is applicable to both the equipment used in the Morristown experiment and the Bristol-Plymouth installation apart from the numbers of channels. In the latter system the carrier frequencies are all multiples of 4 kc.p.s., commencing with 16 kc.p.s., the highest carrier frequency

In an amplifier operating up to 60 kc.p.s. the second consideration is much the more important. Twelve to 60 kc.p.s. gives a ratio of 5. If the 12 channels commenced with a voice channel and a 4 kc.p.s. spacing of carriers were adhered to the frequencies to be transmitted would extend from 200 c.p.s. to 48 kc.p.s. The frequency ratio would then be 240 and the difficulty of design and probably also the cost of providing the equipment would be much increased.

Fig. **6** is a curve showing the attenuation of a typical pair in a 22-mile repeater section. The greater

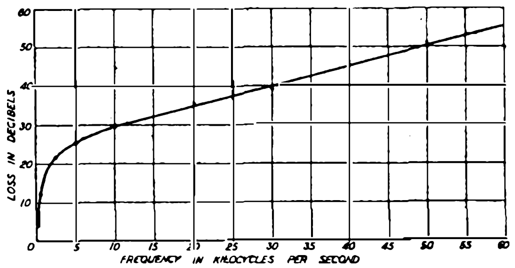

Fig. **6**.—Attenuation of 22 Mile Repeater Section in Bristol-Plymouth Carrier Cables.

difficulty of designing equalizing networks to compensate for the rapidly changing attenuation at the lower end is a further reason for omitting the voice and lower channels. It is, of course, possible that it will yet be found practicable to use at least a portion of this frequency range.

Arrangements are in hand for several new cables in the current year's programme to be provided on the same general lines as the Bristol-Plymouth scheme with 12-channel equipment.

These schemes will, however, be carried out with 24-pair cables which, when fully equipped, will yield 288 circuits. The pairs will be twisted in star-quad formation and will be of approximately the same overall diameter as those of the Bristol-Plymouth scheme, but the increase in the number of pairs will entail a somewhat higher attenuation per mile at 60 kc.p.s. These cables, as also the Bristol-Plymouth cables, are designed to have smaller unbalanced electromagnetic couplings than standard star-quad trunk cable.

500/20 Ringing Receivers and Oscillators for Guernsey-Jersey Circuits

Communication between Jersey and Guernsey is at present carried out over one single cored cable and one 3 cored cable. On the first of these are a telephone circuit and a sub-audio telegraph circuit. Telephone signalling is performed by 500 cycle tone and valve receivers of an experimental type. The three core cable carries three telegraph circuits and will ultimately have two telephone circuits in addition. The ringing facilities on these will take the form of the standard 500/20 tone received and translated into a 17 cycle ringing or a D.C. signal, by the new standard Repeater Station valve receiver. Ultimately the existing circuit is to be converted to this standard form, thus bringing these circuits into line with modern practice.

The ringing receivers are of the two valve type mounted on standard repeater panels similar in design and performance to the 50 volt receiver under installation at Trunk Exchange, but adapted for working on separate heater and anode supplies of 40 and 120 volts respectively. Owing to the large battery voltage variations experienced, special care has been taken to ensure a wide margin and variations of ±20% will not affect the working of the receiver. Speech immunity is obtained in three ways having a cumulative action as follows:—(*a*) by employing the 20 c.p.s. interruption in the 500/20 tone to impulse a standard P.O. relay under signal conditions, (*b*) by utilizing this impulse changeover contact in a special balanced rectifying circuit, incorporating an inherent guard action against operation by irregular impulses, to operate a second relay, and (*c*) by imposing on the third relay a nominal operate lag of some 200 milliseconds. The overall operate lag in the receiver is then 300 milliseconds which is faster than existing types, whilst the speech immunity has been proved to be exceptional.

Owing to the lack of 500/20 generators at Jersey, valve oscillators are to be installed. The design of these is somewhat unique in that the whole of the tone supply is generated in a single valve stage, followed by a power output stage. Five hundred cycle tone, fully modulated at 20 cycles, is obtained by using two resonant circuits of 500 and 520 cycles respectively connected to the anti-resonant condition to the grid circuit of the oscillator valve, the feedback being obtained by a transformer coupled to these circuits and the anode circuit. The full theoretical treatment of such multi-frequency oscillators is given in "Experimental Wireless," September, 1931 (A. T. Starr). The output of the oscillator will be such as to enable 4 rings to be simultaneously operated, with a change in output load of 3 db., and, as the overall transmission loss of the line will be from 3-5 db. and the lower operating limit of the receiver is −20 db., ample margin for reliable operating condition should be obtained.

Carrier System No. 4

1 + 4 Channel Carrier System for Cables

R. J. HALSEY, B.Sc., A.C.G.I., D.I.C.,
and D. P. M. MILLAR, M.Sc., A.C.G.I., D.I.C.

In this article, which will be continued in the January issue of the Journal, the authors describe a carrier telephone system which has been developed to give the maximum number of carrier circuits on existing cables. The description of a new feedback repeater is included and uses of the system apart from the original requirements are discussed.

Synopsis.

CARRIER System No. 4 has been developed by the Post Office to provide the maximum possible number of four-wire telephone channels on existing underground cables. It is not intended to compete with the twelve channel systems which are being developed by contractors for use on specially designed cables. These latter systems require that separate cables shall be used for the two directions of transmissions and these cables will normally be of different construction from the older types. Carrier System No. 4 requires only that the cable shall be divided into " Go " and " Return " groups with separator groups or pairs. The highest frequency transmitted is 16 kc.p.s., the system providing one voice and four carrier channels per four wires, all circuits being of such quality that they may be used as sections of long international trunks. The article is divided into the following sections:

1. Possibilities of carrier working on existing land cables.
2. Requirements of a carrier system for the above.
3. Outline of the system as now developed.
4. Line repeaters.
5. Line equalization.
6. Description of terminal equipment.
7. Performance of terminal equipment.
8. Field trials of the system between London and Canterbury.
9. Future application of the system.

1. Possibilities of Carrier Working on Existing Cables.

Limiting Conditions.

When " Go " and " Return " circuits are operated in separate cables the maximum attenuation lengths which may be permitted and the highest frequency which may be transmitted are determined by

(a) The near-end crosstalk between two cables in the same duct. In a specific case, the worst value measured amounted to 130 db. at 10 kc.p.s. and 160 db. at 60 kc.p.s. average figures being 135 db. and 175 db. respectively.[1] The signal crosstalk ratio for each repeater section will be the near-end crosstalk attenuation less the repeater section attenuation at the appropriate frequency.

(b) The distant-end crosstalk between pairs in the same cable. This is dependent on the electrostatic unbalances and magnetic couplings within the cable and if the latter can be reduced by having different lays for all pairs, the crosstalk may have a worst value as high as 65 db. (signal-crosstalk ratio) per repeater section, for the cable as laid. By using comparatively simple balancing networks this may be improved by a further 20 db.[2] and this gives crosstalk which is adequate even for a large number of repeater sections.

(c) The minimum signal level which can be tolerated on account of extraneous and thermal noises. This may be provisionally taken as − 60 db. but varies with the conditions. The transmitting level will be determined by the power handling capacity of the repeater and the number of channels which it transmits, but will probably not exceed + 10 db. per channel, thus permitting repeater section attenuations not exceeding 70 db.

Consideration of these factors will show that the limiting condition is set by (c) for, if we adopt the 70 db. maximum attenuation suggested by (c), both near-end and distant-end crosstalk will be adequate.

When, as in the case now under consideration, the " Go " and " Return " circuits are in the same cable, a much lower limit is set to frequencies and attenuations by near-end crosstalk. Tests on a number of existing cables, both multiple twin and star quad, indicate that with reasonable grouping of circuits it is possible to transmit frequencies up to 16 kc.p.s. provided that the repeater section attenuation does not exceed 35 to 40 db. Higher frequencies may, of course, be transmitted if the attenuation lengths are shorter, i.e., if the repeater stations are closer, but the limit is set by crosstalk and never by (c) above. Since the cables will be old the condition, as in (b) above, that all lays shall be different, cannot be imposed. This means that the distant-end crosstalk between pairs with the same lay may be as much as 30 db. worse than between pairs with different lays (there are normally two lengths of lay in each layer of a star quad cable) and so it will frequently be necessary to employ balancing networks to improve the distant-end crosstalk, although the upper frequency limit is only 16 kc.p.s.

It must be understood that balancing networks are only effective in reducing distant-end crosstalk and are useless for improving near-end crosstalk.[3] The improvement of distant-end crosstalk has a random effect on near-end crosstalk.

[1] This was measured with two 2,000 yards lengths of cable drawn into one duct, the lead sheaths being in contact with each other.

[2] I.P.O.E.E. Paper No. 157. Page 28.

[3] Idem.

Addition of Crosstalk from Several Repeater Sections.

It will seldom happen that bad crosstalk occurs between two given circuits in several repeater sections and so the overall crosstalk will usually approximate to that of the worst section. Since the problem of addition of comparable interferences arises in connexion with intermodulation in repeaters and loading coils, it is conveniently mentioned at this point, as the argument is equally applicable to cable crosstalk. The law of increase is one of the random addition of voltages, and so ten repeater sections will cause interference, which is about 10 db. worse than that due to a single section. When the number of contributing units is small, however, the operation of the law of random addition cannot be relied upon.

Loading.

When the highest transmitted frequency is as low as 16 kc.p.s. it is sometimes economical to coil load the cables and loading has been designed to give a theoretical cut-off at a little above 20 kc.p.s. This loading, 6 mH at 1,000 yards spacing, gives a characteristic impedance of about 600 ohms and requires special low hysteresis coils to minimize third order modulation which causes interchannel interference. The specified maximum value of the hysteresis constant[4] is 2.0 and in some instances values considerably lower than 1.0 are obtained.

It is not proposed always to load the conductors since many repeater stations are already in existence and where the unloaded attenuation is within the range of the system, loading is obviously uneconomical. Some of the older cables have heavy conductors which enable the new system to operate with repeater sections of reasonable length (say, 40 miles) without loading. Thus, whereas it is economical to load 25 lb. conductors, it is uneconomical to load 70 lb. conductors.

Cable Characteristics.

Fig. **1** gives the attenuation per mile of various cable pairs for the working range of the system.

[4] I.P.O.E.E. Paper No. 147. Page 38.

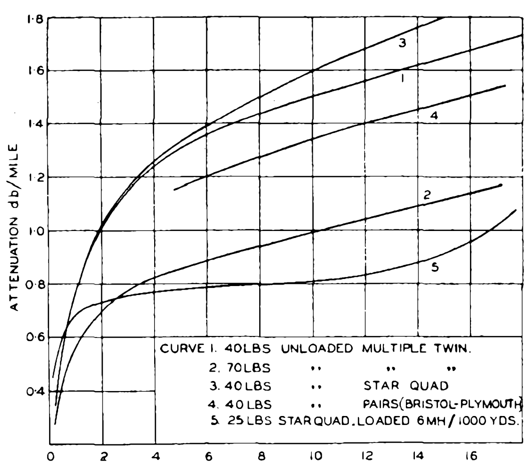

FIG. 1.—ATTENUATION OF CABLE PAIRS SUITABLE FOR CARRIER SYSTEM NO. 4.

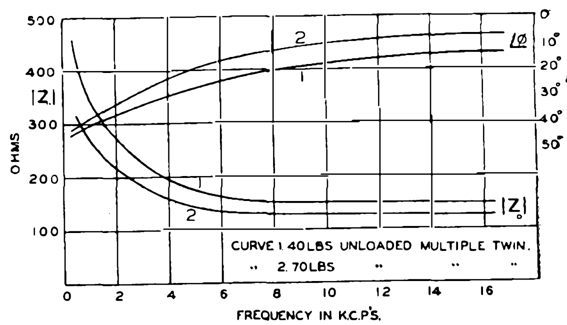

FIG. 2.—CHARACTERISTIC IMPEDANCE OF UNLOADED CABLES SUITABLE FOR CARRIER SYSTEM No 4.

The curve given for the loaded cable is calculated as the loading is not completed. Fig. **2** gives the characteristic impedance of the unloaded cable pairs.

2. REQUIREMENTS OF THE CARRIER SYSTEM.

Performance.

Since the frequency band is limited to 16 kc.p.s. it is necessary to obtain the maximum number of channels below this frequency, conditional upon such channels being suitable as sections of long international circuits. In order that a circuit, a few hundred miles in length, shall be suitable for inclusion as part of an international or transcontinental trunk it is considered that the following conditions should be met.

(a) *Frequency response.* The loss at 300 c.p.s. and 2,600 c.p.s. should not exceed the loss at 800 c.p.s. by more than 2 db. (C.C.I.F. recommendations allow 1 neper = 8·7 db. on the international circuit.).

(b) *Crosstalk.* The worst intelligible crosstalk into the circuit should be about 65 db. (signal to crosstalk ratio).

(c) *Noise.* The maximum noise on the circuit as measured by a frequency weighted psophometer should not exceed about 0.5 mV at any "zero" level point.

(d) *Propagation Time.* The propagation time should not exceed about 50 microseconds per mile in order that the time on the completed circuit shall not exceed 250 milliseconds, which is the accepted desirable limit. This requirement is met by any multi-channel carrier system, whether on loaded or unloaded cable. At high frequencies, the propagation time for unloaded paper cored cables falls to about 8.5 microseconds per mile. (Light and radio waves are propagated at about 5.4 microseconds per mile.)

(e) The overall transmission of the circuit should not vary by more than ± 1 db. due to normal voltage variations and valve variations between maintenance adjustments.

Secondary Requirements.

In order to meet the above primary requirements economically it is necessary that all channels of the carrier system shall be transmitted through common repeaters at the intermediate repeater stations, the output level being at least " zero." To ensure that the repeaters do not overload in this condition and thereby cause excessive interference between the channels, the probability of coincidence of speech voltages must be considered. In a system involving a large number of channels it can safely be assumed that not more than 50 per cent. of the channels will be busy in one direction at any instant. Moreover, the busy channels may be assumed to handle average speech volumes, and since tests have shown that average speech under favourable conditions is 14 db. below Reference Telephonic Power[5], the system may be designed to handle 50 per cent. of the channels simultaneously, each at 14 db. below R.T.P. The probability of coincidence of peak voltages may be taken into account by assuming that these voltages add at random (i.e., on an R.M.S. or power basis). Thus, doubling the number of channels will necessitate doubling the power handling capacity of the repeaters.

In the present case, however, the number of channels (5) is too few to admit the above argument. Even if all circuits are busy with average volume speakers, the voltage will be less than that due to a single speaker at R.T.P.—a condition which may always arise. To be safe, therefore, it is considered desirable that the crosstalk and noise requirements shall be met when two speakers, each at R.T.P., are engaged on the system.

3. Outline of the System Developed.

Carrier System No. 4 requires two cable pairs over its whole length and operates on a true 4-wire basis, i.e., the " Go " and " Return " of each channel operate in different cable pairs at the same frequency. The system provides one voice and four carrier channels, the facilities on all channels being identical. Thus, it is not possible to operate the voice channel on a 2-wire basis.

In deciding the carrier and band frequencies two alternatives were considered.

(a) To adopt the principle now almost universal for multi-channel carrier systems, and employ carrier frequencies which are multiples of 4 kc.p.s. This has the advantage that the carrier frequencies may be interlocked with those of 12-channel systems. Also the frequencies may be generated or controlled by a standard 1, 2 or 4 kc.p.s. master generator. This enables the carrier frequencies at the two ends of a system to be synchronized, thereby ensuring that the system is suitable for 18-channel V.F. telegraphs and for picture telegraphs. This arrangement would give four channels in the frequency band available, but the system would not work in association with the single channel cable carrier system (Carrier System No. 2) already in service. This system, in accordance with recommendations of the C.C.I.F. has a carrier frequency of 6 kc.p.s. and transmits the lower sideband.

(b) To adopt carrier frequencies which will just allow the required band width to be transmitted. In this case the carrier frequency of 6 kc.p.s. already standardized will be the lowest carrier frequency of the new system, which will therefore work in association with Carrier System No. 2. The other carrier frequencies, to transmit similar band widths may then be as follows, 9.2 kc.p.s., 12.5 kc.p.s., and 16 kc.p.s., the lower sidebands being transmitted. This arrangement gives five channels within the available frequency band but has the disadvantage that synchronization of the carrier frequencies is not easily arranged. The frequency stability can, however, be made adequate for 18-channel V.F. telegraphs but picture telegraphs are not practicable with the usual type of equipment.

Alternative (b) has been adopted and the frequency bands corresponding to voice frequencies 300 to 2,600 c.p.s. are given below. Since lower sidebands are used, the bands are inverted.

Band	Carrier Freq.	Working Freq.
1	—	300— 2,600
2	6,000	3,400— 5,700
3	9,200	6.600— 8,900
4	12,500	9,900—12,200
5	16,000	13.400—15,700

Modulation and demodulation are accomplished in a unit known as a " Frequency Changer No. 1," which involves Westinghouse rectifier bridges, suppressing both the input signal frequency and the carrier. These units are valveless, the requisite terminal gains being obtained with line repeaters similar to those at the intermediate stations (Repeater No. 36A).

Where no echo suppressors are fitted, a voice frequency receiving amplifier is fitted for each channel to enable individual channel gains to be adjusted. A special terminal echo suppressor (No. 4A) has been developed for use with this and other multi-channel carrier systems. This suppressor incorporates the features of the valveless suppressor (No. 3C) together with the necessary terminal amplification.

4. Line Repeaters (Repeater No. 36A).

Since the success of the system depends largely on the performance of the line repeaters these are described first. Negative feedback is employed with two-stage amplifiers (pentodes) and the performance of the repeaters is summarized as follows:

(1) Frequency range 250 c.p.s. to 16,000 c.p.s. Gain uniform ± 0.3 db.

(2) Maximum gain 43 db., variable in steps of one decibel between 35 db. and 43 db.

(3) Harmonic level not less than 76 db. below fundamental for an output of 1 mW and not less than 55 db. at an output of 100 mW.

[5] " Reference Telephonic Power" or " Reference Volume" is defined as the electrical power which will give a certain deflection on a volume indicator of specified performance. It is intended to correspond with the greatest signal power which can be expected to occur at the input to any telephone channel.

(4) Singing point of repeater impedances against 600 ohms greater than 27 db.
(5) Gain stability with normal power and valve variations better than 0.1 db.
(6) Power output 29 db. above 1 mW.
(7) Power consumption in heater circuits 8 volts, 3 amps. and in anode circuits 200 volts, 90 milliamps. No grid biassing battery.
(8) Panel width 7 inches, apparatus mounted single side with valves projecting through panel, standard cover height ($4\frac{3}{4}$ inches).

Fig. 3 shows a photograph of an experimental two-way repeater.

networks may be situated at one end of the repeater section and set up with 600 ohm closing resistances.[7]

If the gain variations with normal supply variations do not exceed 0.1 db., the probable overall variation on a circuit with 10 repeaters is 0.3 db.

Principles of Negative Feedback.

The application of negative feedback to an amplifier produces four fundamental improvements.

(1) The harmonic level and the intermodulation level are reduced.
(2) The amplifier is stabilized against gain changes which tend to result from variations in valves and battery supply voltages.

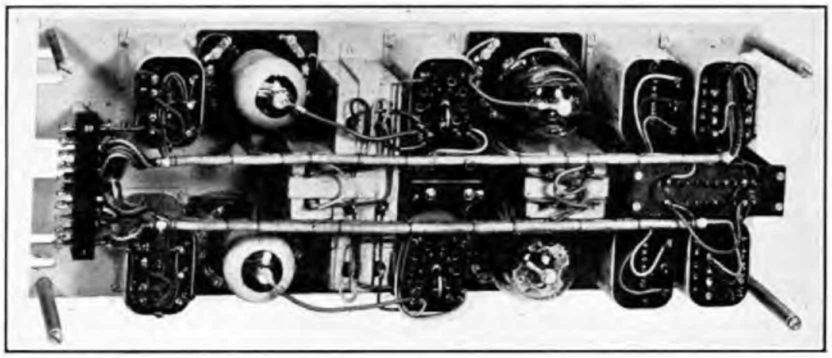

Fig. 3.—Repeater No. 36A.

Design Requirements.

The requirements of the system demand that the repeaters should have a performance approximating to that indicated in the above paragraph. A maximum gain of over 40 db. is required but, whereas with earlier repeaters it has been customary not to work within 2 db. of maximum gain in order to allow for maintenance adjustments, this precaution is unnecessary with the present type. Owing to the negative feedback the gain is practically invariable.

Since the line equalizers are independent of the repeaters, the latter should have a gain which is as nearly as possible independent of frequency.

Tests have shown that if the power handling capacity of the repeater is in excess of 500 mW. and if the harmonic generation is better than 60 db. at 10 mW. output[6] it is reasonable to operate the system at an output level of + 5 db. for each channel. Intermodulation interference will then be negligible when two channels are busy with speakers at R.T.P.

As already indicated in Section 2, distant-end cable crosstalk can be substantially reduced by means of auxiliary networks but this requires that the terminating impedances shall approximate to the characteristic impedance of the line and shall not vary in service (e.g., with changes of valves or repeaters). If the singing point of the input and output impedances of the repeater against 600 ohms non-reactive, is at least 20 db. over the working range, the

(3) The gain-frequency characteristic tends to become that of the feedback path. If the feedback circuit attenuation is independent of frequency, then the amplifier gain also approximates to a uniform frequency characteristic.
(4) The maximum working output level is increased, as the gain of the amplifier is maintained up to a sharply defined overload point.

As a first approximation the first three improvements are proportional to the reduction in gain due to feedback; for example, if this is 20 db. the amplifier is ten times more stable.[8] The reduction of the harmonic level is not always strictly proportional to the reduction in gain; this is possibly due to the theory assuming an undistorted output voltage feedback to the input and not taking into account the harmonic generation in the repeater.

Further improvements resulting from negative feedback, which are not of major importance in the present application, are the reduction of phase shift and the partial reduction of battery supply noise in the last stage valve.

Theory.

The theory of the negative feedback amplifier is fully developed in each of two articles by H. S. Black

[6] Harmonic ratio usually decreases approximately db for db as the output is increased up to the overload point.

[7] This assumes line transformers of suitable ratio where necessary. An alternative 150 ohm closure is provided on the repeater for use with unloaded lines.

[8] Stability here always refers to invariability of gain, not to oscillation.

in *Elec. Eng.,* January, 1934, pp. 114-120, and *B.S.T.J.,* 1934, pp. 1-18, and reference should also be made to the series of articles on "Carrier Telephony," by G. J. S. Little, now appearing in this Journal.

In these articles it is shown that the gain of the repeater is set by the attenuation of the feedback circuit and in an opposite sense, i.e., increasing the feedback circuit loss increases the overall gain. For complete control of the gain and frequency characteristic of the repeater the feedback circuit must include a network with a uniform attenuation-frequency characteristic, plus a network with an attenuation-frequency characteristic of the same shape as that of the circuit to be equalized.

It is not always necessary or desirable for the repeater to include this equalization network in the feedback path, and a uniform gain-frequency response is frequently satisfactory. The use of feedback equalization is attended by a number of difficulties including the following.

(a) The equalizer introduces phase shift which may be sufficient to cause oscillation.

(b) If the repeater has a fairly uniform gain-frequency characteristic without feedback and if the feedback is adequate at the frequency of maximum gain, then the feedback at other frequencies may be excessive and cause oscillation. It will be clear that the characteristics will only be effectively improved to the extent of the minimum gain reduction in the working frequency range.

In (b) above, this difficulty can be overcome by so designing the repeater that the gain-frequency characteristic without feedback is roughly the same as the required characteristic after equalization. Then, if the feedback circuit simulates the required characteristic precisely, the reduction in gain will be fairly uniform over the frequency range.

Thus there are two courses open

(a) To design an amplifier which has an approximately uniform frequency response without feedback, to apply uniform feedback and obtain a final characteristic which is sensibly uniform. The equalizer will then be external to the repeater. This arrangement has been adopted in the present design.

(b) To make the gain characteristic of the amplifier, without feedback, approximately the same as the final equalized characteristic, apply equalized feedback and obtain an approximately uniform reduction in gain over the frequency range.

The negative feedback amplifier with flat gain and an external equalizer is superior to the negative feedback amplifier with equalization in the feedback path on the score of standardization. The former has a performance which should be identical from sample to sample; the latter is dependent on the feedback circuit characteristics in relation to those of the initial non-feedback condition.

Application of Feedback.

To apply negative feedback to an amplifier it is necessary to have a voltage in phase with and proportional to the alternating voltage in the anode circuit of the last stage valve and to apply this approximately in anti-phase with the grid voltage which produces it. In a single stage amplifier the valve phase shift is 180° and provided the feedback path does not introduce further phase shift the application of feedback from the anode circuit to the grid circuit is simple.

In a two-stage amplifier the valve phase shift is 360° and a straightforward feedback from the anode circuit of the second valve to the grid circuit of the first valve is not possible. A further phase change of 180° must be introduced, either by means of a transformer in the feedback path, or by injecting the feedback voltage into some part of the grid cathode circuit where the required phase change is produced. Phase changes will also occur in the intervalve couplings and these must be reduced to prevent the amplifier oscillating at either high or low frequencies.

For example, the feedback voltage may be obtained from a resistance in series with the load circuit, between the output transformer and the output valve cathode, and this is done in the present design. To obtain the correct phase relationship the feedback voltage is applied between earth and the cathode of the first stage valve. This necessitates the use of indirectly heated valves. If the valves are auto-biassed the feedback and bias resistance may be combined and adjustment of feedback made by tappings on the bias resistance.

The phase changes at low frequencies in the intervalve coupling and the output circuit must be reduced by increasing the time constant of these circuits well beyond the values required for adequate transmission of frequencies of the order of 200 c.p.s. Phase changes at high frequencies may be reduced by shunting the load matching impedance with a small condenser, this condenser also comprising part of the low-pass filter formed by the output transformer leakage inductance and capacity.

When negative feedback is obtained from a resistance in series with the load impedance, the internal impedance of the output valve, as seen from the load, increases in proportion to the amount of feedback (i.e., a gain reduction of 20 db. increases the impedance 10 times). Feedback from a resistance in parallel with the load resistance will similarly reduce the effective valve impedance, while a combination of the two arrangements can cancel the two effects. The use of an output bridge also gives a cancellation.

Circuit Arrangement.

Before discussing the design details which have enabled the required performance to be realized the circuit will be described as a whole. A schematic of the repeater is given in Fig. **4.**

The balanced and screened input transformer has a high impedance ratio to obtain the maximum gain

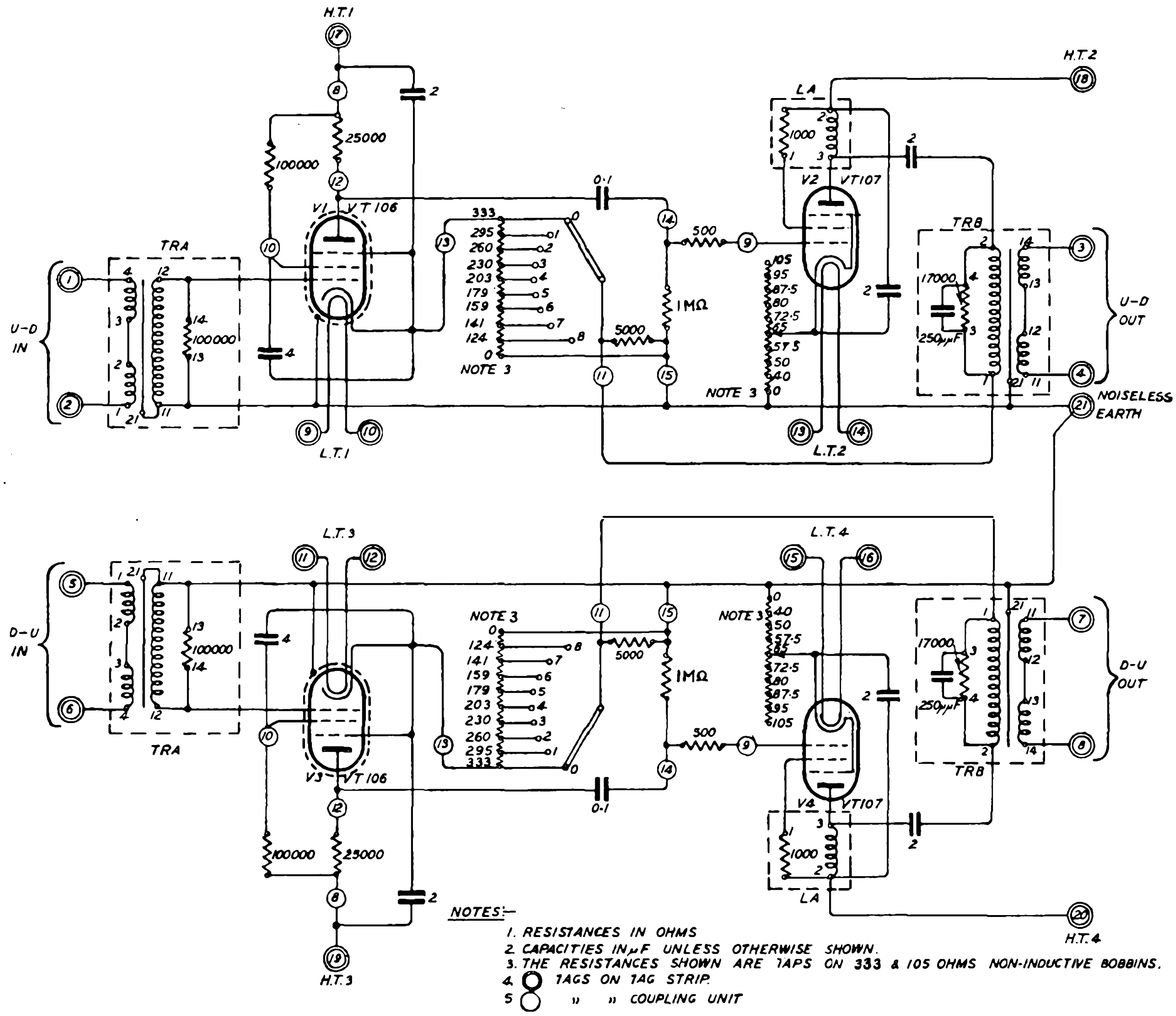

FIG. 4.—SCHEMATIC DIAGRAM OF NEGATIVE FEEDBACK REPEATER NO. 36A.

in this component. The ratio is determined by the total working capacity[9] and the frequency range required. The impedance matching resistance is placed on the secondary side to reduce the effects of resonance between leakage inductance and secondary capacity. For use on unloaded lines, where the impedance approximates to 150 ohms, the two halves of the primary winding are paralleled.

The first stage valve is a Mazda type AC/S2 Pen (V.T.160) which is a H.F. pentode of low input capacity and high working mutual conductance. The screen voltage is maintained at approximately 100 volts by a series resistor of 100,000 ohms, which also forms the screen decoupling circuit in conjunction with a 4 μF. condenser. The anode impedance consists of a 25,000-ohm resistor, and decoupling is provided by the anode relay and a 2 μF. condenser.

The intervalve coupling must have a large time constant in order to reduce phase shift at low frequencies. The values of resistance and capacity chosen give a phase change of 17.6° at 10 c.p.s. The coupling loss at 200 c.p.s. is only 0.001 db. and at 10 c.p.s. is about 0.4 db. These small values of coupling loss are a secondary consideration to the main problem of preventing low frequency oscillation.

The output valve is a G.E.C. Type N.43 (V.T.107), a power pentode giving an output of about 2 watts on 200 volts. The grid is connected to the intervalve coupling *via* a 500-ohm resistor to stop parasitic high frequency oscillations. Auto bias is used and, as the valve specification permits a grid bias variation of ± 33 per cent. for the standard anode current, a variable resistance is provided. This is tapped in 7.5-ohm steps from 50 ohms to 95 ohms, with a further tap at 40 ohms and 105 ohms.

The output transformer is choke-capacity fed and incorporates an impedance matching resistance and a capacity which prevents high frequency oscillation and also provides a low-pass filter section of correct impedance in conjunction with the leakage inductance.

[9] The dynamic input capacity of a valve (due to " Miller Effect ") is reduced by negative feedback.

The feedback circuit consists of a variable resistance in series with the anode load, applying a predetermined fraction of the output voltage to the cathode of the first stage valve. This resistance is variable from 124 ohms to 333 ohms in nine steps, which change the repeater gain in steps of one decibel from 35 db. to 43 db. Auto-bias for the first stage valve requires a resistance of about 300 ohms and the feedback and bias resistance are therefore combined.

Valves.

Both valves will have considerable application apart from their use in the repeater. The first stage valve (Mazda AC/S2 Pen) is a standard radio receiving valve and was selected on account of its high working mutual conductance (3.5 mA/V), its low inter-electrode capacities (Grid-Anode 15 $\mu\mu$F., Screen-grid to Anode 8 $\mu\mu$F.) and its satisfactory performance on life test. The harmonic production in the first stage valve is negligible compared with that in the output valve, and so the working grid bias is not critical. The output valve (G.E.C. N.43) will have applications in broadcast receivers and possibly also for television receivers. It was developed from the existing N.41 valve to give a low dynamic input capacity (35 $\mu\mu$F.) and a high sensitivity (250 mW/V^2 into its optimum load), together with a reasonable life. Life tests on these valves indicate that the emission, amplification and harmonic generation remain practically unchanged after 4,000 hours.

Input Transformer.

The maximum voltage amplification obtainable on the input transformer is desirable, both to permit a large gain reduction by means of negative feedback and to increase the signal to repeater-noise ratio. Limitations to the transformer gain are set at the low frequency end by the primary shunt reactance, and at the high frequency end by leakage inductance and secondary capacity. The permeability of the magnetic core material decides the number of primary turns required to provide a given inductance. The leakage inductance is practically fixed by the primary winding, and the effective capacity by the impedance ratio and the geometry of the windings.

A further limitation is set on the input transformer design by the necessity of matching the impedance, when terminated in the first stage valve grid circuit capacity, to 600 ohms non-reactive. This is achieved by treating the leakage inductance and total working capacity (the latter including valve grid capacity, valve holder and wiring capacities, in addition to transformer winding capacity) as the elements of a low-pass filter. Due to the change of image impedance in the transmitting range, it is necessary to design for a cut-off at least twice the maximum frequency to be transmitted.

The use of 15 mil mumetal fixes the leakage inductance at 2 mH and this in turn necessitates a 48 kc.p.s. cut-off for a 600 ohm filter. The total capacity cannot be reduced below 65 $\mu\mu$F., and for the ideal transformer, the step-up ratio is limited to 9.25 as a maximum. A compromise has to be made between the impedance matching requirements, and the repeater gain before reduction by negative feedback and the choice of a 12.5 step-up ratio provides an initial repeater gain of 73 db and a filter characteristic impedance of 450 ohms. The matching resistance is placed across the secondary side, where it effectively damps resonance and also leaves the primary windings free to be paralleled for use on 150 ohm circuits. Allowance is made for the transformer losses, which may be considered as a shunt resistance, by increasing the matching resistance from 93,500 ohms to 100,000 ohms. An improvement in the appearance of the repeater has been effected by mounting this resistor inside the transformer case and connecting it to separate tags which are strapped across the secondary winding externally.

The capacity of the secondary winding is minimized by using a four section bobbin and spacing each section from earthed screens and stampings in such a way that each contributes equally to the total effective capacity, the four sections being connected in series, with one end earthed. Thus, earth capacities on the section nearest to the cathode (earth) are comparatively unimportant, whereas those on the section nearest the grid are extremely important. The thickness of insulation from screens, etc., is therefore graded to give uniform capacity contributions from each section.

Coupling Unit.

In order to avoid mounting a number of separate resistors on the repeator panel, these are placed in a standard transformer case with a U link switch for gain control. Since a number of the resistors is associated with the intervalve coupling and the feedback coupling the unit is usually referred to as the coupling unit. It contains the anode and screen grid resistors for the first stage valve, grid leak and grid " stopper " resistor and the tapped feedback resistor. The 0.1 μF. coupling condenser is mounted separately.

Output Transformer.

The output transformer design is fixed by the optimum load for the output valve and the inductance on the line side, which should be of the same order as that of the input transformer. Tests on the output valve give an optimum load of 7,500 ohms. The power abstracted from the anode circuit of a screen grid or pentode valve by a transformer is proportional to the resistance component of the transformer impedance when terminated in its load. There is no attempt to match the valve impedance to the load impedance; this would be impossible in the present circuit where the negative feedback increases the valve impedance. To obtain a uniform output impedance of 600 ohms non-reactive the primary side of the transformer is closed with a resistance, which also serves to maintain a uniform anode load. The impedance ratio is 15,000 ohms to 600 ohms, but the matching resistance is 17,000 ohms to allow for the effective shunt resistance of the transformer losses. Half the output power is therefore dissipated in the matching resistance and half in the external load.

To obtain the required low-pass filter characteristics in the output transformer the secondary capacity has to be increased by 250 $\mu\mu$F. The extra capacity is provided by a small fixed condenser across the matching resistance. This condenser also prevents oscillation at high frequencies.

Output Choke.

The output choke has to carry a normal anode current of about 30 mA. The three requirements to be fulfilled are low resistance, high inductance and small changes of inductance with direct current. The voltage drop in the choke should not exceed 20 volts and the inductance should be at least 20 henrys under working conditions. Tests show that the required performance can just be obtained with mumetal (small air gap) using the standard half inch core section. The 1,000 ohms resistor in the screen grid circuit is mounted in the same case as the output choke.

Anode Relays.

The anode relays are of considerable importance as they not only provide adequate decoupling and alarms, but also contribute to the low (motor-boating) frequency gain by virtue of their resistance. At very low frequencies the decoupling condensers have a high impedance and the anode load impedance in the first stage valve circuit then includes the relay. Thus the gain is increased[10] and low frequency instability may result. As designed, the first stage anode relay has an inductance of about 20 henrys with a resistance not exceeding 2,400 ohms. A 3,000 type relay is used with three nickel iron sleeves. The second stage relay (also 3,000 type) has an inductance of 1 henry with a resistance not exceeding 100 ohms. In this stage resistance does not tend to cause oscillation, but it must be kept low in order that the anode voltage on the output valve is not seriously reduced.

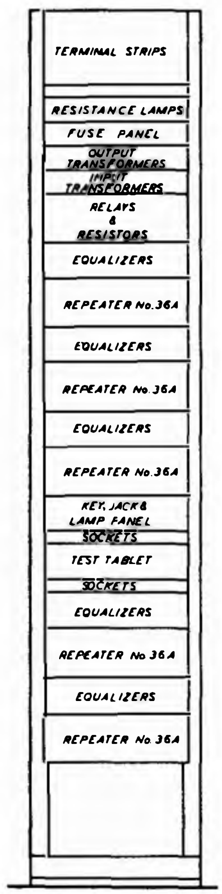

FIG. **5**.—BAY LAYOUT.

Arrangement of Repeater Bay.

Fig. **5** shows how five repeaters and the associated equalizers are mounted on each side of a standard 10 ft. 6 in. bay.

Power Supplies.

The following table gives particulars of the power consumption of each valve with 200 volts anode supply.

Valve	Heater	Anode and Screen 200 v.
V.T. 106 ..	4 V., 1 Amp.	4.7— 5.5 mA.
V.T. 107 ..	4 V., 2 Amp.	36 —41 mA.

No grid biassing batteries are used.

There are three reasonable methods of connecting the heaters.

1. A.C. at 4 volts with all heaters in parallel. Each repeater will then require 6 amps. and this amounts to 30 amps. per bay of five repeaters. The heater wiring must be screened and the transformer must either be screened or mounted at a distance of at least three feet from the repeaters.
2. Heaters may be connected in series-parallel, either 8 volts and 3 amps. or 12 volts and 2 amps. The chief disadvantage of this method is that one heater failure of a parallel pair will probably cause the other to burn out also.
3. Five heaters of one type may be wired in series. One bay side will then require four heater circuits, two at 20 volts and 1 amp. and two at 20 volts and 2 amps., making a total current of 6 amps. Failure of one heater cannot damage any other heater, but an arrangement must be provided for replacing a burnt out heater by a resistor. This arrangement has been adopted for use in repeater stations as it makes most efficient use of the 21 volt battery. Each heater is shunted by a relay which operates and locks when the voltage across it rises to 20 volts. When operated it replaces the faulty heater by a resistor.

The anode current may be supplied either by a battery or by an A.C. mains rectifier system. If

[10] In a pentode the load current is practically independent of the load.

rectifiers are used the internal impedance of the unit must be low to prevent " motor-boating." Tests have shown that one repeater will operate satisfactorily from a mains unit whose internal impedance does not exceed 1,500 ohms.

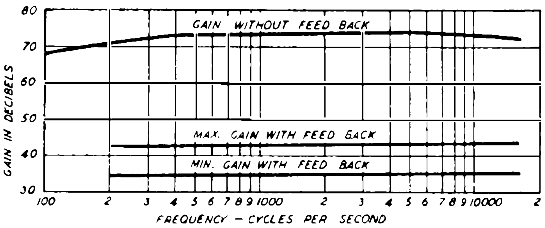

Fig. 6.—Repeater Gain—Frequency Characteristic.

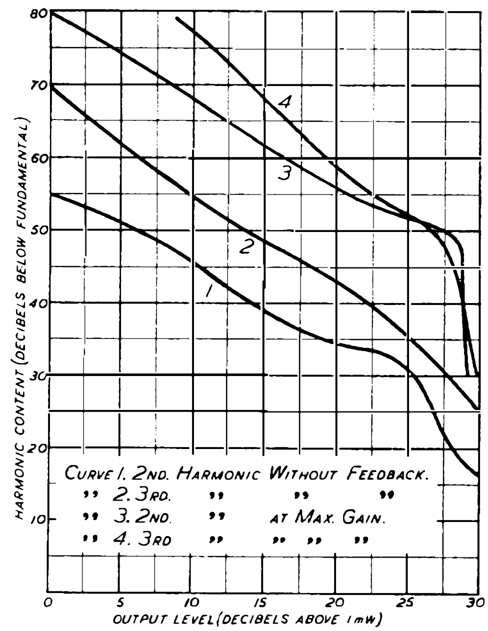

Fig. 7.—Relation Between Harmonic Content and Output Level.

Test Results.

The gain-frequency characteristic of the repeater with and without feedback is shown in Fig. **6.** Fig. **7** shows how the harmonic production varies with output level, the gain being set to maximum (43db). Since the gain control is in the feedback circuit, the harmonic generation becomes less as the gain is reduced.

Fig. **8** shows how the output impedance, expressed in terms of singing point against 600 ohms non-reactive, varies with frequency. The input impedance varies similarly.

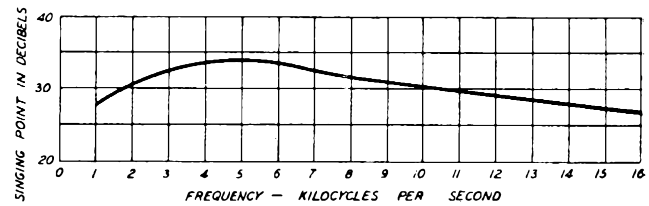

Fig. 8.—Singing Point of Repeater Output Impedance against 600 ohms Non-reactive.

The following table indicates the gain stability with variations of supply voltages.

Percentage reduction of anode voltage	5	10	15	20
Change in gain in decibels . .	0.02	0.04	0.07	0.10
Percentage reduction of heater voltage	5	10	15	20
Change in gain in decibels . .	0	0	0.03	0.05

The values of gain changes for power supply variations less than 20 per cent. have been estimated on a basis of the changes occurring when the repeater is used without feedback, due to the difficulty of measuring gain changes of less than 0.05 db. In a demonstration both anode and heater voltages were reduced 25 per cent., and the gain change was of the order of 0.1 db.

(*To be continued.*)

Sulphuric Acid Spray in and near Battery Rooms

The occurrence of sulphuric acid spray during the " gassing " period of exchange batteries has been considerably reduced in the past by the use of oil layers on the surface of the electrolyte. In view of the discontinuance of the use of such layers in many exchanges, investigation has been made of the liability of spray being carried from battery rooms into adjacent apparatus rooms. It has been ascertained that the bulk of the spray produced during a normal charge is in the form of coarse droplets, which settle within a comparatively short distance of the battery. When a battery is gassing vigorously, as is particularly the case during equalizing charges, a type of spray is produced which remains in relatively stable suspension for longer periods.

In none of the exchanges examined have any dangerous concentrations of spray been detected in apparatus rooms under working conditions, but it is apparent that, in certain cases when the prevailing draughts in the building are favourable, dangerous conditions may arise, particularly when the battery room adjoins the apparatus room. Fortunately, however, effective remedial measures such as sealing doors and windows can be taken without great difficulty.

A Method of Compensation for Supply Voltage Variations in Thermionic Valve Circuits

B. M. HADFIELD,
B.Sc. (Eng.) Hons., Grad.I.E.E.

The compensation of supply voltage variations of the usual order is described with particular reference to the use of a non-linear resistance, such as a barretter, for providing the grid bias to thermionic valve circuits.

Introduction.

IN most thermionic valve circuits, variations in the voltage of the power supply produce undesirable effects, which may adversely affect the true functioning of the circuit in the worst cases. In general, there are three distinct voltages supplied to a valve which can affect the performance, assuming that the grid input and other circuit values do not vary. These are :—

(1) Anode and/or screen grid voltage.
(2) Grid bias voltage.
(3) Cathode voltage—whether the valve is indirectly or directly heated.

Where the anode voltage is of value greater than some 150 volts and the grid bias is automatically derived from the anode current, compensation for these two may be obtained by some form of neon tube stabiliser, which however must inevitably greatly increase the load on the anode supply to be effective. Variations in the cathode supply cannot be readily compensated by such methods, even when the cathode is heated from the same power supply as the anode.

It will be seen, therefore, that a better method is to allow the supply voltages to vary, and to introduce a non-linear device at some point in the circuit which will compensate for such variation. The most effective position is in the grid circuit of the valve, where a small non-linear variation of the grid bias can be made to compensate fully for the variation in supply volts. The non-linear variation is obtained by using the potential drop across a barretter, or a suitable fraction thereof to supply the grid bias voltage.

Description.

The device was originated for use on valve receivers for telephone trunk signalling by means of Voice Frequency tones, which operate entirely from a 50 volt supply, and will be described in detail for such a receiver. It will be shown, however, that it can be applied to other forms of valve-operated apparatus.

The valve receiver referred to above (see Fig. **1**) is designed to provide interrupted impulsing d.c. signals to the subsequent automatic apparatus, upon reception of an interrupted alternating voltage of 750 c.p.s. The receiver employs two valves, the second of which provides interrupted direct current to cause a telephone type relay (X) to impulse. The percentage of a cycle for which the " make " contacts of the relay are operated (*i.e.*, " the make percentage "), must simulate the percentage of time per cycle for which the tone is applied. This valve provides the direct current pulses from the applied tone pulses by working as a rectified reaction stage,[1] in which the valve is usually biassed (from the potential on R) so that the anode current is zero, and rises to a constant value when any alternating voltage greater than the trigger voltage is applied to the control grid circuit.

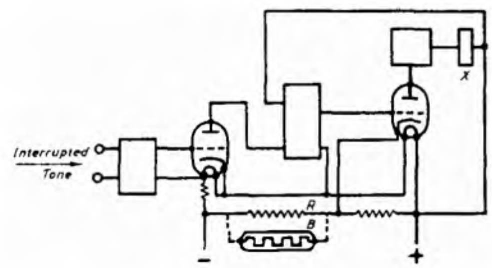

FIG. 1.—VALVE RECEIVER USING BARRETTER.

The first valve provides the necessary power to operate an inter-stage filter. As stated previously, the cathode, anode and grid bias supplies are obtained from the same supply of 50 volts.

If the supply voltage is reduced it will be seen that

(1) the power output of the first stage is reduced;
(2) the anode current of the second stage is reduced, assuming that the grid biasses are linearly derived from the battery.

To offset this, the voltage required to trigger the last valve is less, but on the whole, the make percentage of the relay—due to the duration and value of the anode current in the last valve—is also reduced. The effect of variations in the supply volts is shown in Fig. **2**, from which it will be seen that, taking the normal permissible variation of 46-52 volts, the make percentage varies from 52.7% to 70%.

Now if the grid bias resistance R is replaced with a barretter (B in Fig. **1**) so that the necessary bias voltage is obtained, it should be possible to choose a point on the resistance/current characteristic where the bias voltage variation is greater than the supply variation, by an amount sufficient to compensate fully for the alteration in the power output of both valves. Taking the case of a reduction in the supply voltage, the bias so obtained will be less than normal, so that the trigger voltage for the second valve will be smaller, and the triggered anode current greater.

In practice, it is seldom possible to obtain both the correct bias voltage and variation with the types of barretter available, but it is possible to obtain a barretter which at the correct bias voltage, overcompensates for the voltage variation, and to shunt the barretter with a suitable resistance (at the same

[1] P.O.E.E.J., Oct., 1932.

time reducing the series resistance) so that the correct compensation effect can be obtained. The second characteristic in Fig. 2 shows the effect of such a shunted barretter system, and it will be seen that from 46 to 52 volts the variation in make percentage is only 1% as compared with 17.3% with the uncompensated system.

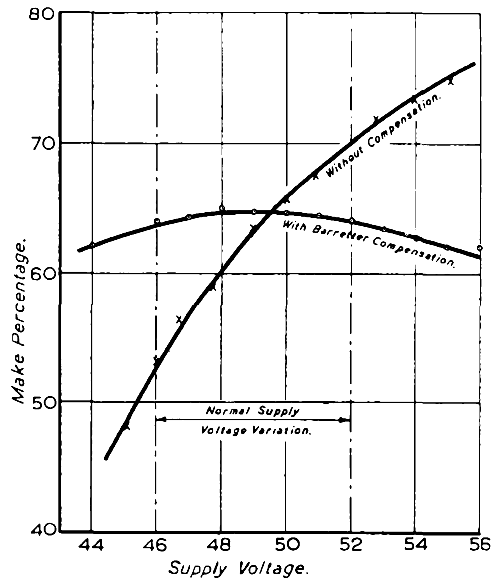

FIG. 2.—EFFECT OF SUPPLY VARIATIONS WITH AND WITHOUT BARRETTER COMPENSATION.

In the above receiver the bias circuit takes power from the supply, which is inevitable in this case since the second valve must be biassed to zero anode current. The addition of a barretter to the circuit need not make the power taken by this circuit any greater, because a fairly low resistance in the cathode lead would have to be maintained normally, in order that the " cathode drop " obtained when the anode current flows, shall not greatly increase the static grid bias.

General Application.

In many thermionic valve circuits, the supplies are obtained from a mains unit which applies rectified voltages to the anode circuits, etc., using automatic biassing in the return cathode lead produced by the anode current, the heaters being supplied with alternating current. The function of such a valve circuit is mainly that of amplifying or of producing A.C. power. The change in these functions due to variations in the power supply is generally small, and therefore a small non-linear change in the grid bias of one or more suitable valves would provide sufficient compensation. Two alternative methods are available :—

(1) Use of a shunted barretter as the cathode resistance or as a portion of this resistance, the shunting resistance being adjusted so that correct compensation is obtained.

(2) Use of a high resistance barretter fed from another high resistance from the anode voltage supply—a suitable portion being tapped off for application to one or more valves as grid bias.

It is also possible to produce any required type of compensation for changes in the power supply, by using a shunt either greater or smaller than that required for correct compensation, or by using a portion of the potential drop on the series resistance, the variation of the latter being, of course, of opposite sense to that on the barretter.

Consistency of Operation.

It will be appreciated from the above, that the barretter is used as a convenient non-linear resistance, so that the portion of the characteristic on which it is normally used (*i.e.*, the constant current portion) is not approached in all normal cases. The barretter current is thus much below its normal rating and in consequence the resistance/current characteristics will not deteriorate with life.

Electrically-heated Waxing Baths for Switchboard Cables

In view of the risk of fire in heating wax in an open vessel over a gas ring, and the now general use of electricity for heating soldering-irons, it has been decided to introduce electrically heated baths for waxing cable and wire forms. A bath has been supplied for working on 200-250 V A.C. and is fitted with an automatic temperature control of 250° F. As the total weight of the bath is only $16\frac{3}{4}$ lb. when filled with wax, it is easily transportable. The bath is at present undergoing trial in the Circuit Laboratory.

The Fatigue Testing of Wire

E. V. WALKER, B.Sc., A.R.S.M.

The principles of fatigue testing are briefly given, and the Haigh-Robertson machine, designed for the fatigue testing of wire, is described.

Introduction.

OVERHEAD line wires used for telephone and telegraph transmission are susceptible to fatigue failure when caused to vibrate by wind velocities, and in consequence it is frequently necessary to determine in the laboratory the fatigue limits of such wires. During the past few years, several machines have been designed for this purpose, one of the more notable being that of Haigh and Robertson. The mechanical testing laboratory at the Research Station has recently been equipped with one of these machines, and it was thought that a description of it would be of some general interest.

Principles of Fatigue Testing.

For those readers not familiar with mechanical testing it will not be out of place first to define " fatigue " and " fatigue limit," and to recall the methods of fatigue testing in general.

" Fatigue " is a term used to describe the failure of metals, which have been subjected to repeated stresses. " Fatigue limit " is defined as being the maximum repeated stress which theoretically can be applied indefinitely to a metal without causing its failure.

Experimentally this value is determined by submitting the material to repeated stresses of various magnitudes with the object of ascertaining the number of repetitions of any given stress it will withstand before failure takes place. A graph is plotted showing the relation between stress (ordinate) and logarithm of the number of cycles to fracture (abscissa). With most metals and alloys it is found that the curve eventually becomes horizontal (Fig. 1), and the stress where this occurs is read off and taken

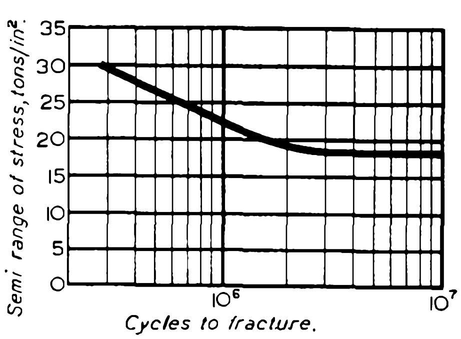

FIG. 1.—TYPICAL FATIGUE CURVE.

as the fatigue limit. When testing steels this value can be obtained by choosing stresses which will give corresponding endurances of between 10^4 and 10^7 repetitions. With non-ferrous metals, however, it is frequently necessary to test to 10^8 or more cycles. To do this is sometimes not convenient, owing to the time taken to complete the curve and, in such cases, the stress corresponding to 10^7 repetitions is noted and reported as the endurance limit based on 10^7 cycles.

Normally fatigue tests are carried out on test-pieces machined to a standard size and shape. Such test-pieces are necessary in order to remove the point of fracture from the effects of clamping stresses imposed upon the metal under test by the grips of the testing machine. The presence of these stresses at this point leads to an inaccurate value of the fatigue limit being obtained.

When consideration is given to the fatigue testing of hard drawn wire, such as is used for overhead lines, a difficulty arises. It is well known that the process of wire drawing causes the surface of the wire to be in a different condition from that of its centre; so that if a true value of the fatigue limit of the wire as a structural shape is to be obtained, it is not permissible to carry out a test on a machined test-piece. This is overcome, and at the same time the fracture occurring within the grips avoided, by the Haigh-Robertson machine in a manner which will be understood from the following description.

The Haigh-Robertson Machine.

The machine consists (see Fig. 2) mainly of three parts, P a base plate, E a swinging headstock, and B a tailstock.

On one end of the base plate is fixed a casting D on which are mounted the bearings AA. These consist of two ball bearings which locate the direction of the axis of swing of the headstock and a spring-loaded sapphire thrust-bearing which carries its weight.

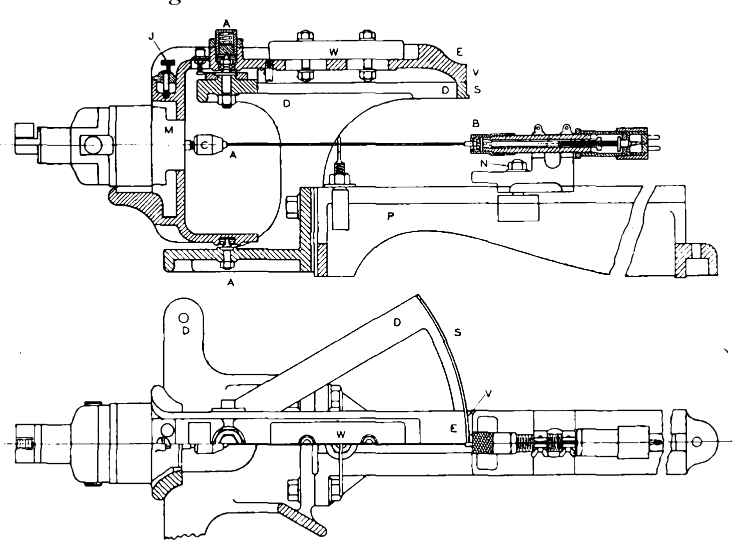

FIG. 2.—HAIGH-ROBERTSON MACHINE.

A motor M is fixed to the swinging headstock, one end of the rotor spindle of which is supplied with a self-centring chuck C. A counter and drip oil feed J are attached to this motor, which is of the " universal " type and gives a direct drive.

On top of the base plate rests the tailstock. It can be clamped in any position by the nut N, according to the length of the test-wire, and contains a particularly ingenious thrust-bearing, consisting of a trio of 5 m.m. balls running in a race of hardened steel, which press up against a disc of the same material.

After straightening and cutting to length, one end of the wire whose fatigue strength is to be measured is inserted in the motor chuck. On the other end is fitted a sleeve which contains a spherical seating in which is placed another 5 m.m. ball. On commencing a test, the tailstock is moved towards the headstock until the ball in the sleeve comes in contact with the trio of balls in the thrust-bearing which causes a slight bow on the wire. The tailstock is then clamped in position, and final adjustments of flexure of the wire are carried out by turning the knurled head B.

The swinging headstock automatically takes up its position on bowing the wire, the flexure of which is measured by means of the scales S and V. A balance weight W ensures the elimination of any error of setting of the vertical axis of swing.

The stress imposed upon the wire is then made alternating by starting up the motor.

On referring to Fig. 3 it will be appreciated that the arrangement of the machine is such that the wire

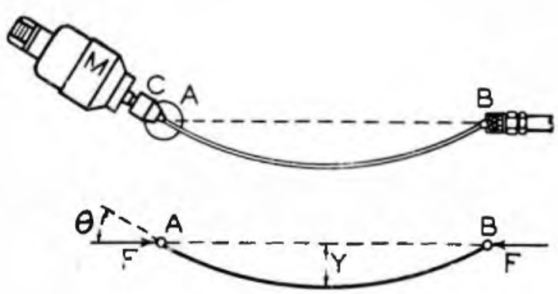

FIG. 3.—WIRE LOADED AS A STRUT.

bends in a horizontal plane under the action of two equal and opposite forces F acting along the line A-B. The bending moment of the wire varies along its length and is greatest at its middle where the deflection Y is the greatest. Thus the point of fracture of the test-piece is at its mid-span and removed from the influence of clamping stresses produced by the chuck C, without the employment of a machined test-piece. It should be noted that the wire does not " whirl," but rotates as a curved shaft.

The speed of operation of this machine varies according to the material and size of wire under test. Thus for copper line wire alternations of stress are applied at the rate of 10,000-13,000 r.p.m.; but with steels, especially for wires of small diameter, speeds as high as 17,000 r.p.m. can be used. The ability to obtain these high speeds in fatigue testing is of great value, since such tests are very time consuming.

When the wire breaks, the hardened steel disc, referred to previously, in the thrust-bearing jumps forward, acting under the influence of a plunger and

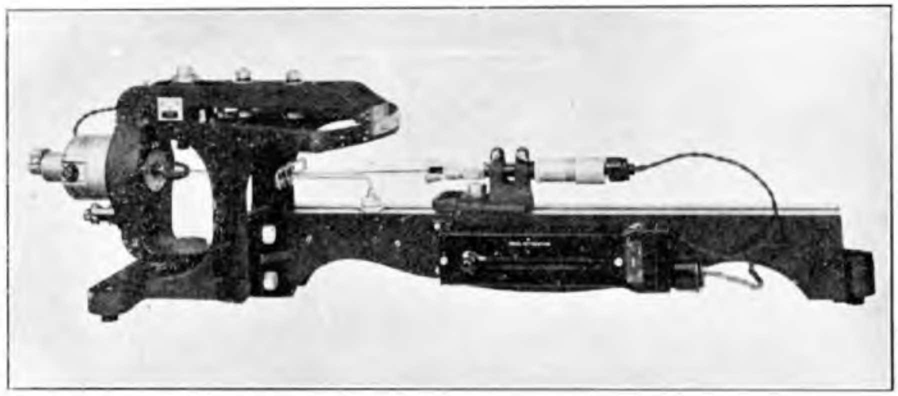

FIG. 4.—HAIGH-ROBERTSON TESTING MACHINE.

spring, and the motor circuit is broken by the operation of a spring switch.

Fig. 4 shows the Haigh-Robertson machine testing

FIG. 5.—TYPICAL FATIGUE FAILURE.

the fatigue strength of a wire and Fig. 5 a typical fatigue failure.

It will be realised that the principle of working is based on the " Euler " strut theory.

It can be shown when θ is small that

$$e = \frac{d}{2R} = \frac{\pi}{2}\,\theta\,\frac{d}{L}$$

where e = bending strain at mid-point of the wire of diameter d.

R = radius of curvature of the wire at this mid-point.

θ = the inclination at the end of the wire in radians.

L = length of the wire.

The bending stress at the mid-point is given by

$$f = E.e.$$
$$= \frac{\pi}{2} \theta \frac{d}{L} . E$$
$$= \frac{\pi^2}{360} (\theta \text{ in degrees}) \frac{d}{L} . E$$

where E denotes Young's Modulus of Elasticity for the material of the wire.

If θ exceeds 10°, a small subtraction from its value as calculated has to be made in order to obtain any given stress on the wire.

In addition to the bending stress there is a small compressive stress on the wire produced in consequence of the thrust. This, however, is very small compared with the former, and does not affect the fatigue limits obtained.

As a means of testing the fatigue strength of wire, the Haigh-Robertson machine has proved to be a valuable addition to the apparatus at the Research Station for investigating the strength of materials, in that little preparation of the test-piece is required, it is comparatively easy to operate, and results obtained can be very exactly reproduced.

Damage to Lead Sheathed Cables by Caterpillars

C. E. RICHARDS, F.I.C., and F. C. BOND

Details are given of damage by caterpillars to lead covered telephone cables

Introduction.

THE telephone engineer has a great many troubles of one kind or another, and the failure of lead covered cables is one of these. Lead is, in the popular estimate, one of the most permanent of metals. This is in fact true, but there are times when it appears to corrode as readily as tinplate. Another trouble which frequently occurs is " fatigue failure " caused by alternating stresses in the metal and usually due to vibration. This can generally be cured or prevented by the use of a suitable lead alloy instead of the pure metal.

Damage by the Goat Moth Caterpillar.

In this country we have hitherto had no trouble from insects, though a short survey of the foreign literature will show that engineers abroad are not so happily placed. During the past two years two remarkably similar cases of insect damage to lead sheathed cables have, however, been reported from opposite ends of the country. The former was discovered at Parkstone (Dorset) in 1934, when a cable which had been laid during 1929 was found faulty. The fault was thought to be due to corrosion and was traced to a length of wood troughing which carried the cable up the side of a building on private property. The cable was drawn out in the usual way and when the faulty place came into sight it was found that a large caterpillar had formed a cocoon at the spot. The grub was dead when found. The damaged sheath was carefully examined as it was thought possible that failure might have been due to corrosive damage caused by the products of decomposition of the grub. This, however, was not the case although a certain amount of superficial corrosion had resulted in this way. The edges of the hole in the lead had unmistakable teeth marks and it was found on examining the cocoon that this had partly been built from the lead pellets which had been bitten from the sheath. Whether the insect found the lead more to its taste than the creosote impregnated timber which was also used is not known, but it appears probable, as these two materials (plus a little petroleum jelly) were the only ones available.

FIG. 1.—INSECT AS FOUND.

FIG. 2.—GOAT MOTH COCOON.

The insect was identified as the larva of the Goat Moth (Cossus ligniperda) which is a native of this country and does considerable damage to trees such as willow, poplar, walnut, elm and ash by boring galleries through the wood.

There does not seem to be any need to anticipate further attacks on lead sheathing by this insect, as it exists in large numbers in this country, but until the identification was certain it was feared that an undesirable alien had been imported, since by a peculiar chance the actual cable fault occurred on the wall of a building in a timber yard where imported wood is handled.

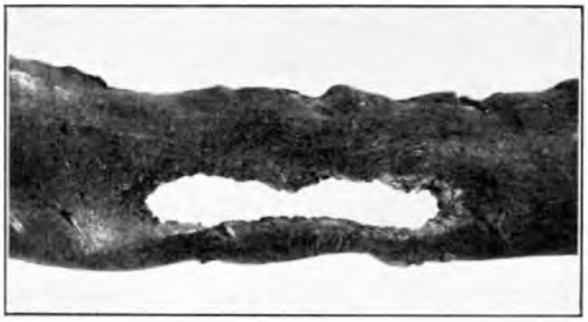

FIG. 3.—CABLE DAMAGED BY GOAT MOTH CATERPILLAR.

Photographs of the grub, cocoon and damaged cable are shown in Figs. **1**, **2** and **3**, which are full size.

Damage by the Puss Moth Caterpillar.

The second case of damage occurred at Ainsdale, Southport (Lancs.) in January, 1935, when a fault was traced to a two pair protected cable which was secured a few inches above ground level to the party wall between two gardens. Here also it was found that a large cocoon was attached to the cable at the faulty place, but in this case further investigation showed that the cocoon contained a living chrysalis. This was transferred to a rearing cage, and the insect emerged between the 9th and 12th June, 1935. It is unfortunate that—owing to the Whitsuntide holidays—the chrysalis was not under observation during the above period, as the moth, in its attempts to escape from the rearing cage, damaged itself considerably. The insect proved to be a Puss Moth —Cerula vinula.

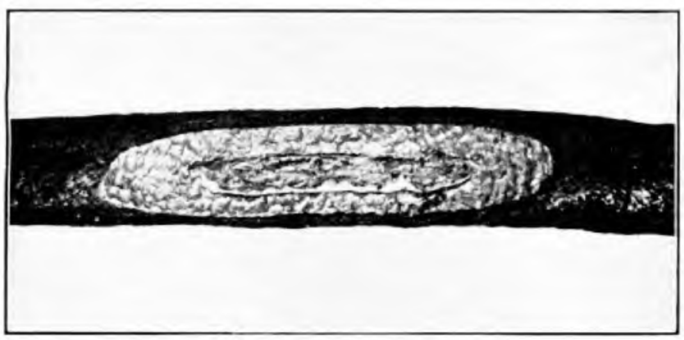

FIG. 4.—CABLE DAMAGED BY PUSS MOTH CATERPILLAR.

As in the previous case, one side of the lead cable sheath was found to have been bitten away at the point where the cocoon was attached, and the edges bore distinct tooth marks. (The teeth of the Puss Moth caterpillar are apparently smaller than those of the Goat Moth caterpillar.) In addition to the fragments of lead so removed, portions of the outer hessian covering, and fragments even of the paper insulation around the conductors were used by the caterpillar in building the cocoon.

Under normal conditions the larva of the Puss Moth feeds voraciously from June to September on the Willow and Poplar, and, less frequently, on the Sallow and Aspen. When fully fed it spins up, usually on the bole of the food plant, working tiny particles of the chipped bark into the cocoon and thereby making it resemble its surroundings so closely that it takes a keen eye to detect it. In the present case the use of fragments of bitumenized hessian for cocoon building, made it almost identical in surface appearance with that of the covered cable.

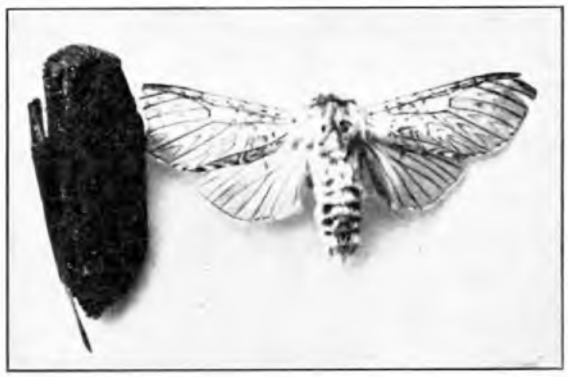

FIG 5.—PUSS MOTH AND COCOON.

As Willow is common enough in the Ainsdale district it is of course not surprising that a caterpillar of the Puss Moth should be the one to go astray, but one cannot avoid a feeling of wonder at the strange instinct which caused the grub to select a protected cable as a substitute for a tree trunk. Perhaps it is more remarkable that the insect, which is a vegetarian, did not succumb to lead poisoning, even though the bitten-off fragments of lead were not used as food, but as building material.

Figs. **4** and **5** show the cable—the bites being distinctly visible—and the actual Puss Moth and cocoon.

The specimens mentioned in this note are now held as museum pieces at Dollis Hill.

Silica Gel

D. W. GLOVER, M.Sc., A.I.C.

A brief description of the nature and properties of Silica Gel and of the uses to which it is put in the Engineering Department.

Introduction.

IN addition to its industrial importance for such purposes as decolourization, oil refining, and solvent recovery, the rapidly extending Departmental use of silica gel and the considerable number of queries which arise respecting it clearly indicate that a brief description of its main characteristics will be of interest to many who have not so far encountered the material.

Properties.

Silica gel is a granular material of similar appearance and chemical composition to sand; it differs physically, however, and possesses the ability to absorb large quantities of the vapours of numerous liquids, and also many colloidal substances from suspension in liquids. When used for the former purpose it never becomes " sloppy " and after saturation may be reactivated by heating in a slow current of air to an appropriate temperature somewhat above the boiling point of the liquid concerned.

Its peculiar properties are apparently due to the existence of an enormous number of sub-microscopic pores or fissures in the material, which hence possesses an effective surface vastly in excess of its superficial area. As the surfaces of all bodies are capable of occluding gases and vapours to a certain limited extent, the absorptive capacity of silica gel is correspondingly great. When left in contact with a water saturated atmosphere at ordinary room temperature under static conditions, it ultimately absorbs about 40% of its weight of moisture.

A description of the mechanism involved in the process is of interest. It is, of course, well known that the molecules of a gas or vapour are in a state of haphazard motion, continually colliding with one another and the boundaries of the containing vessel. In a thermally isolated system a redistribution of energy occurs at each collision, but the total remains constant. If, in a humid atmosphere, a molecule of water vapour impinges upon an active silica gel surface, it is retained and its kinetic energy transformed into a quantity of heat approximating to the latent heat of evaporation at the temperature of the environment.

It will thus be seen that, as no specific attraction capable of operating at finite distances exists between water molecules and gel, the velocity of absorption depends at any instant upon the rate of impacting of the former upon the latter : that is, since the collisions are entirely random, upon the area of the gel surface. The molecules so captured tend to diffuse inwards towards the unsaturated surfaces of the fissures, so making room for further absorption to occur. Ultimately, however, the interior also becomes partially saturated, and a rapidly decreasing percentage of impacts at the surface results in absorption so that equilibrium is finally established. In practice a large number of granules are used, hence a process analogous to the above also occurs with respect to the whole mass of these. At room temperature, in a water saturated atmosphere, equilibrium occurs when the gel has absorbed about 40% of its weight of water, and appears to be dynamic, implying that water molecules are leaving the surface at a rate which balances the arrival rate; this is suggested by the fact that saturated gel commences to lose moisture when transferred to an atmosphere of lower humidity.

It will now be apparent that the rate of desiccation depends upon the size and method of packing of the gel, and that, when a moist gas flows through a mass of granules, effective drying will occur only so long as the water molecules are able to diffuse to the interior of the material at a rate comparable with that at which they impinge upon the exposed surface. When this condition ceases to obtain, the efficiency rapidly deteriorates. Practically, this means that the limiting capacity depends upon the contact time of the gas with the gel, and also upon the humidity of the gas. Fig. 1 shows, very approximately, the effect of the former factor, using almost saturated gas.

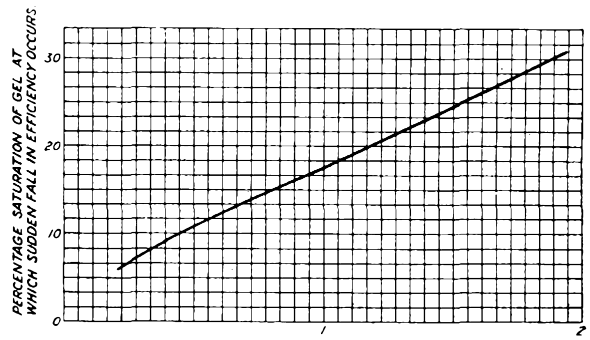

FIG. 1.—EFFECT OF CONTACT TIME ON THE CAPACITY OF THE GEL.

It has been mentioned previously that when a molecule of water is absorbed its kinetic energy is transformed into a quantity of heat approximately equivalent to the latent heat of evaporation at the temperature of the gel. In addition, a further quantity known as the heat of wetting is also evolved. This is apparently due to satisfaction of the mutual affinity existing between the gel surface and water; the precise nature of this attraction is still open to speculation as its explanation lies in the obscure borderland between Physics and Chemistry.

The heat of wetting varies according to the quantity of moisture already present in the gel at the precise instant at which absorption occurs, but for practical purposes a total heat of 1300 B.T.U. per lb. of water absorbed may be taken as a reasonable approximation. For reactivation an equivalent quantity of heat at an appropriate temperature is of course required.

Under static conditions, as for instance in the drying out of a sealed container, the final equilibrium depends purely on the quantity of gel available, the method of exposure will of course only affect the length of time taken to attain equilibrium. It is quite practicable under such conditions to use a considerable excess of gel so that the humidity is reduced to effectively zero; 1 ounce per cubic ft. of sealed space is a suitable quantity unless an excessive amount of textile insulation is present. For purposes of this kind it is always an advantage to include a small percentage of indicating gel; this is impregnated with a cobalt salt which remains blue in contact with dry air and changes by a gradual fading process to pink when the moisture contact has risen to 0.3 – 1.0 grains per cubic ft. (depending on the temperature). In this connexion it is worthy of note that saturated air contains approximately 7.5 grains of water per cubic ft. at 20°C.

A general specification test has recently been devised which involves carrying out a calorimetric determination of the heat evolved by the complete saturation of the material with liquid water and is required to be not less than 45 B.T.U. per lb. of gel. This figure gives an accurate measure of its affinity for moisture.

Uses of Silica Gel.

At present the main Departmental uses for Silica Gel are :—

1. Drying out of cable joints by sealing up a textile container of the material among the conductors. With this method the insulation continues to improve for some days or even weeks.
2. Drying out of sealed apparatus boxes.
3. Many laboratory purposes.

Its extended use as a substitute for calcium chloride in the Departmental petrol driven desiccator is also under consideration. A machine[1] so adapted is at present undergoing trial in the London Engineering District.

It has been estimated that the maximum output required is unlikely to exceed 50 cubic ft. free dry air per hour. Since the prevailing atmospheric humidity is usually above one-third of saturation, preliminary compression by the pump to 30 lbs. per sq. in. is used to squeeze out some of the moisture and reduce the humidity to at least this figure.

As the drying unit it has been found practicable to utilize 6½′ of 1″ bore tube containing about 2½ lbs. of 3/16″—1/4″ mesh gel. At the postulated flow the pressure drop across this resistance does not exceed 5 lbs. per sq. in. Under the conditions of use this quantity of gel is capable of supplying the required output in a substantially dry condition for at least four hours, and requires about 270 B.T.U. for its reactivation. It has been estimated that at least 1500 B.T.U. per hour are available from the exhaust gases of the engine, so that by coiling the drying unit into a lagged container through which these are passed it has been found practicable to regenerate the gel. Two such units have been attached to the machine; they are operated by appropriate cocks which enable one unit to be reactivated while the other is in use. The reactivation can be carried out and the unit cooled in about 2½ hours.

A further refinement is a glass cell containing indicating gel fitted to the output which gives warning when it is necessary to change over the units.

[1] " Gas Explosions, Precautionary Measures." P. J. Ridd. *P.O.E.E.J.*, Vol. 28, Pt. 2, p. 144.

Book Review

" Foundations of Wireless," by A. L. M. Sowerby, M.Sc., 260 pp., 157 ill. Iliffe and Sons. 4/6 net.

This book is confined to the essentials of wireless reception, transmission being touched upon only in the introduction. It is an elementary text book which should be read by all those " interested in wireless." The early chapters deal with technical electricity and alternating currents in unacademic language, but give a mental picture of what is happening in an electric circuit that is most illuminating both to the non-technical reader and to those who have studied the subject academically. Eleven of the eighteen chapters of the book deal with wireless receivers and cover all the essentials of reception including rectification, high frequency amplification, selectivity and low frequency amplification, in addition to the superheterodyne and automatic volume control.

The book is recommended to those wireless amateurs who feel the need of basing their scraps of knowledge on a sure foundation, and in addition it can be read with enjoyment and benefit by serious students of wireless. J.R.

Notes and Comments

Changes in the Post Office Board

Sir Thomas Gardiner, K.B.E.

WE offer our congratulation to Sir Thomas Gardiner, who has been appointed Director-General to succeed Sir Donald Banks. Sir Thomas entered the Post Office as an Assistant Surveyor in 1906, and for some years he was private secretary to Sir Evelyn Murray, a former Secretary to the Post Office. After being employed at the Ministry of Reconstruction, where he was engaged on transport and allied problems, he returned to the Post Office in 1919 as an Assistant Controller in the London Postal Service. In 1926 he succeeded Sir Charles Sanderson as Controller of the London Postal Service, and in 1934 was appointed Deputy Director-General.

Mr. W. R. Birchall.

Mr. W. R. Birchall, whom we welcome as Deputy Director-General, entered the Post Office by the First Division Examination in 1911. He became a Principal in 1921 and was appointed Assistant Secretary in charge of the telephone branch in 1934. Mr. Birchall has for some years past been closely connected with the telecommunications side of Post Office activities; he was Secretary to the Hardman Lever Committee which investigated the Telegraph Service in 1927; more recently he has been associated with the development of the telephone service, especially with its conversion from manual to automatic working.

Mr. J. Innes

During recent years the opportunities for Post Office staff have been steadily widening and there has been a notable tendency to broaden the field of selection for promotion. The appointment of Mr. J. Innes as Assistant Secretary is an example of this quickening influence.

Mr. Innes is well known to readers of the Journal and to members of the Institution of Post Office Electrical Engineers. As Managing Editor of the Journal and Secretary of the Institution for a number of years he did much to add to the prestige of both.

After a period of service as an engineer in the Office of Works he began his career in the Post Office in 1913 at the Headquarters of the Engineering Department and then went to Scotland where, for a period of 14 years, he was actively engaged on a wide variety of work ranging from the erection of pole lines in the remote north to the conversion of Edinburgh city area from manual to automatic working.

Mr. J. Innes.

Selected by the Engineer-in-Chief to advise the South African Government on the automatic system to be introduced in the Johannesburg and Cape Peninsula areas Mr. Innes spent a year in South Africa. He planned boldly and the system he designed there is proving equal to all the demands made upon it for extension.

His subsequent appointments at home have made him familiar with the design and manufacture of underground cables and the provision of telephone exchange equipment. He took an active part in the negotiation of the agreements between the Post Office and its contractors for the supply of this part of its plant.

In 1933 he visited America and examined many features of the telephone system there. The financial and economic studies essential for the security of a large telephone business particularly interested him.

In July of last year he was appointed Assistant Engineer-in-Chief and in addition to the normal duties of that post he has been intimately associated with the introduction of regional organization.

As Assistant Secretary he has been given charge of the Telephone Branch and the good wishes of his many friends and colleagues go with him as he takes over a new post where he will have a wide field for his talents and experience.

Reduction in Telephone Rates

A further stage in the progressive policy of cheapening the cost of using the telephone came into effect on October 1st. From that date residence subscribers on the quarterly account basis will be allowed 50 free local calls each quarter, and those on the monthly account basis will be able to make 16 free local calls a month. Rentals for residential lines fitted with a coin box will be reduced by 2s. 6d. a quarter, and the rentals for ordinary business and small business users are also to be cut by 2s. 6d. a quarter. Rentals for additional lines will be reduced by a similar amount. From January 1 rentals for private telephone lines will be substantially reduced. It is estimated that the cost of these concessions in a full year will be £1,000,000, after allowing for growth of traffic, bringing the total cost of the reductions in charges introduced in 1936 to about £1,500,000.

In making this announcement the Postmaster-General, Major Tryon, said that the number of telephones was now increasing at the rate of more than 200,000 a year, and that during last year the number of calls had increased by about 140,000,000, or more than 8 per cent.

Mr. T. B. Johnson

It is with regret that we record the death in August of Mr. T. B. Johnson, a former Superintending Engineer of the North Eastern District and Chairman of the South Midland Centre of the Institution of Electrical Engineers. He retired in 1928 after 43 years' service in the Department, during the latter part of which he took a leading part in the transition of the Leeds telephones to the automatic system, and supervised the replacement of thousands of miles of open wire by underground cables.

Mr. J. E. Statters

Readers of the Journal will regret to hear that Mr. J. E. Statters, who retired on account of ill-health in 1932, died in September. His final illness had lasted over a year and followed a severe operation. Thus another link with the past has been broken. Mr. Statters was well known during his last 15 years of service as Mr. Harts' chief lieutenant on all transmission matters.

Regionalization

B. O. ANSON, M.I.E.E.

Information is given concerning the formation of the London Region and the appointment of engineering officers to the positions of Regional Director and Chief Regional Engineer.

THE article which appeared in the January issue of the Journal gave briefly the proposals of the Bridgeman Committee, the recommendations of the Gardiner Committee as regards the setting up of two experimental regions in the provinces and particulars of the careers of engineering officers appointed to fill posts as deputy regional directors and chief regional engineers.

The second report of the Gardiner Committee dealt with the Metropolitan organization and recommended that the postal service should remain under separate control. The Postmaster General has now decided to set up a London telecommunications region and a London postal region. The former will consist of the present London telephone service and the London engineering district. The Central Telegraph Office will ultimately be included but for the time being that department will continue to function as at present. The London postal region will cover the London postal service and the present Home Surveyor's district. The report states that it would not be possible to give telephone managers in London the same degree of responsibility as will be assigned to telephone managers in the provinces and therefore the telecommunications region will be divided into eight areas coinciding with the present engineering sections. A Regional Board will be set up in the autumn and the remaining parts of the organization will be brought into operation as soon as the necessary arrangements can be made.

MR. E. GOMERSALL, O.B.E.

Mr. E. Gomersall, O.B.E., M.I.E.E., Superintending Engineer, London, has been appointed Director of the London telecommunications region. Mr. Gomersall has had much experience in London and his knowledge of the peculiar conditions obtaining in the world's telecommunication centre should be a valuable asset, particularly in connexion with the inauguration of the region.

After some years' service at headquarters on specialist duties, Mr. Gomersall was appointed in 1909 Assistant Superintending Engineer, South Metropolitan district. In 1912 as acting Superintending Engineer he took over the National Telephone Company's engineering staff in that district. Later in the year he was transferred to Reading for the formation of the South Midland district. In 1915 he was appointed Superintending Engineer, Dublin, and for his services in maintaining and restoring communication services during the Irish Rebellion of 1916 was awarded the decoration of Officer of the Order of the British Empire. In 1919 Mr. Gomersall was transferred to Nottingham as Superintending Engineer, North Midland district, and in 1928 was appointed Deputy Superintending Engineer, London. His promotion to Superintending Engineer, London, followed in 1929. In addition to his wide knowledge of communication engineering practice and the relevant departmental procedure, Mr. Gomersall has made a special study of the economics of telephone provision, with particular reference to telephone tariffs. In 1930 Mr. Gomersall and Mr. E. J. Wilby visited the United States of America with very valuable results in matters of organization affecting the efficiency of the telephone service as a whole and especially the installation of subscribers' services and speed of connexion. Since 1929 extraordinary progress has been made in London with the construction of new automatic exchanges and the conversion of subscribers' installations to automatic working and over fifty per cent. of the telephones are now automatic. During the same period the number of telephones has increased by 72 per cent.

Mr. R. G. de Wardt, who has been appointed to succeed Mr. P. J. Ridd as Chief Regional Engineer of the London telecommunications region, has had a wide and varied experience.

In 1909 he was appointed to the now obsolete grade of 2nd Class Inspector and he took part in the telephone valuation. Promotion to Assistant Engineer saw his transfer to the Power Section and later to Glasgow as Power Engineer. Duties not usually associated with power were allotted to him and he gained an invaluable experience of district and section work. In 1922 he returned to London and entered the Radio Section. Shortly after he took command of Leafield and then Grimsby Beam Radio Station. He was promoted Executive Engineer in 1925. In 1929 the passing of Beam control to private hands resulted in Mr. de Wardt's return once again to the Radio Section at Headquarters.

In 1931 he was transferred on promotion to Assistant Staff Engineer, Telegraph Section, and was largely instrumental in the introduction of the Multi-Channel V.F. scheme and Teleprinter Private Wire services. In 1933 he was appointed Assistant Superintending Engineer, Bristol, and in January, 1935, became Superintending Engineer, Croydon. A year later he transferred to Manchester as Superintending Engineer of the South Lancashire Engineering District. Now, after nine months there, he returns to London.

Mr. de Wardt is not only a specialist in certain directions, but has also a wide and detailed knowledge of Provincial district work. His energetic mind and his keen insight, together with a distinct gift for organization, will have full scope in his new post. He carries with him to London the confidence and good wishes of all his old colleagues.

MR. R. G. DE WARDT.

P. J. Ridd, M.I.E.E.

Mr. P. J. Ridd, who has been appointed to succeed Mr. Innes as Assistant Engineer-in-Chief, has had a long and varied experience in telephone engineering. He served on the National Telephone Company's exchange construction and maintenance staffs and was for two years exchange manager at Paddington exchange. From 1907 to the transfer of the company's undertaking to the State he was responsible, under the Metropolitan electrician, for all exchange construction and subscribers' installation work in the company's London area.

Mr. Ridd joined the Post Office as executive engineer and for three years was attached to the technical section of the Metropolitan central district. In 1915 he took charge of the London City internal section where he remained until 1926 in which year he was appointed assistant staff engineer in the research section. He returned to the London district as assistant superintending engineer in 1928, when the automatization of the London exchanges was in its early stages, to take charge of the maintenance of internal and external plant in the district. Four years later he re-joined the headquarters staff as staff engineer of the construction section and again returned to London in January of this year on appointment as deputy superintending engineer, being subsequently appointed chief regional engineer.

Mr. Ridd has represented the Post Office on committees of the Institution of Electrical Engineers and the British Standards Institution and has served on the Advisory Committees of the Surrey County Council and the City of Guilds of London Institute. He was for several years a member of the board of editors of the Journal.

Mr. Ridd's interests are mainly of an engineering character but in earlier years he found time for athletics although very busily occupied on technical training courses. He was a member of rowing clubs on the Thames and on the Clyde, and for some years was a leader in the Borough Polytechnic gymnasium. As a cricketer he recalls very pleasant memories of the numerous cricket matches keenly contested by his teams and the London City Section Club. He was the chairman of the Organizing Committee of the London Engineering District Amateur Sports Association formed in 1931, and has been honoured by election as life vice-president of the Association. More recently he has sought recreation in French drama and literature and has taken roles with other Post Office colleagues in French plays presented at the City Literary Institute. B.O.A.

A. Morris, M.I.E.E.

Mr. A. Morris, who is now appointed Superintending Engineer, S. Lancs. District, was born at Portsmouth in 1890, became an indentured apprentice at the Royal Dockyard, Portsmouth, in 1905, and in 1910 obtained a Whitworth Exhibition and Royal Scholarship at the Royal College of Science finishing with a post-graduate course at the City and Guilds Engineering College in the Design of Electrical Machinery.

In June, 1913, he entered the Post Office as assistant engineer under the open competitive examination and after a few months in the Lines Section was assigned to the Research Section. From 1915 to 1929 his work was chiefly concerned with problems connected with the balancing, loading and repeatering of trunk telephone cables.

In December, 1929, he was promoted to executive engineer in charge of the construction group Radio Section, and in October, 1931, he took over the Maintenance Group which also handled radio interference suppression work. In May, 1933, he became a member of the Technical Secretariat of the I.E.E. Radio Interference Committee.

In January, 1935, he was appointed Assistant Superintending Engineer at Bristol and in November was transferred to Leeds.

In December, 1935, he was appointed Regional Engineer to the newly-formed North Eastern Region, where he has been engaged in assisting in the work of setting up a regionalization organization. His collaboration has always had a stimulating influence on his colleagues and those who have the good fortune to have worked with him realize that his present advancement is a well merited recognition of his services to the Department. We tender him our felicitations and wish him further success in the future. A.J.G.

District Notes

Scottish Region

EXCHANGE EXTENSIONS.

Telephone exchanges at Scourie and Durness in the extreme north west area of the Scottish mainland were opened on 8th June and 17th July, respectively. The Durness exchange opening was appropriately the occasion of exchange of addresses between the Postmaster-General, the parliamentary representative of Brighton and the Member for Caithness and Sutherlandshire. With a few special exceptions this work completes the bulk of the Jubilee Kiosks Scheme for Scotland.

INVERNESS REPEATER STATION.

Inverness repeater station was completed on 5th August and with it a direct trunk service between London and Inverness on the longest repeatered circuits in Great Britain (631 miles) was inaugurated.

EDINBURGH MULTI-OFFICE AREA.

Edinburgh Multi-Office Area was completed by the conversion of Leith Automatic Exchange on 25th July. Edinburgh is the largest non-director area in the Kingdom, comprising 24,239 subscribers' lines.

EXTERNAL PLANT.

By the erection of a new trunk route between Dalnacardoch and Newtonmore on the Glasgow-Inverness main road a new trunk connexion has been provided between Fort William and Perth. This road crosses the Grampians and at Dalnaspidal the adjacent railway line at its summit reaches the highest point of any railway line in Great Britain.

MARRIAGE OF MR. J. J. McKICHAN.

Congratulations are extended to Mr. J. J. McKichan, O.B.E., Chief Regional Engineer and some time Managing Editor of the Journal, on his marriage at South Ferryhill Church, Aberdeen, to Miss M. Y. H. Middleton, Aberdeen (formerly of Peterhead), on 15th September, 1936.

The Regional Headquarters and East of Scotland Areas presented an antique bureau and chair; the Glasgow Area a water colour, and the Scotland West Area electric table fittings, as tangible evidences of their goodwill, on the 8th and 9th September, respectively.

London District

London opened its 100th automatic exchange at Stepney Green on August 22nd. This year is a record year in London for opening new exchanges, all of which will, of course, be automatic. Fifteen have already been opened this year, and nine more remain to be opened. In addition there are many extensions to existing exchanges and as many as 60 new exchanges are under treatment in one stage or another.

Two new bridges across the Thames are giving the engineers a very interesting time in providing conduits and connecting up to the thoroughfares on either side. Chelsea Bridge, being a suspension bridge, requires special treatment. The London Passenger Transport Board's new sections of railway and rebuilding of stations is giving many engineers a very busy time, for the construction of underground railways and stations with their entrances, make necessary considerable re-arrangements of the Department's most congested plant.

Preparations are in hand to see that the reduced rentals do not find us unprepared for the orders expected in October and we must also look ahead for the Coronation next year.

On August 31st a farewell presentation was made to Mr. A. H. Baily, Development Officer in charge of the S.E. Section. His wife, who was present, also received a memento of the occasion. His friends spoke of old times and wished him and his wife a long and enjoyable retirement.

Northern Ireland District

STAFF.

It is interesting to note that the large staff engaged for the Belfast M.O. Auto Transfer still remains and increases have already been made. The great gales and snowstorms of January, 1936, did tremendous damage in the district, to the extent of nearly 500,000 manhours, and now that this work is completed arrears have to be picked up, and the large increases in telephone service due to the concessions of the Postmaster-general have to be met.

ULTRA SHORT WAVE WIRELESS.

Ballygomartin, the Northern Ireland terminal of the Ultra Short Wave Radio Link to Scotland, stands on the side of Mount Gilbert at a height of 800 ft. above sea level. The terminal stations were opened in December, 1934, with six-channel equipment installed by the Radio Branch of the Engineer-in-Chief's office, and six circuits were provided. Additional buildings have since been erected to house a further nine-channel equipment which has been provided and installed by the Standard Telephones and Cables, Limited. This equipment is now being lined up and the nine channels should be available for service in a few weeks. These will provide additional high grade trunks between Belfast, Glasgow, London and Manchester.

To meet the recent increase in traffic, five of the new S.T. and C. channels are now in use between 6.30 p.m. and midnight each day after which they are handed back to the S.T. and C. to enable tests to proceed on the whole of the nine channels simultaneously. After the opening of the nine additional trunks, making fifteen in all, experiments will proceed to add carrier working and teleprinter channels.

CARRIER EQUIPMENT.

Considerable use has recently been made in the district of carrier equipment to meet the increase in trunk traffic. Between Belfast and Londonderry a single channel carrier system is now in operation and it is proposed to convert this to a 3-channel system. One 3-channel system has been in operation between Belfast and Dublin for five years; two 3-channel systems between Belfast, Omagh and Enniskillen are now being installed and two additional 3-channel systems between Belfast and Dublin are to be provided in the near future.

MAIN UNDERGROUND.

The main underground cable between Belfast and Ballymena, which was laid in 1934, is to be extended to Londonderry, a distance of approximately 90 miles from Belfast. With the exception of a section through peat bog, provision has been made for two-way multiple ducts throughout, additional ways being provided where necessary for local line purposes. The Ballymena-Londonderry road runs over a peat bog for a distance of about 1,000 yards and the type of construction to be adopted in this section has called for special consideration. The road is undulating, the roots of an avenue of trees providing the only foundation, and in this section it has been decided to lay two asbestos-cement conduits supported on double wattled hurdles. The hurdling will be placed in the trench in two layers with 3 inches of well punned earth between the top and bottom layers. The cable, when completed, will serve the towns of Ballymoney, Coleraine, Limavady and Londonderry.

U.A.X. PROGRAMME.

The establishment of Auto-Manual switching centres and the conversion of manual exchanges to automatic working is proceeding apace. On completion of this scheme there will be 11 switching centres with manual boards and approximately 170 U.A.X.'s of the No. 12, 13 or 14 type in the district. Nearly half of these conversions are at present in hand, including the replacement of the existing C.B. exchange at Londonderry with a Non-Director exchange having an ultimate capacity of 1,700 lines.

South Western District

DIVISION OF THE BRISTOL SECTION.

The considerable recruitment of workmen in the Bristol Section during the past twelve months due to the exceptional telephone development has necessitated the splitting of the Section into two parts, each under the control of an executive engineer.

In considering the best means of splitting the work of the Section several possibilities presented themselves, viz. :—

(a) Functional division into maintenance and construction groups.

(b) Functional division into internal and external section.

(c) Territorial division into an inner (or west) and outer (or east) area.

(d) Functional division into
   (1) Advice notes and maintenance, (2) major internal and external construction.

(e) A combination of territorial and functional working in each part.

The retention of a combined clerical staff and the necessity of making the best use of the existing accommodation rendered the problem more difficult, and ultimately it was decided that a combination of territorial and functional working would be the most satisfactory arrangement.

The Section has, therefore, been divided into :—

(a) *Bristol West.* The executive engineer in charge of this Section controls the maintenance and advice note work in the densely telephoned Bristol automatic area and also the Weston-Super-Mare area and, in addition, is responsible for the major internal construction work throughout the whole Section.

(b) *Bristol East.* This area covers the less densely telephoned but more extensive territory east of Bristol, including the Bath automatic area. The executive engineer in charge is responsible for his own maintenance and advice note work and in addition controls the major external works for the whole Section

This division has the great advantage of retaining the existing specialist organization in respect of the major external and internal works, while at the same time the territorial division of maintenance and advice note work will enable the two Sections to assist each other during work and staff fluctuations.

TRANSPORT COSTS.

The rapid expansion of motor transport in the work of the Department has been one of the most marked features of recent development and the need has been felt for an effective means of assessing the real savings accruing from the extended use of motor vehicles.

The present statistics relate the cost of transport in broad categories to normal maintenance expenditure, advice note works and to other construction works, but the information so obtained is insufficient to provide an accurate assessment of the true effects of transport on works costs.

An experiment is in progress in this district to decide the possibility and cost of subdividing transport, travelling and subsistence costs between all classes of maintenance and construction work in order that an equated performance rating may be obtained after allowing for the expenditure on conveyance, subsistence, freight and cartage and motor transport.

The result of the experiment will be watched with great interest.

South Lancs District

MANCHESTER REGIONAL TRAINING SCHOOL.

As long ago as October, 1935, a decision was reached that a Regional Training School to serve the South Lancashire, North Western and North Ireland Districts should be established in Manchester.

Extreme difficulty was experienced in finding suitable premises that could be rented, and when the vacation of the old manual switchroom and operators' quarters at Trafford Park Exchange on transfer to the new automatic exchange made possible the use of the spare accommodation for school purposes, arrangements to that end were effected, the first course being instituted on May 16th, 1936.

LECTURE ROOM.

During the period that has elapsed since that date courses have been held in subscribers' fitting and underground and overhead construction, some 130 students having passed through the school.

Although not all that could be desired, accommodation for lectures and completely equipped practical workrooms are available. A plot of open ground some two acres in extent, in the immediate vicinity, has also

CONSTRUCTION PARK.

been rented as a construction park for field training in erection of poles, running wire, and laying and jointing underground cables, several manholes and joint boxes being connected to each other and to D.P.'s by short lengths of track, forming an underground scheme in miniature.

One feature of the construction work is a specially constructed wall consisting of separate sections of the different types of wall surface met with in the various classes of building. This permits first hand experience to be gained in fixing apparatus and wiring to walls with a minimum of damage, and allows ample experience in wall plugging.

The students have shown marked enthusiasm and the officers in charge of the school have been surprised at the knowledge and skill acquired by even new entrants into the service after a few weeks intensive training.

North Wales District

BURST WATER MAIN DAMAGE AT BIRMINGHAM.

The damage caused by a burst water main at Short Heath Road, Erdington, Birmingham, is well illustrated in the accompanying photograph.

The main that caused the trouble occupied the space in the front portion of the illustration; the new main can be seen in the immediate foreground. The under portion of the pipe burst at 7 a.m. on Sunday, July 12th, and the rush of water washed out a hole about twelve yards long by five yards wide and ten feet deep, and flooded the road for about sixty yards. The other water main and the gas main in the rear did not suffer damage, but, as can be seen, the Department's duct line, carrying a 100 pair and 25 pair cable, fared badly. The swirl of the escaping water smashed the ducts away from the cables, and stretched the cables sufficiently to fracture the sheaths.

It was not possible to approach the scene of the damage until 5 p.m. when the water had subsided, and some of the mud and silt had been removed. Even then, temporary repairs were executed with difficulty, as the edges of the hole were badly undermined by the water. Nevertheless, service was restored by 8 p.m. to the whole of the one hundred subscribers affected, by means of the interruption cable seen in the background.

Some idea of the amount of soil forced out by the water can be gained from the fact that about fifty cart-loads of mud were removed from the road during the subsequent clearing up operations.

BIRMINGHAM TRUNK EXCHANGE.

On Bank Holiday Sunday, August 2nd, the new trunk exchange at Telephone House, Birmingham, was brought into service, replacing the old exchange at the H.P.O., which has housed the Birmingham trunk exchanges for over 40 years. The transfer was carried out in two parts, the first at 8 a.m. when approximately 20 per cent. of the lines were cut in and the second two hours later, when the remainder of a total of 1,479 trunks and junctions were transferred.

The choice of the day for the opening was made to reduce to a minimum any inconvenience to the telephone public. The arrangements made worked smoothly and uneventfully, only five faults being carried over to the following day, the absence of noise usually associated with automatic transfers being particularly noticeable.

The new manual board equipment, which is of the sleeve control type, consists of 211 positions (this figure including demand, delay, incoming, enquiry and telex positions) and is located on the top floor of the building in a room which also accommodates the 166 positions of the new Toll exchange, which is being brought into use in October.

These figures serve to show the great advance during the present century, since 40 years ago the Birmingham trunk exchange consisted of some seven positions in a room which also served as the test room and was supplied with current from primary cells of the agglomerate block type. The power plant at Telephone House consists of two 10,000 ampere hour batteries with arrangements for floating during peak loads. This plant will also serve the Central automatic exchange when this is completed in 1937.

South Eastern District.

RETIREMENT OF MR. H. R. J. DUNTHORNE, A.M.I.E.E.

Mr. H. R. J. Dunthorne, Sectional Engineer, Canterbury, retired on the 30th June, 1936, after 36 years' service in the Scotland West, Northern and South Eastern Districts. Following a period of training as a mechanical engineer with the London and North Western Railway Company, Mr. Dunthorne entered the Department in 1900 as a Senior Circuit Officer and quickly progressed through the ranks as shift officer, sub engineer, and 2nd class engineer, to become an assistant engineer in 1911. In 1928 he was appointed Sectional Engineer in the Canterbury West Section and later took charge of the combined East and West Canterbury Sections.

Mr. Dunthorne's exceptional ability as an engineer and his gift for solving any problem which confronted him proved an inspiration to his staff and enabled him to take in his stride all those emergencies which to most people are major difficulties. On several occasions his work won him the commendation of the Engineer-in-Chief. His staff will remember him for years to come not only for his talent as an engineer, but also for his sympathetic understanding of the troubles of individual members. No doubt Mr Dunthorne's success in the Canterbury Section throughout a most difficult period can be attributed in part to his superlative knowledge of the staff which enabled him not only to understand their troubles, but also to see the potentialities in each man.

At a smoking concert held in his honour on the evening of his retirement a presentation consisting of a gold watch, a typewriter and a garden settee was made by the Superintending Engineer, Mr. Harvey Smith. The District Manager and the Head Postmaster joined Mr. Dunthorne's own staff in expressions of appreciation and good wishes for the future.

RETIREMENT OF MR. G. BALCHIN, M.I.E.E.

After a period of over 42 years, spent in the Post Office service, Mr. George Balchin, M.I.E.E., Sectional Engineer at Tunbridge Wells, retired on the 30th April, 1936.

Mr. Balchin entered the Service in 1894 as a telegraphist in the C.T.O. After eight years' service there he spent two years in the Superintending Engineer's office at Leeds, and was then transferred to the London Engineering District as a Sub-Engineer, serving successively in Mayfair, C.T.O., City and Hornsey sections. In 1909 he was transferred to the Engineer-in-Chief's office, and served there in the Telephone and Construction sections until 1930, when he was promoted Executive Engineer, South Eastern District, first at Canterbury and afterwards at Tunbridge Wells.

Mr. Balchin was closely associated with the Society of Post Office Engineers from the date of its formation. From 1913 to 1930 he held office continuously and was its general secretary for the greater portion of that period. He took part in negotiations involving several appearances before the Arbitration Court, which resulted in the War Bonus being extended to salary grades of the Post Office. He also took part in the important negotiations which led to the introduction of the Whitley Committee in the Post Office Engineering Department. He was secretary of the staff side of the Departmental Whitley Council for many years, and only relinquished this post on transfer to the Provinces in 1930. He was also a member of the staff side of the National Whitley Council for a number of years prior to 1930. Both on the National and Departmental Whitley Councils he served as a member of many important committees. As staff side secretary of the Departmental Council he was closely identified with reports upon which are based the present regulations concerning recruitment, promotion and subsistence rates.

On the last day of his service, at Tunbridge Wells, he was the recipient of a presentation, marking the esteem and goodwill of his many friends. Mr. Harvey Smith, Superintending Engineer, in the course of some humorous remarks, outlined the many notable services rendered to the Department and to the Staff Associations by Mr. Balchin, whose quiet and unobtrusive manner had added to, rather than detracted from, the value of his work. The speaker also expressed the opinion that it was largely as a result of the efforts of men like Mr. Balchin that such a high standard of co-operation existed between the official side and the staff side, through the medium of the various staff associations and the Whitley Committees. He then asked Mr. Balchin to accept an electric clock, a nest of mahogany parlour tables and a greenhouse.

In the course of an excellent and feeling speech, Mr. Balchin expressed his thanks to all those, whether present or absent, who had associated themselves with the tokens of esteem which had been presented to him. He hoped to spend many happy hours in the greenhouse. He recounted some of his experiences in the early days of staff representation, and said that he had always given his best in the interests of the staff, and he felt to-day that he was not entirely dissatisfied with the results of his labours.

Book Review

" Proceedings of the International Telephone Consultative Committee " (Plenary Meeting in Budapest, 3rd-10th September, 1934). English Edition (London: Bernard C. Holding, Ltd., 87 Albion House, New Oxford Street, W.C.1), 660 pp. 25s. net.

This volume is a full translation of the " Livre Blanc " of the Comité Consultatif International Téléphonique. It gives the latest international recommendations concerning transmission, protection, operating and tariffs and much valuable informatory matter, including typical specifications for the constituent parts of an underground cable system and the questions for study in the immediate future. The French text has been most carefully translated without abridgement, and all the diagrams have been reproduced with English wording, yet the original six volumes, totalling some 1,200 pages have been included in a single volume of 660 pages, and this adds greatly to the convenience of the work as a reference volume. It is perhaps a matter for regret that the editor has not distinguished by bolder type the actual recommendations in the Transmission Section, since they are somewhat submerged in documentary matter, but the basic fault lies in the "Livre Blanc" itself, which requires recasting at the next revision. All the *errata* in the French text have been rectified in this English edition, and no reference to the original should normally be necessary, but the translators have added a column to the sectional and general indexes giving the page correspondence between the English and French texts, which will prove useful to anyone engaged in the work of the C.C.I.F.

An exhaustive bibliography of English, French and German publications, of which over 1,000 references are listed, is included in the volume.

This work may truly be said to give a most comprehensive account of modern telecommunications practices. It contains the accumulated experience and knowledge of the foremost telephone experts in the world who have contributed to the work of the C.C.I.F. It should be in the hands of all concerned with long line planning, construction and maintenance, of all lecturers and engineers who wish to keep abreast of progress in telecommunications.

F.E.A.M.

The Institution of Post Office Electrical Engineers

ESSAY COMPETITION, 1936.

The Council has decided to offer Five Prizes of Two Guineas each for the five most meritorious essays submitted by members of the Engineering Department of the Post Office below the ranks of Inspector and Draughtsmen, Class II., and, in addition, to award a limited number of Certificates of Merit.

A prize-winner in any previous competition is not eligible to enter, but this restriction does not apply to a competitor who has been awarded a certificate only.

In judging the merits of an essay, consideration will be given to clearness of expression, correct use of words, neatness and arrangement, and although technical accuracy is essential, a high technical standard is not absolutely necessary to qualify for an award. The Council hopes this assurance will encourage a larger number of entries. Marks will be awarded for originality of essays submitted.

Information concerning the competition is given in the leaflets which have been issued to the centres for distribution. The Council hopes that supervising officers generally will bring the competition to the notice of those eligible to compete.

The Essays must reach the Secretary, The Institution of Post Office Electrical Engineers, G.P.O. (Alder House), E.C.1, before the 31st December, 1936.

RETIRED MEMBER.

The following member, who has retired from the Service, has elected to retain his membership of the Institution:

J. W. Turner, 22 Lyndhurst Gardens, Finchley, N.3.

CORRESPONDING MEMBERS.

The following have been elected:—

B. D. Sud, Electrical Engineer-in-Chief's Telegraph Storeyard, Alipore, Calcutta, India.

T. C. Tsao, Telephone Administration, Hanchow, Chekiang, China.

PROVISIONAL PROGRAMMES OF CENTRES 1936-37.

London Centre

1936.

13 Oct. "Development of the British Long Distance Telephone Line Network."—Capt. J. G Hines, M.I.E.E.

10 Nov. "Developments in the Organization of an Engineering Section."—C. E. Calveley. B.Sc.(Hons.).

8 Dec. "Modern Repeater Station Power Plant."—F. W. G. Dye.

1937.

12 Jan. "The Inspection and Testing of Materials."—G. F. Tanner.

9 Feb. "V.F. Signalling for Telephone Circuits."—T. H. Flowers and B. M. Hadfield.

9 Mar. "Automatic Exchange Trunking Design."—H. E. Francis (Scot. East).

11 May Being arranged.

INFORMAL MEETINGS.

1936.

27 Oct. "Chairman's Address"—P. B. Frost, A.M.I.E.E.

24 Nov. Films.—R. W. Palmer, A.M.I.E.E.

1937.

26 Jan. "The Logic of Line Construction."—R. MacWhirter.

23 Feb. "The Prevention and Removal of Faults on Subscribers' Cables."—T. G. Turley.

23 Mar. "The Planning of External Works."—A. W. Whittaker.

27 Apl. "Lightning and Lightning Protection."—Dr. W. G. Radley.

Northern Centre

1936.

1 Sept. Summer Outing.

21 Oct. "Modern Passenger Lifts." R. S. Phillips, A.M.I.E.E.

18 Nov. "Carrier Wave Telephony."—D. Smith, B.Sc.(Hons.)

16 Dec. "Wireless Interference, Prevention and Cure." W. F. Smith, B.Sc.(Hons.), A.G.G.I., A.M.I.E.E.

1937.

20 Jan. "The Co-axial Cable."—A. Morris, A.R.C.Sc., M.I.E.E., Assoc.I.R.E.

17 Feb. "Organization and Functions of Drawing Office Staffs."—E. C. Baker and F. Owles (E.-in-C.O.).

17 Mar. "Some Aspects of Line Plant Economics."—T. Pitlch and G. W. Hall.

North Eastern Centre

1936.

13 Oct. "An Outline of Television."—A. G. McDonald, B.Sc., A.C.G.I., A.M.I.C.E., A.M.I.E.E.

10 Nov. "High Frequency Cables."—A. Morris, A.R.C.Sc., M.I.E.E., Assoc.I.R.E.

8 Dec. "Telephone Exchange Accommodation."—A. D. Carrette, Grad.I.E.E.

1937.

12 Jan. "Interference with Radio Reception."—F. W. Allan.

9 Feb. "The Development of the British Long Distance Telephone Line Network."—Capt. J. G. Hines, M.I.E.E. (E.-in-C.O.).

9 Mar. "Some Aspects of the Post Office Underground Construction."—G. K. Hall.

North Western Centre

1936.

Sept. Visit to Electrical Cable Manufacturers' Works.

19 Oct. "Lancaster Repeater Station."—F. Huntington.

17 Nov. "The Development of the British Long Distance Telephone Line Network."—Capt. J. G. Hines, M.I.E.E. (E.-in-C.O.).

14 Dec. "Economic Provision of Local Line Plant."—H. R. Brown.

1937.

18 Jan. "Works Planning."—J. W. Gould.

15 Feb. "Electrolytic Damage to P.O. Cables."—H. Cheetham.

15 Mar. "Induction from H.T. Power Lines."—H. S. Thomsett, A.M.I.E.E., A.I.R.E.

South Lancs. Centre

1936.

12 Oct. "Chairman's Address."—R. G. de Wardt, M.I.E.E.

9 Nov. "The Development of the British Long Distance Telephone Line Network."—Capt. J. G. Hines, M.I.E.E. (E.-in-C.O.).

1 Dec. " Recent Developments in Telegraph Transmission and their Application to the British Telegraph Service."—L. H. Harris, M.Sc.; E. H. Jolley, A.M.I.E.E.; F. O. Morrell (E.-in-C.O.).

1937.

11 Jan. "Developments in the Organization of an Engineering Section."—C. E. Calveley, B.Sc.(Hons.) (S. Eastern).

8 Feb. "Tools and Mechanical Aids for External Works."—J. J. Edwards, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E., (E.-in-C.O.).

8 Mar. Two short papers—(i) " Voice Frequency Keysending from Manual Exchanges," W. C. Huff, A.M.I.E.E.; (ii) "Traffic Records in Automatic Exchanges."—W. Owen, A.M.Tech.I.

12 Mar. To be selected later.

North Midland Centre

1936.

5 Oct. "Wireless Interference."—R. G. O. Wearn.

2 Nov. " Power Plant."—J. R. Milnes, A.M.I.E.E.

7 Dec. "12 Channel Voice Freqency Systems."—N. F. Sephton, A.M.I.E.E.

1937.

4 Jan. "Installation of Automatic Exchanges."—R. N. Palmer.

1 Feb. " Problems of Organization and Control of an Engineering Section."—J. M. C. A. Owen, A.M.I.E.E.

1 Mar. " The Development of the British Long Distance Telephone Line Network."—Capt. J. G. Hines, M.I.E.E. (E.-in-C.O.).

North Wales Centre

1936.

Oct. "Modern Developments in Television."—S. T. Stevens.

Nov. " The Testing and Inspection of Materials."—G. F. Tanner, M.I.E.E.

Dec. " The Development of the British Long Distance Telephone Network."—Capt. J. G. Hines, M.I.E.E. (E.-in-C.O.).

1937.

Jan. " The Organization of an Engineering Section."—C. E. Calveley, B.Sc.(Hons.) (S.E. Centre).

Feb. " Inspection of Telephone House, Birmingham, with Short Descriptions of its Facilities."

Mar. Works Visit (to be arranged).

South Midland Centre

Oct. " Transmission."—R. M. Chamney, B.Sc., A.M.I.C.E. (E.-in-C.O.).

Nov. " Developments in the Organization of an Engineering Section."—C. E. Calveley, B.Sc.(Hons.) (S.E. Centre).

Dec. " Wayleaves on New Estates."—H. C. Gray, A.M.I.E.E.

1937.

Jan. "Automatic Exchange Design."—H. E. Francis.

Feb. " Logic of Line Construction."—R. MacWhirter.

Mar. " U.A.X Construction."—Author not yet arranged.

South Wales Centre

1936.

6 Oct. " The Development of the British Long Distance Telephone Line Network."—Capt. J. G. Hines, M.I.E.E. (E.-in-C.O.).

10 Nov. A Visit to Cardiff Docks.

8 Dec. " Function and Organization of Drawing Office Staff."—E. C. Baker (E.-in-C.O.).

1937.

12 Jan.—" Advice Note and Small Works Control."—R. A. Kibby.

9 Feb. " Some Criticisms of the Engineering Department."—E. B. M. Lord.

9 Mar. " Procedure Involved in the Provision of a U.A.X."—F. W. Gill.

South Western Centre

1936.

13 Oct. " Bristol-Plymouth Cable and Carrier Working."—A. C. Warren, B.Sc., A.M.I.E.E.

10 Nov. " Drawing Office Organization Routine and Procedure."—L. G. Wharmby.

15 Dec. " Some Aspects of ' Costs.' "—D. Williams.

1937.

12 Jan. 10 minute Papers:—
" Underground Contracts."—S. R. Harris.
" Staff Training."—G. Moore
" Overhead Construction with Particular Reference to Its Effects on Line Faults, etc."—E. T. M. Woodley.
" U.A.X Construction and Maintenance."—J. D. Tough.

9 Feb. " Bristol Area Maintenance Experiment."—S. W. Bull.

9 Mar. " The Development of the British Long Distance Telephone Line Network."—Capt. J. G. Hines, M.I.E.E. (E.-in-C.O.).

Eastern Centre

1936.

22 Sept. " Wireless Interference Suppression."—W. E. T. Andrews.

20 Oct. " Chairman's Address and Short Paper on Decibels."—Capt. Cave, B.Sc., M.I.E.E.

17 Nov. " Transmission; Testing and Complaints."—A. D. V. Knowers.

17 Nov. "Main Cable Design and District Programme."—R. N. Hamilton, B.Sc.(Eng.) Hons., A.C.G.I.

15 Dec. " The Development of the British Long Distance Telephone Line Network." Capt. J. G. Hines, M.I.E.E. (E.-in-C.O.).

1937.

26 Jan. " Efficiency; Service and Costs."—H. G. Smith.

23 Feb. " The Nature of Television Signals."—G. B. W. Harrison, B.Sc.(Eng.) Hons.

23 Mar. " Developments in the Organization of an Engineering Section."—C. E. Calveley, B.Sc.(Hons) (S.E. Centre).

Northern Ireland Centre

1936.

13 Oct. " Chairman's Address."—T. T. Partridge, M.I.E.E., M.I.Struct.E.

10 Nov. " Curious Dielectric Effect Illustrated by Experiments."—G. H. Metson, B.Sc., A.M.I.E.E.

8 Dec. " Developments in the Organization of an Engineering Section."—C. E. Calveley, B.Sc.(Hons.) (S.E. Centre).

1937.

12 Jan. " Alternating Current and the Communication Engineer."—W. T. Palmer, B.Sc.(Hons.), Wh.Ex. M.I.E.E.

9 Feb. "The Maintenance of Secondary Batteries in Unattended Exchanges."—M. C. Cooper, A.R.C.Sc.(I.), A.M.I.E.E., and W. S. Keown.
16 Mar. "The Development of the British Long Distance Telephone Line Network."—Capt. J. G. Hines, M.I.E.E. (E.-in-C.O.).
13 Apr. To be arranged.

Scotland East Centre

1936.
20 Oct. "Maintenance."—F. A. Haugh, M.Sc., A.C.G.I.
9 Nov. "The Logic of Line Construction."—R. MacWhirter, B.Sc., A.M.I.E.E. (Joint Meeting with Scotland West Centre to be held at Glasgow).
8 Dec. "The Development of the British Long Distance Telephone Line Network."—Capt. J. G. Hines, M.I.E.E. (E.-in-C.O.). (Joint Meeting with Scotland West Centre to be held at Edinburgh).

1937.
19 Jan. "Exchange Equipment and Accommodation under Regional Organization."—Capt. H. Hill, B.Sc., M.I.E.E.
16 Feb. "Co-Axial Cables."—A. Morris, A.R.C.Sc., M.I.E.E. (N.E. Region).
16 Mar. "Estimating and Checking in Telephone Areas." J. McIntosh.
13 Apr. To be arranged.

Scotland West Centre

1936.
5 Oct. Vice-Chairman's Address. F. I. Ray, B.Sc., A.M.I.E.E.
9 Nov. "The Logic of Line Construction."—R. MacWhirter, B.Sc., A.M.I.E.E. (Joint Meeting with Scotland East Centre at Glasgow).
8 Dec. "The Development of the British Long Distance Telephone Line Network."—Capt. J. G. Hines, M.I.E.E. (Joint Meeting with Scotland East Centre at Edinburgh).

1937.
11 Jan. "The 2,000 Type Selector."—D. E. Wadeson.
1 Feb. "V.F. Signalling for Telephone Circuits."—T. H. Flowers and B. M. Hadfield.
1 Mar. "Development in the Organization of an Engineering Section."—C. E. Calveley, B.Sc. (Hons.).

Local Centre Notes

Scottish Centres

Co-ordinating Committee

In accordance with the scheme devised by the Institution for the Scottish Region, two Centres—Scotland East and West respectively have been formed and the officers have been elected. A Co-ordinating Committee has been formed consisting of the following members :—

Chairman—J. J. McKichan, Esq., O.B.E., M.I.E.E.

East Centre.

Vice-Chairman—Capt. H. Hill, B.Sc., M.I.E.E., Regional Engineer.
Assistant Engineer—Mr. F. N. Lucas, B.Sc., Grad.I.E.E.
Inspector—Mr. R. Arthur.
Secretary—Mr. T. Lawrie, H.C.O.

West Centre.

Vice-Chairman Mr. F. I. Ray, B.Sc., D.F.H., A.M.I.E.E., Telephone Manager.
Assistant Engineer—Mr. A. H. Brown.
Chief Inspector—Mr. T. Davidson.
Secretary—Mr. F. W. Turner, H.C.O.

The Committee has met to consider the papers offered with a view to holding a number of joint meetings and joints visits to works or other points of common interest, particulars of which will appear under programme announcements.

A successful session under Regional auspices is fully anticipated.

South Lancs. Centre

Summer Visit 1936

On Tuesday, July 7th, 1936, through the kindness of the Chloride Electrical Storage Company, Ltd., 51 members of this Centre paid a visit to their works at Clifton Junction, near Manchester. This is the largest secondary battery works in the British Empire. The tour proved exceptionally interesting and informative, and was very thorough. The various stages of manufacture from the casting of lead grids to the testing of the complete batteries were seen for all sizes of batteries from the very small cells for use in aeroplane radio sets to the large stationary batteries used in submarines and in P.O. telephone exchanges.

The staff welfare arrangements were of especial interest, and the thoroughness of the precautions which are taken to avoid any risk of lead poisoning were somewhat surprising to the uninitiated.

The thanks of the Centre to the Company were expressed by the Chairman, Mr. R. G. de Wardt, after tea, and Mr. Brown in replying on behalf of the Company expressed a justifiable pride in the organization and production of the factory.

A photograph of the party and the guides was taken after the conclusion of the visit, and is reproduced herein.

We should like to take this opportunity of publicly expressing our thanks to the Company, to Mr. E. C. Kinnon, who made the arrangements for such a successful tour, and to the guides whose knowledge of the processes involved rendered the visit so interesting.

Junior Section Notes

Derby Centre

The Annual General Meeting was held on Thursday, April 23rd. The Secretary reported a successful season during which seven papers were read.

With the exception of the penultimate paper when practically the whole staff attended, the attendances were only moderate. Lack of numbers, however, was more than balanced by the keenness of the discussion following each paper, opinions being expressed freely, without fear or favour.

On the financial side the Treasurer also was able to report a successful season with a bank balance of £2 15s. 0d. and cash in hand 14s. on April 20th, 1936.

The following officers were elected to serve during Season 1936-37.

Chairman—W. F. Rathbone.
Vice-Chairman—R. T. G. Sallis.
Treasurer—D. E. H. Stafford.
Secretary—W. C. Twigg.
Committee—H. Baker, W. Dixon, W. H. Leney, G. A. Renshaw and W. G. Stokes.

A comprehensive syllabus of papers has been arranged the range of subjects being much wider than during preceding sessions. A number of outside speakers have agreed to give papers and it is hoped that the support of the membership will be forthcoming.

Guildford Centre

The Fourth Annual General Meeting of the Guildford Centre was held on July 23rd at Stoke House, Guildford, the Sectional Engineers' Headquarters.

At the opening of the proceedings the Sectional Engineer, Mr. F. Lock, M.I.E.E., who presided, expressed his appreciation of the work done during the session and appealed for increased support from new entrants to the Department. He also urged members to assist the committee in the preparation of the programme for the ensuing session.

The Secretary endorsed Mr. Lock's remarks and stressed the fact that the greatest support which could be given by individual members was regular attendance at the monthly meetings.

The election of officers for the forthcoming session resulted as follows:—

Chairman—S. R. Choules.
Vice-Chairman—R. Welburn.
Hon. Treasurer—F. B. Amey.
Hon. Secretary—R. J. Myerson.
Assistant Secretary—L. S. Downing.
Hon. Auditors—C. F. White, R. J. Dye.

Committee.

Guildford—W. E. Chapman, H. Hayes, H. Beagley and D. Wilkins.
Cranleigh—A. N. Titheridge.
Woking—W. Horwood.

Peterborough Centre

The Annual General Meeting was held on Wednesday, April 8th, 1936, and the existing committee was re-elected for the 1936/37 session.

The 1935-36 session was satisfactory, the financial position of the centre was sound, and there is a good balance in hand.

During the summer the centre has visited the Peterborough Power Station, L.N.E.R. Locomotive Works, the Ketton Cement Works and the Rugby Radio Station. All the outings were very interesting.

The committee has pleasure in announcing the following programme for the forthcoming winter session:

Oct. 7th, 1936, "The U.A.X. No. 12," J. D. Andrews, Peterborough.
Nov. 4th, 1936, "Some Problems of Construction," G. Nixon, Leicester.
Dec. 9th, 1936, "The Draughtsman's Office," W. A. Watson, Peterborough.
Jan. 6th, 1937, "Underground Construction," T. Rosam, Peterborough.
Feb. 3rd, 1937, "V.F. Signalling on Trunks and Junctions," F. E. Bland, B.Sc., Leicester.
Mar. 10th, 1937, "Wayleaves," E. G. Williams, Peterborough.
Apl. 7th, 1937, Annual General Meeting.

Subscriptions are now due and may be forwarded to Mr. Welch, the treasurer, direct, or *via* your inspector.

The membership last year was good, and we hope to better it this year. The newcomers to the Department are cordially invited to join and any member of the committee will be pleased to enlighten you on the centre's and the Institution's activities.

The following is a list of the office bearers and committee.

Chairman—J. Mc.Owen, M.I.E.E.
Vice-Chairman—R. W. R. Porter.
Secretary—V. P. List, H.P.O. Peterborough. (Telephone 2915.)
Treasurer—C. Welch.
Committee—Messrs. Andrews, Ball, Clewer, Daniels, Gant, Hands.

Preston Centre

Interest has been well maintained during the past session and the attendances showed considerable improvement. A high standard was set by those members who read papers. The committee wish to thank all for the way the members pulled together to make the session a success.

The annual general meeting held on the 15th April, 1936, resulted in the election of the following officers:

Chairman—J. W. Gould.
Vice-Chairman—H. Crook.
Hon. Secretary—L. Hall.
Hon. Treasurer—H. Freeman.
Committee—J. Seed, R. E. Porter, J. Shorrocks, T. Singleton, G. Pritchard, J. E. Moorhouse.
Auditors—H. Simpson, W. H. Eaton.

A large number of our members took part in the Annual Outing on June 20th, 1936, when a visit was made to the Strowger Works, Liverpool, where a very interesting afternoon was spent round the various departments, the journey being continued in the evening *via* Southport.

We are embarking on the 1936-37 session and an interesting programme, which we hope to issue at an early date to each member, is being compiled.

We offer a welcome to all members of the staff to our meetings.

We hope to record an increased membership this session.

L.H.

Staff Changes

PROMOTIONS.

Name.	From.	To.	Date.
Innes, J.	Asst. Engr.-in-Chief	Asst. Secretary	18-8-36
Ridd, P. J.	Deputy Supt. Engr., London.	Asst. Engr.-in-Chief	3-9-36
de Wardt, R. G.	Supt. Engr., S. Lancs.	Deputy Supt. Engr., London	8-9-36
Morris, A.	Regl. Engr., N.E. Region	Suptg. Engr., S. Lancs.	To be fixed later
Beer, C. A.	Exec. Engr. E.-in-C.O.	Asst. Staff Engr. E.-in-C.O.	1-4-37
Radley, W. G.	Exec. Engr. E.-in-C.O.	Asst. Staff Engr. E.-in-C.O.	1-10-36
Cohen, I. J.	Exec. Engr. E.-in-C.O.	Asst. Staff Engr. E.-in-C.O.	29-8-36
Manning, F. E. A.	Exec. Engr. E.-in-C.O.	Actg. Asst. Staff Engr., E.-in-C.O.	29-8-36
Eason, A. B.	Area Engr. Scot. Region	Actg. Asst. Staff Engr. E.-in-C.O.	17-8-36
Straw, J. G.	Asst. Engr., London	Exec. Engr., London	1-11-36
Beard, A. T. J.	Asst. Engr., S. Wales	Exec. Engr., N. Western	1-1-37
Jackman, A. J.	Asst. Engr., E.-in-C.O.	Exec. Engr., E.-in-C.O.	1-10-36
Powell, H. W.	Asst. Engr., S. Lancs.	Exec. Engr., S. Lancs.	1-12-36
Harrison, R. H.	Asst. Engr., E.-in-C.O.	Exec. Engr., E.-in-C.O.	2-9-36
Berkeley, G. S.	Asst. Engr., E.-in-C.O.	Exec. Engr., E.-in-C.O.	1-10-36
Chew, W. G. N.	Asst. Engr., E.-in-C.O.	Actg. Exec. Engr., E.-in-C.O.	2-9-36
Jarvis, R. F. J.	Asst. Engr., E.-in-C.O.	Actg. Exec. Engr., E.-in-C.O.	2-9-36
Franklin, R. H.	Asst. Engr., E.-in-C.O.	Actg. Exec. Engr., E.-in-C.O.	2-9-36
Judd, F. J.	Asst. Engr., E.-in-C.O.	Actg. Exec. Engr., E.-in-C.O.	2-7-36
Turner, H. M.	Asst. Engr., London	Actg. Exec. Engr., London	2-7-36
Beach, W. R.	Asst. Engr., E.-in-C.O.	Actg. Exec. Engr., London (seconded to Personnel Dept.)	To be fixed later.
MacWhirter, R.	Asst. Engr., Scot. Region	Actg. Area Engr., Scot. Region	17-8-36
Kennard, E. G.	Chief Insp., Test Section	Asst. Engr., Test Section	1-6-36
Layton, N.	Chief Insp., London	Asst. Engr., London	1-6-36
Luckhurst, J. E.	Chief Insp., Cupar Radio Stn.	Asst. Engr., Baldock Radio Stn.	29-6-36
Wade, A. H.	Chief Insp., N.E. Region	Asst. Engr., N.E. Region	26-6-36
Casterton, E. J.	Chief Insp., E.-in-C.O.	Asst. Engr., E.-in-C.O.	29-6-36
Diggle, A.	Insp., N. Western	Chief Insp., N.E. Region	To be fixed later
Naylor, S. E.	Insp., S. Midland	Chief Insp., S. Midland	,,
Lally, J.	Insp., N.E. Region	Chief Insp., N.E. Region	,,
McDonald, W.	Insp., N.E. Region	Chief Insp., Scot. Region	,,
Pettit, E. W.	Draughtsman, Cl. I., E.-in-C.O.	Chief Insp., E.-in-C.O.	16-6-36
Wilkinson, R. H.	Mech.-in-Charge, Grade I., Preston	Tech. Asst., Leeds	To be fixed later.
Lingwood, A. L.	Mech.-in-Charge, Leicester	Tech. Asst., London	To be fixed later.
Palmer, O. A.	S.W.I., Eastern	Insp., Eastern	27-1-36
Rutland, G. A.	S.W.I., S. Wales	Insp., S. Wales	20-6-36
Kibby, R. A.	S.W.I., S. Wales	Insp., S. Wales	1-7-36
Adams, G. H.	S.W.I., S. Wales	Insp., S. Wales	19-7-36
Bacon, E. W.	S.W.I., London	Insp., London	15-3-36
Bedley, E. H.	S.W.I., London	Insp., London	24-5-36
Buckoke, S.	S.W.I., London	Insp., London	23-2-36
Clark, C. W. A.	S.W.I., London	Insp., London	5-2-36
Cockhill, H. G.	S.W.I., London	Insp., London	11-1-36
Durrant, H. L.	S.W.I., London	Insp., London	3-6-36
Groombridge, H. E.	S.W.I., London	Insp., London	24-5-36
Lewis, F. G.	S.W.I., London	Insp., London	27-10-35
Moore, B. H.	S.W.I., London	Insp., London	7-1-36
Pannett, C.	S.W.I., London	Insp., London	18-1-36
Perks, J.	S.W.I., London	Insp., London	9-2-36
Pugh, R.	S.W.I., London	Insp., London	10-11-35
Sawyer, A. E.	S.W.I., London	Insp., London	10-12-35
Ward, G. E. V.	S.W.I., London	Insp., London	31-5-36
Waterman, W. R.	S.W.I., London	Insp., London	29-11-35
Turner, A. E.	S.W.I., London	Insp., London	15-4-36
Giles, S.	S.W.I., S. Midland	Insp., S. Midland	5-6-36
Lockwood, C. R.	S.W.I., S. Midland	Insp., S. Midland	21-11-35
Holt, R. E.	S.W.I., S. Western	Insp., S. Western	28-6-36
Hurn, J. M.	S.W.I., S. Midland	Insp., S. Midland	11-7-36
King, D. B.	S.W.I., S. Western	Insp., S. Western	19-7-36
Rogers, F.	S.W.I., S. Western	Insp., S. Western	19-4-36
Wallington, F. S.	S.W.I., S. Western	Insp., S. Western	22-6-36
Wicks, W. L.	S.W.I., S. Western	Insp., S. Western	4-2-36
Woodnutt, H.	S.W.I., S. Midland	Insp., S. Midland	11-7-36
Nelson, L. C.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	2-5-36
Irwin, A. E.	S.W.I., Portishead Radio Stn.	Insp., E.-in-C.O.	16-5-36
Peach, R. S.	S.W.I., S. Lancs.	Insp., E.-in-C.O.	15-2-36
Hurlock, B. T.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	9-2-36
Northeast, S. G.	S.W.I., Test Section, London	Insp., E.-in-C.O.	1-2-36
Armitstead, N. C.	S.W.I., N. Western	Insp., E.-in-C.O.	18-4-36
Mercer, A. E.	S.W.I., Test Section, London	Insp., E.-in-C.O.	15-3-36

Name.	From.	To.	Date.
Ferguson, K. H.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	8-8-36
Walters, T. L.	S.W.I., St. Albans Radio Stn.	Insp., E.-in-C.O.	28-3-36
Gray, W.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	8-8-36
Beak, K. L.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	2-5-36
Stiles, O. A.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	8-8-36
Williams, W.	S.W.I., S. Lancs.	Insp., E.-in-C.O.	18-4-36
Jackman, T. W. P.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	2-5-36
Bronsdon, E. G.	S.W.I., St. Albans Radio Stn.	Insp., E.-in-C.O.	8-8-36
Kingston, F. G.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	2-5-36
Tinsley, W. S.	S.W.I., N.E. Region	Insp., E.-in-C.O.	29-2-36
Walker, W. A.	S.W.I., N.E. Region	Insp., E.-in-C.O.	18-4-36
Head, J. E.	S.W.I., Portishead Radio Stn.	Insp., E.-in-C.O.	23-5-36
Gearing, A.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	1-1-36
Read, R. A.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	23-2-36
Groom, D. E.	S.W.I., London	Insp., E.-in-C.O.	14-4-36
Mowbray, A. H.	S.W.I., London	Insp., E.-in-C.O.	23-2-36
Brown, E. H. K.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	5-5-36
Bryan, B. H.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	19-4-36
Conn, C. A.	S.W.I., S. Lancs.	Insp., E.-in-C.O.	14-3-36
Chipp, S. W.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	15-12-35
Parr, F. D.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	10-6-36
Lipscombe, J. E.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	28-7-36
Mackie, G. W.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	2-2-36
Haythornthwaite, F.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	11-3-36
Chisnall, W. E.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	8-3-36
Catt, L. H.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	7-4-36
Fudge, G. A. E.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	15-3-36
Sims, A. E. J.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	5-4-36
Raby, R. E.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	2-5-36
Attwood, J. W. A.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	29-3-36
Clarke, E. F. S.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	4-4-36
Fleetwood, C. H. J.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	8-3-36
Thirsk, R. D.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	9-2-36
Donaldson, A. L. L.	S.W.I., N.E. Region	Insp., E.-in-C.O.	14-3-36
Hotham, J. W.	S.W.I., N.E. Region	Insp., E.-in-C.O.	9-5-36
Bouquet, H. F.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	12-4-36
Lawrenson, S.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	22-3-36
Rowe, J. F.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	15-3-36
Cox, E. B.	S.W.I., Rugby Radio Stn.	Insp., E.-in-C.O.	8-8-36
Peck, E. J. M.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	8-8-36
Stevens, C. A.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	26-4-36
Wilson, K. E.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	1-4-36
Wass, C. A. A.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	6-8-36
Harris, E. T. C.	S.W.I., E.-in-C.O.	Insp., E.-in-C.O.	14-4-36
Allan, A. F. G.	U.S.W., E.-in-C.O.	Insp., E.-in-C.O.	1-5-36
Sharman, H. W.	S.W.I., N. Midland	Insp., N. Midland	2-2-36
Mitchell, S. C.	S.W.I., S. Western	Insp., S. Western	1-7-36
Howard, J. K.	S.W.I., S. Western	Insp., S. Western	11-8-36
Pratten, L. W.	S.W.I., S. Western	Insp., S. Western	9-7-36
Tuffin, F. A. T.	S.W.I., S. Western	Insp., S. Western	11-8-36
Penny, W. J.	S.W.I., S. Western	Insp., S. Western	9-8-36
Tyler, G. O.	S.W.I., S. Western	Insp., S. Western	1-1-36
Rummings, W. C.	S.W.I., S. Western	Insp., S. Western	1-7-36
Boadella, J. W.	S.W.I., Baldock Radio Stn.	Insp., Baldock Radio Stn.	15-8-36
Turner, A.	S.W.I., Test Section	Insp., Test Section	To be fixed later.
Lewis, F. S.	S.W.I., Test Section	Insp., Test Section	,,
Satterthwaite, H.	S.W.I., Test Section	Insp., Test Section	,,
Bouler, W. R.	S.W.I., Test Section	Insp., Test Section	,,
Bridges, G. W. M.	S.W.I., Test Section	Insp., Test Section	,,
Price, S. E.	S.W.I., Test Section	Insp., Test Section	,,
Greaves, D. H.	S.W.I., N. Wales	Insp., N. Wales	,,
Hall, H.	S.W.I., N. Wales	Insp., N. Wales	,,
Pinfield, E.	S.W.I., N. Wales	Insp., N. Wales	,,
Whitnall, E. J.	S.W.I., N. Wales	Insp., N. Wales	,,
Wildig, H.	S.W.I., N. Wales	Insp., N. Wales	,,
Yates, J. T.	S.W.I., N. Wales	Insp., N. Wales	,,
Allen, G. H.	S.W.I., S. Western	Insp., S. Western	,,
Brett, A. W.	S.W.I., S. Western	Insp., S. Western	,,
Cooper, R. S.	S.W.I., S. Western	Insp., S. Western	,,
Hopkins, G. J.	S.W.I., S. Western	Insp., S. Western	,,
Barber, N.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Barrass, J. W.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Bell, W. J.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Bickerton, J.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Eastwood, D.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Fisk, F. G.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,

PROMOTIONS—continued.

Name.	From.	To.	Date.
Goulden, C. J.	S.W.I., S. Lancs.	Insp., S. Lancs.	To be fixed later.
Graham, A. W.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Hough, J. H.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Jackson, R.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Johnston, J.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Jones, A.	S.W.I, S. Lancs.	Insp., S. Lancs.	,,
Kibble, R.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Large, G. V.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Savage, A.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Street, A. D.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Thomas, W. C.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Wallace, K. C.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Wareham, J. H.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Wootton, F. C.	S.W.I., S. Lancs.	Insp., S. Lancs.	,,
Leversuch, E. J.	S.W.II., London	Insp., London	18-1-36
Marsh, W. G. E. J.	S.W.II., London	Insp., London	5-1-36
Dacombe, R. S.	Draughtsman, Cl. I., N. Wales	Senior Draughtsman, N.E. Region	23-8-36
Warrand, H. T.	Draughtsman, Cl. I., N. Midland	Senior Draughtsman, Scot. Region	3-9-36

TRANSFERS.

Name.	Rank.	From.	To.	Date.
Palmer, W. T.	Exec. Engr. ..	E.-in-C.O.	N. Ireland	1-6-36
Luxton, W. G.	Exec. Engr. ..	Eastern	S. Western ..	10-6-36
Howard, J. L.	Asst. Engr. ..	E.-in-C.O.	S. Western	12-7-36
MacWhirter, R.	Asst. Engr. ..	E.-in-C.O.	Scot. Region ..	26-7-36
Whitehead, W. C.	Chief Insp. ..	London.	S. Western	26-6-36
Sulston, W. J.	Proby. Asst. Engr.	Eastern	E.-in-C.O.	5-7-36
Lawton, J.	Proby. Asst. Engr.	London.	E.-in-C.O.	1-9-36
Armstrong, R. G.	Proby. Asst. Engr.	E.-in-C.O.	N. Midland ..	1-9-36
Kilvington, T.	Proby. Asst. Engr.	S. Western... ..	E.-in-C.O.	1-9-36
Chorley, J. W. A.	Proby. Asst. Engr.	S. Lancs.	E.-in-C.O.	1-9-36
Cooper, A. B.	Proby. Asst. Engr.	S. Midland	E.-in-C.O.	1-9-36
Stevenson, H. C.	Proby. Asst. Engr.	Scot. Region ..	E.-in-C.O.	1-9-36
Coombs, A. W. M.	Proby. Asst. Engr.	S. Lancs.	E.-in-C.O.	1-9-36
Mayo, S. J.	Proby. Asst. Engr.	E.-in-C.O.	S. Wales	1-9-36
Brown, R. C. C.	Insp.	S. Western ..	E.-in-C.O.	1-6-36
Clark, R. J.	Insp.	E.-in-C.O.	N. Wales	20-6-36
Manley, E. H.	Insp.	E.-in-C.O.	S. Western	15-7-36
Stewart, T.	Insp.	Baldock Radio Stn.	E.-in-C.O.	21-7-36
Kirkpatrick, F. E.	Insp.	Scot. Region ..	S. Western ..	23-7-36

APPOINTMENTS.

Name.	From.	To.	Date.
Clarke, E. F. S.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
Neate, A. D.	P. Insp., E.-in-C.O.	Proby. Asst. Engr.	
Webber, F. W. J.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
Dolan, W. H.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
Roberts, W. G.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
Turner, A. F.	Insp., E.-in-C.O.	Proby. Asst. Engr., N. Wales ..	1-8-36
Hoare, E.	Insp., London	Proby. Asst. Engr., Eastern ..	1-8-36
Robins, A. G.	Insp., S. Midland	Proby. Asst. Engr.	
Warren, F.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
Edwards, S. J.	Insp., S. Western	Proby. Asst. Engr.	
Robertson, C. D. S. G.	Insp., London	Proby. Asst. Engr., S. Eastern	1-8-36
Read, R. A.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
Mayo, S. J.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
Soper, D. C.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
French, E. J.	Insp., S. Western	Proby. Asst. Engr., N. Midland	1-8-36
Hunt, A. M.	Insp., London	Proby. Asst. Engr., N.E. Region	1-8-36
Renton, R. N.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
Probert, G. A.	Insp., N. Wales	Proby. Asst. Engr.	
Atherton, W. S.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
Weaver, E. W.	Insp., London	Proby. Asst. Engr., S. Midland	1-8-36
Beaumont, E. B. M.	Insp., E.-in-C.O.	Proby. Asst. Engr.	
Watson, L. R.	Insp., London	Proby. Asst. Engr., N. Western	1-8-36
Leach, F.	Insp., S. Lancs.	Proby. Asst. Engr. N. Western..	1-8-36
Dunn, W. K.	Insp., E.-in-C.O.	Proby. Asst. Engr., London ..	1-8-36

Appointments—continued.

Name.	From.	To.	Date.
Billington, R. M.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	10-8-36
Taylor, R.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	12-8-36
Tillman, J. R.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-9-36
Clarke, A. C. W. V.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-9-36
Lawton, J.	Open Competition	Proby. Asst. Engr., London	1-7-36
Lillicrap, H. G.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-9-36
Armstrong, R. G.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-7-36
Hibbs, N. L.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-9-36
Glover, R. P.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-7-36
Mascall, T. H. A.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	6-7-36
Kilvington, T.	Open Competition	Proby. Asst. Engr., S. Western	1-7-36
de Jong, N. C. C.	Open Competition	Proby. Asst. Engr., S. Wales	1-7-36
Hoare, E. R.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-9-36
Chorley, J. W. A.	Open Competition	Proby. Asst. Engr., S. Lancs.	6-7-36
Merriman, J. H. H.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-7-36
Cooper, A. B.	Open Competition	Proby. Asst. Engr., S. Midland	1-7-36
Colledge, T. A. P.	Open Competition	Proby. Asst. Engr., S. Eastern	1-7-36
de Courcy, F. J.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-9-36
Bawtree, K. O.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	9-7-36
Stevenson, H. C.	Open Competition	Proby. Asst. Engr., Scot. Region	1-7-36
Hanman, B. L. G.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-9-36
Mew, R. J.	Open Competition	Proby. Asst. Engr., E.-in-C.O.	1-7-36
Barron, H.	Wireless Oper., Burnham	Repeater Officer, Class II., Newcastle-on-Tyne	10-3-36

Retirements.

Name.	Rank.	District.	Date.
Letty, S. F.	Chief Insp.	S. Eastern	20-7-36
Jones, G. E.	Chief Insp.	London	31-8-36
Bailey, A. H.	Chief Insp.	London	31-8-36
Charlish, B. R.	Insp.	S. Midland	16-7-36
Barrow, W.	Insp.	S. Lancs.	3-7-36
Bolton, J.	Insp.	N. Western	30-6-36
Bull, C.	Insp.	London	31-7-36
Wood, T. E.	Insp.	London	31-7-36
Lee, W. H.	Insp.	London	4-8-36
Robinson, J. A.	Insp.	N. Wales	2-8-36
Courtis, C. H.	Insp.	N. Midland	27-7-36
Wendler, W.	Insp.	Test Section	17-8-36
Phillpott, T. H.	Cable Foreman	H.M.T.S. " Alert "	20-7-36

Deaths.

Name.	Rank.	District.	Date.
Osbourn, W.	Chief Insp.	Test Section, London	30-7-36
Richardson, R. B. H.	Insp.	S. Eastern	4-8-36

CLERICAL GRADES.

Promotions.

Name.	From.	To.	Date.
Brown, W. S.	C.O., N. Wales	Actg. H.C.O., N. Wales	15-5-36
Ruffhead, E. J.	C.O., London	H.C.O., London	27-5-36
Oughton, F.	C.O., London	H.C.O., London	27-5-36
Williams, R. E.	C.O., London	H.C.O., London	21-6-36
Bull, E. J.	C.O., London	H.C.O., London	21-6-36
Ambrose, A.	C.O., London	H.C.O., London	21-6-36
Cooper, L. J.	C.O., London	H.C.O., London	21-6-36
Layton, E.	C.O., London	H.C.O., London	21-6-36
Cole, G. H.	C.O., London	H.C.O., London	27-6-36
Cross, A. W.	C.O., London	Actg. H.C.O., London	27-6-36
Ramsay, J.	Staff Officer, E.-in-C.O.	Actg. Principal Clerk, E.-in-C.O.	1-7-36
Williams, A.	C.O., S. Wales	H.C.O., S. Wales	1-7-36
Humphrey, R.	C.O., London	Actg. H.C.O., London	24-7-36
Campbell, T.	H.C.O., Scot. Region	Staff Officer, Scot. Region	24-7-36
Brown, A. T.	C.O., Scot. Region	Actg. H.C.O., Scot. Region	24-7-36

PROMOTIONS—continued.

Name.	Rank.	District.	Date.
Weston, A. S.	E.O., E.-in-C.O.	Actg. Staff Officer, E.-in-C.O.	1-8-36
Walker, F. H.	C.O., E.-in-C.O.	Actg., E.O., E.-in-C.O.	14-8-36
Baker, F. S.	C.O., E.-in-C.O.	Actg. E.O., E.-in-C.O.	14-8-36
Russell, J. F.	C.O., Scot. Region	Actg. H.C.O., Scot. Region	14-8-36
Bence, W. R.	C.O., S. Western	Actg. H.C.O., S. Western	9-9-36
Wood, J. U.	C.O., S. Western	Actg. H.C.O., N. Wales	To be fixed later.
Holdway, F. W.	C.O., S. Wales	H.C.O., N.E. Region	13-9-36

RETIREMENTS.

Name.	Rank.	District.	Date.
Mizen, W. H.	E.O.	E.-in-C.O.	31-7-36
Smith, A. C.	Staff Officer	N. Wales	31-8-36
Miller, W.	H.C.O.	S. Western	31-8-36
Friar, J.	H.C.O.	N.E. Region	12-9-36

DEATHS.

Name.	Rank	District	Date
Scott, W. H.	H.C.O.	London	26-6-36

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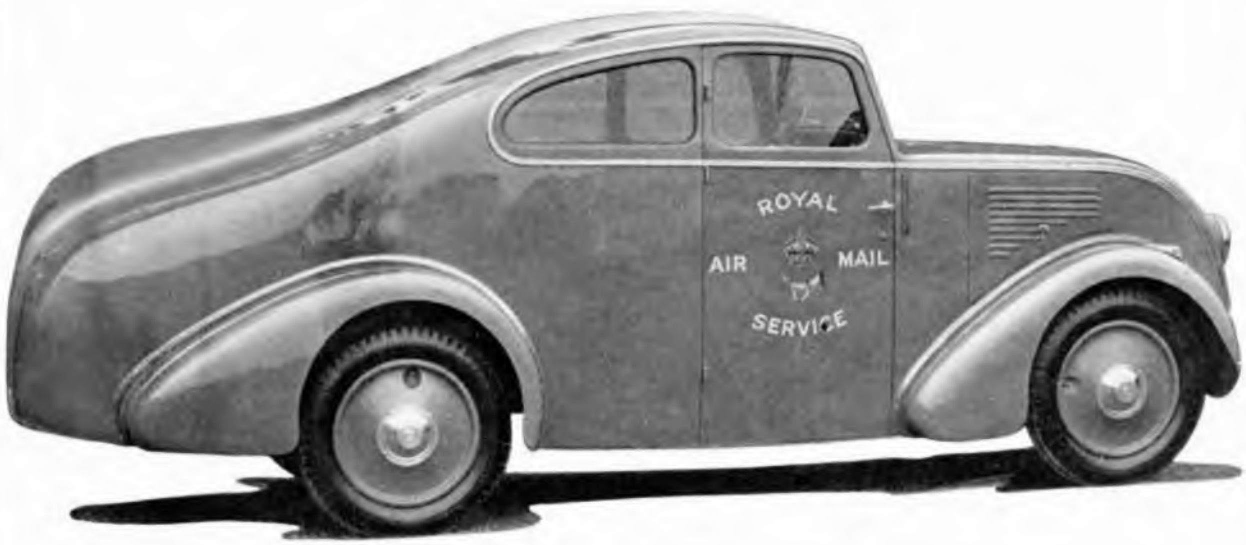

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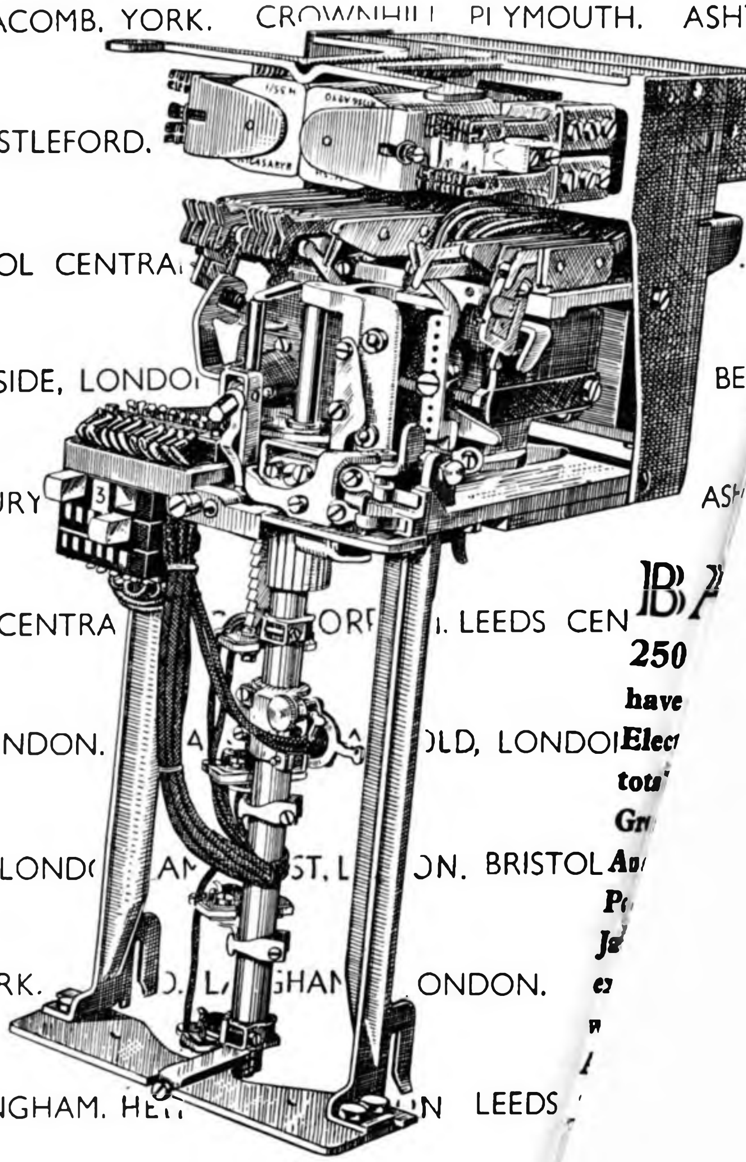

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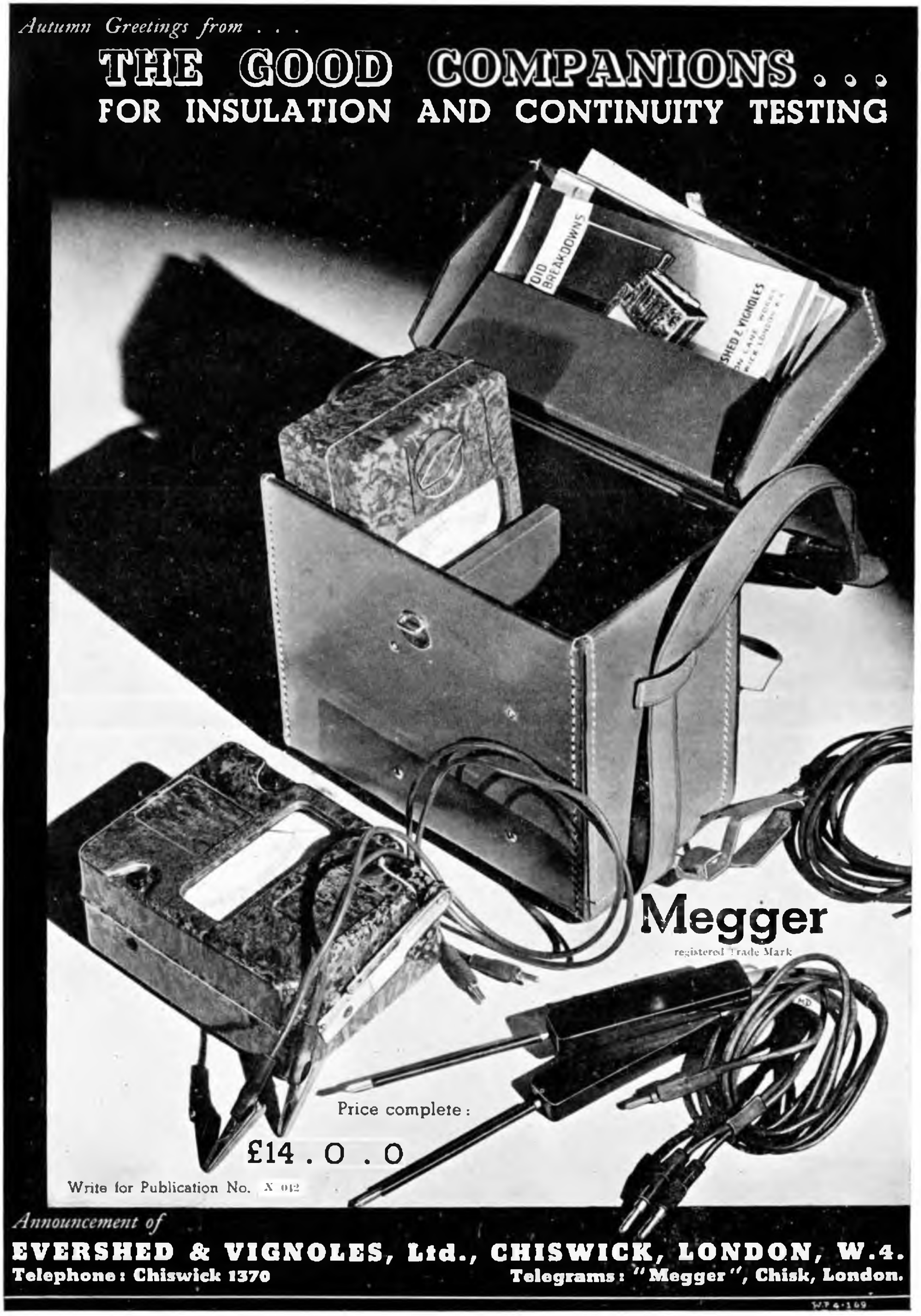
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