THE
Post Office Electrical Engineers' Journal

"DEMAND" TRUNK SERVICE.

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THE British Post Office has recently decided to reorganise its Trunk service with the object of effecting communication as nearly as possible on a demand basis. The purpose of this article is to outline the work involved in providing the necessary equipment and to indicate, in a general way, the trend of design which is being adopted for the switchboard equipment.

Calls which involve recording on tickets for accounting purposes, as hitherto operated in Great Britain, fall into two categories: those known as Toll Calls, and those known as Trunk Calls. Toll calls are completed normally on demand by an " A " operator or by a Toll operator to which the subscriber is immediately connected. The area around London represented by the South Eastern corner of England, enclosed by an arc struck approximately from Southampton, through Newbury, Cambridge and Ipswich, forms the most important toll area, in which the calls are completed on a no-delay basis immediately a demand has been received from the subscriber. A similar service exists between the Liverpool and Manchester areas and between the Edinburgh and Glasgow areas. Calls made over the longer distances, for example between the London area and the Manchester area, are known as Trunk calls. These calls have been handled on what is known as the trunk basis, that is, the subscriber is connected to a record operator, who records the call on a ticket which is passed to an operator in charge of the trunk lines concerned and completed by her when the trunk line is available, the calls being dealt with in code time order. The objective aimed at in reorganising the trunk service is the immediate completion of calls on demand, similarly to Toll calls, without the necessity of the subscriber having to hang up his receiver and be recalled. This service is known in the British Post Office as the Demand Trunk Service.

Trunks have been operated on the basis of assigning to each operator a small number of trunk lines, these lines being terminated at each end on a single jack and calling signal. It is the duty of the operator to pass as many calls, represented by tickets, as possible over the lines under her charge. This might be described as a " line " basis of operating. In " On Demand " operating, the operator in the Trunk exchange will make out the ticket and immediately proceed to set up the connection. She also makes all enquiries which may be necessary to effect the connection and satisfy the caller. This might be described as a " call " basis of operating.

The demand operator must be in a position to spend as much time as necessary in handling the call; some form of traffic distribution must therefore be provided for incoming calls from subscribers requiring trunk connection. She must also have access to all available trunks, both on direct and alternative routes, to the point to which the trunk call is required.

The supervisory signal in the cord circuit must be controlled by the calling subscriber, and the connection held by the operator whether from a manual or an automatic exchange. It will also be necessary for the demand operator to be able to ring the subscriber, so as to hold his line in case of delay in setting up a trunk connection.

In order to give full availability over the trunk network to all operators, trunks will work bothways and be multipled on incoming trunk positions for through connections, as well as on demand positions.

Under the present method of line operating, trunks are provided on a basis of a maximum of 15 minutes delay in the busy hour. It is anticipated that a "demand service" can be given on this plant of the order of 72% of calls completed within 1½ minutes, 12% within 10 minutes, the remainder being of a more difficult nature, due to unusual circumstances such as the wanted subscriber being unavailable. The improvement in service will be entirely due to the methods of operating and the availability of alternative routes.

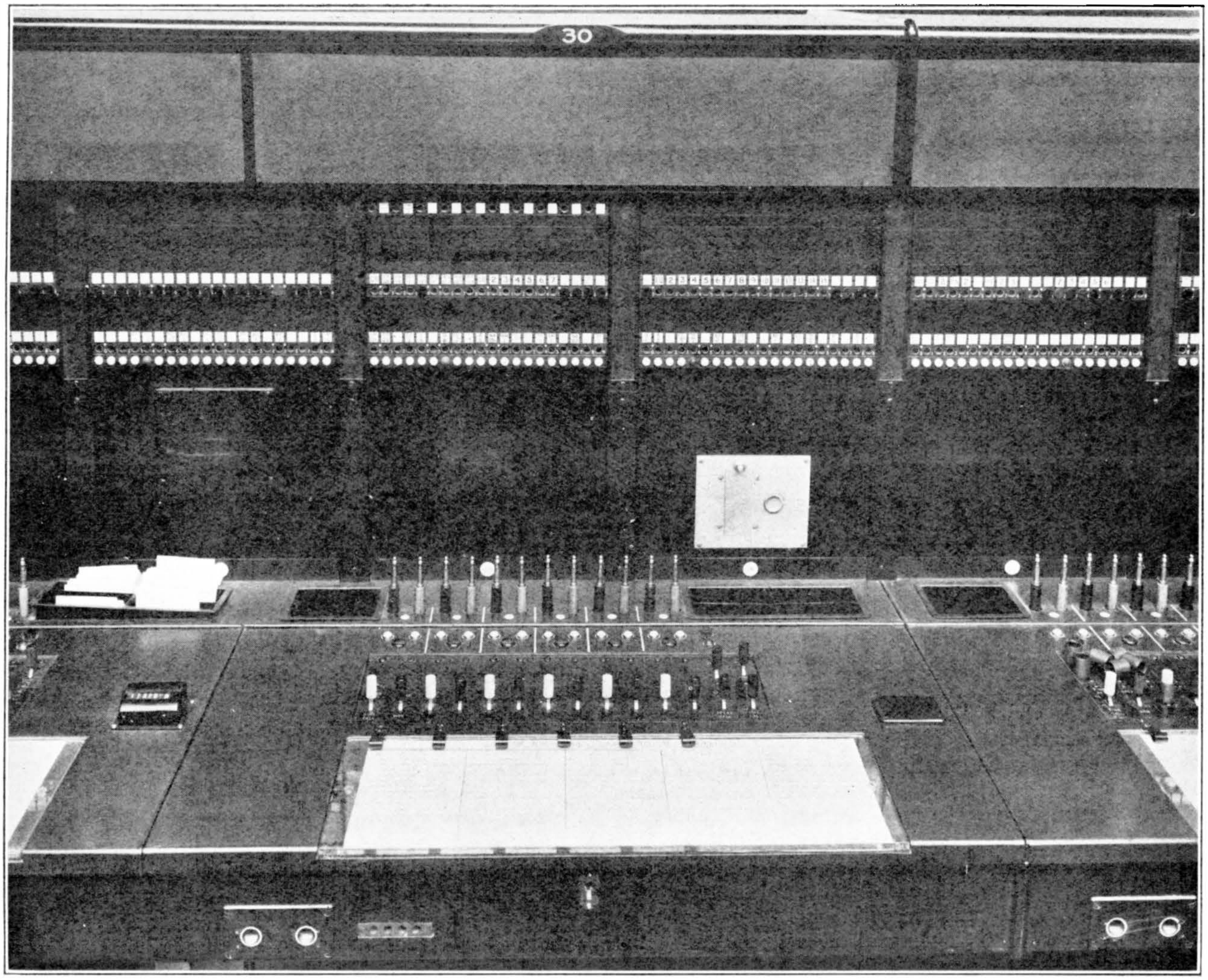


FIG. 1.—KEYBOARD AND JACK PANELS, NEW TYPE TRUNK SWITCHBOARD.

Repeater cord circuits will, wherever possible, be replaced by terminal repeaters associated with the trunk lines to simplify operating and to avoid risk of low grade transmission due to repeater cords being omitted when setting up a call.

Hitherto, trunk calls have been controlled in zone centres of which there are about twelve in the British Isles. Under the reorganisation, trunk calls will also be controlled at group centres which will be directly connected to the zone centres for access to the trunk network. The devolution of control will facilitate routing of the call by direct lines wherever traffic warrants it, and also facilitate the provision of the signalling and ringing facilities previously referred to.

Existing trunk plant, designed for operating on a line basis with separate recording positions, is entirely unsuitable for demand service, and it has been necessary to design entirely new circuits and a new type of switchboard section.

The switchboard section is of the type usual in manual exchanges, but accommodates the large type jack commonly used in British Post Office No. 10 Exchanges. Seven panel sections giving a twenty-seven inch wide position will be employed. The keyboard is of ample width to provide bulletin and writing space. Fig. 1 illustrates the keyboard and

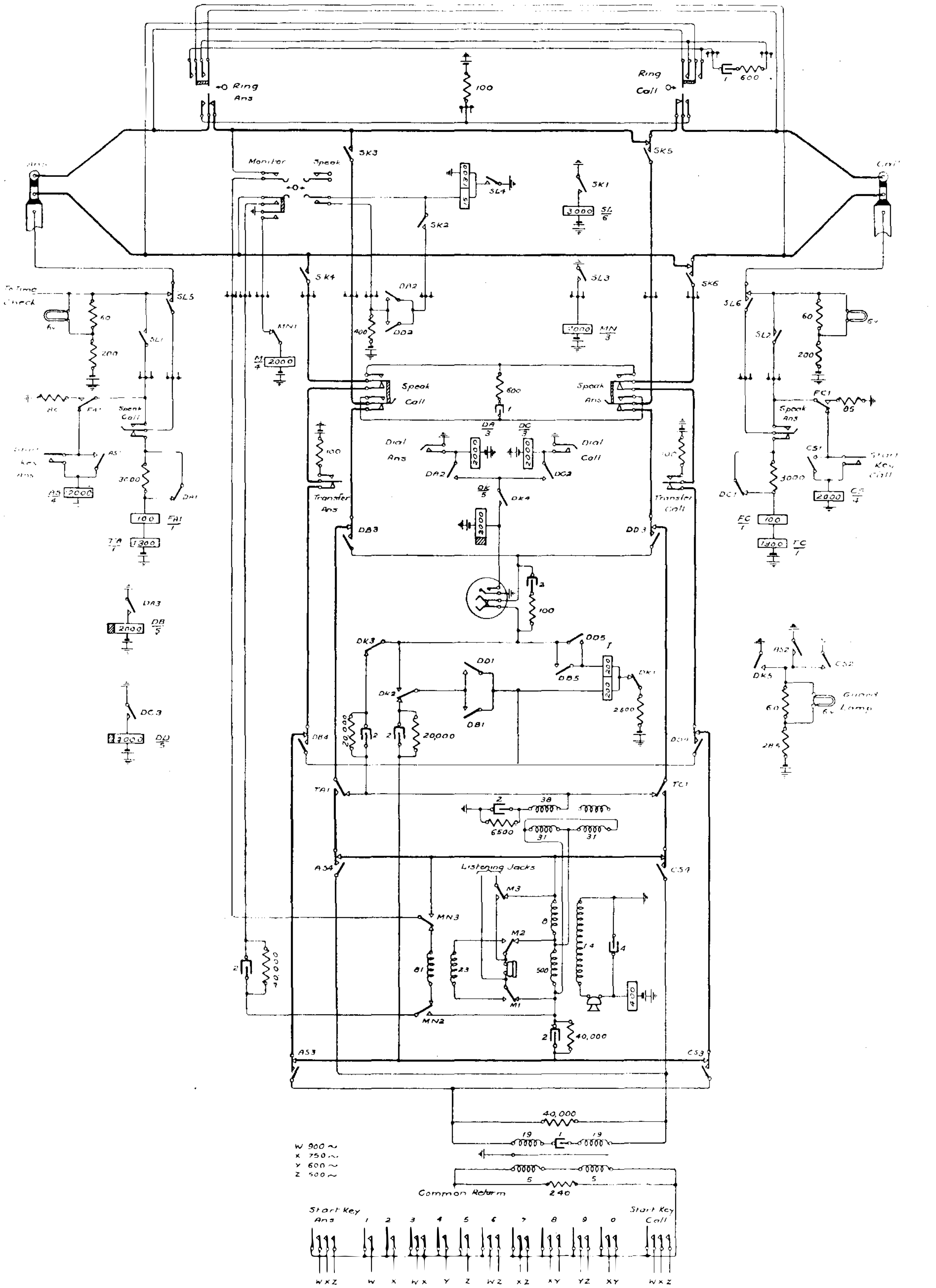


FIG. 2.—CORD CIRCUIT AND POSITION EQUIPMENT.

jack panels; it is from a photograph of a low section designed for a special case.

The cord circuit is of the sleeve control type, the signalling being effected over the third conductor from terminal equipment associated with the lines. No bridging or other apparatus, except ringing and speaking keys in connection with the talking conductors of the cord, will be necessary.

Answering jacks and calling lamps, for both the demand lines carrying originating trunk traffic and incoming trunk lines, will be multipled in order to provide for traffic distribution. In the larger exchanges this multiple may consist of as many as twenty appearances giving access to some forty operators.

Outgoing trunk multiples will be provided with idle trunk indicators, consisting of multipled lamp signals indicating an available trunk in the group. On this trunk being taken up by an operator, the signal will move automatically to another idle trunk. This signal is of a new type and consists of placing the lamp behind a translucent number plate instead of the practice hitherto employed of using a separate lamp jack and designation strips. The adoption of the idle trunk scheme, as compared with the older practice of visual engage signalling, will very materially reduce current consumption and, what is more important, heating, which arises from a large number of lamps alight simultaneously in a multiple jack field.

The cord and position equipment is shown in Fig. **2** and typical terminal equipment in Figs. **3** and **4**. In the normal condition, without keys thrown, the cord circuit consists simply of straight through conductors from plug to plug with a lamp connected from battery to each plug sleeve. These lamps are controlled by means of a double wound third conductor relay in the line terminal equipment, the high resistance winding being short-circuited when a clearing signal is received, by the line relay allowing sufficient current to flow to light the lamp.

Throwing the cord circuit speaking key operates relays SK and SL. Relay SK operates in series with 400 ohms initially through its 1300 ohm winding, which is immediately short-circuited by relay SL. This arrangement prevents more than one SK relay being operated simultaneously and is to prevent more than one cord circuit being connected at the same time to the position equipment. The contacts of relays SK and SL split the talking and sleeve conductors of the cord and carry the two plug and lamp circuits separately into the position equipment. All necessary facilities such as tertiary busy test, dialling, key sending and disconnecting either side of the line circuit for challenging purposes are provided in the position equipment.

The sleeve circuit, when carried into the position equipment, is disconnected from the lamp and spools of about 240 ohms and taken to battery through relays of 1400 ohms resistance. This change in resistance is utilised to operate a relay in the terminal equipment when required for releasing ringing relays or other purposes. The relay DR shown in Fig. **3** is differentially wound; the currents flowing in each of the two windings are opposed to each other and are approximately equal when the cord circuit speaking key is normal. When thrown, the current in one winding is increased sufficiently to operate the relay.

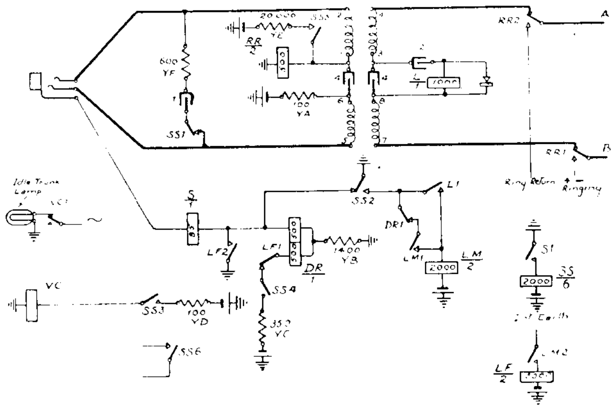


FIG. **3**.—LINE EQUIPMENT FOR OUTGOING MANUAL RING-DOWN TRUNK.

When no speaking key on the position is thrown, the monitoring key taps the cord through a high impedance transformer with the operator's transmitter disconnected, but when any speaking key is thrown all monitorings keys function as speaking keys.

The terminal equipments on lines working on manual ring-down principles are designed to flash the cord circuit lamp when a ring is received from the distant end. Relay LF (Fig. **3**) is flashed when relay LM is locked up, relay LF disconnects battery from relay DR and applies earth to relay S. If the cord circuit speaking key is thrown, DR will operate during the flash interval and release LM.

Lines working on CB signalling principles will, when the distant end clears, cause the cord circuit lamp to glow continuously. (See Fig. **4**). Relay

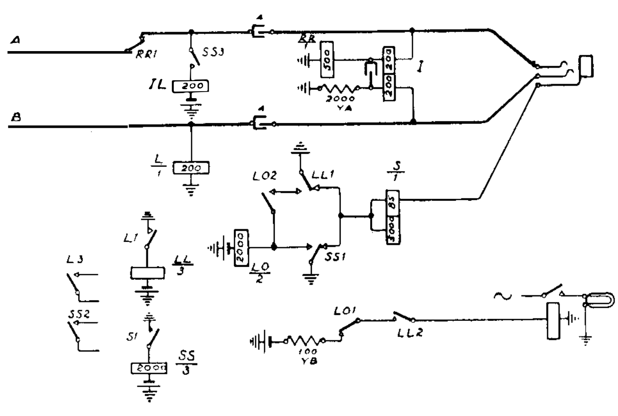


FIG. **4**.—LINE EQUIPMENT FOR INCOMING C.B. SIGNALLING TRUNK.

LO is, however, provided to lock out the calling signal until the distant end clears should the trunk exchange take down the connection first.

Voice frequency key sending, intended in this design for use on short CB signalling trunks or junctions, is controlled automatically on principles similar to regular CB junction signalling. On the depression of the start key, relay CS in Fig. **2** operates and locks itself in; it also connects the digit key strip to line and lights the guard lamp. The line equipment will be somewhat similar to Fig. **4**. The L relay in the terminal equipment will remain operated until the sender at the distant end has stored all the digits sent out and for which it is designed. The L relay then releases until the called subscriber has answered. The release of L will operate FC in Fig. **2** and in turn release CS.

Dialling conditions are set up by throwing a locking key in the position equipment. By means of relays DC and DK in conjunction with the arrangements in the line terminal equipment, not shown in this article, the dial is connected directly in series with the line so long as the dialling key remains thrown or the dial is off normal. Relays SK and SL are also held under these conditions to avoid risk of clipping the last train of impulses should the operator prematurely replace the speaking key.

Fig. **5** shows the connection of multipled calling lamps. Six volt lamps are being used, and these are wired on a three-wire scheme to avoid excessive voltage drop and the risks of signal failure should a lamp become short-circuited. The lamps will give satisfactory signals over a very wide range of voltage. They will be lit with raw AC transformed off the supply mains. Relay LC and the transformer will be mounted near the end of the switchboard suite to avoid the necessity for installing heavy wire which would be required for long low voltage leads.

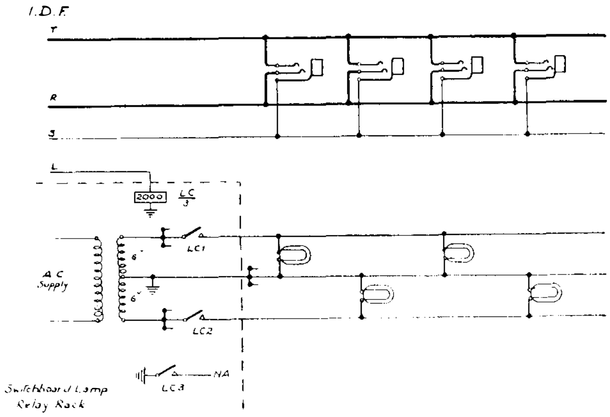


FIG. **5**.—MULTIPLED CALLING LAMPS.

Sixty positions have been installed and are in service at the London Trunk Exchange built to designs indicated in this article. New equipment is in hand for Birmingham, Leeds, Liverpool, Manchester, Newcastle and other Zone centres. Development is proceeding on the basis of the design outlined to meet the different conditions which arise both in the Zone trunk exchanges and in the various types of exchanges concerned in the group centres.

ACORN EXCHANGE.

" Great things from little Acorns grow,
And though the progress may seem slow,
Yet wise men have been known to say
That Rome was not built in a day;
And what is Rome compared to this
Full mechanised Telephonist."

PROGRESSIVE INSTALLATION OF THE NEW STANDARD OPEN TYPE RACKS AND SHELVES.

B. HOUGHTON BROWN,

Engineering Division, Standard Telephones and Cables, Limited.

THE preceding articles in this series have dealt with stages 1 and 2 in the progressive installation of Acorn Exchange, and we are now left with the third and final stage consisting of shipping and placing the apparatus in position on the shelves.

Before detailing the method of handling the apparatus, it is thought that a brief outline of the changes which have been made to the Acorn Exchange lay-out, due to the improved method of dealing with the order wire junction traffic and to the growth of automatic routine testing, would be of interest.

Fig. **16** shows the manual room carrying the traffic for Acorn, Southall and Perivale Exchanges, and it is here that one of the biggest changes in

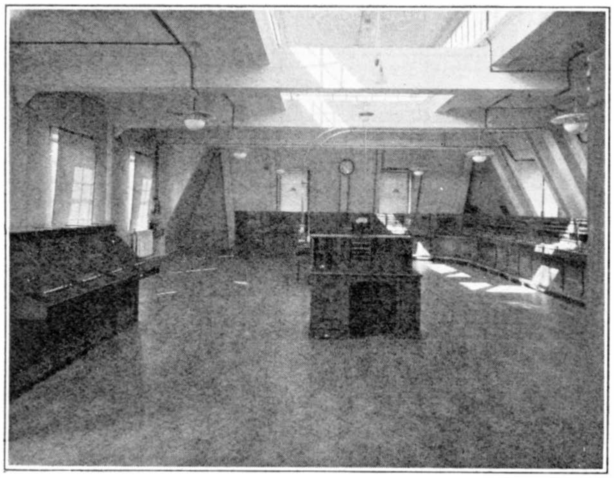


FIG. 16.—MANUAL ROOM.

lay-out has taken place due to the reduction in the number of " B " operators' positions, as indicated by the gap in the line up, consequent on the order wire traffic being handled on a 4-frequency signalling basis.

Conversely, as the number of " B " positions has been reduced, so additional 4-frequency signalling relay sets have been added to the automatic apparatus room.

Automatic routing is another item which has received a considerable amount of attention, and its growth has been responsible for changes both in cabling and lay-out, all apparatus, with the exception of the uniselectors, now being automatically tested except in cases where the quantities are not sufficient to warrant the added expenditure. The following routiner racks have been installed at Acorn :—

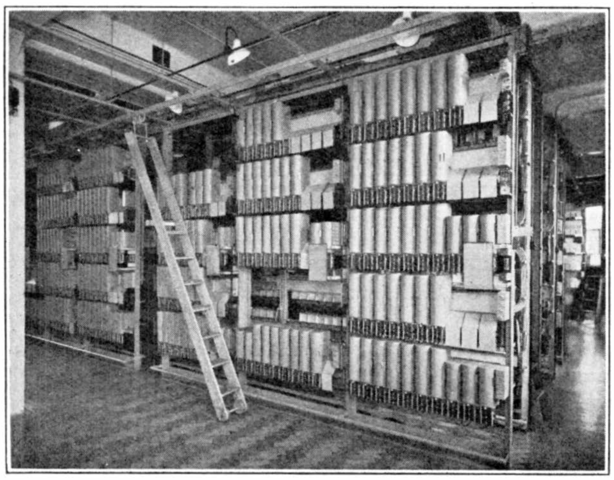


FIG. 17.—FINAL SELECTOR RACKS.

1. Sender routiner.
2. Outlet relay set routiner.
3. Auto and C.C.I. junction routiner
4. C.C.I. relay set routiner.
5. 1st code selector routiner.
6. Coder routiner.
7. Director routiner.
8. Junction relay set routiner.
9. Regular and P.B.X. final routiner
10. 4-frequency routiner.

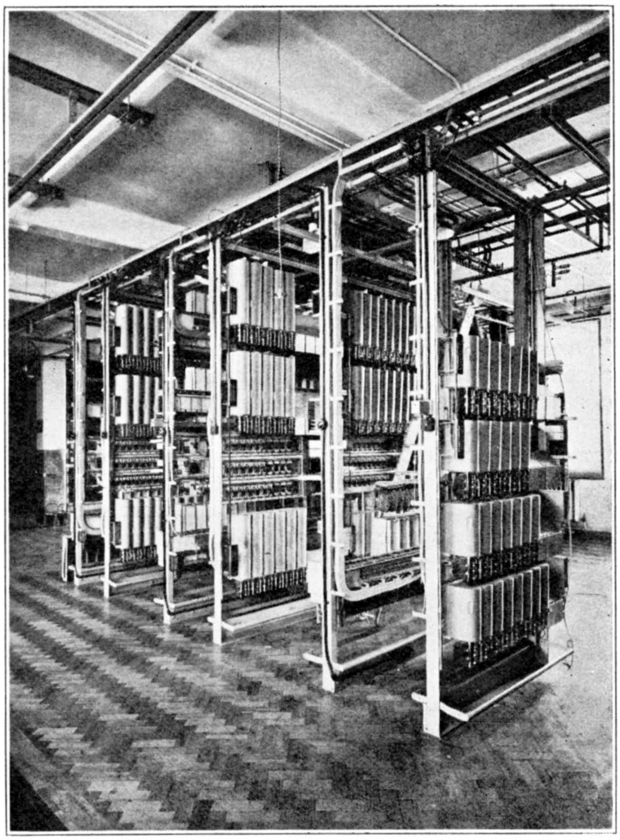


FIG. 18.—FIRST CODE AND A DIGIT RACKS.

These features, *i.e.*, 4-frequency signalling and routiner testing, represent two of the latest developments in automatic telephony, and their introduction should have far reaching effects in improving the general performance of exchange working.

The previous issue of this bulletin left us with the racks and shelves fully erected and cabled, with the banks held in position by temporary bank supports awaiting the arrival of the switches, and we will now show, by means of a series of photographs, how these switches have been mounted in position, and how the channel shelf has been adapted to all types of selectors and relay sets.

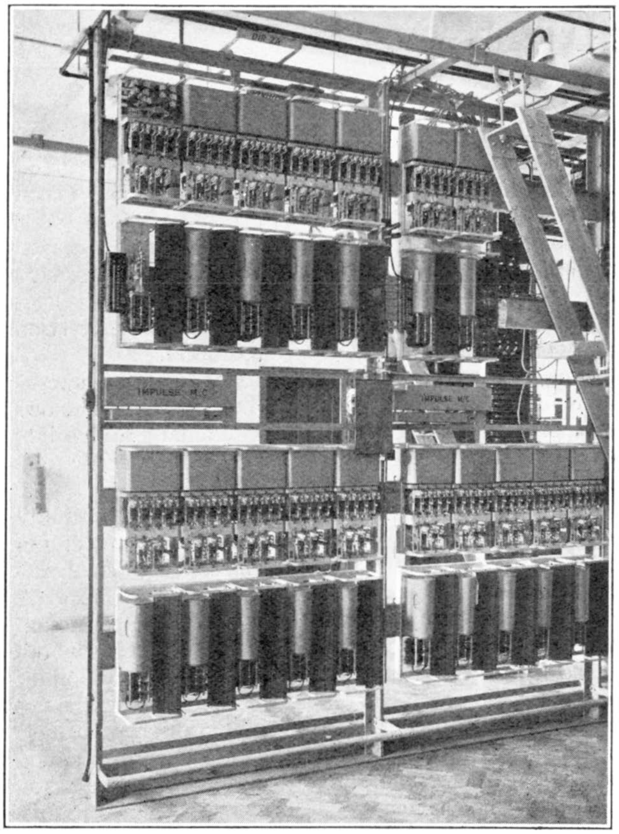


FIG. 19.—DIRECTOR RACK.

Fig. **17** shows the final selector rack fully equipped and should be compared with Figs. **5**, **6**, and **15** in the previous issues of this Journal, when the four distinct stages of installation will be seen, *i.e.*,

1. Framework erected.
2. Cables run in position.
3. Shelves erected.
4. Switches mounted in position.

Fig. **17** also shows the rack grading charts mounted on the right hand side in the centre of the rack. These charts are carried on hinged brackets enabling them to be swung out at right angles to the rack, thus ensuring accessibility to all switches.

Switches controlling the flood lights can be seen mounted on the end of the racks down the right hand gangway.

Fig. **18** includes the 1st code and "A" digit selectors and, together with Fig. **19**, shows how the varying types of switch base have been accommodated on the standard channel shelf.

Fig. **20** is of particular interest since it shows the director panels split into two sections; the upper carrying the control relays and storage switches, and the lower the B.C. switch and translation field. It will be noticed that the translation field has been set at an angle of 45°, giving full access to the B.C. switch and field terminals.

All the switches in the accompanying photographs have been shipped direct from the factory benches to the exchange in dust proof cases and have received, therefore, the minimum amount of handling, and this gives us the final advantage claimed for piece-meal shipping.

With this article we have now completed the series describing the installation of the first exchange in the London area using throughout the Post Office standard open type racks.

The Author hopes that he has achieved his object of showing the advantages of the "piece-meal" method of handling such a contract, although it is not claimed that such a method would be the most suitable under different conditions.

It must be remembered that in order to reap the full benefit of this system, very close co-operation must be maintained by the Engineering Manufacturing and Installation branches in order to ensure every item falling into its correct position on the schedule.

By the next issue of this Journal, Acorn Exchange should be in service, and it is hoped that we will be able to show a few photographs taken at the actual cut-over, so terminating the complete series.

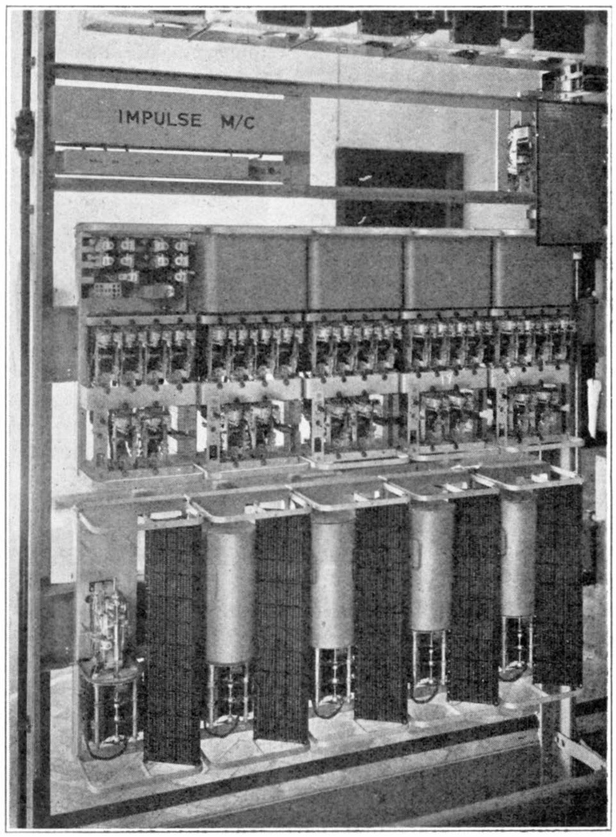


FIG. 20.—DIRECTOR SHELVES.

PRESTON MULTI-EXCHANGE AREA.

A. S. Carr, B.A.

THE recent transfer at Preston has been one of the chief events in the history of the telephone system in the North Western District. Preston, although not the county town, is the practical centre of the County Palatine and the Headquarters of the Lancashire County Council and Police, the P.O. Surveyor, Superintending Engineer and District Manager. Its station houses the largest railway sorting office in the country. There, one sees the ancient fair, the towering cotton mill, the smoky tanker scurrying to the Docks and Leyland chasses in their coats of grey. These features in an agricultural province represent a curious mixture of interests and call for every class of service.

The equipment, which was installed by the General Electric Co., Ltd., is of the standard step-by-step system.

The size of the undertaking can be judged from the following schedule :—

Exchange.	Numbering Scheme.	Present Subs'. lines. Equipment.	Capacity Subs'. lines.
Preston ...	2000-5599 56000-59899	3800	7500
Ashton-on-Ribble ...	6100-6899 69000-69699	600	1500
Fulwood ...	7100-7899 79000-79499	700	1300
Leyland ...	81000-82099	600	1100
Penwortham ...	83100-83799	300	700
Ribbleston ...	84100-84899	300	800
Bamber Bridge	85100-85899	Manual	800
Broughton ...	86100-86699	Manual	600
Goosnargh ...	87100-87199	Manual	100
Longton ...	89100-89799	Manual	700

Penwortham and Ribbleton are hypothetical exchanges and are housed temporarily in the H.P.O. which was extended to accommodate the central plant.

New buildings were erected at Ashton-on-Ribble, Leyland and Fulwood. Owing to a variety of causes the Fulwood building was delayed, but although the installation could not be commenced until less than three months before the transfer it was completed according to plan.

At the main exchange the work involved the removal and rearrangement of all the main and local telephone and telegraph cables, and as Preston is a telegraph centre and the largest repeater office in the Kingdom particular care was necessary.

About 6200 subscribers' stations were converted and in connection with the through clearing 1100 stations were condensered.

In order to bring the outcentre exchanges up to the latest standards, modifications were necessary at 31 exchanges.

The Manual Board has a total of twenty-two operating and two unequipped positions.

There are four monitors positions and one supervisor's desk. A three-position Test Desk has also been provided and each satellite exchange has its own Test Desk. It is unnecessary to describe the automatic equipment in detail.

Discriminating selector repeaters at the satellite exchanges are arranged to discriminate on certain digits indicating that the call is for the local exchange. This " drop back " feature enables the switch to fulfil the functions of a second selector on local calls. For other than local calls the switch acts as an auto-to-auto relay set (repeater), holding the connection forward, repeating the impulses from the subscriber's dial over the junction, operating the meter of the calling subscriber when the called party answers and supplying transmitter current to the calling subscriber.

In other cases the preselector hunts and finds an idle discriminating selector repeater, and the secondary line switch then hunts for an idle junction to a first selector at Preston. The first digit dialled is received by both the selector repeater and the first selector, but the wipers of the former are disconnected by the contacts of a relay, thus preventing the call from proceeding in the local exchange. The dialling of the subsequent digits operates the group and final selectors at the other exchanges in the usual manner.

When the call at a satellite is local the discriminating selector repeater drops back after rising to the desired level. The secondary line switch is then disconnected by the operation of a relay, thus releasing the junction to the Preston first selector. The circuit of the wipers of the selector repeater will then be closed by relay contacts, and when the next digit is dialled the wipers will step up again and hunt for a disengaged final selector. The discriminating selector repeaters drop back twice in the case of numbers having five digits.

The inaugural ceremony at Booth's Café was well attended and the stained glass window behind Mr. Shackleton's chair incidentally portrayed his remarks about the former telephone exchange in Glovers Court.

THE PROPOSED POST OFFICE STANDARD TELEPHONE RELAY FOR AUTOMATIC EXCHANGES.

IN the past few years very considerable progress has been made by the Department in its policy of standardising equipment in automatic telephone exchanges. A standard racking scheme and a standard uniselector have been designed and adopted, and concurrently standard circuits have been produced in a large number of cases. It was realised, however, that the full benefit of these developments could not be obtained until standardisation of the relay had been achieved, and to this end Messrs. F. I. Ray and A. W. Biddlecombe, of the Engineer-in-Chief's Office, were instructed to study the relay problem and to produce a relay (either by design, or by selection or modification of an existing type) to be manufactured by all Contractors as the Department's standard for automatic exchanges.

Valuable co-operation and assistance were given by the various sections of the Engineer-in-Chief s Office and by Messrs. A.T.M. Co., Ericssons, G.E.C., Siemens and S.T. & C. Co., and, as a result, a relay was produced incorporating the experience of many years of automatic exchange maintenance and manufacture.

Requirements of a Standard Relay.—Before proceeding with a detailed description of the special features of the proposed P.O. Standard Telephone Relay, brief consideration will be given to the conditions under which relays are used in automatic exchanges and an outline of the chief qualities they must possess. In a director exchange there may be as many as 100,000 relays and during a single call 200 relays and 1500 contact operations may be involved. Many relays have to operate more than 1,000,000 times per annum and a few have to operate as many as 16,000,000 times per annum. The increased size of exchanges and the extended use of common equipment render it more difficult to localise relay faults, and the greater danger of unguarded intervals necessitates a considerable degree of accuracy and uniformity in relay time lags. From these facts it will be understood why, for some time, it has been felt that reliability and uniformity of operation, accessibility and ease of adjustment are qualities of the utmost importance to the Department, since maintenance costs loom large in the balance sheet of an automatic exchange and since a high quality service is needed. A low first cost is of course essential although this must be considered in conjunction with the running costs; for example, battery consumption must be considered, since a cheap but less efficient relay may materially increase the power costs.

The space occupied by the relay should be as small as possible, consistent with maintenance accessibility, but on the other hand facilities must be provided for fitting a reasonable number of springs to avoid the necessity of employing relief relays. In considering the question of space saving it must also be appreciated that in most cases the relays are to be mounted on the same standard base plate as a selector mechanism, *e.g.*, on the group and final selectors. In such cases a saving of even 25% in relay space would only have the effect of decreasing the height of the racks by a few inches and would not permit an extra shelf of selectors to be fitted on the same racks. Consequently it is only on the larger but less frequently used type of apparatus, such as directors and senders, that any substantial space saving would result from the use of a smaller type of relay. Line and cut-off relays present a special case, however, and justify the provision of a smaller type of relay, which is now being developed. The fact that the standard telephone relay must be mounted on a standard selector base has imposed a limitation on its size since two relays must fit side by side within the width of the base plate. This restricts the maximum width of the relay to just over two inches.

Magnetic Circuit.—In considering the proposed P.O. standard relay the first point to be mentioned is its high magnetic efficiency. This is vitally important, because it permits heavy contact pressures to be used and so decreases the risk of contact failure. Magnetic efficiency also permits the use of large residual air gaps and so lessens the possibility of armatures failing to release. Another advantage is that fewer ampere-turns are required to carry a given spring load and, consequently, a winding of higher resistance can be employed with a saving in current consumption.

Magnetic tests made by the Research Section have shown that the magnetic circuit of the Siemen's type knife-edge relay is extremely efficient, and this magnetic circuit has therefore been adopted in the standard relay (Fig. 1). It consists of three pieces, the core over which the coil is wound, the yoke or "heel piece," and the armature. At the front end of the core is welded a round disc of soft iron which provides a pole-face of large cross-section, and so decreases the magnetic reluctance between the core and the armature. The yoke also is provided with an enlarged end which is machined into a knife-edge on which the armature pivots. It will be seen from Fig. 1 that the armature is shaped into a special V bend so that it fits fairly closely over the knife-edge, thus ensuring a low reluctance joint between the armature and the yoke or "heel piece." The only other magnetic joint is that between the yoke and the core, and in order to ensure low reluctance while permitting the core, complete with its winding, to be readily withdrawn without removing the relay from the mounting plate, the method of securing the core to the yoke has been specially designed. The proposed arrangement consists of a

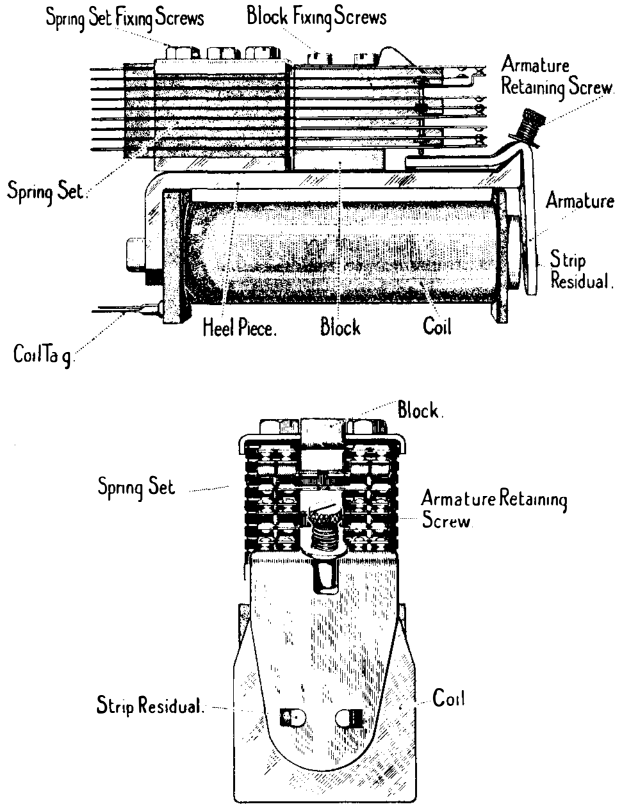


FIG. 1.—THE PROPOSED P.O. STANDARD TELEPHONE RELAY.

flanged nut running on a threaded portion of the core which passes through a clearance hole in the yoke, the yoke itself being recessed to accommodate the flanged portion of the nut. The relay is mounted by means of two screws inserted from the back and threaded into the heel piece quite independently of the core fixing nut.

The Research Section's tests also showed that the anti-corrosion finish of the metal parts greatly effects the magnetic efficiency. Hitherto zinc plating has been extensively employed, but this material, which is non-magnetic, has to be deposited in rather a thick coat and tends to " build up " at the edges. The result is that the zinc protected relays have low impedance at speech frequencies and poor magnetic joints. Nickel, although not as good an anti-corrosion protection as zinc, is highly magnetic, and this metal has therefore been adopted on the proposed standard telephone relay. The use of a very thin deposit or " flash " of cadmium underneath the nickel to improve the protective qualities of the finish, is being considered.

When determining the most desirable form of magnetic circuit the question of magnetic interference between adjacent relays must be considered. To save space, relays must be mounted close to one another and consequently there is a risk that some of the flux produced by the coil of one relay may affect the armatures of adjacent relays. It therefore follows that the performance of a relay may be altered to some extent by the energisation of adjacent relays as regards both sensitivity and speed of operation or release. If the amount of interference be large, great care is necessary on the part of the circuit designers in specifying the position and polarity of all the relays so that the functioning of a circuit is not adversely affected by the operation of groups of relays in all the possible combinations, not forgetting of course the possible interference from relays in other circuits that might be mounted on the same base plate. Further, when a maintenance officer is readjusting a relay, he must make certain that it is not being affected by the flux from other relays, otherwise the readjustment he applies will be incorrect. Cases of magnetic interference have already occurred with a certain existing type of relay, necessitating the removal of the relays affected away from their associated equipment.

It has been suggested that magnetic interference may be advantageous, since a clever designer can make use of it to improve the circuit operation. Thus, a relay could be made more sensitive by placing it near to some other relay that is energised simultaneously, so arranging the polarity of the coils that the leakage flux tends to operate the relay concerned. Such a procedure, however, is dangerous as the correct functioning of the circuit would be jeopardised if a maintenance officer, in replacing a disconnected coil, were to transpose the connections and so alter the polarity, or if the conditions for correct interference were to be altered by modifications to the equipment. It is therefore safer as well as simpler to use a type of relay in which magnetic interference is as small as possible.

The more efficient the magnetic circuit, the smaller the amount of leakage flux and consequently the smaller is the amount of magnetic interference; another factor is the proximity of the armature of one relay to the coils of others. Tests have shown that the amount of flux leakage with the Siemens' knife-edge magnetic circuit is particularly small and this is an additional reason for its adoption in the standard relay.

As has been mentioned previously, the increased magnetic efficiency permits the use of a large residual air gap between the armature and the core when the relay is energised. In certain cases this gap must be adjustable to permit the releasing lag to be controlled, and in such cases a small screw is placed in the armature, the tip projecting into the air gap a sufficient distance to provide the required clearance when the armature is operated. This arrangement suffers from the disability that the area of contact between the tip of the screw and the core is very small, and consequently wear takes place causing the residual air gap to be gradually decreased. The effect of this wear has been minimised in the proposed standard relay by fixing a minimum gap of 4 mils, and also by the design of the relay which ensures that the residual screw strikes the core perpendicularly. Whenever an adjustable residual screw is not essential, it is better to employ a strip of non-magnetic metal foil instead of a screw, as by this means the area of contact can be increased. In the standard relay two holes have been made in the armature (Fig. 1) to provide a fixing for this strip, for which thicknesses of 4, 12 and 20 mils have been proposed. To facilitate identification it has been arranged that the 4 and 20 mil strips should be of phosphor bronze and the 12 mils strip should be of nickel silver.

The relay is normally mounted with the springs at the side as shown in Fig. 2, since experience has

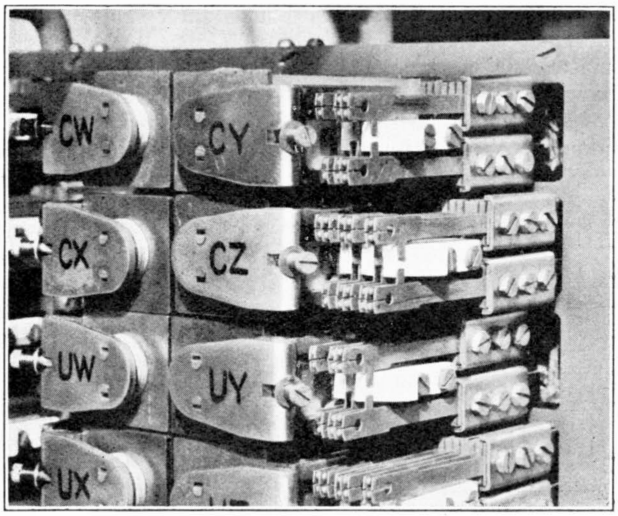


FIG. 2.—P.O. RELAYS MOUNTED. EARLY EXAMPLES AT SHEPHERDS BUSH EXCHANGE.

shown that in that position the fault liability of the contacts is a minimum. Means must, however, be provided to prevent the armature falling away from the knife-edge. This is effected by an armature retaining screw fitted with a spring loaded washer. (Figs. 1 and 3). When in position the spring is compressed and therefore thrusts the armature against the knife-edge. The lower part of this screw is of slightly larger diameter than the hole in the washer, so that the washer and spring will not fall off when the screw is removed. It will be appreciated that the function of this armature retaining screw is merely to hold the armature against the knife-edge when the relay is demagnetised, since the combined forces of the spring pressure and the magnetic pull will assuredly hold the armature in position as soon as magnetisation commences.

Spring Assembly.—The space available for the springs is limited by the necessity of mounting two relays side by side on a standard mounting plate; also, the distance between successive springs and between adjacent piles of springs must be sufficient for visual inspection, and for the insertion of adjustment tools. In view of these requirements it was decided to restrict the number of spring piles per relay to two, and to permit no more than nine springs to be assembled in any pile. The distance between adjacent springs is 55 to 60 mils and a very simple spring bender has been designed to facilitate adjustment, the corners of the front cheek being cut off in the latest design, as in Fig. 1, to give ample room for the manipulation of such adjusting tools.

Each pile of contact springs is formed into a unit, being held together by the central of the three screws provided, the others serving to secure the pile rigidly to the yoke (Fig. 3). The clamping plates and insulators have been made of ample dimensions to give a rigid assembly, while the insulators are arranged to project through the mounting plate to decrease the danger of contact faults being caused by spring tags touching or being bridged by pieces of solder, etc. The insulators are of the half-sheared type, which render the spring

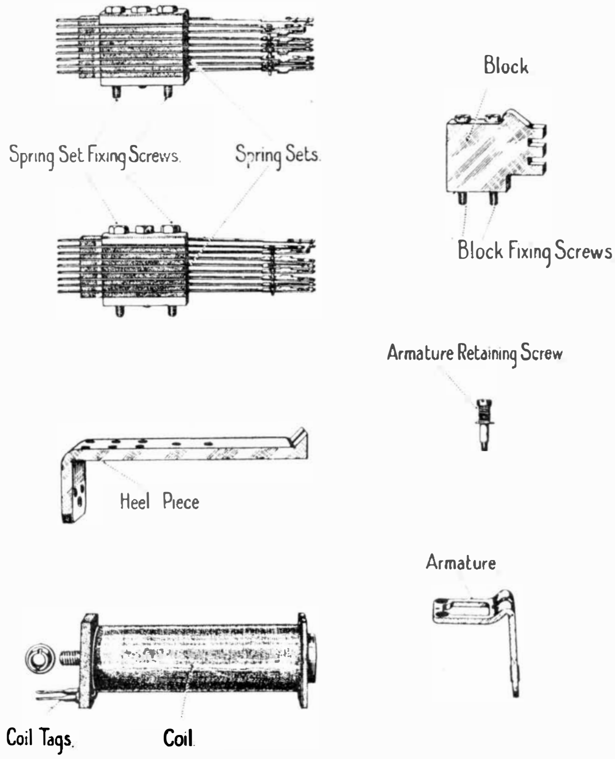
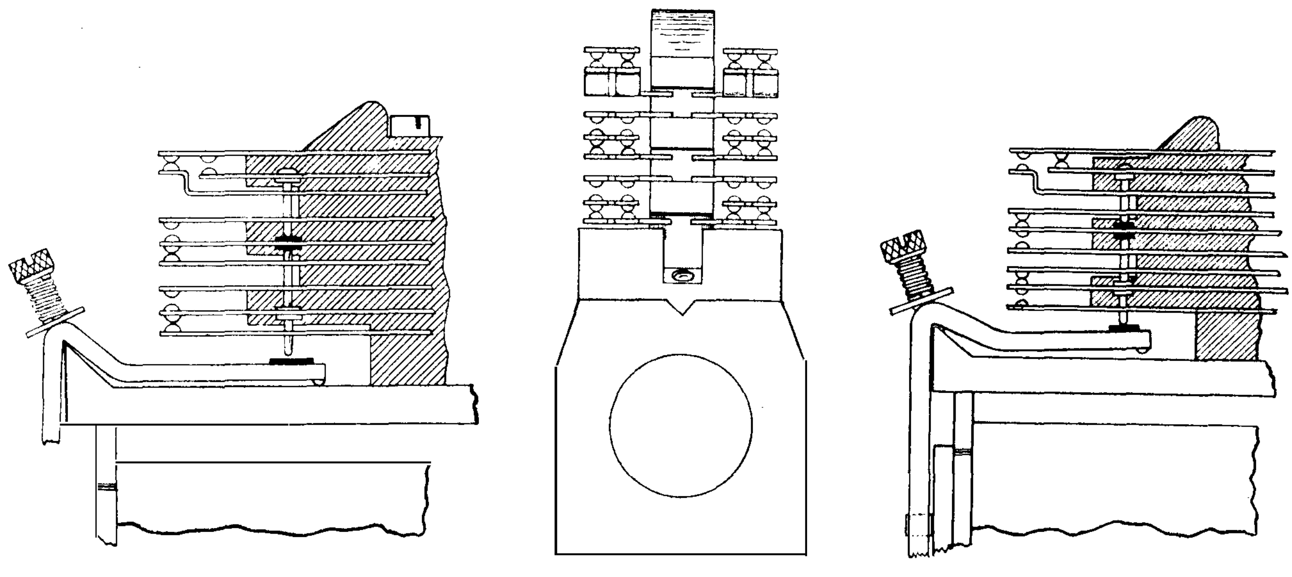


FIG. 3.—ASSEMBLY DETAILS OF P.O. RELAY.

pile self-locking, and so make assembly easier than with some earlier type springs which were threaded over ebonite tubes through which the fixing screws were passed. Except for heavy duty contacts which will be of platinum, twin silver contacts are proposed, since tests have shown that their fault liability is only a small fraction of that of single or double contacts of any other material.

The actual shape of the contact springs adopted is closely bound up with the method of adjustment to be employed. Except in the case of relays which have to meet some marginal circuit requirement (and with sound circuit design such cases should not occur frequently) the sole object of adjusting a relay is to ensure that when the contacts are closed the pressure between them is adequate, and that when they are separated the distance between them is sufficient. Hitherto, the most common method of adjustment has been by specifying that individual contacts shall touch when a feeler gauge of a given thickness is inserted in the armature air gap and the armature is attracted. For example, it might be specified that with a 4 mil gauge a pair of " make " contacts should just touch; then, if the ratio of movement of the contacts to the movement of the armature is 3:1, the contacts will move through a distance of $3 \times 4 = 12$ mils when the relay operates fully. This displacement will result in a certain pressure between the contacts, the value of which depends upon the thickness, shape and material of the contact springs. This process, known as "gauging," is not sufficient by itself, adjustable resistance in series with the coil of the relay, a process which, in view of its practical maintenance difficulties, may well be avoided except for meeting special marginal conditions of operation.

It was therefore considered preferable to adopt a scheme in which the contact pressures were obtained by direct measurement and in which adequate contact opening was obtained by the design of the relay rather than by the adjustment of the contact springs. The spring set which has been specially designed for the purpose has very considerably simplified the adjustments, representing an advantage to the manufacturer who can thereby decrease the time required for adjustment in the factory, and to the maintenance officer who has to readjust a faulty relay. On the P.O. relay, a buffer block (Fig. **3**), made of white insulating material, is placed between the two spring sets. The so-called " fixed " springs, both " make " and " break," are provided with projections which rest upon shoulders in this block and



(*a*) Armature unoperated.

(*b*) Front view. Armature removed.

(*c*) Armature operated.

FIG. **4**.

since it does not control in any way the tension of the moving springs or of the break contacts, and consequently it is also necessary to specify operate, and non-operate, currents for the relay—not because the relay has to meet marginal circuit conditions, but as part of the adjustment of the springs. Even so, this method of adjustment fixes only its *total* break contact pressure, and the pressures at individual break contacts are not controlled. " Gauging " is a process which requires considerable care and experience, even when applied to single contact relays on an adjustment bench, and it is still more difficult when twin contacts are used and when the relay is mounted on a rack. Adjustment to an operate current necessitates the insertion of an the springs are tensioned so that a pressure of, say, 30 grammes applied by a pressure gauge at the contact will just lift the projection away from the block. It follows that if, when the relay operates, the projection is just lifted away from the block, then the contact pressure must be at least 30 grammes. A study of Fig. **4** will show that on each change-over spring set, the " break " spring rests on one side of a shoulder and the " make " spring rests on the other. The moving spring lifts the " break " spring off the block when the relay is normal, but changes over and lifts the " make " spring off the block when the relay is energised. The contact opening will depend chiefly upon the distance between the break and make springs and as this distance is fixed by the width of the shoulder of the buffer block, adequate contact clearance is obtained by relay design and is not dependent upon adjustment. The process of adjusting a relay is therefore (i) to tension all make and break springs against the block, (ii) to tension the moving springs so that they will lift the break springs away from the block when the relay is de-energised, (iii) to check that the armature travel is correct, and (iv) to check that the make springs are lifted away from the block when the relay is operated. Adjustments to operate and non-operate currents are required only in cases where special circuit requirements render them necessary, *i.e.,* when a relay must operate under one circuit condition and not under another. With this type of spring assembly the adjustment can be checked roughly by inspection, *i.e.,* by seeing that the fixed springs lift correctly, and can be checked accurately by testing the tension in the fixed springs by a tension gauge, a very simple method, especially as all springs on one relay will have the same tension. The buffer block, being white, forms an excellent background when making such inspections.

For small spring assemblies a block with two shoulders is proposed, giving a capacity of four moving springs (see relays CY and UY in Fig. **2**). In larger assemblies a block with three shoulders is used, permitting six moving springs to be employed. With the relay in its present form it is not possible to use more than six moving springs and this involves a slight limitation upon the circuit designer. It was felt, however, that to exceed this number would be to prejudice the ease of adjustment and therefore to increase the fault liability under service conditions.

Relays which have an adequate operate current and which do not have to be slow to release are fitted with 18 mils nickel-silver springs and adjusted to a standard spring pressure of 30 grammes, measured as described above. For other relays a pressure of 18 grammes and a thickness of 14 mils has been standardised. It is realised that in exceptional cases the circuit conditions would necessitate thinner springs and lower contact pressures and that 12 mil springs with 10 grammes contact pressure might be unavoidable. These should, however, be considered as non-standard. At present it is customary to judge a circuit by the number of relays or contacts that it involves. By adding the third criterion, that the number of non-standard relays should be as few as possible, it is considered that a more accurate method of estimating the relative merits of different circuits would be available and that the number of such special relays would therefore gradually be decreased. The use of springs of different thicknesses on the same relay is avoided, thus reducing the number of types of assembly to be manufactured or to be stocked by the department for replacement purposes.

Contact Bounce.—In the design of the proposed P.O. Standard Relay, special attention has been paid to contact bounce. When the circuit of a relay is disconnected and the flux begins to decay more or less rapidly according to the presence or absence of slugs, short-circuited windings, etc., a stage is reached when the pull of the armature is less than the restoring force of the springs and the armature begins to return to normal. As soon as the make contacts open, however, a large part of the restoring force is removed and, unless the flux decay has been extremely rapid, the pull on the armature will momentarily exceed the restoring force. The movement of the armature is therefore checked, but the armature does not stop instantly, owing to its inertia, and so an oscillation is set up causing the contacts to be opened and closed momentarily. This results in what is usually called " contact bounce." The effect is particularly noticeable on a slow releasing relay, owing to the slow collapse of the flux. It has been found possible to prevent this oscillation of the armature by placing a copper plate near it and this plate has been incorporated in the standard relay, being threaded over the core and adjacent to the pole face, where it also acts as a front cheek for the relay coil. The movement of the armature and the current in the contacts of a relay with and without this copper plate are shown in oscillograms in Fig. **5**. This plate is intended for use on all except high impedance relays.

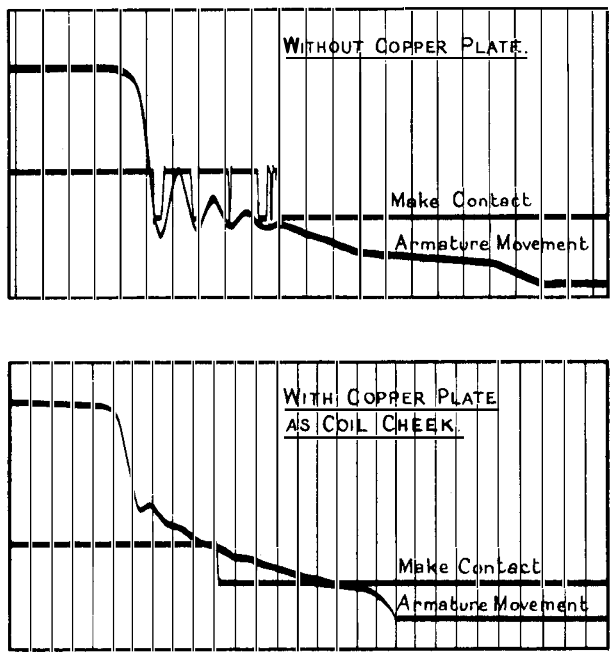


FIG. **5**.—CONTACT OPERATION ON SLOW RELEASE RELAY.

Service trials.—At various stages in the development of the proposed Post Office Standard Telephone Relay a number of samples were produced and were subjected to laboratory tests, but since the final proposals did not involve any radical departures from existing relay practice, it was thought that no good purpose would be served by subjecting a large number of samples to an extensive durability test in the laboratory. It was decided therefore to proceed at once with service trials, and for this purpose five large London Exchanges were equipped with a 4-digit keysender with relays of the proposed standard type. The Exchanges selected were Flaxman, Ilford, Shepherds Bush, Fulham and Primrose, G.E.C., Siemens, Ericssons, S.T. & C., and A.T.M. Co. respectively, and an order was placed with each contractor to manufacture and supply one model shop sample keysender with relays of the new type (Fig. 6). These five samples were then brought into service side by side with the old equipment, special records being taken of all faults that developed in them. The senders at Flaxman and Ilford Exchanges have now been in service for 12 months, having completed 300,000 operations between them, and the others, installed later, have added a further 100,000 operations to date, making a total of 400,000 operations in all.

During this time no relay faults whatever have occurred, nor has it been necessary to interfere with the new relays in any way. This result is striking when it is considered that the average relay fault liability at the five Exchanges for such a number of operations is 18 per sender with existing types of relays. In some respects it is unfortunate that a trial which was intended to reveal the fault liability of the new relays should have given a negative result, since it is obvious that no commercial telephone relay could be entirely immune from faults of one kind or another during its life, but undoubtedly the results obtained during a 12 months service trial of two complete sets of relays working under some of the most onerous conditions in an automatic exchange are of more value than any prolonged laboratory life test which cannot simulate the actual service conditions.

In view of the satisfactory results obtained, orders have now been placed for 100 Rural Automatic Exchanges to be equipped with the proposed Post Office Standard Telephone Relay, and there is no doubt that this step will be fully justified by reduced maintenance costs and higher service efficiency.

R.W.P.

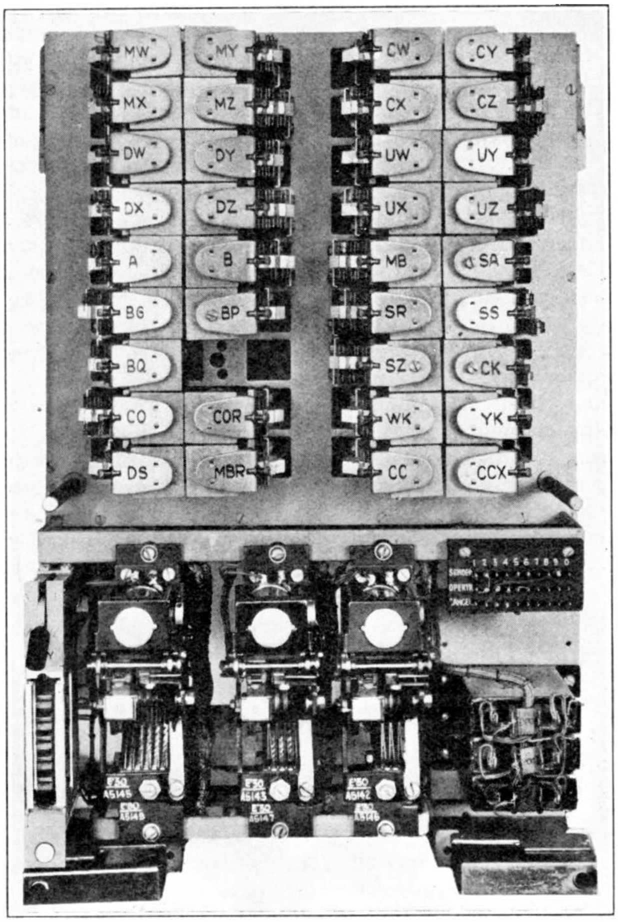


Fig. 6.—Keysender at Shepherds Bush Exchange. (Early samples).

AN OSCILLOGRAPHIC METHOD OF RECORDING MAGNETIC FLUX.

AND SOME RECORDS OF THE FLUX IN TELEPHONE RELAYS.

L. H. Harris, M.Sc., A.C.G.I., M.I.E.E.

THIS article describes an oscillographic method of obtaining records of varying flux. Typical examples of such records are included, showing the flux in telephone relays under various conditions.

In Research Work on electromagnetic relays and similar apparatus the oscillograph affords an excellent means of examining current transients during switching processes. It has been universally used for investigations of impulsing and automatic telephone relay operation generally, including the examination of armature and spring bounce, and in connection with the latter it has been modified to enable the actual movement of the armature and springs to be recorded simultaneously with the coil and contact currents. In general, records of current are neither a measure nor a direct indication of the flux-time characteristics, since the latter are dependent not only on the currents in the windings but on all the current paths (*e.g.,* the core itself) linked with it. Measurements of flux have had to be confined to static conditions and while theory, indirect confirmation of theory and familiarity with the subject give considerable insight into the behaviour of the flux, the need for a ready means of obtaining direct confirmation by an oscillographic method has become increasingly apparent.

Providing a suitable amplifier capable of dealing with very low frequencies (*e.g.,* D.C. impulses at 10 per second) and having a final stage suitable for the operation of the electromagnetic oscillograph is available, the problem of using the latter to record flux reduces to a simple application of well known principles.

Method.—The E.M.F. induced in a search coil linked with a varying flux is proportional to the time rate of change of flux. The flux at any instant is therefore proportional to the time integral of the search coil voltage.

If the search coil voltage is employed to charge a condenser sufficiently large through a resistance sufficiently high to render the condenser voltage negligible compared with the search coil voltage, then the charge current to the condenser will be proportional to the search coil voltage and the condenser charge (and therefore voltage) will be proportional to the time integral of the search coil voltage. The P.D. of the condenser will therefore be proportional to the flux. Amplification of this condenser P.D. to suit the oscillograph then enables records of flux to be made simultaneously with currents or voltages.

An alternative to this large condenser and resistance method of integrating a variable voltage is the similar one of using a large inductance of low resistance, in which case the current flowing is approximately proportional to the time integral of the voltage. These methods have been described at various times in connection with schemes which have been developed for recording hysteresis loops and for which reference can be made to E. L. Bowles, J.A.I.E.E., p. 849, 1923, Charlton and Jackson, J.A.I.E.E., p. 1,220, 1925, and J. B. Johnson, Bell System Journal, p. 286, VIII., 1929.

Theory of Integrating Circuit.—The instantaneous E.M.F. induced in a search coil by a varying flux ϕ is given by

$$v = -N\frac{d\phi}{dt}$$ where N is the number of turns on the search coil.

Applying this E.M.F. to a circuit consisting of a high resistance R and a large capacity C in series gives:

$$\frac{q}{c} + Ri = -N\frac{d\phi}{dt}$$

where q and i are the instantaneous values of the condenser charge and current respectively. Since $i = \frac{dq}{dt}$ this can be rewritten

$$\frac{dq}{dt} + \frac{1}{CR}q = -\frac{N}{R}\frac{d\phi}{dt}$$

The solution of this differential equation is

$$q\epsilon^{\frac{t}{CR}} = A - \int \frac{N}{R}\frac{d\phi}{dt}\,\epsilon^{\frac{t}{CR}}\,dt$$

where A is a constant depending on the initial condition of the circuit.

In any practical case ϕ can be expressed as a Fourier series thus:

$$\phi = \Phi_0 + \sum_{n=1}^{n=\infty}(\Phi_n \sin n\omega t + \Phi_n \cos n\omega t)$$

where n is made successively equal to all the positive integers and Φ_0 is the arithmetic mean value of the flux.

Differentiating the flux gives:

$$\frac{d\phi}{dt} = \sum_{n=1}^{n=\infty} - \Phi_n n\omega \sin n\omega t + \Phi_n n\omega \cos n\omega t$$

and the solution of the above differential equation now becomes:

$$q\epsilon^{\frac{t}{CR}} = A - \frac{N}{R}\int \epsilon^{\frac{t}{CR}} \sum_{n=1}^{n=\infty} n\omega\,\Phi_n(\cos n\omega t - \sin n\omega t)\cdot dt.$$

Now $$\int \epsilon^{\frac{t}{CR}} \sin n\omega t \cdot dt = \epsilon^{\frac{t}{CR}}\frac{CR}{1+\omega^2n^2C^2R^2}(\sin n\omega t - \omega n CR \cos n\omega t)$$

and $$\int \epsilon^{\frac{t}{CR}} \cos n\omega t \cdot dt = \epsilon^{\frac{t}{CR}}\frac{CR}{1+\omega^2n^2C^2R^2}(\cos n\omega t + \omega n CR \sin n\omega t)$$

Substituting these values and dividing throughout by $\epsilon^{\frac{t}{CR}}$ gives:

$$q = A\epsilon^{-\frac{t}{CR}} - \sum_{n=1}^{n=\infty}\frac{N}{R}\frac{CR\omega n}{1+\omega^2n^2C^2R^2}\Phi_n[(-1+\omega nCR)\sin n\omega t + (1+\omega nCR)\cos n\omega t]$$

Supposing ωnCR is large compared with unity this becomes

$$q = A\epsilon^{-\frac{t}{CR}} - \frac{N}{R}\sum_{n=1}^{n=\infty}\Phi_n(\sin n\omega t + \cos n\omega t)$$

As the second term is proportional to the variable part of the flux it will be seen that the accuracy with which the condenser voltage follows the flux variation depends on the values of the capacity and resistance used and on the fundamental frequency of the flux variation. With 20 μF and 100,000Ω at 10 p.p.s. $\omega CR = 125$, showing that the departure from true integration of the search coil voltage at impulsing speeds is small as regards the fundamental of the flux and smaller still as regards the harmonics.

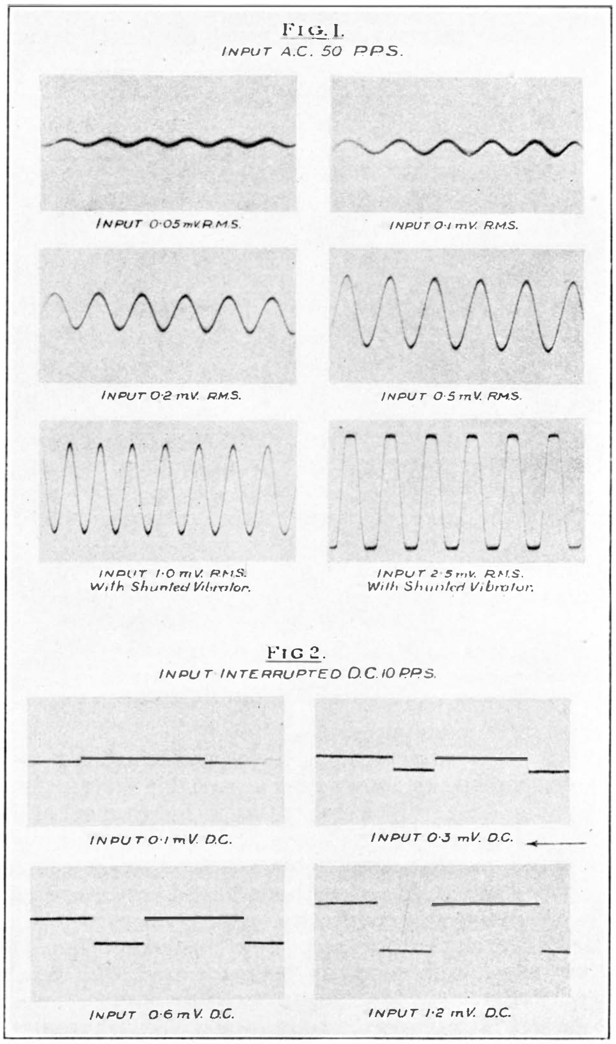
The term $A\epsilon^{-\frac{t}{CR}}$ represents the transient condition due to the condenser being initially discharged when the flux has a definite value $\Phi_0 + \sum_{n=1}^{n=\infty} \Phi_n$ at $t = 0$. Where tests of a continuously repeated nature are being made, this term has no effect after the first few seconds, since it has by then become zero, but it is important when it is desired to test a condition which is not continuous and which persists for sufficient time for $\epsilon^{-\frac{t}{CR}}$ to depart appreciably from unity. When the test consists of a single operation occupying a small time compared with the value of CR seconds, the error introduced by this term may be neglected.

Amplifier.—Neglecting the flux harmonics the condenser P.D. is of the order of $\frac{N\Phi_1}{RC} \times 10^{-8}$ volts which with a search coil of 50 turns, $\Phi_1 = 2000$, $R = 100{,}000$ ohms and $C = 20\ \mu F$, gives 0.5 millivolts. This P.D. is applied directly to the grid of the first stage of an amplifier, the anode circuit of the fourth stage of which is connected directly in series with the oscillograph vibrator. The latter has a sensitivity of the order of 40 mA per cm. and the last stage was therefore made capable of dealing with overall variations of the order of 80 mA (2 cms.) by using four L.S.5 valves in parallel and a battery voltage of 300. The first three stages consist of valves H.L.610 (amplification factor = 40) with capacity resistance couplings comprising 160,000Ω anode resistances, 5 μF coupling condensers (of high insulation resistance) and 2 MΩ leaks. The amplification per stage given by these valves when used with a 150 volt battery and 160,000 ohms anode resistance is of the order of 25. The large time constant of the couplings (10 secs.) enabled the amplifier to be used down to 10 cycles per second without appreciable distortion. Owing to the large filament current taken by the power stage (4 × .8 amps) and the effect of the large emission on the filament brightness it was found beneficial to use a separate filament battery (6 v.) for the first stage. The use of decoupling resistances and condensers in the anode supply to each stage was found to affect the characteristics adversely and a separate 150 volt battery was therefore used to supply the first stages instead of tapping the 300 volt power stage battery.

Grid bias was provided on the first stage by direct connection *via* the integrating resistance and search coil to the earthed negative of the filament battery and on the second and third stages by utilizing the voltage drops in resistances used to supply the 6 volt valves from an 8 volt battery. A grid bias battery variable up to −36 volts was provided for the power stage.

The first three valves were packed in cotton wool inside cardboard and lead cylinders for acoustic and electrostatic screening and the whole assembled in a subdivided screened box, the batteries also being screened separately.

Performance of Amplifier and Oscillograph.—Fig. 1, Sheet I., shows the overall performance of the amplifier and oscillograph. The input consisted



SHEET I.—PERFORMANCE OF AMPLIFIER AND OSCILLATOR.

of A.C. of 50 p.p.s. having values of 50, 100, 200, 500, 1000 and 2500 R.M.S. micro-volts; with the last two voltages the vibrator was shunted by 20Ω. The oscillograms show that saturation of the last stage occurs with an R.M.S. input of about $1\frac{1}{4}$ millivolts, but the wave tends to become unsymmetrical before this value is reached. By limiting the overall width of records to approximately 2 cms., distortion due to overloading may be neglected.

As the magnetic properties of relays at ringing or impulsing frequencies was of particular interest, the frequency characteristic of the amplifier was tested by means of 10 p.p.s. square topped input voltage. Fig. **2**, Sheet I., shows the results obtained when the overall voltage change on the input grid was 0.1, 0.3, 0.6 and 1.2 millivolts.

The evidence of Figs. **1** and **2**, together with similar oscillograms and measurements, indicated that the amplifier could be relied upon to give a record of the integrating condenser P.D. with satisfactory accuracy.

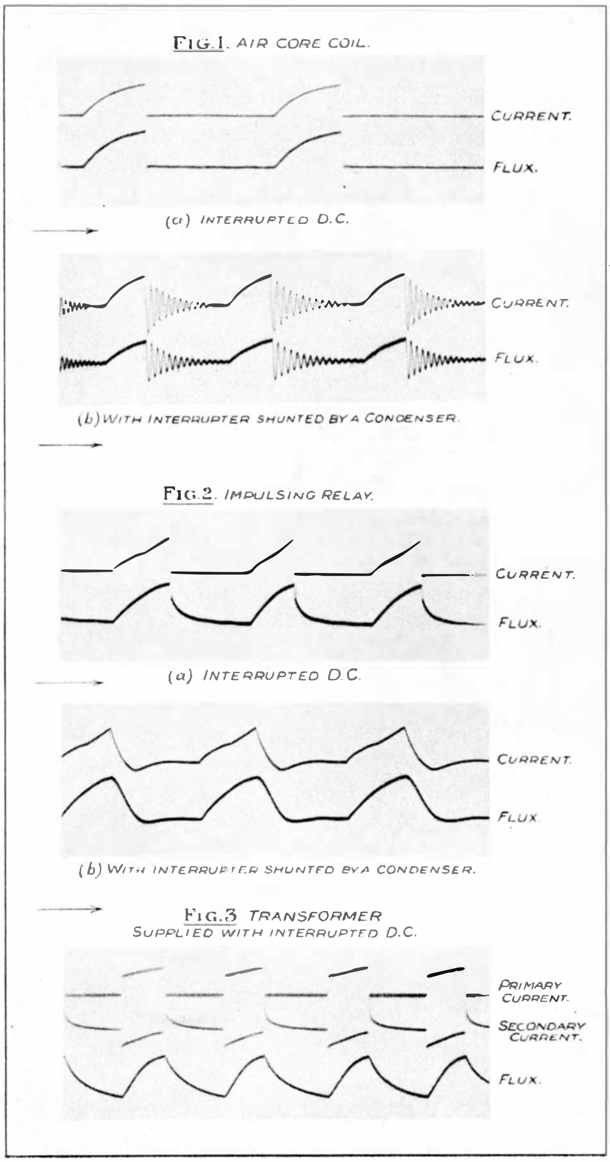
Check of Method.—Comparison of simultaneous records of the current and the flux of air cored coils in which, in the absence of eddy current paths and secondary circuits, the flux and current waves are identical, gives an experimental means of checking the overall performance of the method.

Fig. **1** (*a*), Sheet II., shows the current and flux for an air cored coil when supplied with interrupted D.C. at 10 I.P.S. Fig. **1** (*b*), Sheet II., is similar but includes the oscillation that occurs at break when the interrupter contacts are shunted by a condenser. The records indicate that the apparatus is capable of reproducing repeated flux waves embodying frequencies as low as 10 periods per second and at least as high as the oscillograph vibrator (3000 periods per sec.) warrants. Records of single impulses lasting 200 milliseconds served as a further check for the reproduction of a flux wave lasting a small time compared with the time constants of the integrating circuit and amplifier couplings.

Examples of Flux Records using Iron-Cored Coils.—Oscillograph records of current and flux for various conditions occurring frequently in telephone practice have been obtained with the object of examining the possibilities and limitations of the method and at the same time obtaining information as to the mode of flux variations not previously possible by direct means.

The Impulsing Relay of the Strowger Impulsing Circuit.—Fig. **2**, Sheet II., shows the current and the flux in the case of this relay under impulsing conditions. Fig. **2** (*a*), Sheet II., refers to the condition existing when the interrupter contacts are connected directly in series with the battery and the relay winding, while Fig. **2** (*b*), Sheet II., refers to the more usual condition in which a 2 μF condenser is connected across the interrupter contacts. In the first case the flux is dependent solely on the M.M.F. of the circulating currents in the iron since the winding current drops instantaneously to zero. The flux curve at " break " therefore shows an initial sudden drop (due to the disappearance of the leakage flux) followed by a slower decay dependent on the circulating currents. In the second case the flux is dependent on the sum of the M.M.F's of the condenser current and circulating currents. The effects of saturation and the core currents are well shown by the difference between the current and flux curves.

Interrupted D.C. applied to a Transformer.—This provides an example of current records which are no direct indication of the flux, owing to the latter being dependent on the sum of the M.M.F's of the two windings. If the coupling between the windings is complete, the primary current rises instantaneously at " make " to $\frac{T_2}{T_1 + T_2}$ of its final value where T_1 and T_2 are the primary and secondary



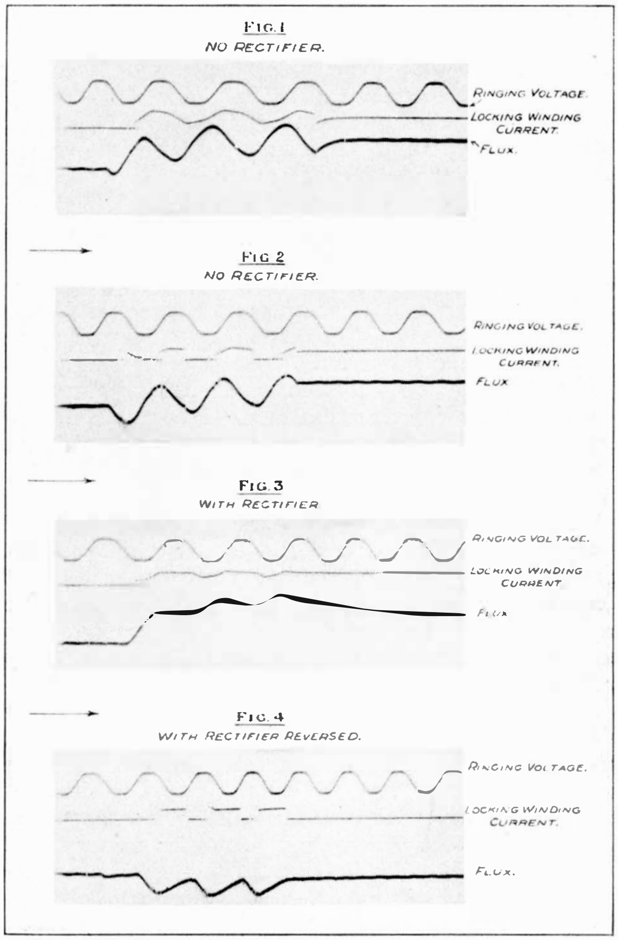
SHEET II.—THE CURRENT AND FLUX IN VARIOUS INDUCTIVE CIRCUITS WHEN SUPPLIED WITH INTERRUPTED D.C.

time constants, and then, assuming constant permeability, grows logarithmically (time constant $T_1 + T_2$) to its full value $\frac{E}{R_1}$, and finally drops instantaneously to zero at " break." The secondary current also rises instantaneously at " make " to a value $\frac{E}{R_2} \frac{T_2}{(T_1 + T_2)} \times \frac{n_1}{n_2}$ where n_1 and n_2 are the primary and secondary turns. It then dies away logarithmically (time constant $T_1 + T_2$) until " break " when it rises instantaneously to $\frac{E}{R_1} \frac{n_1}{n_2}$ on the transfer to the secondary of the primary M.M.F. Finally, the secondary current dies away logarithmically, the time constant being T_2. Unlike the currents, the flux cannot rise instantaneously and therefore obeys a law at " make " of simple logarithmic growth from zero to its maximum value, the time constant being $T_1 + T_2$, while at " break " the time constant of the decay is T_2. Fig. **3**, Sheet II., illustrates the primary and secondary currents and the flux on connecting interrupted D.C. to the primary of a repeating coil having a short-circuited secondary. In this particular record the " make " period was not quite sufficient for the primary current and flux to rise to their full values.

The Operation and Locking of a Relay Shunted by a Rectifier when supplied with Ringing Current.—In connection with another investigation which referred to the use of ordinary D.C. relays shunted by a rectifier as A.C. relays, the opportunity was taken of examining the flux and current on operation under various conditions. Each of the oscillograms on Sheet III. shows the applied voltage, the locking winding current and the flux when about 3 cycles of A.C. at 16 periods per second (flat topped) are applied to the operating winding of a relay having a second winding supplied with D.C. *via* its own " make " contact. The irregularities in the flux curves are due to the direct pick up by the amplifier of the inductive voltages due to the chattering contacts carrying the locking winding current. Figs. **1** and **2**, Sheet III., are two examples taken without a rectifier. Fig. **1**, Sheet III., shows the operation when at the instant of switching on the A.C., the point in the cycle is favourable to quick locking. Fig. **2**, Sheet III., shows the operation where the relay first operates with the A.C. M.M.F. in a direction opposed to that of the locking winding and also shows the irregularities consequent on the chattering of the contacts due to the opposing M.M.F's. The use of a rectifier shunt on the operating winding of the relay (connected with correct polarity) ensures that the operating M.M.F. is of the same sign as that of the locking winding and therefore avoids the trouble shown in Fig. **2**. The flux growth with a rectifier is shown in Fig. **3**, Sheet III., where the satisfactory quick operation of the locking winding is apparent. Fig. **4**, Sheet III., is a record obtained with the rectifier wrongly connected and it will be seen that the relay failed to lock during the 3 cycles for which the A.C. was applied. After the locking winding has been closed by the contact, this winding acts as a secondary winding short-circuited through a battery and it has therefore ringing current superimposed on the D.C. until the operating winding is disconnected. This is well shown in Figs. **1** and **3** of Sheet III.

The C Relay of the Strowger Impulsing Circuit.—This relay is of low resistance (4Ω) and works in series with the switch magnet (46Ω). It receives therefore from 1 to 10 impulses of one ampere and is designed to come in on the first and hold in until after the last impulse.

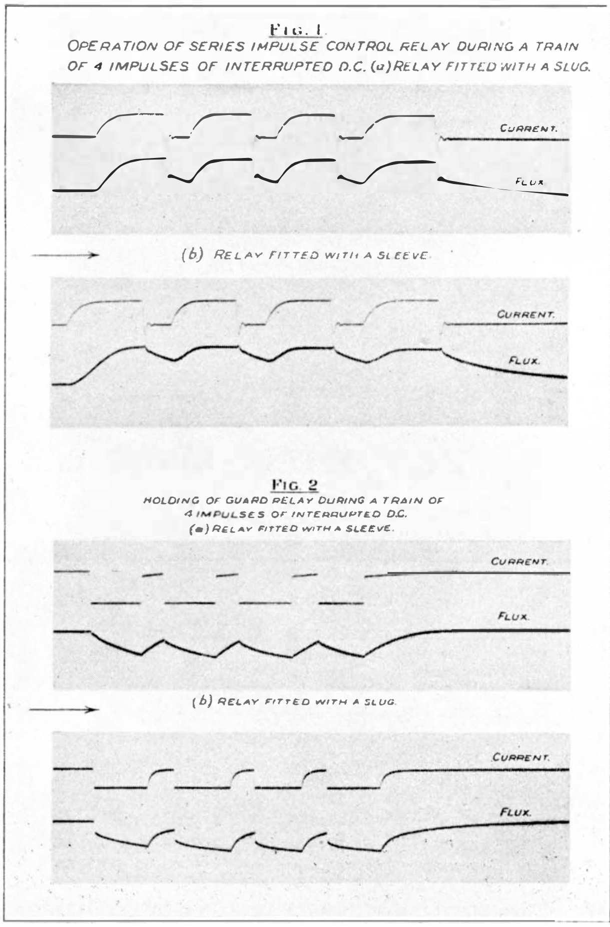
The current in the circuit is determined almost entirely by the magnet since this preponderates both in resistance and inductance. The C relay is fitted with a small slug or a sleeve to enable it to hold over the no current periods of about 38 milliseconds



SHEET III.—OPERATION ON 3 CYCLES OF RINGING CURRENT OF A RELAY WITH A D.C. LOCKING WINDING. EFFECT OF A RECTIFIER SHUNT.

duration. Fig. **1** (*a*), Sheet IV., shows the current and flux in a slugged relay during a train of 4 impulses. It will be seen that the relay flux on " make " rises with the circuit current and reaches its maximum soon after the current. The relay flux on make is therefore chiefly dependent on the time constant of the vertical magnet and not on the time constant of the slug as is the case if the latter is completely coupled with the winding. On " break " the current drops to zero, accompanied by the quench oscillation, while the leakage flux of the relay similarly decays in phase with this oscillation. The flux coupled to the slug subsequently dies away at a slow rate, depending on the time constant of the slug, but not to a value sufficiently small for the relay to release. On the next " make " the flux again rises from the minimum value reached to the same maximum as before.

In the case of the sleeved C relay, Fig. 1 (*b*), Sheet IV., the coupling is almost complete and, although the winding current is still largely determined by the switch magnet, the relay flux now lags considerably behind the current. At each " break " of the current the M.M.F. of the winding is transferred almost completely to the sleeve, the leakage flux is negligible and instead of a sudden drop occurring in the flux curve, as in the case of the relay fitted with a slug, the flux now decays logarithmically until the next " make."



SHEET IV.—OPERATION OF GUARD AND SERIES IMPULSE CONTROL RELAYS OF STROWGER IMPULSING CIRCUIT.

The above disproves the generally held idea that the flux curve in the C relay is of the form of a rising saw tooth. It appears that in predicting this shape the most important effects of the 46Ω switch magnet itself and the leakage in the series (slugged) relay have been neglected, while the effect of saturation of the iron cannot be neglected in this case without further deviation between theory and practice.

Saturation complicates the process of flux and current growth and decay to a very marked extent. If the time constant of the winding predominates, as compared with those of the other coupled circuits, the growth of flux on closing the winding circuit is relatively quicker than the growth of current, while on the decay due to the equivalent condition of short-circuiting the winding the flux decays relatively more slowly than the current. If secondary circuits are present, the same applies to the relative rates of growth of the M.M.F. and the flux, but the winding current is now no indication of the rate of growth of the M.M.F. Under the same condition of energisation as of de-energisation (*e.g.*, removal or application of a short-circuit to the winding which, in the case of constant permeability, would give precisely the same growth and decay curves) the flux growth is more rapid than the flux decay, showing that the equivalent time constants of the various current paths are different for the two cases, while in the case of a relay further variation is of course introduced due to the reluctance altering on operation.

The " B " Relay of the Strowger Impulsing Circuit.—In this case a high resistance relay fitted either with a heavy copper slug or sleeve is required to hold after initial saturation when its circuit is interrupted during impulsing. The current and flux curves are shown in Figs. 2 (*a*) and 2 (*b*), Sheet IV., for the case of a relay fitted with a sleeve and a slug respectively. The difference in the current curves is of interest, as it shows the closeness of the coupling between the sleeve and the winding, as compared with the slug. The flux being almost completely linked in the former case, the current can rise instantaneously to a large fraction of its full value, while in the latter case logarithmic rise is necessitated by the considerable leakage flux. The completeness of the linkage between winding and sleeve is also well shown in the record of flux. The curve at each break is continuous, indicating a complete transfer of the M.M.F. of the winding to the sleeve instead of a sudden drop due to the disappearance of the leakage flux as in the case of the slugged relay.

It will be seen that for both slugged and sleeved relays the flux at the end of the first break is higher than at the end of the second, but no further marked decrease is noticeable for succeeding breaks, even allowing for slight drift of the spot due to the finite time constants of the integrating unit and the couplings of the amplifier.

Interference.—The apparatus was used in a laboratory where inductive disturbances were considerable and it was found impossible to eliminate this with the present apparatus in all cases. The most serious type of interference, however, was that arising from the apparatus under test when the conditions were such as to produce a high inductive E.M.F. This E.M.F. occurs necessarily at an important instant in the flux curve and therefore has a masking effect on the flux record. The use of screened leads, spacing the amplifier and the apparatus under test and the use of an earthed search coil, minimised these effects.

. . . .

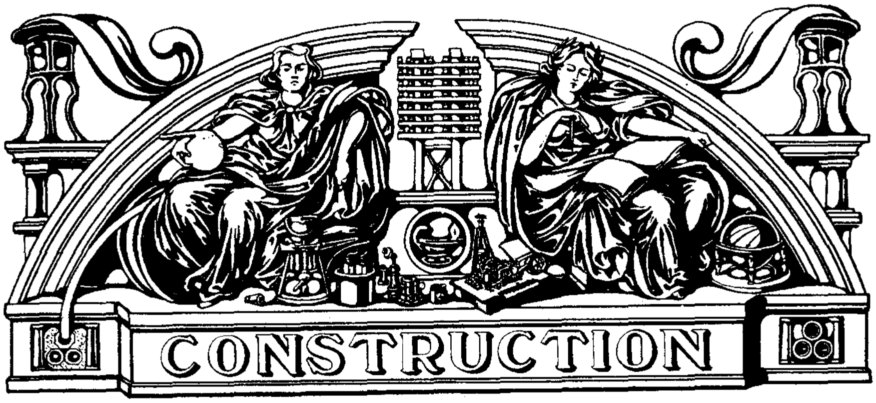
Although the foregoing is mainly concerned with the operation of telephone relays, the method itself should be of wider interest since the necessary amplifier and integrating circuit may be regarded as a useful oscillograph accessory which widens still further the scope of this already indispensable instrument.

The above work was carried out in the Engineering Research Laboratories of the G.P.O. at Dollis Hill.

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, 1931.

No of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
719,538	593	3,941	52,899	130	London	25,436	107,399	2,872,004	58,552
96,800	2,227	21,282	72,676	3,149	S. Eastern.	4,169	73,942	314,243	29,349
101,062	4,446	34,310	71,155	3,998	S. Western.	23,176	22,117	228,850	66,792
82,192	6,247	40,206	75,718	7,195	Eastern.	24,683	52,259	177,682	60,106
113,465	8,555	47,006	69,480	4,819	N. Mid.	36,075	77,434	297,603	91,490
100,959	4,785	32,458	84,883	4,047	S. Mid.	15,000	43,546	256,805	88,617
64,762	4,456	30,612	63,178	3,587	S. Wales.	8,006	34,889	153,568	64,117
124,918	7,965	27,473	60,183	4,603	N. Wales.	14,312	42,423	352,723	132,676
176,330	1,369	15,748	46,076	3,286	S. Lancs.	15,541	95,943	569,460	64,556
105,904	6,094	30,674	53,163	3,813	N. Eastern	16,316	58,370	289,535	64,998
71,904	3,786	23,546	42,784	3,173	N. Western.	8,970	39,502	194,185	39,710
55,304	2,434	16,464	29,283	3,187	Northern.	9,432	26,198	154,466	32,315
25,697	4,385	9,673	15,658	708	Ireland N.	145	3,129	59,629	2,681
76,543	4,594	28,364	45,137	1,522	Scotland E.	7,838	21,780	172,012	52,021
99,161	7,246	26,018	48,094	1,161	Scotland W.	12,005	32,206	253,431	32,202
2,014,539	69,182	387,775	830,367	48,378	Total	221,104	731,137	6,346,196	880,182
1,991,808	69,142	384,215	820,092	47,184	Figures as at 31 Mar., 1931	217,768	711,636	6,215,565	884,133



TRUNK LINE AERIAL CABLE CONSTRUCTION.

LONDON-BRIGHTON EXPERIMENTAL CABLE.

G. W. CRUDDUCK and W. H. BRENT, B.Sc.

As part of the scheme for the introduction of the Demand Trunk Service, it was decided to investigate the possibilities of 4-wire repeater working over aerial cables having conductors of 10 lb. gauge. The London-Brighton route was selected for the trial, and it is thought that a description of the methods employed in adapting the line to the carrying of an aerial cable will be of interest to many readers of this Journal.

The route was first carefully examined and it was decided to lay the cable underground from London to a point near Coulsdon. From this point to Redhill the existing trunk route was suitable for the aerial cable, but through Redhill the open route consists of steel poles in the footpath without proper staying facilities, and the cable was run underground for about two miles to Earlswood Common from whence it was continued overhead to Patcham near Brighton, with the exception of " Grid " Power Crossings and the lead-in and out for the repeaters at Crawley Exchange. From Patcham the underground route was used to Brighton Exchange. An advantage of aerial construction using lead-covered cables is of course that changes can be made from underground to overhead without having any effect upon the characteristics of the circuits.

The overhead trunk route carried, in addition to trunk circuits, a number of junction and subscribers wires, and preliminary work consisted of diverting the trunk circuits to spares in the existing London-Crawley-Brighton underground system and rearranging the remainder to provide adequate headroom for the aerial cable.

The route generally had to be strengthened by the addition of a number of stays and struts, which involved the procuring of a considerable number of wayleaves. As, however, the breaking stress of the suspension strand, upon which the staying required at angles depends, is 12 times that of 150 lb. copper wire, the release of the existing trunk wires reduced to a certain extent the expense of providing stays.

Design.—It was necessary that the aerial cable construction should conform as far as possible to the standard design for this type of route, described in the Technical Instructions for Aerial Lines. These specify for use with cables up to 1.5 lbs. per foot a main Suspension Strand of 7/14 Steel Strand Wire. A calculation of the factor of safety under a wind load of 50 m.p.h. with $\frac{1}{4}''$ thickness of ice gives a factor of 2.34 on a 60 yard span, the weight of this cable being 1.31 lbs. per foot run and as a factor of 2 is regarded as satisfactory, the standard tensions were used for spans up to 65 yards. The following table gives the unloaded tensions of the main strand for various temperatures, together with the tensions and dips which result in a 60 yards span when the cable is in position. The minimum breaking weight of the strand is 5700 lbs.

Temperature.	Unloaded Tension.	When carrying 37 quad 10 lbs. cable.	
		Tension.	Dip.
20°F.	1020 lbs.	1850 lbs.	37.0 ins.
40 ,,	890 ,,	1800 ,,	38.5 ,,
60 ,,	760 ,,	1750 ,,	40.0 ,,
80 ,,	640 ,,	1650 ,,	41.5 ,,
100 ,,	510 ,,	1600 ,,	43.0 ,,

In the case of spans exceeding 65 yards a "Long Span" construction was adopted. This consists of the addition of an auxiliary strand attached to the poles at a suitable distance above the main strand attachments and clamped to the main strand in the centre of the span. Fig. 1 illustrates this method. The problem was to calculate the tension in the auxiliary strand

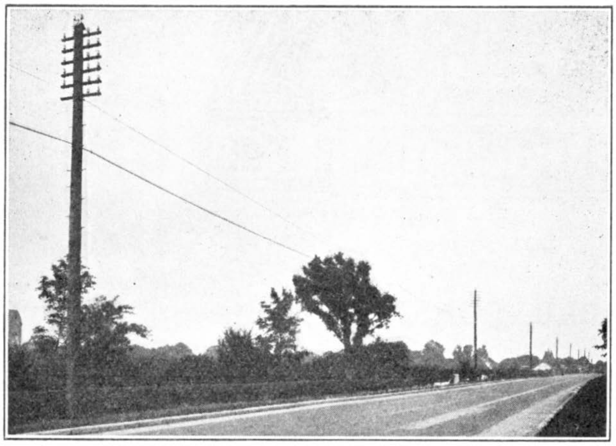


Fig. 1.—Long Span Construction.

when the centre clamp is maintained level with the brackets holding the main strand, and to select a size of strand and separating distance at the poles so that a satisfactory factor of safety is given. With the assumed storm load already referred to, and a separation at the poles between strands of 4 feet, it was found that a 7/12 auxiliary strand wire was required to give a factor of safety of more than 2 and this was therefore worked to generally. In a few cases where the length of span exceeded 75 yards the separation between the Main and the Auxiliary strands at the pole was made 5 to 7 feet. Fig. 2 shows a 90 yard span at Merstham for which 7 feet separation was given. Often, spans below

Fig. 2.—A 90-yard Span at Merstham.

65 yards occurred among a series of 65-70 yard spans and in these cases long span construction was followed to retain continuity, so that such sections run for several miles. A further problem was to provide data for the erection of the auxiliary strand unloaded and in order not to complicate matters for the construction men unduly, one set of tensions to suit all spans had to be given. This results in the centre clamp being rather high for shorter spans and rather low for the longer spans in a section. Measurements on the route after the cable was in position showed that the centre point was with a few exceptions within 6 inches of the correct position and indeed the general aspect of these portions of the route indicate that considerable success was obtained. Apart from the improved appearance of the line it is anticipated that this type of construction will increase the life of the cable by reducing the swaying action of winds. The reduction of the sag of the cable to approximately 2 feet is also a useful advantage.

The cable itself was manufactured by Messrs. Johnson & Phillips and the Pirelli-General Cable Company, who provided the London - Crawley and Crawley-Brighton portions respectively. The sheath is of lead alloy containing approximately 0.8% of Antimony to resist vibrational stresses. The core of paper-insulated 10 lb. conductors is laid up in star quad formation, for which the area occupied by the conductors is some 40% less than the corresponding multiple twin type, thus giving a much more compact cable. This is an important point when aerial working is considered as the weight is less and the area exposed to storms is less for the same number of wires. The diameter of the 37 quad cable is 0.82 inches.

Except for the steel cable rings the fittings were of standard pattern. Fig. 3 illustrates the Bracket which grips the main strand and which is attached to the pole in all cases by a $\frac{5}{8}''$ double-ended bolt, thus providing for the erection of an additional cable later if required. The figure also shows the 3-bolt bracket used to carry the 7/12 auxiliary strand and a splice in the main strand where the wire is taken round thimbles and held by two 3-bolt clamps on each side.

Construction Work.

Boring poles for Brackets.—About 32 miles of pole line had to be bored to take the $\frac{5}{8}''$ bolts and as the completion of the cable was a matter of some urgency a mechanical means of boring was introduced, in addition to hand boring with augers. After consideration of electric and other means of transferring power, a method using a length of flexible steel shafting sufficient to reach a point 30 feet from the ground was developed. The power was obtained from a 2 H.P. petrol engine mounted in a 1-ton Ford van. Several types of drills were tried and the most suitable was found to be the Irwin twist drill with which a pole could be bored in about ten seconds. The operation required three men, of whom the driver of the van attended to the petrol engine, whilst one man carried out the drilling operation from a ladder, and the third man took the weight of the shafting by means of a sash line thrown over an arm of the pole. The bolt was then fitted and the bracket added.

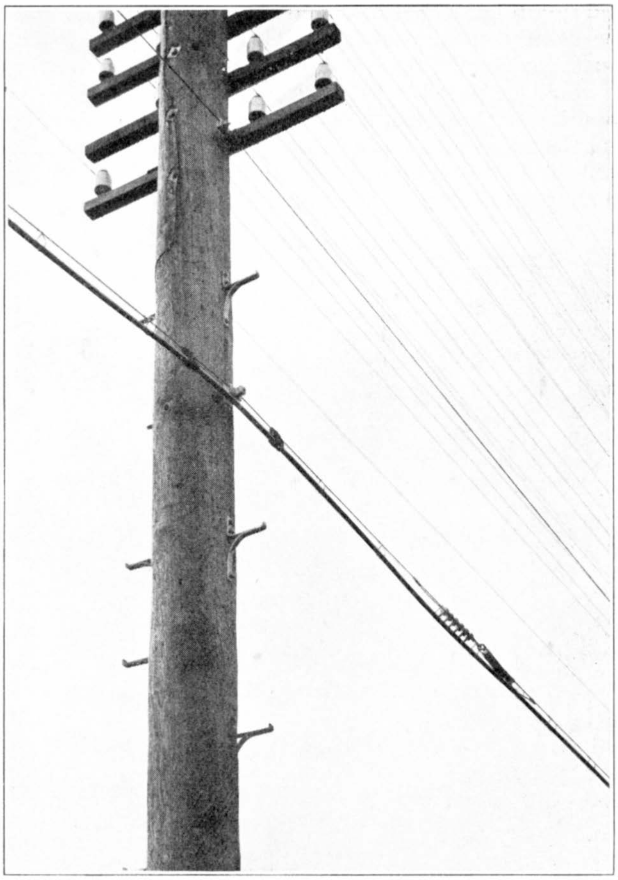


FIG. 3.—BRACKET HOLDING MAIN STRAND.

Erection of Main and Auxiliary Suspension Strands.—The road is one which carries a large volume of motor traffic and particular care had to be exercised in this, as also in the succeeding operation of cabling to comply with the restrictions of the recent Road Traffic Act. The work was allotted to several gangs placed at suitable points along the route between Coulsdon and Patcham, each gang being provided with motor transport for carrying men and stores and aiding generally in the operation. Prior to the commencement and in addition to written instructions which were issued, the foreman of each gang was instructed in the methods to be adopted by the erection of a half-mile section of strand on a convenient portion of the route. The method to be adopted depends entirely upon the obstructions met with, such as road or power crossings, trees and stays which interfere with the raising of the strand to the brackets, but in all cases the wire drum containing half a mile of strand was set up at one end of the section. In straight sections it was economical to run out the strand wire with the aid of a 30-cwt lorry by an attachment at the rear of the vehicle, but many cases occurred where bends in the road or the obstructions already referred to prevented this and the wire was run out by hand. The wire was then lifted into position in the brackets and the tension applied by means of blocks and tackle. With the correct tension on the strand, the nuts and bolts of the brackets and clamps were tightened, and as it was found in practice that owing to the strands compressing under tension the nuts became loose, it was found important to retighten splices and terminations made before tension was applied.

The tension was determined by an oscillation test. As the tension of the wire can be obtained from the length of span, the mass per foot of the wire and the time of vibration, tables were constructed giving the correct times for 40 oscillations and, in view of the varying lengths of span existing, these were made to show the variation from 55 to 65 yards for the same tension in case a 60 yards span was not conveniently available. When making an oscillation test, the best method was found to be for a man stationed on the pole at one end of the chosen span to strike the strand with his hand a few feet from the bracket. The succeeding vibrations at this point were readily discernable and well maintained. The following tables were used :—

UNLOADED TENSION OF 7/14 MAIN SUSPENSION STRAND. BREAKING WEIGHT 5,700 LBS.

Temperature.	Unloaded Tension.	Time for 40 oscillations.		
		55 yds.	60 yds.	65 yds.
20°F.	1020 lbs.	27.6 secs.	27.6 secs.	29.[illegible] secs.
40 ,,	890 ,,	27.1 ,,	29.6 ,,	32.1 ,,
60 ,,	760 ,,	30.0 ,,	32.8 ,,	35.5 ,,
80 ,,	640 ,,	32.1 ,,	35.0 ,,	37.0 ,,
100 ,,	510 ,,	35.8 ,,	39.1 ,,	42.3 ,,

UNLOADED TENSION OF 7/12 AUXILIARY SUSPENSION STRAND WITH 4 FEET SEPARATION BETWEEN MAIN AND AUXILIARY BRACKETS. BREAKING WEIGHT 8,700 LBS.

Temperature.	Unloaded Tension.	Time for 40 oscillations.	
		65 yard span.	70 yard span.
20°F.	1730 lbs.	30.0 secs.	32.2 secs.
40 ,,	1530 ,,	32.0 ,,	34.2 ,,
60 ,,	1310 ,,	34.5 ,,	37.0 ,,
80 ,,	1100 ,,	37.5 ,,	40.5 ,,
100 ,,	930 ,,	41.0 ,,	44.0 ,,

When applying tension, extra stress is required to counteract any give in the strand or the line itself, and the times for 40 vibrations were made at least 4 to 5 seconds shorter than those given in the tables before gradually slackening until the correct time was reached. At true terminations a loss of tension may occur, and to allow for this a deduction of about 2 seconds from the times given may be necessary when testing the last length of a section.

Ring Placing.—The steel rings, which were of the type known in America as the "National" ring, grip the strand securely and are placed by hand from a travelling chair at 20-inch intervals, so that in effect they form an aerial duct for the cable to be pulled into. For pulling the draw-rope into position a sash line had to be left in the rings during this operation and two methods of doing this were considered. Either the line could be pulled in by attaching it to the bosun's chair as it proceeded along the strand, or it could be run out for a cable length and placed in position first of all by a ring near each pole. The latter was deemed to be the better way and was used throughout. The sash line was enclosed by each ring as it was fitted by the men and the accurate spacing of the rings was obtained by a marked horizontal wire attached to the framework of the chair on the right-hand side. Fig. 4 shows a man in the act of placing a ring and it will also be seen that a supply of rings sufficient to complete one span was carried upon a triangle of stiff wire hanging from the chair. It was found in practice that the men propelled themselves to the centre of a span without difficulty, but in the upward climb near the next pole assistance was required from a man on the ground pulling on a sash line attached to the chair. The men "ringing" soon adapted themselves to their somewhat novel surroundings and became quite expert in the placing of rings, a good average in the span being 10 to 12 rings per minute.

A peculiar and somewhat troublesome effect was observed in the rotation of the strand wire as the chair travelled the span. This caused rings already placed to revolve so that often on completion of a span rings were found to have reached the vertical above the wire or even beyond. Later this led to difficulty in bringing the draw rope into place owing to the increased friction with the sash line riding in the neck of the ring. It is possible that if the draw rope were erected direct in the rings without the use of sash line the weight of the rope would minimise the rotation of the rings, as well as effect a direct saving of the cost of replacing the sash line by rope before the cabling work is done. This will of course involve a large issue of draw rope or require the ringing party to work just ahead of the cabling party.

In the case of Long Span construction the connection between main and auxiliary strands by means of a 3-bolt clamp was made at this stage by a man travelling on a bosun's chair along the top strand so that his weight caused the wire to sag and made the attachment of the clamp a simple matter. This was found more practicable than working from a ladder and pulling the strands together by a sash line passed round them.

Erection of the Cable.—The cable was requisitioned in scheduled lengths so that each joint would be near to a pole. Each length was approximately 500 yards, including a margin for dip and jointing. The intended organisation was for the cable drums, each containing one length, to be located correctly along the route in sequence so that it would be possible to draw in the cable at a fairly rapid rate. Owing, however, to certain cable lengths failing to pass works inspections, sequence could not be strictly adhered to and it was necessary to alter the arrangements to meet the cable deliveries.

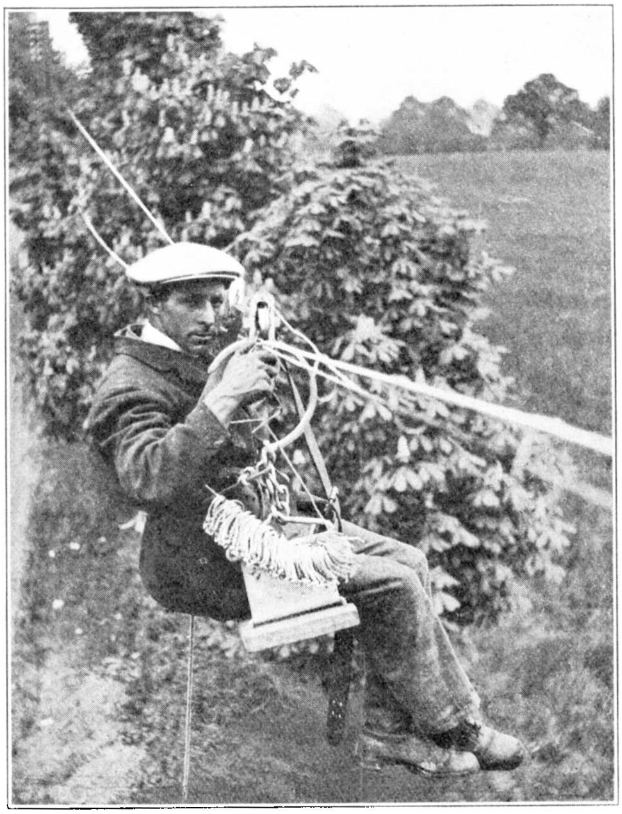


Fig. 4.—Workman fitting Rings.

Two cable gangs were employed, each provided with transport, and the work proceeded towards Crawley from Coulsdon and Brighton respectively.

The drums, which had previously been offloaded at the scheduled pole, were jacked up in position at a suitable distance from the pole and snatch-blocks attached to a temporary rope stay guided the cable to the rings. At the other end the draw-rope was led to the ground-line of the next adjacent pole where a snatch-block enabled the pulling to proceed towards the drum of cable. The rope was attached to the rear of the lorry, which was run at a speed of about three miles per hour until the last few yards were reached. A complete pull was not always obtained. In congested thoroughfares where footways were crossed by the rope and where side roads intervened or where serious bends in the roads existed, it was necessary for the lorry to proceed towards the drum for a part of the way only, after which it was returned to the starting point for a fresh pull.

The correct lubrication of the cable is an important matter. Too liberal a supply of petroleum jelly with the consequent drippings from the rings in the first few spans besides being wasteful would probably give rise to serious complaints. Cabling with the total absence of jelly was tried, but the friction and the chattering of the rings when this was done showed that lubrication was necessary. A mechanical greaser with a gland which constricts the jelly to a thin film was loaned by the Standard Telephone Co., but, although useful for underground work, it was found not easily adaptable for aerial work and accordingly a greasing box was devised locally for the purpose. This was a strong wooden box, slotted at each end to enable the cable to be passed through. A short length of rubber hose was passed round the cable where it emerged from the box and regulated the film of grease. The grease box was attended to by one man, who was also available at the drum in an emergency. A considerable saving in jelly resulted.

An experiment made during the cabling work was the use of a high speed winch loaned by the Standard Telephone Company. For this a light flexible steel draw rope of $\frac{1}{4}''$ diameter was used and drawing in proceeded at a speed of about $2\frac{1}{2}$ to 3 miles per hour. The winch is mounted on a lorry and is stationary during the operation so that road obstruction problems do not arise. A winch geared so as to be suitable for aerial as well as underground work is being obtained by the Department and it is hoped to make an extended trial of it on this type of work as soon as possible.

Mention should be made of occasional displacements of rings, both during the introduction of the draw rope into the rings and during actual cabling operations. Modifications had to be made to the cable grip by removing the thimble from the eye of the standard $1''$ grip and fitting a special swivel and link. Care in the preparation of the grip was generally repaid by a reduction in the number of rings moved.

Upon completion of the cabling and jointing work it was found necessary to overhaul the whole of the route to put on finishing touches, such as the tightening of bolts, attending to stays and fitting "false" terminations. The marline ties to hold the cable at each pole, as shown in Fig. 3, were added and at angles where the cable touched the pole raw-hide strip was bound round the lead.

Jointing.—As the joints had to be made some 26 feet from the ground a platform capable of allowing some degree of comfort as well as protection from

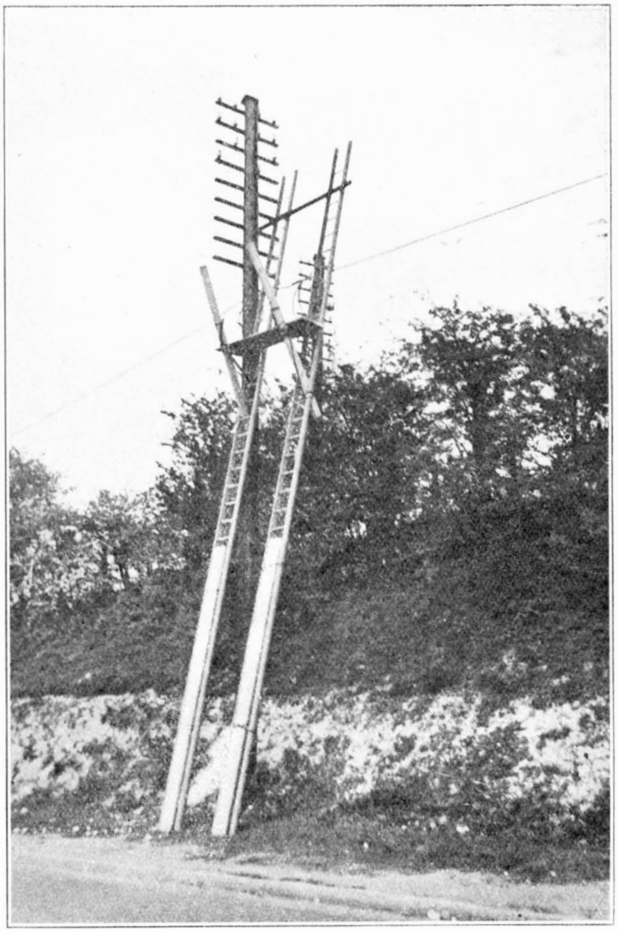


FIG. 5.—ERECTION OF JOINTING PLATFORM.

adverse weather conditions was necessary. Fig. 5 shows the type of structure when in course of erection, and it will be seen that painters' cripples on the ladders carried the planks which constituted the jointer's seat and tool bench. The pieces of timber projecting upwards and that across the top of the ladder or, alternatively, the auxiliary strand where it existed formed supports to which a tarpaulin could be made fast to shield the platform from wind and rain.

To maintain the insulation of the cable special precautions had to be taken. A drying oven was made locally to fit over strand and cable. (Fig. 6). The blow lamp at the base of the oven and about one foot below the joint maintained a good supply of hot air in the top of the oven, and a small door beside the joint enabled the jointer to ascertain the state of the cable.

All joints were made to a "Systematic" jointing schedule specially prepared for this type of cable with the object of dispensing with cable balancing tests. This was applied at all joints, with the exception of a straight joint on one stub of each loading coil pot and certain crossed joints to secure agreement in numbering of the pairs.

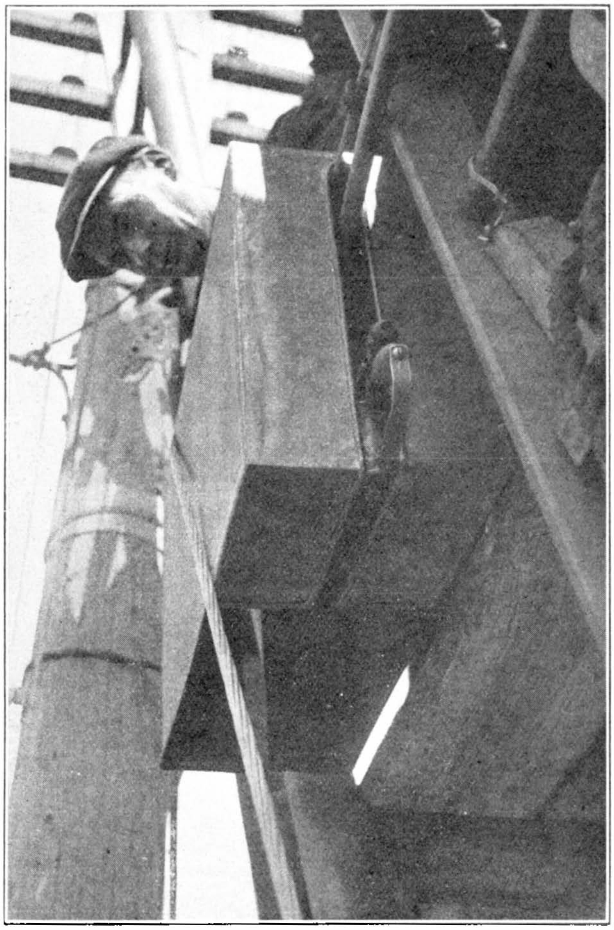


FIG. 6.—DRYING OVEN.

Loading Coil Pots.—The pot provided for the aerial section of the route was attached to the poles. It was fixed to the field side of the pole upon special brackets in a position two feet below the cable. Tackle was used to lift them into position on the brackets and they were made fast to the pole by steel straps. This work was carried out by a gang of four men with motor transport.

The position of the joint gave rise to some discussion, as there appeared to be some benefit in having the joints secured to the pole vertically above the pot, but the position occupied by the normal type of joint between cable lengths, that is to say, suspended horizontally from the strand near a pole, was, however, that adopted. Every joint, whether at a loading coil or at a through cable position, is supported by marline ties at the centre and on each side of the sleeve.

The general appearance of a pole carrying a loading coil pot can be judged from Fig. 7. The pot and the fittings are finished with a coat of black paint which prevents the pot from becoming conspicuous.

The jointing of the loading coil stubs to the aerial cable was carried out from a platform made up of 78″ and 48″ arms across which were placed boards and which were supported from the arms on the pole by wire stays. These platforms were, of course, intended to remain until all testing at these points was completed.

Testing.—Before each loading pot was jointed up tests for insulation and contacts were made between the up and the down stubs, using a 250-volt megger. Each loading coil section was also tested for insulation, conductivity and contacts with a 500-volt megger and cross-talk tests were made. After the loading coil sections had been proved satisfactory, these were joined up in groups of three and nine with re-testing in each case until the cable was complete.

These represent all the necessary tests for the connecting up of the cable. It is an important point that throughout the work no cable balancing tests were made, thus effecting a considerable saving in time as well as a reduction in the cost of providing the circuits.

It was particularly noticeable that after the ends had been opened for testing a short while, even in fine weather, the insulation dropped rapidly and low readings were obtained. This necessitated further

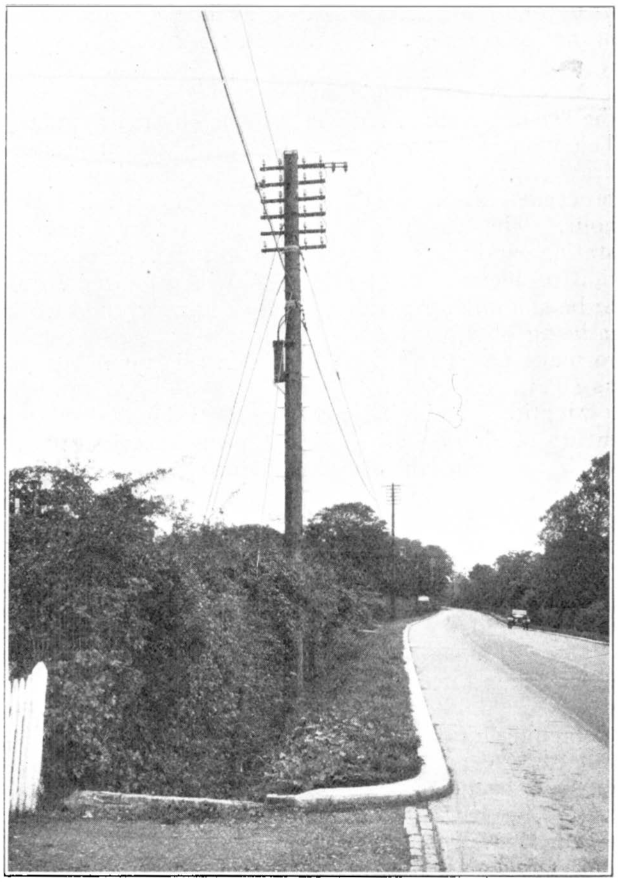


FIG. 7.—LOADING POT ON POLE.

drying out at the open ends of the cable. The exposed position of the joints some 25 ft. above the ground calls for considerably more care in protecting the cable than is the case with underground cables.

Costs.—It is difficult to produce figures for the erection of this type of cable based on the actual expenditure on the present experimental work, as of course much would not recur in future work. It is sufficient to say that the work was recorded in detail as it proceeded and that information has been collected which will be of use in the preparation of further schemes.

In conclusion, it should be recorded that two very able Inspectors supervised the work throughout. The work was well organised and the men were zealous and keen to make the work a success.

COVERED DROP WIRE FOR SUBSCRIBERS' DISTRIBUTION.

A METHOD of using covered wire from distribution poles to subscribers' premises, developed at the Research Station, Dollis Hill, is being tried in various parts of the country. Briefly, the method is as follows :—

A new type of insulated twin wire known as "Cable, rubber covered and braided for drop wiring, one pair, Cadmium Copper Conductors" is cleated from the "Block, Terminal" on the distribution pole to a "Drop wire pole-head"

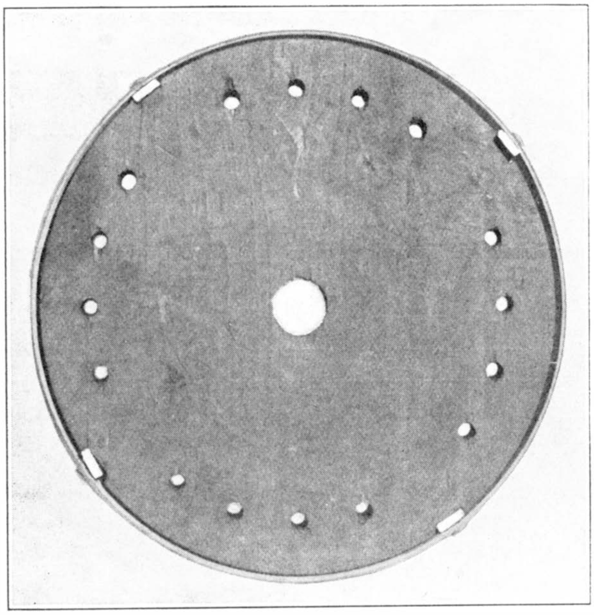


Fig. 1.—Drop Wire Pole Head, showing Drillings for Clamp Spindles and Finial Dowel.

where it passes through an eccentric clamp used for anchoring the wire. From this point the wire goes to the subscribers' premises where again it passes through another eccentric clamp fitted in a suitable fixing. The wire is then cleated on the subscribers' premises direct to the telephone when the span from the distribution pole to the subscribers' premises does not exceed 60 yards, and to the protector when the length of span exceeds this distance.

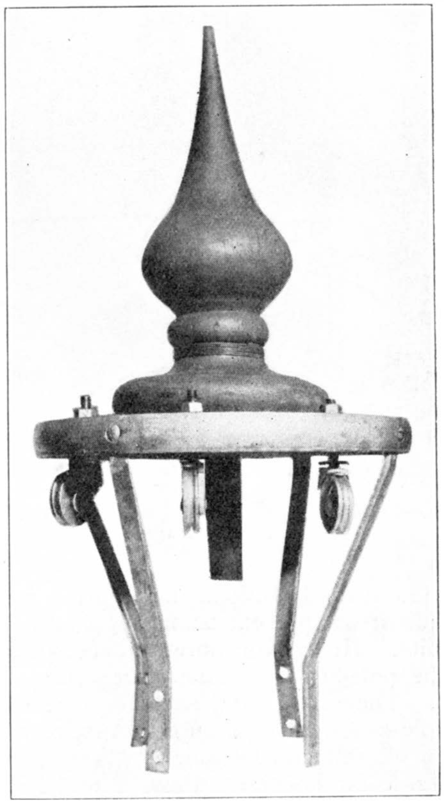


Fig. 2.—Finial, Clamps and Stays.

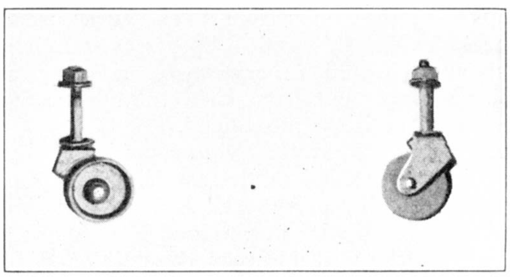


Fig. 3.—Eccentric Clamp: Both sides.

The drop wire pole-head, being circular, renders the method most suitable for use in cases where the

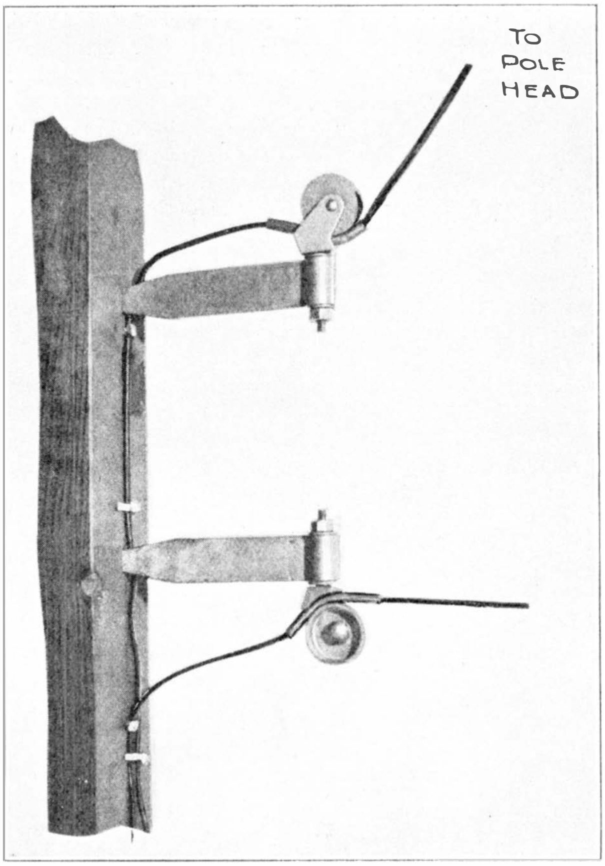


Fig. 4.—Shows the Split Lead Sleeve and Method of fixing Clamp.

distribution at the D.P. is of the umbrella formation. Pole-heads are at present being supplied for 16 and 28 circuits. Holes are bored at equal distances round the pole-heads to admit the eccentric clamp spindles. The pole-head is seated on the flat top of the pole and is made secure by the insertion of a pole finial dowel, and by four iron stays, one fitted at each side of the pole. Figs. **1** and **2** illustrate the drop wire pole-head.

The eccentric clamp and the spindle are made up in one piece and Fig. **3** illustrates the item. The clamps at the subscriber's end are used with "Brackets No. 5" and "Spikes No. 1," but, to avoid what would otherwise be a loose fitting, tubular washers cut from E.L. tubing are fitted in the eyes of the items mentioned.

In order to protect the twin drop wire at the point where it is tightened in the clamp and to ensure a more secure grip, a split lead sleeve No. 1 is placed over the covered wire and nipped in with the pliers. The pull of the wire between the pole-head and the subscriber's end pulls the clamp wheel round to the correct clamping position, and when this is found, the nut on the spindle is screwed up tightly. The clamp wheel is tightened by means of a special spanner.

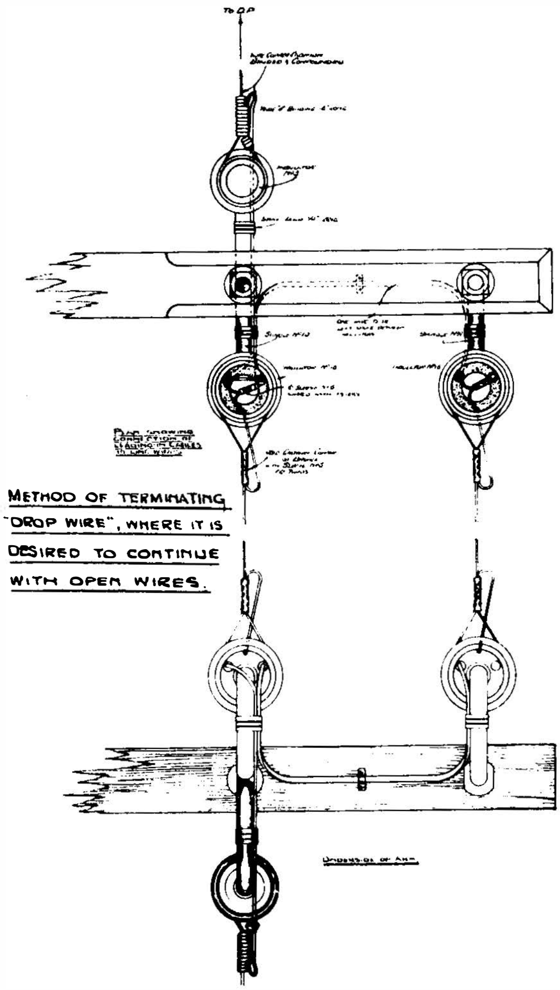


Fig. 5.

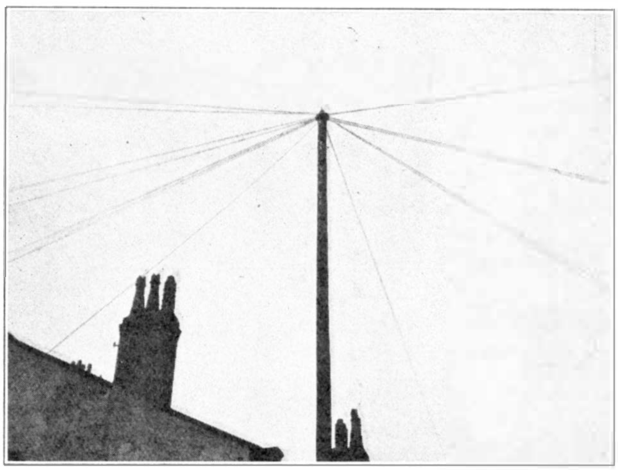


Fig. 6.—Pole fitted for Drop Wire Distribution.

The clamps may be fitted with the eccentric wheel either above or below the spindle according to the position of the fixing at the subscriber's end relative to the height of the pole-head. If the fixing at the subscriber's end is much lower than the pole-head the clamp wheel should be uppermost in the fixing at the subscriber's end. Fig. 4 illustrates this.

Whilst the method is designed for simple direct drops at distribution poles with umbrella distribution, it can also be used conveniently and economically in cases where there is an intermediate pole or other fixing between the distribution pole and the subscriber. A method of dealing with a case of this kind is illustrated in Fig. 5. A covered drop wire distribution pole is shown in Fig. 6.

The success of the method will largely depend upon the behaviour and life of the drop wire.

J.E.F.

THE HOT WIRE GAS LEAK INDICATOR.

General: C. E. Richards, A.I.C., Dollis Hill.

SHORTLY after the events of December, 1928, when an explosion occurred in a section of the old parcels tube, due to a leak of coal gas, various methods of ensuring the safety of cable tunnels from explosion were considered, and, in addition to the installation of forced ventilation for the remaining sections of the parcels tube, the provision of an automatic system for giving warning of the presence of inflammable gases was thought desirable.

A number of schemes have been suggested from time to time, and several instruments are in fact on the market. It was seen, however, that none of these schemes was quite suitable for the purpose, and the problem of designing an instrument specially suited to Post Office requirements was undertaken by the Research Section.

Briefly, these requirements are as follows :—

1. The instrument should be sensitive to all probable inflammable gases when they are present in amounts considerably below the lower explosive limit.
2. The instrument should be capable of operation on one of the commonly occurring Exchange battery voltages.
3. The line current should be kept as low as possible so that ordinary telephone conductors may be utilised if necessary.
4. Maintenance should be reduced to a minimum.

It was assumed that the instrument should operate electrically.

There are various methods which may be used to detect the presence of inflammable gases, these being based on the physical or chemical properties of the gases. The methods which depend on the physical properties of the gases are not in general so reliable as those based on the chemical behaviour. For example, the common gas leak indicator operates because gases of different molecular weights diffuse at different rates through a porous diaphragm. The lighter the gas, the more rapidly does it diffuse. For detecting the presence of coal gas in air, this instrument is quite satisfactory for amounts over about 0.5%, since coal gas is distinctly lighter than air, *i.e.*, it has a lower average molecular weight than air. If, however, we take the case of another commonly occurring inflammable gas, petrol vapour, which is distinctly heavier than air, having in fact an average molecular weight about twice that of air. Thus, petrol vapour is shown by a gas leak indicator as a heavy gas, and coal gas as a light gas. It is quite conceivable therefore that an explosive mixture of these gases and air could be tested with a gas leak indicator and show the presence of little or no foreign gas. There are other methods which depend on the physical properties of the gases, but they suffer from similar disadvantages. They are quite satisfactory when working in mixtures of gases of known qualitative composition, and can be used to determine their quantitative composition quite satisfactorily.

An example of this type is the Shakespear Katharometer (B.P. 124453/1916) which was used successfully for testing hydrogen for balloons. This apparatus depends on the different thermal conductance rates of gases.

There is only one universal property of inflammable gases, and that is their property of releasing energy as heat when they are burned. The amount of heat liberated by equal volumes of different gases is not the same; for example :—

Hydrogen—$H_2 + O = H_2O$ (liquid) $+ 68.4$ Cals.
Carbon Monoxide—$CO + O = CO_2 + 68$ Cals.
Methane—$CH_4 + 2O_2 = CO_2 + 2H_2O$ (liquid) $+ 211$ Cals.
Benzene—C_6H_6 (gaseous) $+ 9O_2 = 6CO_2 + 3H_2O$ (liquid) $+ 770$ Cals.

It will be observed that in all the above reactions heat is liberated, so that if we can find some means of measuring the heat evolved in burning inflammable gases, although we shall not be able to determine them quantitatively without calibrating the apparatus, yet in no case is it possible for an inflammable gas mixture to fail to give an indication of its presence, because they invariably evolve heat on combustion.

The method adopted in this case to measure the heat evolved is to burn the gases quietly at the surface of a heated platinum wire, and to measure the increase in resistance of the wire due to the heat of combustion. There are a few wires, such as platinum and palladium, which possess the property of causing gases to burn at their surface catalytically at low temperatures, no matter what is the concentration of gas. Other metals, such as gold, will only cause combustion in a definitely explosive mixture and at a comparatively high temperature.

The method actually used in the hot wire gas leak indicator is to make the platinum wire which causes combustion, one arm of a balanced Wheatstone bridge. If the bridge is balanced in the absence of inflammable gas, as soon as any comes into contact with this wire it will cause the temperature to rise and unbalance the bridge. Since the amount of heat liberated on combustion is strictly proportional to the amount of gas burned, for low concentrations of gas the rise in temperature of the wire will be proportional to the concentration of inflammable gas, and thus the amount of unbalance of the bridge is a measure of the concentration of gas.

The actual circuit used is shown in **Fig. 1.** It will be seen that it consists essentially of a Wheatstone bridge, two arms and part of the third being accommodated in the home end set at the Exchange, the remainder of the third and all the fourth being outside the Exchange. It is necessary to use line wires as part of two arms, instead of the more convenient way of making them part of one arm only, in order to compensate for air and earth temperature changes. The circuit is balanced originally by means of tapped resistances across the peak of the bridge. In place of the usual galvanometer, a modified Weston Model 30 relay is used to detect the unbalance of the circuit. This instrument has a resistance coil of 300-400 ohms and can readily be set to operate at any stated unbalance.

General Description of Apparatus.—The general appearance of the apparatus can be gathered from Figs. **2** and **3**. As far as possible the parts used in the circuit are standard Departmental issue, so that spare parts will be readily available. In the instal-

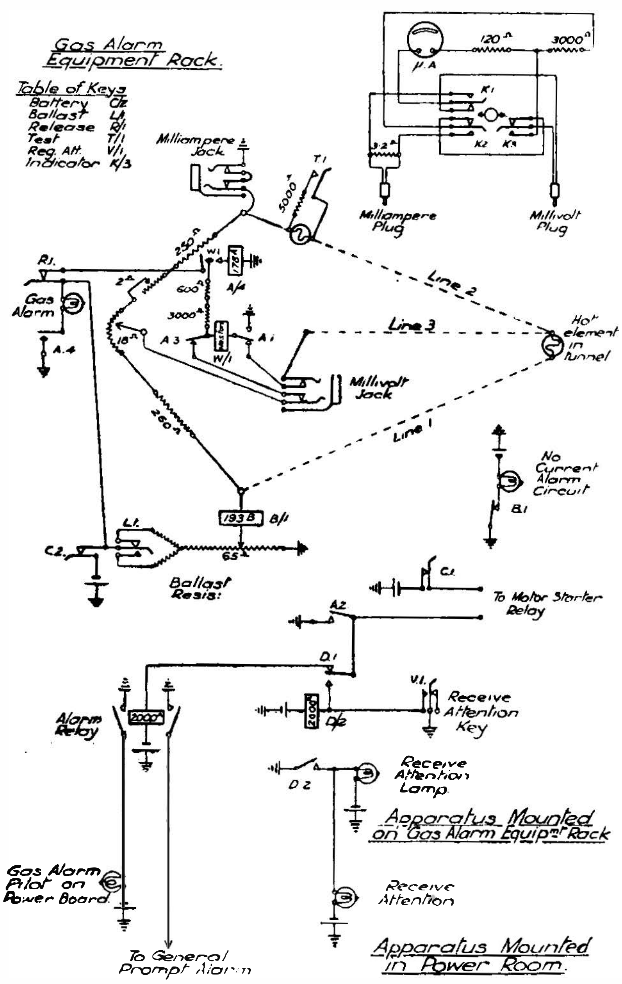


FIG. 1.—HOT WIRE GAS LEAK INDICATOR. CIRCUIT DIAGRAM.

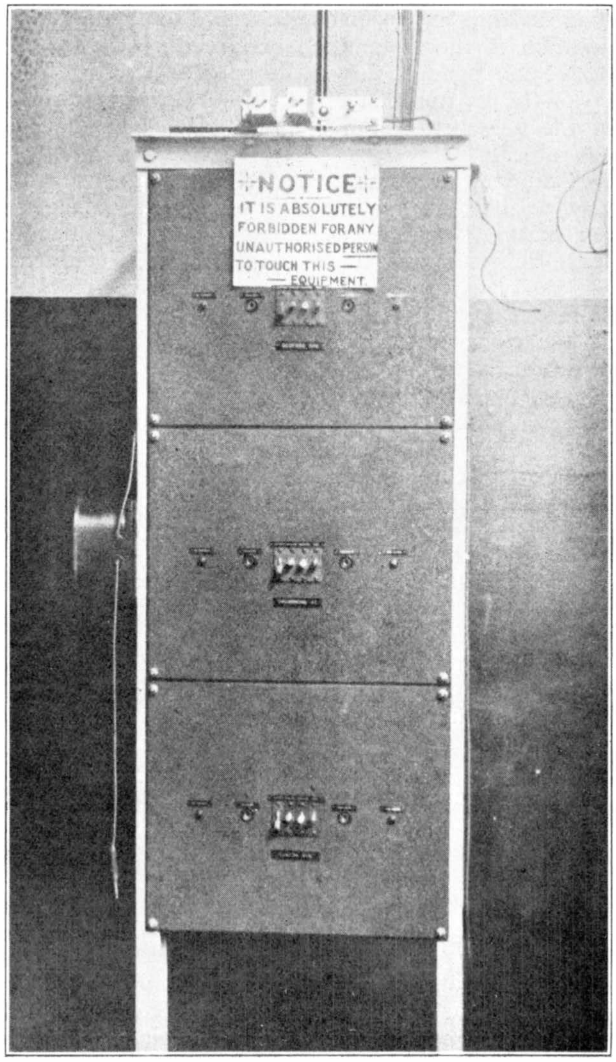


FIG. 2.—THREE SETS MOUNTED ON RACK. COVERS ON. SHOWS ALSO DETECTOR, PLUGS AND CORDS.

FIG. 3.—ONE COVER REMOVED TO SHOW CLOSE-UP OF ONE SET.

lations already made, three sets have been mounted on each rack, but, as they are quite independent, any number can be installed without mutual interference. The apparatus is designed to work from the 50 volt Exchange battery. The voltage limits of this are 46-52 volts and in order to maintain the bridge feed constant, the actual feed is taken from a 65 ohm potentiometer which is maintained at constant current by means of an Ediswan ballast resistance ("barretter"). This consists of an iron wire in a bulb of low pressure hydrogen, and was specially manufactured by Messrs. Ediswan to compensate for a voltage change of 8 volts and to give over this range a constant current of 0.7 amps. The current-voltage characteristic of this type of ballast is shown in Fig. **4**. Two alternative circuits are provided in each bulb, so that should one fail it is not immediately necessary to replace the bulb, but a temporary re-instation of service may be made by switching on the set after throwing the key on the front panel which is labelled "ballast." Current from the potentiometer is fed to the bridge through a relay 193B, which is arranged to operate a lamp circuit when the current drops below working range, and thus indicates when an element has burned out or the current to the bridge has for any reason failed.

The actual bridge consists of four arms, two of which are resistance coils of 250 ohms, the other two being fine platinum wires supported in a mechanical bridge of glass. The wire used for these elements is 0.0005" diameter. Two hot elements are used, one at the home end and one in the tunnel, the one at the Exchange being to compensate for temperature changes and any current changes which occur due to the ballast characteristic not being quite horizontal over the working range. The advantage of this double compensation is that whilst perfectly matched hot elements would compensate entirely for current and temperature changes, without the introduction of the ballast, the use of the ballast enables sufficient compensation to be obtained using only roughly matched elements, thus saving a considerable amount of testing. Incidentally the use of the ballast ensures such a constancy of current that the hot elements may be set working at the

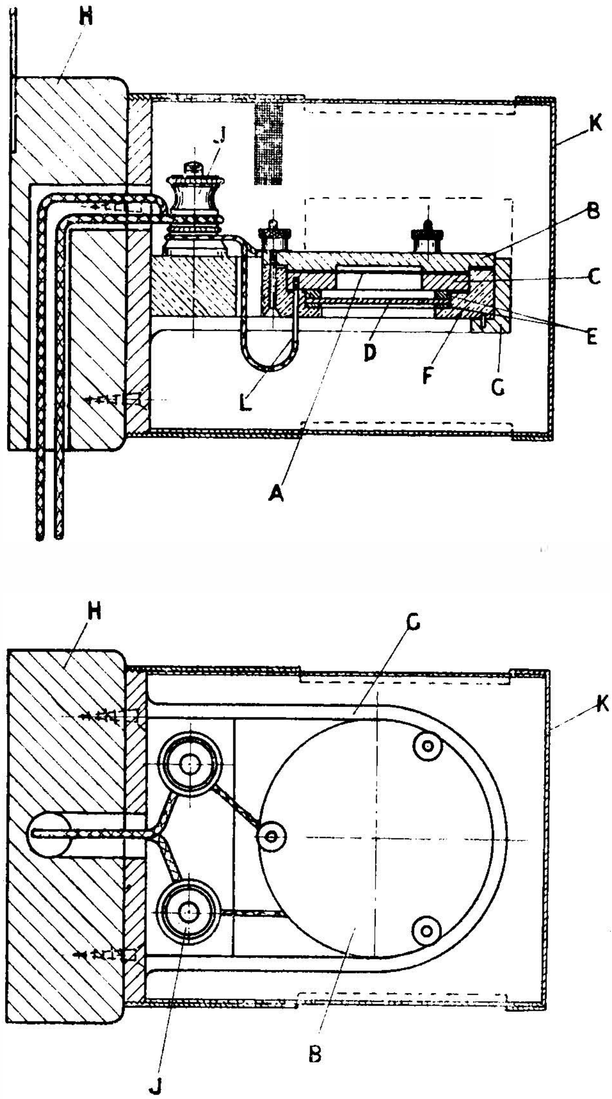


FIG. 4.—ELEMENTS OF INDICATOR.

optimum current for efficient gas detection and long life.

These hot elements are housed in cases shown in Fig. **4**, the respective parts being :—

- A. Hot element.
- B. Upper contact plate.
- C. Lower contact plate.
- D. Porous (alundum) diaphragm.
- E. Rubber sealing rings.
- F. Ebonite container.
- G. Brass bracket.
- H. Wood (teak) base plate.
- J. Terminals.
- K. Outer canister with gauze windows.

Parts A-F are held together by nuts and bolts, the whole system being rendered tight by pressure against the rubber sealing rings.

To complete the bridge the two 250 ohm arms are joined by two stepped resistances of 18 ohms and 2 ohms respectively. By adjustment of these resistances it is possible to compensate for the different resistances of the various hot elements, and balance the bridge within about 1 millivolt.

When the bridge goes out of balance due to the presence of inflammable gas, the Weston Model 30 relay, which locks itself in and also operates relay A/4. When relay A operates the following things happen :—

1. A signal is sent to the main alarm circuit.
2. A lamp is lit on the particular set operating.
3. The fan in the cable tunnel is started.
4. The Weston relay is disconnected from the line.

This state of affairs is maintained until the set receives attention.

The signal to the main exchange alarm is not taken directly, but through a relay which is connected to a non-locking key. If, when the alarm has operated, this key be thrown the signal is transferred from the general prompt alarm system to silent warning lamps in the power room and on the set rack. The set can be momentarily put out of action by throwing the key on the panel marked " Release " [R.I.]. When the fan has been running for some time after the receipt of an alarm signal, the " Release " key is thrown. It is a non-locking key, and on its restoring, the set is again in an active condition to detect gas, and if there is still gas around the active element it will operate again, starting the fan, etc., just as before.

Facilities are also provided for testing the operation of the whole set by throwing the key on the panel marked " Test " [T.I.]. Since the presence of inflammable gas at the active element causes its resistance to rise, this condition may be simulated for test purposes by shunting the inactive element. Throwing the " Test " key puts a 5000 ohm shunt on the inactive element and operates the set just as though a gas alarm had been received.

Each rack of instruments is completed by a combined millivoltmeter and milliammeter. This is constructed from a Ferranti microammeter connected through suitable resistances and with a key to change the circuits. Connection to the detectors is made by means of plugs.

Performance of the Apparatus.—The sensitivity of the apparatus is affected somewhat by the line resistance as this reduces the relative resistance change due to the presence of gas at the hot element. In designing the outfit it was assumed that 100Ω was the longest line over which it would be necessary to work, and in practice it has been possible to keep the line resistance below this figure. Curves showing the sensitivity of the bridge at various line resistances are shown in Fig. **5**. In this figure also is shown the sensitivity curve of the apparatus working as a Shakespear Katharometer at zero line resistance.

The apparatus has also been tested for operation in hydrogen and petrol vapour and responds to both of them when present in quantities well below the lower explosive limit.

In conclusion the author would like to thank Captain Cohen, of the Research Section, for permission to publish this matter and members of the staff at Dollis Hill for sympathetic co-operation, particularly Mr. H. J. Gregory and Mr. D. W. Glover. The assistance and patience of officers of the London

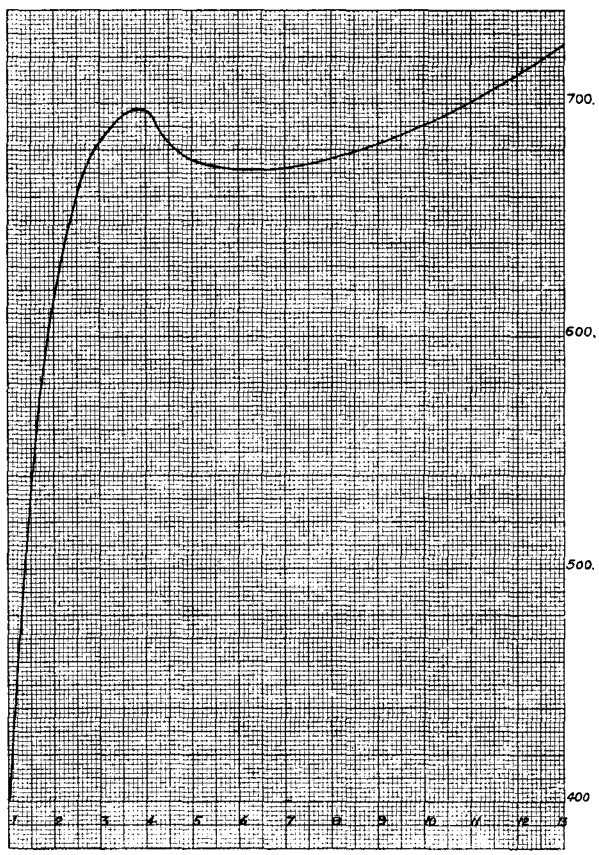


Fig. 5.—Characteristic Curve of Ediswan 0.7 Amp. Barretter.

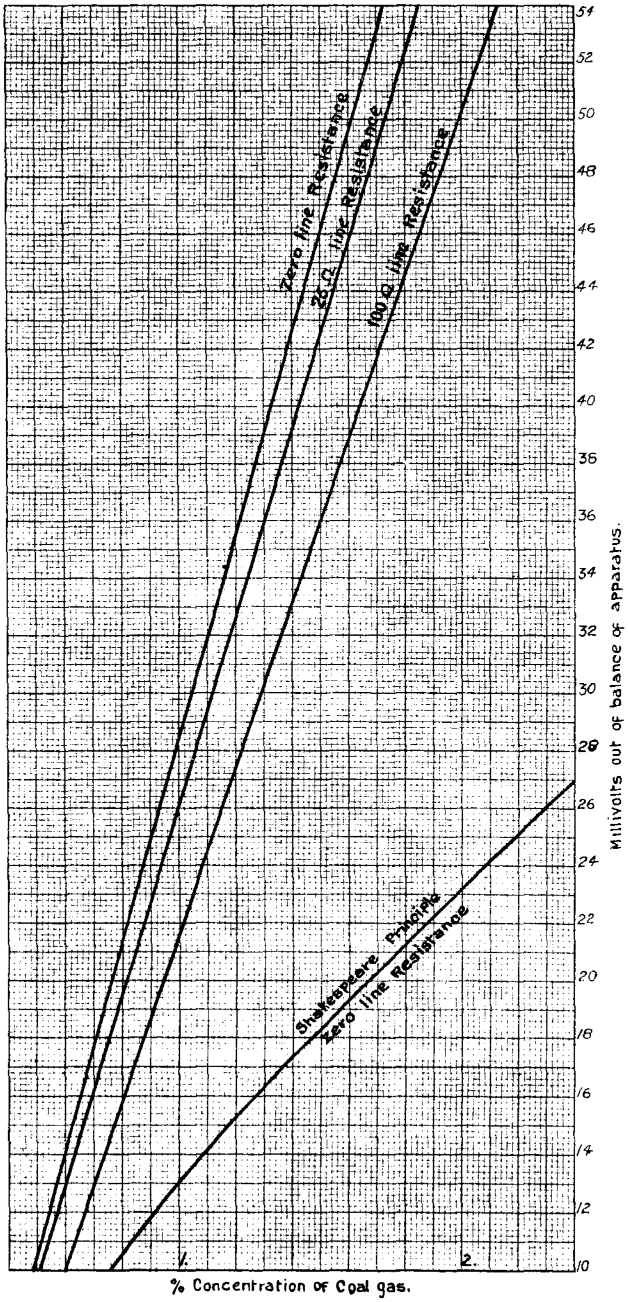


FIG. 6.—RESPONSE CURVES OF HOT WIRE GAS LEAK INDICATOR.

Engineering District during the trial period is also greatly appreciated.

. . . .

Details of schemes for detecting inflammable gases are given in the following :—

Philip & Steele. B.P. 3002/1913. B.P. 5467/1913.
Shakespear. B.P. 124,453/1916.
Ringrose. B.P. 267,990/1925.
Weaver and Weibel. Bureau of Standards, Scientific Paper No. 334.

Installation and Practice : G. MOWER, I.C.T. Section.

The rack shown in Figs. **2** and **3** is designed to embody three circuits which are linked with manholes at Bedford Avenue, Euston and Drummond Street, each circuit being quite separate from the other. The various apparatus comprising the circuit is mounted at the back of the panel immediately behind the particular row of keys and lamps. In the cable chamber, a relay set, motor and fan are installed, and also a pressure gauge, by which it can be verified that the fan is actuating properly. Extension bells working in conjunction with the main alarm bell associated with the particular panel are fitted in the exchange switchroom and test room for the purpose of indicating the alarm to the test clerk and exchange supervisor should the panel be unattended.

The apparatus is set to operate at 2% concentration of coal gas. Combustion takes place at a very early stage, and the excess heat due to combustion is communicated to the platinum wire, which causes a further rise in temperature, and consequently a rise in resistance of the element which causes the arms of the bridge to become unbalanced.

Balancing the Circuit.—At this point it would be perhaps best to explain that the circuit has to be "Balanced" before it is possible to put the apparatus into service. To do this we have to have some indication for reading the current flowing through the bridge and therefore we plug our milliamperemeter plug into the milliamp-jack to read any such current that may be flowing.

Special normal currents for the particular circuits have been arrived at, and in the case of Bedford Avenue manhole have been decided at 134 milliamps. Adjustment to the specified current is made by means of the 65Ω potentiometer. When the prescribed current has been obtained, the milliamperemeter plug is removed, and the millivoltmeter plug is inserted into the millivolt jack, the millivoltmeter is then balanced to zero by first using the 18Ω tapped resistance and making a final adjustment with the 2Ω tapped resistance.

Having done this, all plugs are removed and keys set at normal with the exception of the "Battery key," which is kept in the operated position to supply current to the apparatus, which is then ready for use.

Operation for Gas Alarm.—If then an inflammable gas comes into contact with the remote end element, as already explained the heat developed due to combustion causs that arm of the Bridge to become higher in resistance and therefore unbalances the Bridge.

This has the effect of producing a PD across the Weston relay, and consequently a current flows through it. The relay then operates and upon this depends the operation of other apparatus in the circuit. A special pilot contact of the Weston relay makes first and this provides a locking circuit *via* 3600Ω resistance and the coil of A relay to earth. The second contact operates immediately after, and provides a circuit for the operation of "A" relay, *via* the Release key and Battery key contacts to battery.

When the "A" relay operates, the Weston relay is disconnected from the circuit, but does not fall away when A1 and A3 contacts are broken due to the special construction of the relay, and therefore remains operated; it is then locked in parallel with A to battery. The operation of A also causes the gas alarm lamp to light, *via* A4 contact to earth, the main and extension alarms, and also the motor start relay which operates the motor and fan *via* A2 contact to earth. This operation signals a gas alarm and the attendant carries out his instructions which he has in printed form in a holder adjacent to the plant.

He, first of all, stops the alarm bells ringing, by operating the "Receive Attention key," which is of the non-locking type, and this causes D relay to energise and lock to the earth at A2 contact, thus causing the alarm bell relay to restore to normal. At D2 contact a circuit is made for the Red pilot, Receive attention lamp, which lights and indicates that the attendant is dealing.

Description of the Motor and Fan.—The operation of A relay provides a circuit for the motor start relay, *via* earth at A2 contact and battery at C1, the armature of which is arranged to automatically cause the motor to start up slowly until it attains half speed. If it is desired to increase the speed of the motor so as to expedite the clearance of gas from the manhole, this can be done by operating a hand rheostat which is adjacent to the start relay set. The motor is directly coupled to the fan, and this runs continuously until the manhole is cleared of gas.

The fan acts as a blower and causes fresh air to be forced through the cable tunnel into the manhole concerned, thereby causing the gas in the manhole to be ejected through a grid in the cover of same. The functioning of the fan can be checked by the operation of a pressure gauge, one side of which is connected by means of a rubber tube to the tunnel which goes to the manhole.

Fig. 7 shows the apparatus in question, the fan cannot be seen as it is in the background of the photograph and is enclosed.

The other apparatus can be seen fairly clearly, the pressure gauge being in the centre of the picture between the motor and starter, the rubber tubing only is seen, which is connected to the shaft between the fan and the cable ducts.

Testing the Apparatus.—To enable the apparatus to be tested conveniently it has been arranged for the hot wire element, which is mounted on the panel, to have a 5000Ω shunt placed across it, which is normally disconnected by the springs of the Test key.

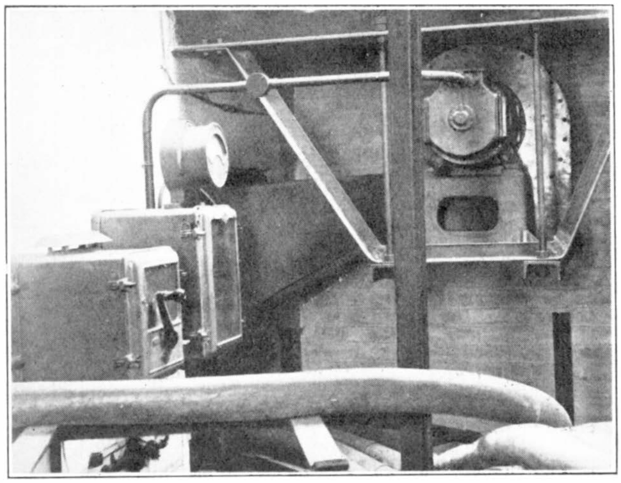


FIG. 7.—GENERAL VIEW OF FAN.

By throwing the Test key which is of the non-locking type, the home end element is shunted, thereby causing the resistance of the arm to alter and unbalance the bridge.

The Weston relay and other apparatus operate as previously described, thus proving the circuit to be in order.

To restore the apparatus to normal, the Release key, which is also non-locking, is thrown and at R1 disconnects the battery, which hold the A and Weston relays locked, thus releasing them, and the circuit is again normal.

No or Low Current.—The "no or low current lamp" is provided to ensure a means of indication should the prescribed current for the particular circuit fall below its rated value.

The lamp is normally out, owing to the B relay being held operated by the current in the circuit.

In considering the apparatus it would be as well to explain that there are two indications of "no or low current" and are due to the following causes :—

1. Fall of current below the prescribed value to a total failure in the upper bridge arms.
2. Fall of current below the prescribed value to a total failure in the lower bridge arms
3. Fall of current below the prescribed value to a total failure in the whole circuit.

The causes of failure that are most likely to be experienced are due to :—

1. Failure of the hot wire element at the remote end, due to burning out or other causes.
2. Failure of the home element due to the same reason.
3. Failure of the main current, due to the ballast resistance burning out.

Other failures due to faults in the ratio arms are not likely to occur, as the apparatus is well protected from outside interference.

If failures do occur in the ratio arms one or two of the alarms will operate.

Operation of Alarms. Case I.—Failure of Remote end elements. If the remote end element fails or becomes high in resistance owing to its nearing the end of its normal life, the shunting effect of the element to the corresponding ratio arms is altered.

It has been arranged that if the total current in the circuit falls below 30 milliamps the no or low current alarm is given.

Two alarms are received—

(1) The no current alarm due to the B relay falling away, owing to the increased resistance of the circuit, resulting in decreased current, and

(2) The gas alarm due to the Weston relay operating by the current flowing through it in its operative direction.

Case II.—Failure of the Home end element results in one alarm being given and that is the "no current alarm."

A point of interest here is that although the conditions appear to be similar in both cases the gas alarm is not given in Case II.

This can be explained by saying that the Weston relay is designed so as to operate when current is caused to flow through it in one direction only.

Case III.—Failure of the main current in the circuit results in the "B" relay releasing and causing the no or low current lamp to light.

There is no audible alarm given in this case, as it is not provided for, and appears to be a point that requires attention.

Although it is highly improbable that the current will fail, it is possible that the ballast resistance may eventually burn out.

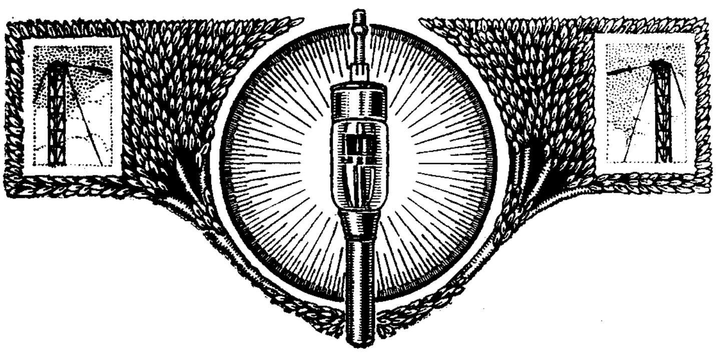
If this should happen, the circuit can be restored by throwing the ballast key in the reverse direction, thus bringing in circuit a spare ballast resistance as shown in the diagram. There is no doubt that the circuit will be modified in the near future so as to give an audible alarm in this case. [*This has now been done.—C.E.R.*]

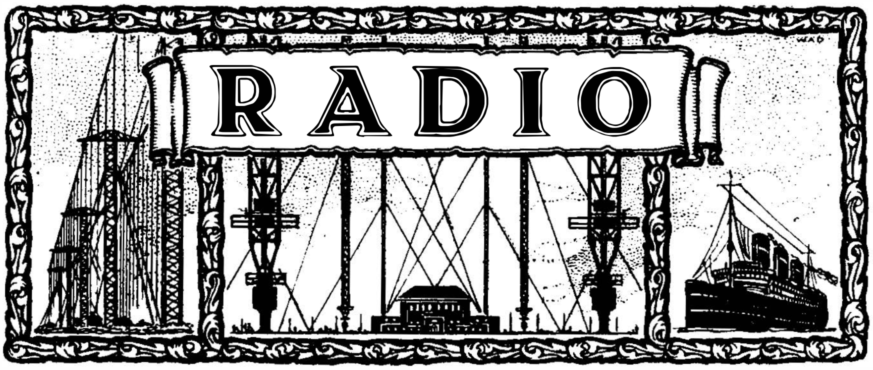
Routining.—A routine test is carried out daily and the apparatus is tested by operating the test key. The motor is allowed to run for two hours and a record is kept of the condition of balance of the circuits, re-balancing being made when necessary.

In conclusion, I should like to add that if a gas alarm is received the gas company are advised and they send their men to the manhole concerned to work in conjunction with the engineering officers.

After normal hours of duty, the gas company are advised and they send out their men with a lorry who pick up two of the Department's officers at their home addresses, proceed to the exchange for tools and thence to the manhole concerned to deal with the trouble.

ERRATUM.—*It is regretted that the name of Mr. Cradduck, joint author of the article beginning on page 213, is incorrectly spelt. The correct spelling is Cradduck.*





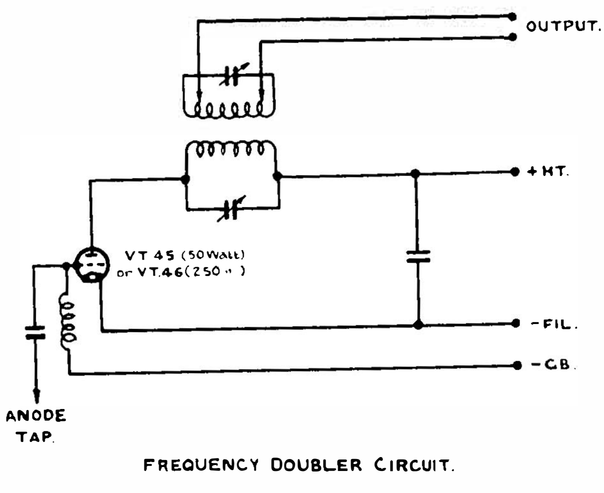
FREQUENCY CONTROL EQUITMENT OF POST OFFICE SHORT WAVE TRANSMITTERS.

E. J. C. DIXON, A.C.G.I., B.Sc., D.I.C.

II.

IN the first part of the article published in the last issue of this Journal an account was given of the quartz oscillators which are the foundation of the system used by the Post Office. The quartz oscillators are operated at frequencies of the order of 2,000 kc/sec and the present article describes the circuits by which the frequency is changed to that of the carrier which is of the order of 10,000 kc/sec. The apparatus described herein is followed by amplifier circuits, which raise the carrier power to 20 kW, which is then conveyed by transmission lines to directional antennæ and radiated in the required direction.

The Frequency Multiplier.—The frequency multiplying circuit is a simple tuned anode circuit with a direct tapped grid excitation from the previous anode circuit usually at half the frequency. (Fig. 11). A value of negative grid bias just less than the peak value of the grid exciting voltage is used so that anode current flows for only half the period of the exciting positive half cycle, and the wave form is such that there is a large component of second harmonic in the anode circuit. Since the anode circuit is tuned to the second harmonic frequency, it has a high impedance to the fundamental frequency and harmonics other than the second, which is thus selected and applied to the grid of the next multiplier circuit or, if the carrier frequency has been



FREQUENCY DOUBLER CIRCUIT.

FIG. 11.

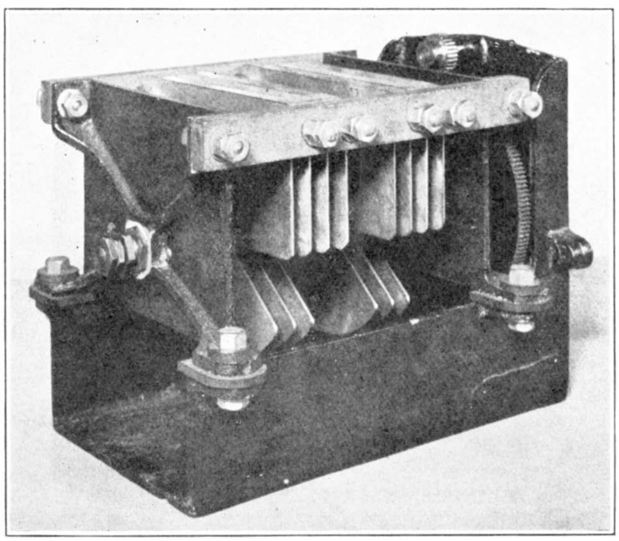


FIG. 12.—ANODE TUNING CONDENSER FOR FREQUENCY DOUBLER STAGES.

reached, to the grid of the first amplifier by means of a coupled circuit. In order to reduce the tendency of this type of doubler circuit to self-oscillate at the anode frequency, both the anode and grid circuits are made highly capacitative. On most short-wave channels it is necessary to use more than one frequency and where possible the frequencies are made multiples of the crystal frequency, so that more than one frequency may be accommodated on one set of multiplier stages simply by short-circuiting one stage. Where intermediate frequencies are necessary, *e.g.*, the Trans-Atlantic channels, where four frequencies of the order of 6,000, 9,000, 12,000 and 18,000 kc/sec are desirable, it is necessary to use more than one set of multiplier stages and switch the outputs to the amplifier stages which are common to all frequencies.

Description of Frequency Multiplier Equipment.—Post Office type valves V.T.45 (50 watt) are used with an anode voltage of 1,500 to 2,000 and grid bias values up to 500 volts negative. In the case of the higher frequencies a V.T.46 (250 watt) is used, as the efficiency of frequency doubling is less and a greater dissipation is therefore required. The circuit components are designed for robustness and minimum maintenance requirements and are arranged in the framework in such a manner as to be as accessible as possible. Fig. **12** illustrates a typical anode tuning condenser in which the supports are cast aluminium, the plates brass and the spindle steel, while high frequency insulation is provided by mycalex bars and D.C. insulation by ebonite bushes. A reduction gear drive is obtained by means of a toothed fibre wheel engaging a brass pinion and insulating the plates of the condenser from the operating knobs.

The lay-out of a bay of frequency control equipment is shown in Fig. **13**. This bay is of the same width as a standard telephone rack and the compartments correspond in depth to panels of standard size. The lowest compartment contains the quartz oscillator oven which rolls into position on wheels and guides. Above the oven is an amplifier stage followed by two doubler stages. At the top right hand side of the rack can be seen the gate switch which disconnects all high tension and grid bias supplies to the equipment when the gate is open.

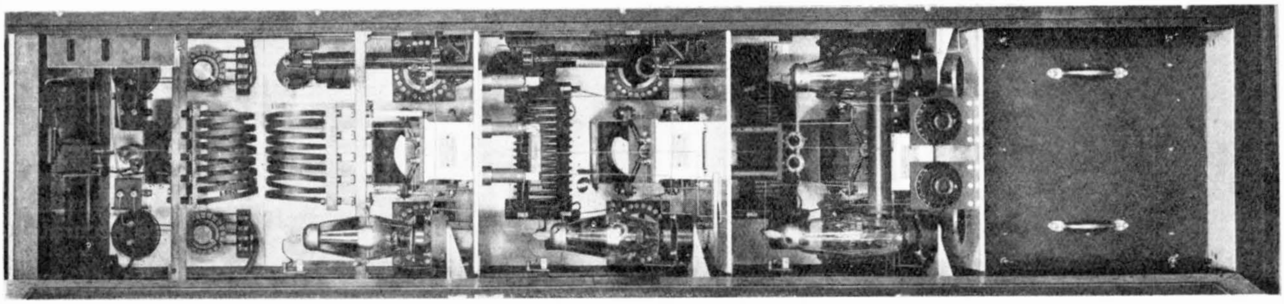


FIG. **13**.—SINGLE BAY OF FREQUENCY CONTROL EQUIPMENT.

A complete frequency control equipment usually consists of two bays of oscillator and doubler stages, as shown in Fig. **13**, and a bay devoted to switching, supplies and auxiliary stages. Fig. **14** shows such a bay with supply switches and oven heating transformer in the lowest compartment; above them the rectifier supplying the crystal oscillator supplies and a push-button panel; next a modulation panel; then a panel with valve keying equipment; and, finally, the bridge and switches for the resistance thermometer. A front view of the complete equipment is shown in Fig. **15**. The equipment illustrated was built into a brass framework at the Experimental Laboratories at Dollis Hill and moved *en bloc* to the transmitter site, where it is was joined up to the

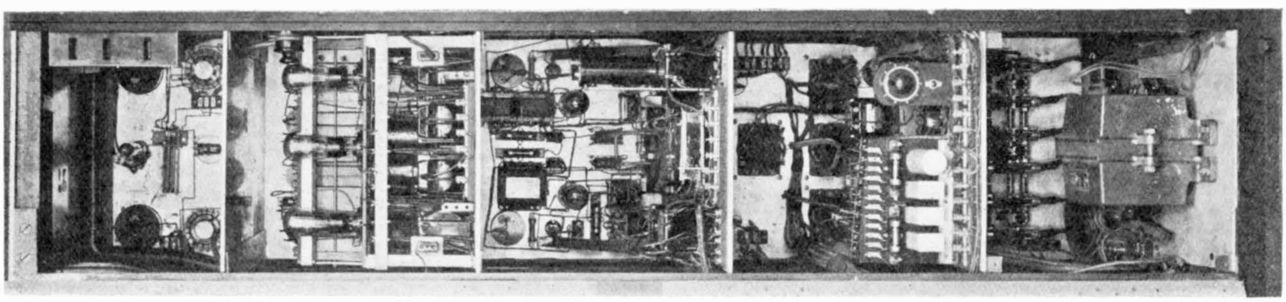


FIG. **14**.—AUXILIARY BAY OF FREQUENCY CONTROL EQUIPMENT.

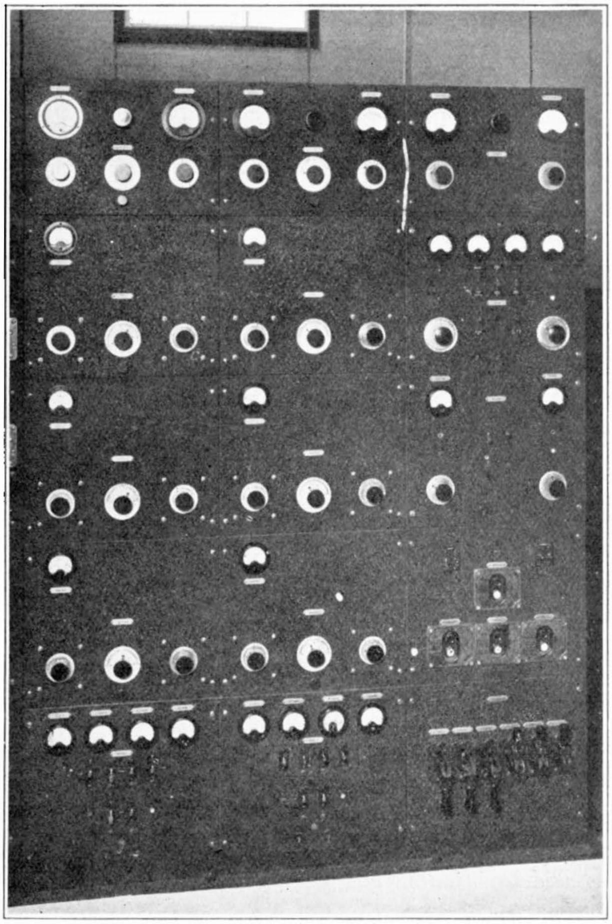


FIG. 15.—FRONT VIEW OF COMPLETE FREQUENCY CONTROL EQUIPMENT.

amplifying stages. The transmitter illustrated is the telegraphy channel GBM at Oxford Radio Station, but the equipment for telephony transmitters at Rugby Radio Station is similar.

Performance Curves.—Curves of frequency taken on two different days during a test run on the 6,985 kc/sec channel of GBM are shown in Fig. **16**. Each curve covers a period of fifteen hours continuous working and both curves refer to the same quartz oscillator. During the intervening day the run was made on the alternative quartz oscillator and gave, on the whole, slightly better results. It will be seen that the maximum deviation from the allocated frequency was 200 cycles/sec and by reference to the lines showing a range of 100 parts in a million about the mean frequency it will be obvious that the performance of the frequency control is well within these limits. The frequency measurements were made at the Post Office measuring station at Colney Heath and are accurate to better than 20 parts in a million.

For the sake of interest Fig. **17** is added. These curves are records of the variation of frequency of the telephony transmitter GBP at Rugby Radio Station, which were taken at Dollis Hill. They were taken for a period of one hour only on three different days and are accurate to five parts in a million. It will be seen that the deviation from the allocated frequency on two days did not exceed 150 cycles, *i.e.*, 14 parts in a million, but that on the third day there was a continual fall from a figure 500 cycles above the correct frequency to the allocation. On enquiry it was found that there had been a power failure at Rugby, that the oven had fallen in temperature by several degrees and that during the hour of measurement it was just regaining its equilibrium temperature. Measurements made over a period of a year on GBP show that the

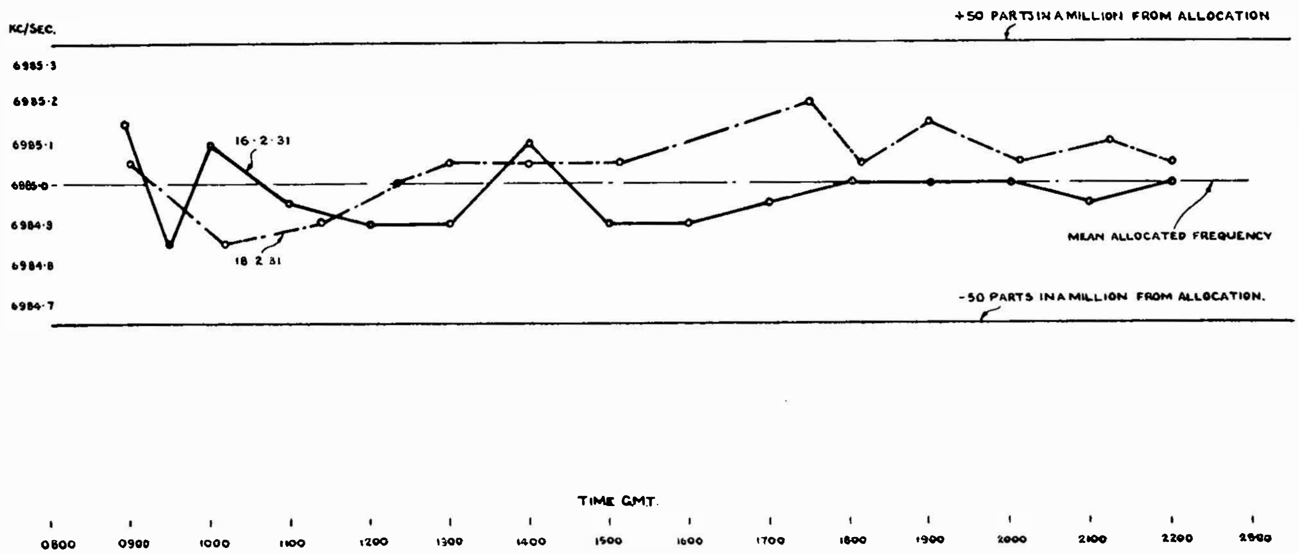


FIG. 16.—FREQUENCY MEASUREMENTS ON GBM. ALLOCATION 6985.0 KC/SEC.

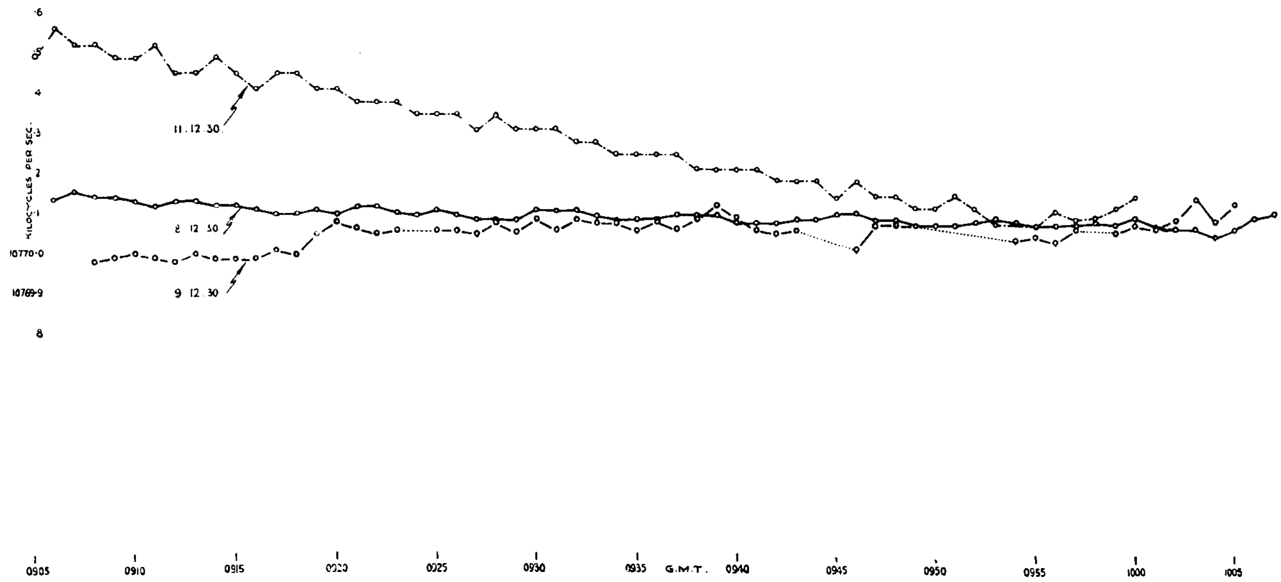


FIG. 17.—FREQUENCY MEASUREMENTS ON GBD. ALLOCATION 10770 KC/SEC.

normal variation is not greater than 50 parts in a million.

Conclusion.—There has been considerable advance in the art of frequency control and frequency measurement during the past five years, and it is now possible to operate short-wave transmitters under commercial conditions with a frequency constancy better than 100 parts in a million.

In anticipation of demands for still further accuracy of frequency control, development will probably proceed on the following lines :—

(*a*) A further reduction in the power taken from the quartz oscillator circuit. A quartz oscillator and buffer amplifier would be designed as a complete unit and treated as a unit source of frequency.

(*b*) A limitation of the range of frequency over which it is possible for the crystal to oscillate by the use of screen grid valves or neutralised circuits.

(*c*) Refinements in the construction of thermostats and ovens.

(*d*) The design of quartz crystal mountings which will compensate for the temperature coefficient of the quartz.

(*e*) Control of the gas pressure in the space around the quartz crystal.

With well-designed apparatus using these refinements it should be possible to produce frequency controls accurate to better than 1 part in a million.

[ERRATUM.—*In the previous article (on p. 161, July Number) the figures for the thickness coefficient should read 2700 and 2000 kc/sec. mm. respectively.*]

PRINCIPLES OF RADIO TOWER DESIGN.

THE " compleat " radio Engineer must indeed be a man of many parts, his knowledge extending from the infinitely small to the stupendously large. From the fascinating study of the behaviour of electrons, he must be prepared to pass on to the consideration of problems relating to electrical mechanical and civil engineering.

All embracing though radio engineering is, there appears to be a tendency in the radio press to devote a disproportionate amount of attention to the physics of the Science to the detriment of the mechanical and civil aspect. And yet, in the design of radio stations whether for " beam " or broadcast working, probably no section offers greater scope for economies than mast design. Within the author's experience, quotations for radio towers from reputable firms vary in the ratio of two to one—this though all forms are quoting to a standard specification in which factors of safety, loading and strut formula are given.

It seems opportune, therefore, to give consideration of some principles of radio tower design. The first essential is to gain a clear idea of the stresses produced by external loading. To this end, consider Fig. 1.

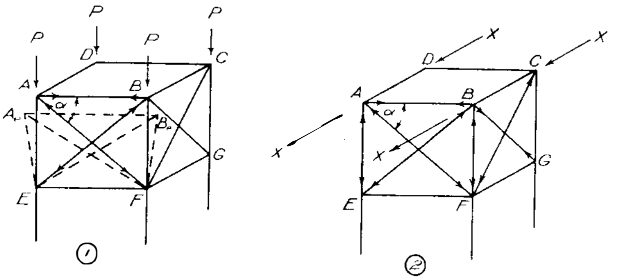


FIG. 1.

Aerial Loading.—The sketches represent the section of a mast having horizontal and double cross bracing. In Fig. **1** (1) vertical loads P due to the superstructure and the mass of the aerials are shown acting along the posts. The usual assumption made is that the posts take the whole of these loads. Actually as the material is not incompressible the section of the posts will be shortened and in consequence stresses will be set up in the bracings. For example, the post sections AE and BF will be compressed to AeE and BeF, thus tending to shorten the cross bracings AF and BE. The resulting stresses produced in the cross bracings give rise to stresses in the horizontal bracings as shown by the arrows.

Flexural Couples.—In Fig. **1** (2) horizontal loads XX set up compressive stresses in the posts AE and BF and tensile stresses in the opposite posts. Here again the assumption is usually made that the bracings AF and BE and the corresponding bracings on the opposite panel are not affected by the shear loads XX. Actually the compressibility of the posts AE and BF causes a shortening of the bracings AF and BE and an extension of the companion bracings in the opposite panel.

Thus in both the cases considered, the bracings take some share of these stresses, usually considered to be taken entirely by the posts.

This fact has given rise to the conception of a "fictitious"* member parallel to the posts which replaces the two cross bracings in the appropriate panels and contributes its quota towards the stresses usually considered to be taken by the posts.

To obtain the constants of this fictitious member consider the point A, Fig. **2** (1) and regard the points E and F as fixed. Let the superstructure above A and B transmit vertical loads P.P. which include the loads in the posts and the vertical components of the loads in the bracing immediately above A and B.

Now according to Castigliano's theorem of least work a structure not initially stressed will store a minimum amount of strain energy under the action of applied external forces.

From this it follows that if W is the total energy in a structure and F is the load in any one member $\frac{\delta W}{\delta F} = 0$. Thus if the members AE, AF and AB have lengths V, D and H, cross sectional areas A_v, A_d and A_h and loads P_v, P_d and P_h respectively, the strain energy in these members

$$= \tfrac{1}{2}\frac{P^2_v V}{A_v E} + \tfrac{1}{2}\frac{P^2_d D}{A_d E} + \tfrac{1}{2}\frac{P^2_h H}{A_h E}$$, where E is Young's modulus.

Again, since A is in equilibrium, the algebraic sum of the vertical forces and of the horizontal forces on A are Zero. Thus, since the diagonal bracing both above and below A gives rise to horizontal loading in AB

$$P + P_v + P_d \sin\alpha = 0$$
$$2\,P_d \cos\alpha + P_h = 0$$

Moreover since A and B are similarly loaded, only half the strain energy in AB is associated with A.

$$\therefore \quad W_A = \frac{1}{2E}\left[\frac{(-P-P_d\sin\alpha)^2}{A_v} + \frac{P^2_d D}{A_d} + \tfrac{1}{2}\frac{(-2P_d\cos\alpha)^2 H}{A_h}\right]$$

$$\therefore \quad \frac{\delta W_A}{\delta P} = \frac{1}{2E}\left[\frac{2\sin\alpha\,(P+P_d\sin\alpha)V}{A_v} + \frac{2P_d D}{A_d} + \frac{4\,P_d\cos^2\alpha\,H}{A_h}\right] = 0$$

$$\therefore \quad -\frac{PV^3}{A_v EVD} = \frac{P_d}{D^2}\left[\frac{V^3}{A_v E} + \frac{D^3}{A_d E} + \frac{2H^3}{A_h E}\right]$$

$$\therefore \quad \frac{P}{\Omega_v VD} = \frac{P_d}{D^2}\left[\frac{1}{\Omega_v} + \frac{1}{\Omega_d} + \frac{2}{\Omega_h}\right] \quad \text{.............(i)}$$

where Ω_v, Ω_d, Ω_h are the constants $\frac{V^3}{A_v E}$, $\frac{D^3}{A_d E}$ $\frac{H^2}{P_h E}$

Now the load in AE is reduced by $P_d \sin\alpha$ due to the bracings AF and AB, and from (i)

$$P_d \sin\alpha = -\frac{P}{\Omega_v\left[\frac{1}{\Omega_v} + \frac{1}{\Omega_d} + \frac{2}{\Omega_h}\right]} \quad \text{..........(ii)}$$

Thus the load in AE

$$= -P - P_d \sin\alpha = -\frac{P\left[\frac{1}{\Omega_d} + \frac{2}{\Omega_h}\right]}{\frac{1}{\Omega_v} + \frac{1}{\Omega_d} + \frac{2}{\Omega_h}} \quad \text{........(iii)}$$

Now both AF and BE (Fig. **2** (1)) will contribute in equal measure towards the reduction in loads taken by the posts AE and BF. This reduction is

* *See R.V. Southwell Aeronautical Research Committee. Reports and Memoranda No. 790.*

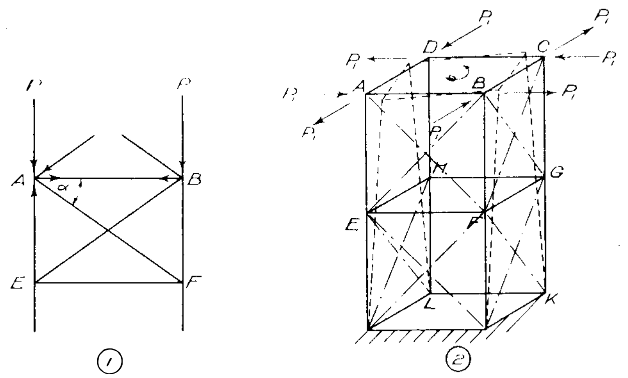


FIG. 2.

Pd. sin α per each post and thus if the two diagonal bracings are regarded as responsible for a single fictitious member having a cross sectional area A_f, the following relationship is obtained :—

$$\frac{A_f}{A_v} = \frac{\Omega_f}{\Omega_v} = \frac{2x \text{ expression (ii)}}{\text{expression (iii)}} = \frac{2\Omega_h\Omega_d}{\Omega_v(\Omega_h + 2\Omega_d)}$$

$$\therefore \Omega_f = \frac{2\Omega_h\Omega_d}{\Omega_h + 2\Omega_d} \text{ where } \Omega_f = \frac{V^3}{A_f E}$$

It follows from this expression that if the horizontal bracing is omitted $\Omega_h = 0$ and therefore $\Omega_f = 0$; in other works the " fictitious " member disappears, thus relieving the cross bracing of stresses due to axial loading and flexure.

Regarded from the physical viewpoint, the removal of the horizontal member AB (Fig. **1** (1)) enables the points A and B to move outward to the positions A_e and B_e when the posts are compressed so that the bracings AF and BE still maintain their original length. Similarly when the stresses in the posts are tensile, the original length s of AF and BE are maintained by the points A and B moving inwards.

In Fig. **3** the value of Ω_f, for the fictitious member has been plotted in terms of Ω_d for various values of the ratio $\frac{\Omega_h}{\Omega_d}$

It has already been shown when $\Omega_h = 0$ $\Omega_f = 0$. When $\frac{\Omega_h}{\Omega_d} = \infty$; $\Omega_f = 2\Omega_d$, but as Ω_d now approximates to Zero, the fictitious member again does not operate when the diagonal bracing is non-existant. However, under certain conditions the value of Ω_f might be considerable, as for example when $\Omega_h = \Omega_d$. In this case $\Omega_f = \frac{2}{3}\Omega_d$, and the " fictitious " member takes an appreciable load.

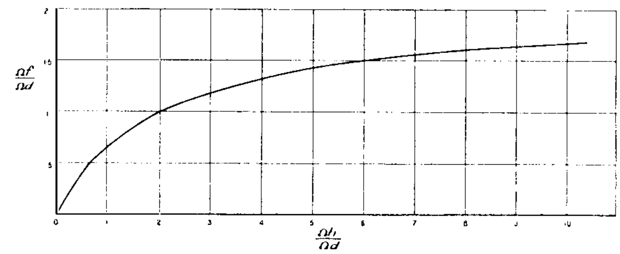


FIG. 3.

It is thus obvious that to ignore the " fictitious " member might result in too much metal being used on the posts and too little in the bracings. This probability leads to the belief that main horizontal bracings can usually be omitted with advantage from radio towers, since their omission enables a readier and more exact computation of the stresses to be made.

Furthermore the elimination of the horizontal face bracing may result in a more economical structure.

Consider Fig. **4** which represents a panel of a tower built of square angle mild steel. The diagonal bracings are regarded as tension members and thus only one of these members can be considered as resisting shear. The loading and stresses in the various members of the panel are shown in Table 1 below.

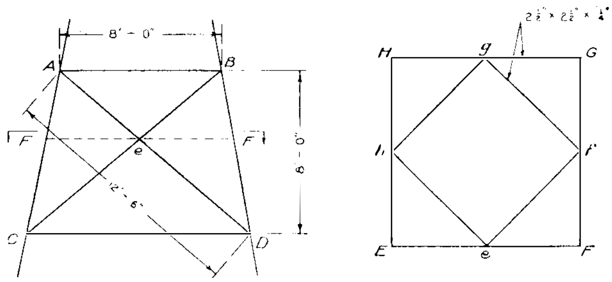


FIG. 4.

TABLE 1.

Member.	Dimensions of angle. Length. Ft.	Dimensions of angle. Size of flanges inches.	Load lbs.	Actual Stress lbs. sq. in. c = compressive e = tensile	Permissible Stress $18000 - \frac{80l}{r}$ for compressive members. lbs. sq. in.
BD	8	$6 \times 6 \times \frac{3}{4}$	98900	11700 c	11500
BC	12.5	$3 \times 3 \times \frac{3}{8}$	29600	14000 e	17000 on net section, *i.e.*, 14800 on full Section Allowing for bolt holes).
AB	8.0	$4 \times 4 \times \frac{7}{16}$	18900	8050 c	8250

If the diagonal bracings had been designed as struts and the small supporting angles Ee Ff Gg Hh had been inserted instead of the horizontal bracing AB, etc., both diagonals would have been effective bracings and the stresses would have been as shown in Table 2.

and the force in the bracing $= \frac{T.AF}{4AB^2}$. This result is the same as that obtained from Batho's theory which states that the shear perpendicular to the plane of two parallel trusses is equal to the torque

TABLE 2.

Member.	Dimensions of angle.		Load lbs.	Actual Stress lbs. sq. in.	Permissible Stress $18000 - \frac{80l}{r}$ for compressive members. lbs. sq. in.
	Length. Ft.	Size of flanfies inches.			
BF	4.0	$5 \times 5 \times \frac{3}{4}$	98900	14250	14000
FD	4.0	$5 \times 5 \times \frac{3}{4}$	98900	14250	14000
Be	6.25	$3\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{4}$	14800	8750	9170
CC	6.25	$3\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{4}$	14800	8750	9170

Thus in the case considered a saving in metal of about 18% and a reduction in exposed wind surface of 7.5% is made by eliminating the main horizontal bracing. This double reduction affects the size of the section of the posts and bracings required in the lower portion of the structure very appreciably.

In addition to the horizontal shearing loads due to aerial pull and wind which produce a flexural couple increasing in value with distance from the top of the structure, towers supporting curtains of wires on cross arms might be subjected to appreciable uniform flexural couple. For example, should one of the two steel cables which support the exciter and reflector curtain respectively, fail, there will be a uniform bending moment equal to WD where W is the vertical component of the tension in the remaining cable, and D the horizontal distance of the cable from the centre line of the tones.

Torsion.—Moreover the horizontal component will set up a uniform torsional couple to resist which provision must be made. Consider a torsional couple (Fig. **2** (2)) applied to the top of a structure which is fixed at the base. It is evident that this structure, if diagonal face bracings are absent, will present little resistance to torque, nor will the addition of any other horizontal bracing such as E F G H have any appreciable effect.

If however diagonal face bracings are added as shown by the Chain lines, the torque is opposed by compressive stresses induced in members such as AF, FK and tensile stresses in other members such as BE, EL.

The torque applied to the top of the mast can be substituted by forces P_1 applied at the posts. In each panel round the mast, bracing such as AF will have compressive forces induced in them equal to $P_1 \frac{AF}{AB}$ whilst bracings similar to BE will have tensile forces numerically equal to the compressive forces. Since AB = BC, the torque $T = 4\ P_1\ AB$

multiplied by the distance between the trusses divided by twice the area of the trusses : or

$$\text{Shear} = \frac{T.AE}{2AB^2}$$

Since two diagonal bracings resist this shear, the forces induced compressive in one case, tensile in the other—

$$\text{equal } \frac{T.AE}{2.AB^2} \times \frac{AF}{2AE} = \frac{T.AF}{4AB^2}$$

The various types of loading which a radio tower is required to resist have now been described. It must not be assumed, however, that all are applied simultaneously. For example, in the case of towers supporting a beam array maximum torque and uniform flexural couple occur when the cable supporting one curtain fails, but in this condition neither the variable flexural couple nor the axial loading are a maximum. The design must provide for the worst combination of loading likely to occur simultaneously.

Columns.—An accurate strut formula applicable to all conditions obtaining in tower structures, is not realizable. The posts and bracings, between unsupported lengths, form a series of struts with varying and unascertainable degrees of fixation. It is common practice to regard the struts as pin jointed, the deflection curve of posts being regarded as shown exaggerated in Fig. **5** (1). It is, however, obvious that the type of bracing joint will influence the degree of fixation and the extent of the free length of strut. When a single bolt or rivet is used, it is logical to regard the slope as a maximum at the joint. Such, however, is not the case when a stiff plate joint is used (Fig. **5** (2)) and the designer is therefore justified in regarding the length of the strut as varying between the actual length and $\frac{2}{3}$ the length, according to the type of joint. With regard to a suitable strut formula, within working limits

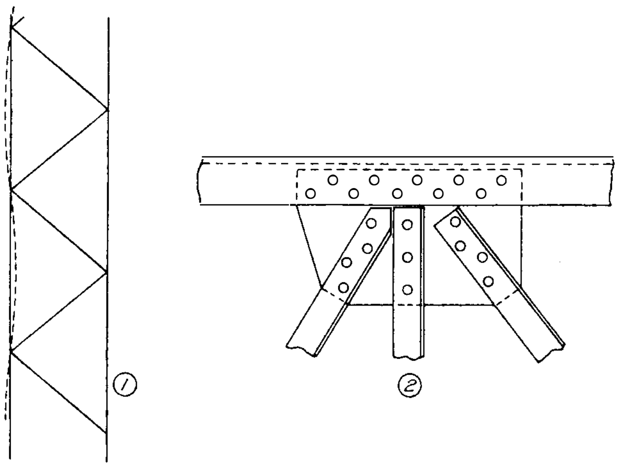


FIG. 5.

of stress a straight line formula of the form $f_s = f_0 - \frac{kl}{r}$ is probably as accurate as any of the numerous formulæ suggested by various authorities. The experimental investigations of Robertson* have shown that, in general, for mild steel struts having free ends, Euler's formula is correct within the limits of proportionality and that Southwell's modification for variation in the value of Young's Modulus of Elasticity gives accurate results up to the yield point. These results, however, are contingent upon ideal conditions. The strut must be straight and non-eccentrically loaded, conditions never realized in practice. Robertson further shows that the many published results of tests on practical struts, having fixed or flat ends, the critical loads lie within an area enclosed by the yield line, the Euler curve and the Perry curve, the latter having a simplified coefficient to account for probable initial curvature eccentricity and variation of Young's modulus. The area is, in most cases considerable and illustrates the difficulty of obtaining reliability. It is this lack of certainty that causes designers to prefer the simple straight line formula, the accuracy of which within the limits of $\frac{l}{r} = 50$ to 160 is not unreasonable, where l is the effective length of strut and r is the minimum radius of gyration. For mild steel angles, a suitable formula for struts is $f_s = 18.000 - \frac{80l}{r}$ where f_s is the permissible stress.

Wind Loading.—Except with small towers the effects of horizontal loading due to wind, usually predominate over all other loading. This being so, it is surprising how little has been published upon investigation into the question of wind resistance of various sections and types of lattice structures.

Various cross sections of post have been proposed and employed for the purpose of reducing the ratio of greatest to least radius of gyration, but little attention has been given to the equally important question of wind resistance of the member. The assumption generally made is that the resistance to wind is equal to the product of the Area of the Section, projected on a vertical plane, and the horizontal wind pressure on a plane surface per unit area normal to the direction of the wind. In other words all types of section having the same projected area on a vertical plane of reference, are regarded as offering the same wind resistance. Such an assumption is obviously wrong. The shape of Cross Section, the aspect ratio, the angles of incidence of the wind, the degree of screening, all effect the problem. The most reliable method of arriving at the wind loading is to build a model and test in a wind tunnel. The model should be rotated about a vertical axis to ascertain how the wind resistance varies as the angle of incidence is changed. It has been ascertained that for objects geometrically similar the scale effect on wind resistance has little importance. Thus results obtained from a model can be applied to the full sized structure. Failing a model a reasonably accurate computation of the wind resistance can be made by testing a few lengths of post and bracing. The sections tested should be geometrically similar, but need not be the same size as the working members. Tests on several lengths are necessary to obtain a curve of the force coefficient for varying aspect ratio, *i.e.*, ratio of length to breadth. The necessity for this precaution will be realized from an inspection of Fig. **6** which gives the force coefficient K_f or a V angle iron in the expression $R = KAV^2$

where R = the wind resistance in lbs.

A = area of one flange of the angle in sq. ft.

V = velocity of wind in miles per hour.

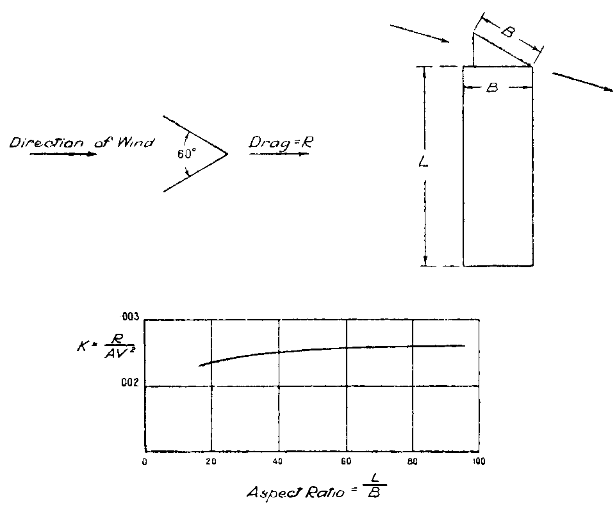


FIG. **6**.

* *"The Strength of Struts," selected Engineering Papers, No. 28, Inst. Civil Eng.*

As the corner posts of towers are nearly vertical it is sufficiently accurate to rotate the post section about the longitudinal axis normal to the wind. The bracing however should be tested in such a manner as to simulate actual conditions, and should therefore be rotated about an axis making appropriate angles with the longitudinal axis of the member. To illustrate the variation in the value of K for different angles of incidence of the wind, a typical curve is given in Fig. **7** for a V section having equal flanges. Fortunately the large variations in the value of K for individual members is usually nullified in practice due to the fact that the various members present different fronts to the wind. For example, a square tower presents four faces to the wind, each face making $\pm$ 90° with its neighbour. Thus there is an averaging effect. In the case of a square tower, a good average value for K is 0.0035.

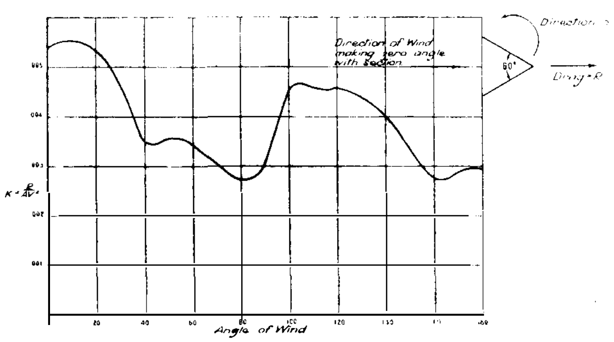


Fig. 7.

A considerable degree of uncertainty exists as to what wind pressure per square foot of surface should be taken. Opinions differ widely; for example, some firms of repute specializing in steel towers, allow 25 lbs. per square foot of surface uniformly distributed over one and a half times the normal projected area of the tower. This forms a marked contrast to the values taken in the design of the Rugby 820 ft. masts, viz., 60 lbs. per square foot over 1.8 times the projected area of one face. This high value was taken owing to the meagre information available when the masts were designed of the wind velocity at considerable heights above ground. The ratio of total loading in these two cases is thus 1 :2.9. In America wind pressures are taken at a much less value than in England. The Californian Railway Commission, for example, allow—or used to allow within recent years—13 lbs. per square foot of projected area on both sides of the tower. It is therefore interesting to examine some recent figures of wind velocities and from these to calculate possible values of wind load when a typical structure. The maximum wind velocities which, according to the meteorological office, have been recorded in the British Isles are shown in the Table **below**.

Place.	Year.	Highest Gust on record Miles per hour.	Height of aerometer above ground.
Pendennis (Cornwall) ...	1905	103	65
Quilty (Clare, Ireland)	1920	110	40
Scilly	1922	108	32

In the gales during the end of 1929, a wind velocity of 110 miles per hour was recorded in S.W. England.

The first point of interest is that the above pressures were recorded at heights not far removed from the ground. At higher elevations it is safe to assume that the velocities were higher. Taking 110 miles per hour for the wind velocity and 0.0035 for the value of K for square, equal angle towers, the wind resistance will have a value of 42 lbs. per square foot. A safe maximum value would therefore appear to be 45 lbs. per square foot. However, since gusts of even 90 miles per hour are not often experienced in the British Isles, it may be economically sound in some cases to design smaller towers up to about 120 feet for wind pressures of 30 lbs. per square foot; the type of service, the location and the economics of the question decide the exact values.

Screening.—In the foregoing discussion upon wind resistance no allowance has been made for screening.

With ordinary lattice towers where the ratio of distance apart of posts and face bracing to the width of flange is considerable, the allowance to be made for screening effects is not great. Stanton, in some of his early experiments,* showed that the total loading upon two similar parallel lattice plate frames varied from 1.6 to 1.78 times the load upon the windward plate when the ratio of distance apart to the width of the plates increased from 16 to 70. Thus within wide limits of variation of the ratio, the screening coefficient does not vary greatly and converges towards 1.8 for great values of the ratio. It is the practice in the British Post Office Engineering Department to use a maximum value of 1.8 for tower design. It is, however, evident that the value of the coefficient will change appreciably in an ordinary tapered self supporting tower, usually increasing towards the ground end of the structure. In a detailed design allowance should be made for this variation.

Particularly at the top of a tower should advantage be taken of the reduced value of the screening factor in order to start the design of the top panels with as small sections as practicable. Each increment of top horizontal loading, whether due to wind load or to aerial pull, necessitates additional increments of section throughout the tower.

There is an economical limit to the dip permissible with every aerial supporting cable. The

* *Proc. Inst. Civil Eng., 1904, Vol. CLVI.*

weight of a tower increases considerably with top pull and it is thus frequently more economical to erect a higher tower to allow an increased dip, since the resulting reduction in top pull enables lighter steel sections to be used.

T.W.

TRANSMISSIONS OF WIRELESS WAVES OF STANDARD FREQUENCIES FROM THE NATIONAL PHYSICAL LABORATORY.

(STATION CALL SIGN G.5 H.W.)

IN connection with the work of the Radio Research Board of the Department of Scientific and Industrial Research, waves of accurately known frequency have been transmitted for some years past from the Wireless Station at the National Physical Laboratory for checking the calibration of wave meters and other apparatus.

Up to this year the frequencies employed have been suitable for commercial purposes, but commencing on 3rd March last, at the request of the Post Office, arrangements have been made for a standard frequency transmission to be sent out which enables owners of Amateur Experimental transmitting stations to enjoy the same facilities. This standard frequency transmission is made on a frequency of 1785 kilocycles per second (*i.e.,* 168.6 metres), and is transmitted on the first Tuesday in March, June, September and December, commencing at 9 p.m. G.M.T. The standard transmission is preceded by the announcement C.Q. de G.5 H.W. repeated several times followed by standard wave transmission on 1785 kilocycles. The announcement is followed by a continuous dash, the whole lasting 10 minutes. This procedure is repeated six times, *i.e.,* at 2100 (9 p.m.) 2110, 2120, 2130, 2140 and 2150.

By the use of this standard frequency transmission a very accurate calibration of wavemeters or transmitters can be made although, as is the case in all accurate measurements, a certain degree of skill is required. The method detailed below is that suggested by the Post Office for utilising this standard frequency transmission to obtain the greatest accuracy with the apparatus usually available at amateur transmitting stations.

The apparatus required to check a crystal controlled transmitter or to calibrate a crystal wavemeter by means of this transmission, is, firstly, a receiver, the settings of which can be accurately determined, having a range from 1785 kilocycles to the highest calibration frequency required, secondly, a calibrated oscillator having a range of 200 to 1785 kilocycles. If the receiver is not of the self oscillating type it will be necessary to employ a separate hetrodyne in conjunction with it.

Dealing first with the case of a crystal controlled transmitter working in the 42 metre band and which utilises a wavemeter of the absorption or resonance type. The receiver is first set to the silent point of the standard frequency transmission, that is, to 1785 kilocycles.

The output from the oscillator is then closely coupled to the receiver (which is assumed to self oscillate), care being taken to ensure that there is no frequency interaction between the receiver and oscillator. The oscillator is then set to oscillate on 1785 kilocycles by varying its frequency until the silent point of its oscillation is obtained on the same setting of the receiver as that obtained for the silent point of the standard wave transmission. Leaving the oscillator unchanged, the receiver is next tuned to the 4th harmonic of the oscillator, that is, 7140 kilocycles per second, or the mid point of the 42 metre band.

The oscillator is then stopped and the transmitter made to self oscillate and its frequency adjusted to the same setting as the receiver, that is 7140 kilocycles per second. The wavemeter setting for this frequency is then obtained by measuring the transmitter frequency in the normal way. It is desirable that this setting should correspond with the middle of the wavemeter scale.

To obtain a calibration curve of the wavemeter on this band points are required separated by a smaller frequency interval than 1785 kilocycles from the mid point calibration already obtained, a separation which would be obtained by taking the 5th and 3rd harmonics of the previous oscillator settings.

To obtain two further points which will be less widely separated, the receiver is set to the silent point of the calibrated wave transmission and the oscillator frequency is decreased until its 5th harmonic corresponds with this setting of the receiver that is 1785 kilocycles. The fundamental of the oscillator will therefore be 357 kilocycles per second. The receiver is retuned to the setting previously obtained for 7140 kilocycles and the 20th harmonic of the oscillator will then be heard on this setting. The tuning of the receiver is then slowly varied until the 21st harmonic of the oscillator is heard, that is 7497 kilocycles per second. The transmitter is then tuned to oscillate on this frequency and the wavemeter reading again obtained. In a similar way the 19th harmonic of the oscillator may be tuned in and the process repeated giving a third point on the wavemeter at 6783 kilocycles per second.

To obtain accurate measurements the wavemeter range should be such that the three calibration frequencies are respectively near the minimum mid-point and maximum of the scale.

Even greater accuracy may be obtained by utilizing the 6th or 7th harmonic of the oscillator in place of or in addition to the 4th, thus obtaining check points with less separation.

A similar procedure is adopted to obtain checks on the 20, 10 and 5 metre bands, as it will be found that the mid points of these bands correspond with a harmonic frequency of 1785 kilocycles per second. It is not, however, necessary to employ such a high order harmonic of the oscillator for obtaining check points and harmonics should be selected to suit the range of the wavemeter used.

For example, in the 5 metre band it may be found satisfactory to set the oscillator to 3570 kilocycles per second, and to utilise the 15th, 16th and 17th harmonics corresponding to frequencies of 53550, 57120 and 60690 kilocycles per second.

To calibrate a non-crystal controlled transmitter, which in consequence uses a crystal controlled wavemeter under the regulations relating to amateur transmitters, the procedure is similar to that already described except that the transmitter is calibrated instead of the heterodyne wavemeter, and this calibration is used to check the crystal wavemeter.

NOTES & COMMENTS

THE LATE DR. HANSFORD.

THE many friends of the late Dr. Hansford will be glad to learn that the education of his two sons, as he had intended, is now assured. The elder son has been awarded a Scholarship at Shrewsbury School with a grant of £140 p.a. and enters the School immediately. The younger son was admitted last January to Christ's Hospital in recognition of his father's public service.

The two sons are happily endowed with many of their father's qualities and their careers will be watched with kindly interest.

A NOVEL APPLICATION OF THE PHOTO-ELECTRIC CELL.

A description of some recent developments, involving the novel application of at least three modern pieces of apparatus, may be of interest.

One type of recorder used by the Department for trunking investigations consists of 20 pens which draw 20 lines on a paper ribbon or chart. When the pens are operated, the lines drawn move away from the zero position by about one eighth of an inch and remain off normal until the pen is released. The analysis of these records, involving the accurate determination of the total time the pen has been operated, and the number of times, is very tedious, and experiments are being made with a view to avoiding this monotonous work which has hitherto been done by human effort.

The instrument involves the use of a photo-electric cell, a valve amplifier, and a modern A.C. synchronous clock. The chart with the pen records on it is drawn forward so that any one of the 20 lines passes under a powerful source of light focussed to a point on the line. The light passed through the paper is collected by a photo-electric cell. Obviously when the line moves off normal, *i.e.*, out of the light, the paper will pass more light to the cell as there is now no ink line in the way. The cell therefore will give an increased electrical output. If the light to the cell is rapidly interrupted by means of a shutter, the output will rise and fall rapidly and may then be dealt with by a valve amplifier, which, of course, is useless for amplifying D.C. variations. Any increase of light to the cell (caused by an off normal portion of the line) causes the average value of the cell output to increase. This in turn will cause the amplifier output to rise sufficiently to operate a relay in the circuit. The relay closes two local contacts, one to operate a meter of the Veeder type and the other to close the circuit of an A.C. synchronous clock. These clocks work off 50 cycle A.C. and have a very small starting lag. The meter will show the number of calls and the clock will show the actual total time the pen has been operated provided the original and analysis speed of the chart are known.

THE FARADAY CENTENARY EXHIBITION.

The above exhibition in the Albert Hall, London, was opened on the 22nd ult. and continues till the 3rd October. Organised jointly by the I.E.E. and the Royal Institution, the floor space is divided into five sections, one of which, dealing with Electrical Communications, was arranged by the P.O. Engineering Department. Valuable assistance and co-operation was freely given by the Telephone Development Association, the Cable Manufacturers' Association, the Accumulator Makers' Association, the Radio Manufacturers' Association, the B.B.C., the Science Museum and the Imperial and International Communications, Ltd. Part of the space allocated was taken up by the Institution of Radiology.

The lay-out was divided into the following groups, arranged radially outwards from the Royal Institution stands which surrounded a statue of Faraday in the centre of the hall. On the R.I. stands fundamental experimental work was being shown to link up the original with the later developments of the art.

(1) Early telegraph apparatus and plant.
(2) Telegraph Land Line operation.
(3) Telegraph Submarine Cable operation.
(4) Early telephone apparatus and plant.
(5) Modern telephone equipment in operation. Manual and Automatic.
(6) Telephone Repeaters, Carrier Telephony.
(7) Underground and Submarine Cable.
(8) Early Radio apparatus and equipment.
(9) Modern Radio: Telegraph and Telephone, Commercial.
(10) Modern Radio Broadcasting.

The early specimens were drawn mainly from the Science Museum, South Kensington, which holds an unique assembly of telegraph, telephone and radio apparatus. The A.T.M. Co. showed a model of the Director system in operation, Ericssons' a Manual exchange with an R.A.X. satellite from the G.E.C. Messrs. Creed had two Teleprinters No. 7A (column printers) in operation side by side with P.O. Wheatstone sets, while the I. and I. Communications showed two terminal submarine stations working through a regenerative repeater. Marconi's lent a valuable display of early and modern radio material, and the B.B.C. installed the six units which will, later in the year, form the Scottish Regional Transmitter. The S.T. & C., Pirelli-General, the B.I. and Henleys sent samples of typical telephone cables and Thos. Bolton & Sons specimens of line wires, etc. Siemens Bros. showed a very fine exhibit of submarine cables, telegraph and telephone, loaded and unloaded. The P.O. Radio Section exhibited a 500 kW thermionic valve made by Met-Vickers, a model short-wave aerial array, a long and a short-wave receiver, and with the aid of the S.T. and C. Co. illustrated " speech inversion " on the T.A.T. The Research Section demonstrated the effects of distortion on speech and music. The Accumulator Makers' Association installed a 50 v 300 Ah battery which supplied current to the exchanges and for sundry other purposes.

AUSTRALIAN TRANSCONTINENTAL TELEPHONE CIRCUIT.

The first commercial telephone circuit connecting Western Australia with the eastern portion of the continent was completed recently. Australian settlement may be divided into two distinct groups, one on the West coast and the other on the East, with a large tract of practically uninhabited country in between. Prior to the completion of the telephone channel, rapid communication between the groups was supplied by telegraph circuits which have existed for many years.

The total length of the new circuit which runs from Adelaide to Perth, is 1600 miles, in which length there are seven intermediate voice frequency repeater stations. Between Port Augusta on the edge of the eastern settlement, and Kalgoorlie, the outpost of the western settlement, the circuit follows the Transcontinental railway.

An eight channel carrier telegraph system is superimposed on the telephone circuit and carrier repeaters are installed at the same stations as the voice frequency repeaters. The carrier telegraph apparatus and the voice frequency repeaters were supplied by Standard Telephones and Cables, Ltd., the equipment being manufactured in England.

Since the opening of the new circuit, it has been extended gradually to all the Eastern States, the final extension being to Queensland on 25/5/31. The route distance between Brisbane (the capital of Queensland) and Perth is 3400 miles, but commercial calls have been completed between Townsville and Perth—a circuit length of 4200 miles.

The present daily calling rate between the Eastern and Western States is approximately 20. The charge for a three minute conversation between Adelaide and Perth varies from 12/- to 6/-, depending upon the time of the day the call is made, whilst the maximum and minimum rates for Brisbane-Perth connection are 18/- and 9/- respectively. The main source of revenue on the route is of course from telegraph traffic.

R.B.

COMMUNICATION ENGINEERING IN AUSTRALIA.

In the Journal of the Institution of Engineers, Australia, Vol. 3, No. 2, February, 1931, Mr. J. M. Crawford, Engineer-in-Chief of the Australian Commonwealth Posts and Telegraphs, who was at one time Secretary of the I.P.O.E.E., contributes a paper under the above heading, which was read before the Engineering Conference, Melbourne, March, 1931. The paper describes the scope of the work of the Communication Engineer, with particular reference to the telegraphic and telephonic problems which have to be overcome in Australia. The organisation and research facilities of the P.M.G's Department are outlined, and conclusions as to the possible lines of future development are given.

A TELEPHONE DICTIONARY IN SEVEN LANGUAGES.

We have received from M. Dayat, Chef du Service Commercial de la Librairie de l'Enseignment Technique, 3 Rue Thénard, Paris (5e), a copy of " Vocabulaire Téléphonique International " in seven languages. This valuable publication is a product of the Consultative International Committee (the C.C.I.) for Telephone Communication over Long Distances, which set up a special commission for the purpose of preparing a technical dictionary of telephone terms and definitions. The Commission has completed its work, which has been checked by the Telephone Administrations of Germany, Spain, France, Great Britain, Italy, Sweden and the Union of R.S.S., and this volume of 386 pages (229 pages of telephone vocabulary and 157 pages of alphabetical index) is the result.

The dictionary is published by Librarie de l'Enseignment Technique and copies can be obtained by remitting 100 francs, plus 9 fr. 40 postage for countries outside France, to M. le Directeur de la Librairie at the above address, 3, Rue Thénard, Paris (5e).

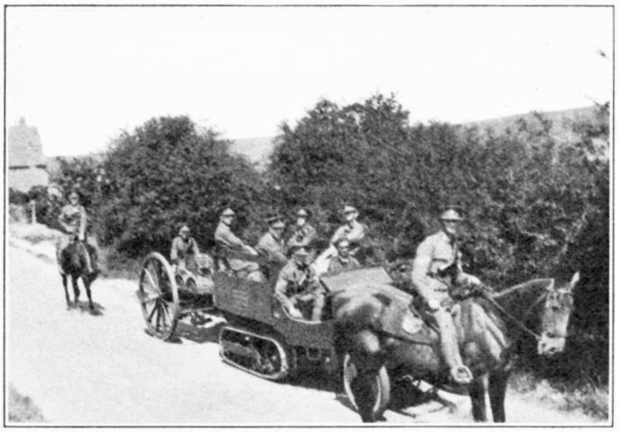
2nd September, 1931.

The Managing Editor,
P.O.E.E. Journal.

Sir,

MECHANISED SIGNAL WAGONS.

Your last issue contained a sketch of a telegraph wagon used in the Crimea, 1854, also a plough for laying covered cable.



MECHANISED SIGNAL WAGON.

The attached photograph may be of interest to your readers as it shows the latest development in cable laying from a mechanised cable wagon manned by representatives of the G.P.O. and of Messrs. Siemens Brothers, of Woolwich.

Yours truly,
"SIGNALS."

THE GRUB MENACE.

The Managing Editor,
P.O.E.E. Journal,
Engineer-in-Chief's Office,
Alder House,
London, E.C.1.

General Post Office,
Suva, Fiji Colony.
11th August, 1931.

Sir,

I have the honour to refer to an article, "The Grub Menace," which appeared in your July issue and related to an attack on the jumper wires by a type of clothes moth at the Tandem Exchange.

It may be of interest to those concerned to know that a similar serious onslaught was made on the jumper wires on both the main and intermediate frames of the Suva Exchange during December, 1930. The attack in many instances was so severe that only the enamelling was left untouched, the complete covering of the wires having been eaten away. A noticeable feature was that all waxed wires were left untouched, only wires which had not been waxed being attacked. A specimen piece of wire is enclosed.

The assistance of the Department of Agriculture was obtained and a copy of the report by Mr. H. R. Surridge, A.R.C.Sc., is enclosed. In order to carry out the fumigation proposed by the Department of Agriculture a wooden case was built round the intermediate frame—the main frame having previously been cased in glass to withstand climatic conditions. The fumigation process described by Mr. Surridge proved entirely satisfactory and there has been no recurrence of the trouble.

In order to gauge the quantity of fumigant used it may be stated that the Suva Exchange is a magneto multiple of 600 lines with one trunk panel.

I have the honour to be, Sir,
Your obedient Servant,
P. D. BERGO,
Postmaster-General.

MR. SURRIDGE'S REPORT.

From the Agronomist, Coconut Committee.
To the Director of Agriculture, Suva, Fiji Colony.
Subject: Anthremus vorax attacking insulations at the Telephone Exchange, Suva. 28th January, 1931.

1. It was reported to you that the insulation of certain important telephone wires at the Suva Exchange was being destroyed by a small grub and beetle, and advice and assistance asked for its destruction and control. At the request of Mr. Taylor, Entomologist, I accompanied him for the purpose of examining the damage reported and giving what assistance was possible.

2. The insulation of the cables was untouched, and the insulated wires that were covered with paraffin wax were also untouched, whereas those wires covered with a dry insulator, that is, one without wax, were found to have the cotton, etc., destroyed, thus leaving the wires exposed with the possibility of creating innumerable short circuits.

3. After a thorough examination of the damage and of those other wires and cables within the Exchange, it was recommended to the Postmaster-General that the Exchange should be closed down at a convenient time to allow for the building to be thoroughly fumigated with cyanide gas for a period of twelve hours.

4. After due consideration by the Postmaster-General he decided against this type of fumigation on the grounds of possible damage by corrosion to

some of the most delicate parts of the metal mechanism in the Exchange. Reference to the Government Chemist on this matter failed to re-assure the Postmaster-General, with the result that other possible means of control had to be explored.

5. Mr. Taylor, on reference to various authorities, noted that most fumigants suggested would probably attack metal to a greater degree than H.C.N. except in the case of Tetrachlorethane. This substance is not freely obtainable at present in this Colony, so that Paradichlorbenzene was suggested.

6. The Government Chemist confirmed the statement that the use of this substance as a fumigant would be harmless to the mechanism and also to human beings in the strength used.

7. In the meantime a wooden cabinet had been fitted around the damaged wires and thus ensured that fumigation with paradichlorbenzene could be carried out under control during normal working hours without danger to human beings or the telephone mechanism.

8. At this stage of the investigation Mr. Taylor had to proceed to SavuSavu, so that in his absence I carried on.

9. On Wednesday, 21st January, I supplied Mr. Alcock, in charge of the Telephone Exchange, with three cigarette tins holding half a pound each, six test tubes ($6'' \times \frac{3}{4}''$) and six test tubes ($5'' \times \frac{1}{2}''$) which absorbed another half pound between them, with instructions to place in the enclosed wooden cabinet, one cigarette tin and the six large test tubes, placing the tin on a shelf and suspending the test tubes from the cables above the wired terminals. The remainder of tins and tubes to be placed in similar positions in the larger cabinet fitted with glass doors.

10. These instructions were carried out by 4.0 p.m. that day. At 9.0 a.m. on Thursday, 22nd January, the wooden cabinet was examined when it was noted that the presence of the fumigant was objectionable, but at that concentration not effective.

11. Some small boards were obtained and one pound of the paradichlorbenzene spread out on them and placed just above the infected wires in this cabinet, the doors replaced and all cracks and holes plugged with cotton wool. This was completed by 4.0 p.m. on the 22nd and no examination made until 8.0 p.m. on the 23rd, when it was discovered that many of the larvæ were lying on the floor of this cabinet, apparently dead. As this cabinet was not required for working operations, it was resealed and left until January 27th when it was duly opened, and some of the bodies of the larvæ collected, placed in a test tube and sent to this Office for further examination. The reason for this is that it is stated that such larvæ can live for considerable periods without air. It is necessary therefore to know whether they were killed by the gas, or were just in a resting stage.

12. This fact stands out that paradichlorbenzene if it does not destroy the larvæ or beetle at least acts as a deterrent, and it is recommended that some should always be kept in these cabinets as a preventative. Also that in future, all wires should be waxed, since it was found that waxed wires were not attacked.

13. The beetle has been identified by Mr. Taylor as possibly Anthremus vorax, pending confirmation of specimens forwarded to the British Museum for identification.

(Sgd.) H. R. Surridge,
Agronomist, Coconut Committee.

THE GROWTH OF A LEGEND.

Summer Heath,
Hutton,
Nr. Preston.
5th September, 1931.

The Editor,
P.O.E.E. Journal.

Dear Sir,

Although relegated to the herbaceous border for the last five years, I still look with interest for the quarterly record of Telegraph and Telephone matters contained in " our " Journal, and it was with some amusement that I saw that the " rat " story was again to the fore. This process of threading a duct has ever been like the performance of the Indian juggler and the disappearing boy, nobody has actually seen it done, but lots of people know somebody who was told of it by someone whose veracity is unimpeachable.

Now it is really time that that rat was led out of the duct.

Mr. Stubbs has given the official version of an occurrence in the London District of about fifty years ago. A slightly different account was current among the " Works Order " and " Maintenance " men of the period.

This was before the time even of " G.P. quad " cables, single G.P. covered wires only being used. The method of drawing in additional wires was to cut one of the existing wires, and use it to draw a sash line into the pipe. The wire thus drawn out was included with the new ones, and all drawn in by means of the sash line. It sometimes happened where wires were few, and an easy " pull " was anticipated, that time was saved by using the existing wires to draw in the full complement of wires required. This method was not officially recognised, for obvious reasons, and it happened on one occasion (probably that referred to by Mr. Stubbs) that unexpected difficulty caused the two groups of wires to part company in the pipe. The foreman got a well deserved " telling off " from his Inspector, with dire threats of what would happen if the wires were not restored early.

When the Inspector arrived on the spot the following morning, he was agreeably surprised to find the wires in position, and jointing in progress. On enquiring how it was done, he was informed

" We sent down a rat." Relations were too strained after the slating of the previous evening for further explanation to be sought or volunteered, but everyone who knew the Underground Inspector of that time, will know that a good story would not be lost for the want of telling. Also it is well known that a frequently repeated story gains " trimmings " on its way, and so the rat quickly became fitted with an " accelerator " in the form of a ferret. According to Mr. Proctor, by the end of the last century, the work of drawing in the twine had been transferred to the ferret, the rat being used as " bait."

And now the very latest version appears in the " Lancashire Daily Post " of yesterday's date (enclosure) from which it will be seen that a squad of ferrets, complete, with collar, drew in the electric lighting cables on the embankment by direct labour, sans twine, sans line, sans gang, sans everything, except a little bit of meat at the farther end of the pipe!

It only remains to disclose the species of rat used on the historic occasion earlier referred to, I believe in 1882. It was not, as was generally accepted, the common *" mus rattus,"* but a different *" mus "* altogether, the *" calamus viminalus,"* a light cane popularly known as rattan, rat for short. It was, as Mr. Stubbs says, before the time of sweeps rods, but these canes which could (and still can) be obtained for a few coppers in about 20 feet lengths doubled in the shape of a hairpin, were frequently used for clearing blocked drains, and similar purposes. The process was known to the workmen as " using a rat," and this is the species of rat from which the ferret and electric trolley have evolved.

By the way, I *would* like a technical description of that electric trolley for carrying cables through ducts, if you could spare the space in an early issue.

Yours sincerely,
W. J. Rolfe.

The following is the extract from the paper referred to by Mr. Rolfe :—

" London's First Electric Lights.

" Nobody seems to have noticed that the floodlighting of London has come in what may well be accounted the jubilee year of the electric light. Curiously enough, it was a French firm that introduced electric street lighting to London—the Societé Générale d'Electricité, which charged sixpence an hour for some lights that dazzled and spluttered on the Embankment.

That was rather more than 50 years ago, but it was not till 1881 that electric lighting began to ' take on.' The first provincial town to have it, Godalming, adopted it in that year, and in the same year it was introduced to ships.

I have been given a very interesting account of how the first cables were laid along the Embankment. Nowadays cables are carried through pipes on a sort of electric trolly, but before this idea was hit upon it was not easy to lay cables. The engineer in charge of the Embankment job went into the country one week-end and brought back some ferrets, which he fitted with collars.

Fastening a cable to the collar, he put a ferret in at one end of the pipe and at the other enticed it with a piece of meat. At least, he tried to entice it, but on the whole the ferrets did not rise to the occasion. Sometimes they would emerge minus the cable, sometimes they would go to sleep in the pipe! "

HEADQUARTER'S NOTES.

EXCHANGE EQUIPMENT.

The following works have been completed :—

Exchange.	Type.	No. of Lines
Prestbury	New Auto	240
Folkestone Area (5)	,,	2200
Watford Area (3)	,,	3420
Shepherds Bush	,,	4100
London Auto School	,,	Training Equipment
Pendleton	,,	1620
Westcotes (Leicester)	,,	400
Preston (Brighton)	Auto Extn.	970
Amherst	,,	100
Darlington	,,	700
Moss Side (Manchester) ...	,,	200
Headingley	,,	200
Bournemouth	Auto Extn.	Observation Equipment
Ewell	New Manual	1220
London Trunk Record and Demand Suite	,,	44 Positions
St. Albans	Manual Extension.	Observation Equipment
R. Taylor (Liverpool)	P.A.B.X.	20
Burnley Corporation	,,	3●
Thorpe Meadows (Hastings) ...	,,	20
Morris Cars (Smethwick) ...	,,	50
London County Council ...	P.A.B.X. Extension	300

Orders have been placed for the following works :—

Exchange.	Type.	No. of Lines
Bishopsgate Tandem	New Auto	Positions
Wolverhampton	,,	Power Plant
Bilton	,,	do.
Blackheath (Birmingham) ...	,,	do.
Broadwell ,, ...	,,	do.
Springfield ,, ...	,,	do.
Stone Cross ,, ...	,,	do.
Sutton Coldfield ,, ...	,,	do.
Stechford ,, ...	,,	do.
Tipton ,, ...	,,	do.
Portslade (Brighton)	,,	do.
Adel	,,	do.
Gibbet Hill	,,	do.
Pinhoe	,,	do.
Park (Dundee)	,,	do.
Bishopsgate Tandem	,,	do.
Priory	,,	do.
Preston (Lancs.)	Auto Extn.	Routiner Equipment
Flaxman	,,	do.
Macaulay	,,	do.
Reliance	,,	do.
Gladstone	,,	do.
Western (London)	,,	do.
Hampstead	,,	do.
Shepherds Bush	,,	do.
Whitehall	,,	do.
Gulliver	,,	do.
Maida Vale	,,	do.
Pollards	,,	do.
Welbeck	,,	Routiner Equipment
Sloane	,,	do.
Temple Bar	,,	do.
Fulham	,,	do.
Bermondsey	,,	do.
Tandem (London)	,,	do.
Bishopsgate	,,	do.
Metropolitan	,,	do.
Holborn	,,	do.
National	,,	do.
Monument	,,	do.
Hendon	,,	do.
Primrose	,,	do.
Amherst	,,	do.
Birmingham (North)	,,	do.
Birmingham (Victoria)	,,	do.
Middlesbrough	,,	do.
Coventry	,,	do.
Hanley	,,	do.
Edinburgh	,,	do.
Ardwick	,,	do.
Brighton	,,	do.
Hove	,,	do.
Leicester	,,	do.
Swansea	,,	do.
Dudley	,,	do.
Sheffield	,,	do.
Rochdale	,,	do.
Southend	,,	do.
Newcastle-on-Tyne (Central) ...	,,	do.
Maidstone	,,	do.
Nottingham (Central)	,,	do.
Sherwood	,,	do.
Basford	,,	do.
Leeds	,,	do.
Arkwright	,,	do.
Blackburn	,,	do.
Manchester (Tandem)	,,	do.
Blackfriars (Manchester) ...	,,	do.
Southport	,,	do.
Torquay	,,	do.

Exchange.	Type.	No. of Lines
Watford	Auto Extn.	Routiner Equipment
Hampstead	,,	Voice Freuency
Western	,,	do.
Ilford	,,	do.
Pollards	,,	do.
Whitehall	,,	do.
Beckenham	,,	do.
Livingstone	,,	do.
Maida Vale	,,	do.
Mitcham	,,	do.
Gulliver	,,	do.
Addiscombe	,,	do.
Gladstone	,,	do.
Shepherds Bush	,,	do.
Metropolitan & National ...	,,	do.
Amherst	,,	do.
Monument	,,	do.
Hendon	,,	do.
Hillside	,,	do.
Primrose	,,	do.
Bishopsgate	,,	do.
Flaxman	,,	do.
Archway	,,	do.
Fairfield	,,	do.
Reliance	,,	do.
Leytonstone	,,	do.
Edgware	,,	do.
Macaulay	,,	do.
Preston Area	,,	Observation Equipment
Brighton Central	,,	2320
Addiscombe	,,	1600
Western	,,	2000
Moss Side (Manchester) ...	,,	200
Linthorpe	,,	300
Portsmouth	,,	100
Epsom	New Manual	3000
Epsom	,,	Power Plant
Pinner	,,	do.
Northwood	,,	do.
Brighton Corporation	P.A.B.X.	30
Torbay Hospital	,,	30
Thrift Stores	,,	30
Nusenbaum & Sons (Newcastle-on-Tyne)	,,	20 lines
Manchester Telephone Service	,,	505 ,,
Northern Aluminium (Banbury)	,,	30 ,,
H. & G. Simonds (Reading) ...	,,	30 ,,
Newcastle-on-Tyne Police ...	,,	30
Crane Bennett (London) ...	,,	30
Arthur Lee, Ltd. (Sheffield) ...	,,	55
Southend Corporation	,,	40

The following items may be of interest :—

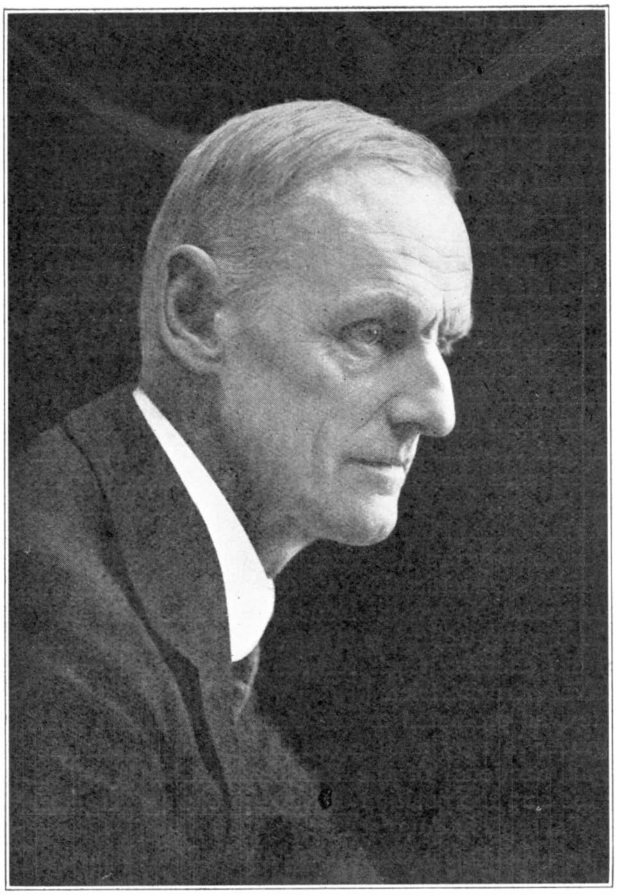
In preparation for the introduction of the "On Demand" system of Trunk Working, which it is proposed to initiate in the near future, 60 positions have been installed on the 5th Floor at the London Trunk Exchange.

The new system of Toll Junction operation whereby Toll calls are dealt with at the originating Exchange on a "no-delay" basis, is being introduced in Exchanges in London within the 5 mile area, and the conversion of a number of positions at various exchanges is now being proceeded with. In this connection, an ingenious time check known as a

"Chargeable Time Indicator" has been devised. The maximum number of cord circuits on Toll Control Positions is 10, and the Operator can ascertain the duration of a call connected by any one of these cord circuits by throwing the relative key. Strips of lamp jacks are mounted in the panels in front of the Operator, and the duration of the call at any given moment is indicated in minutes by illuminated figures.

The effective lighting of Apparatus Rooms in telephone exchanges has long been an engineering problem. Portable hand-lamps and lamps on running leads, in addition to the general lighting, have been tried with little success. The introduction of the Automatic system and the supersession of the "Selector Board" type of equipment by single-sided apparatus racks has called for the adoption of new methods. A system of flood-lighting of the racks has now been developed, and it is being installed in new exchanges. Lamps and reflectors are fixed to the ironwork of the racks and are independent of the ceilings or walls. The difficulties of arranging the lighting points, before the erection of plant, in the most effective position, and ensuring their freedom from the obstructions of apparatus and cable racks, are thus overcome, and the results of the experiment will be watched with considerable interest.

MR. P. T. WOOD.



MR. P. T. WOOD.

MR. P. T. WOOD was educated at the Liverpool College Upper School and largely as a result of a visit from a phrenological friend of the family was diverted from the University career enjoyed by four brothers to the more exacting profession of the electrical engineer.

He entered the service of the National Telephone Co. in October, 1894, under Mr. W. M. France, who was the Chief Electrician at Liverpool at that time. In the next six years he acquired a practical knowledge of apparatus fitting and maintenance and of exchange construction and maintenance which is not generally possible in these days of specialization. In October, 1900, he resigned his position as Exchange Inspector to take up duties with the United River Plate Telephone Co. as Assistant Chief Electrician, and was engaged in Buenos Aires on exchange construction and underground development work till February, 1903, when he resumed with the National Telephone Co. in London, taking up the post of Assistant City Electrician vacated by Mr. F. P. Edmonds on his transfer to the Traffic side. He recalls the responsibility resting on him for the successful operating of the unveiling mechanism on the occasion of the unveiling of the memorial to Michael Faraday by Lord Kelvin on November 24th, 1906. Throughout this period and for 14 years he lectured on Telephony at the Northampton Institute.

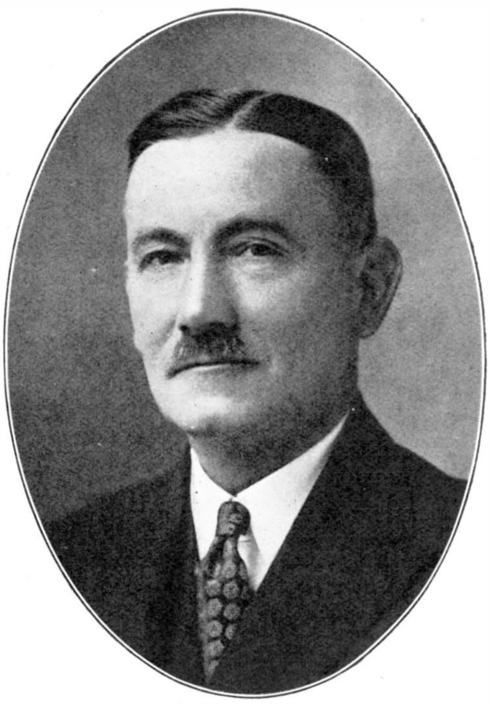
In 1907, on the reorganisation of the London District, he was promoted to the position of Assistant Metropolitan Electrician, which position he held at the transfer when he was graded as Executive Engineer and took charge of the newly formed Central Internal Section. Throughout the strenuous years of the war the Telephone Stations under his responsibility grew to the one hundred thousand figure, largely as a result of the mushroom growth of Government Departments. His duties brought him in contact with many men of national importance and he remembers with satisfaction Lord Curzon commenting on his similarity of features to a cousin, at one time a member of his Lordship's Indian Secretariat. He has also had the honour and pleasure of attending in an official capacity on His Royal Highness the Prince of Wales, and holds an interesting memento of the first time a member of the Royal Family broadcast, viz., on the occasion that the Prince of Wales broadcast a message to Boy Scouts in October, 1922.

During this period he served in the Post Office Special Constabulary, attaining the rank of Chief Inspector. In this capacity he had the honour of being presented to their Majesties the King and Queen at a Garden Party held in July, 1919.

He was transferred to the Engineer-in-Chief's Office in March, 1924, as Assistant Staff Engineer and was responsible for the initial organisation of the new Standards Group in the Equipment Section and became a member of the Committee, under the chairmanship of Mr. Ramsay, that brought to a successful conclusion the preliminary studies of the London Automatic system.

His hobbies are unconnected with the hitting of a ball, as he prefers the less strenuous country walk and can still manage a 40 mile tramp without discomfort. He is interested in cabinet making and philately.

MR. H. KITCHEN.



Mr. H. Kitchen.

Mr. Kitchen was appointed telegraphist at Newcastle-on-Tyne in 1889, and during the succeeding seven years he acquired a fundamental knowledge of the telegraph and telephone systems in use during that period.

After successfully negotiating a departmental examination (an innovation at the time) he was transferred to the Engineering Branch and appointed to the East Dean Repeater Station in 1897. He advanced to Haverfordwest in 1898, was made 2nd Class Engineer in 1901 and returned to Newcastle. Here his activities were concentrated in particular in the replacement of an underground system of gutta-percha covered conductor with lead-covered air space paper core cables, and in opening new telephone exchanges in the northern part of the county of Durham.

Executive Engineer rank was attained in 1911. At the 1912 transfer he took charge of the re-arranged Newcastle Section and lived a strenuous life for some years afterwards in co-ordinating the plant taken over from the National Telephone Co. with that of the Post Office.

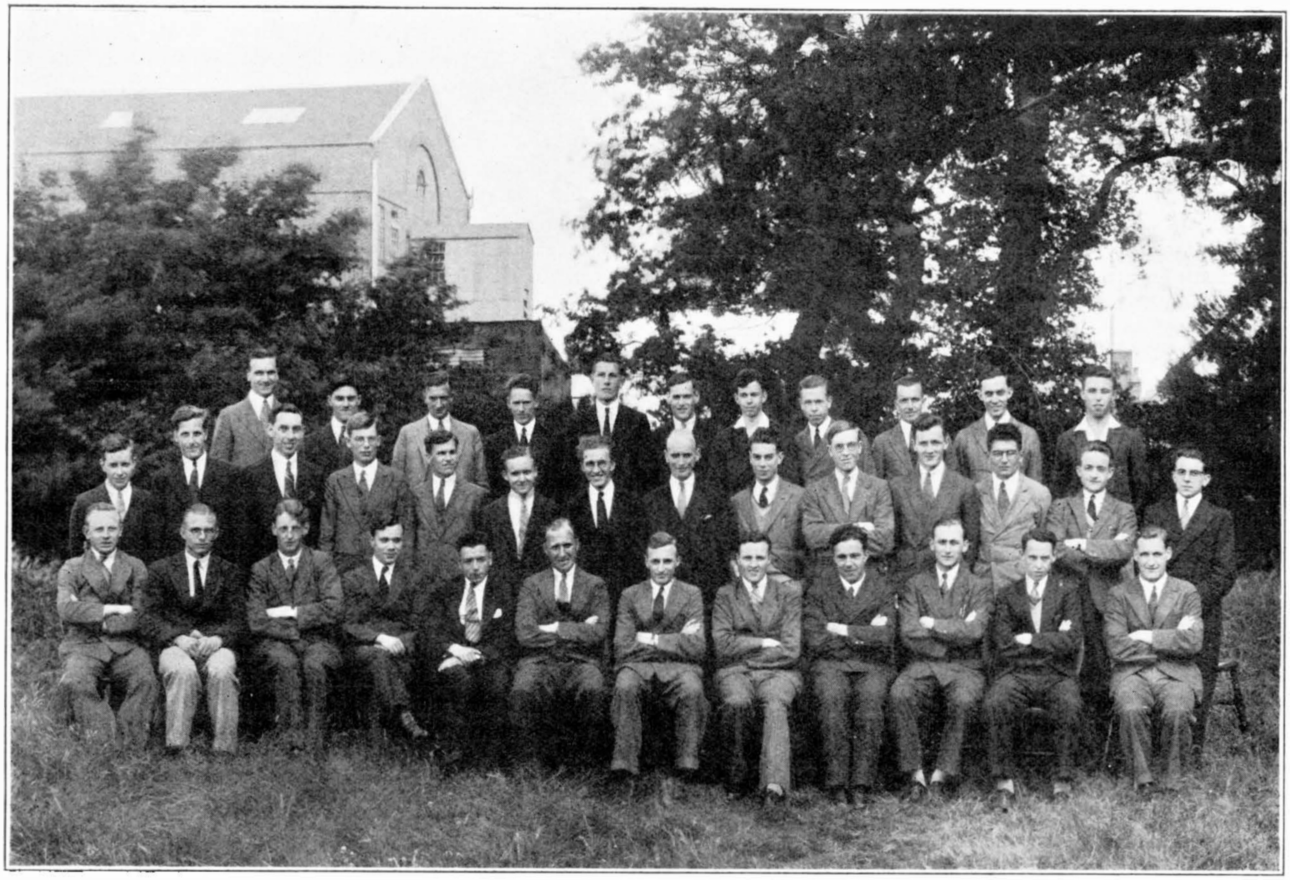
For some years he conducted evening classes in electrical communication subjects under the Durham County and Newcastle Educational Authorities.

During the war he was gazetted Lieutenant R.E. and did effective work for the Army and Navy in the Northern District.

He was promoted to the class of Assistant Staff Engineer in 1925 and served in the Lines and Telegraph Sections of the Engineer-in-Chief's Office. He took up the position of Superintending Engineer at Edinburgh in August last.

Mr. Kitchen has been a member of the Board of Editors of this Journal since 1926.

PER ARDUA AD ASTRA.



L. R. James, R. F. Goodchild, J. Prescott, J. Atkinson, E. A. Mayne, J. H. Cambridge, A. B. Marnden, L. R. Watson, D. F. Hamilton, A. F. Turner, C. H. J. Fleetwood (School Staff)
C. J. F. Pilcher, A. M. Stonebanks, C. E. C. Walling, A. H. Ellenden, W. F. Porter, A. D. Carrotte, W. H. Owens, J. E. Judson, W. H. Maddison, G. E. Button, W. H. Dolan, N. V. Knight, R. H. Renton, W. Prickett
S. E. Pugh, C. A. L. Nicholls, S. J. Edwards, W. K. Dunn, F. Leach, A. F. E. Evans (School Staff), G. R. Sudell (School Staff), R. E. Reed, L. J. Trott, A. E. Fears, G. H. Fogg, H. A. Turner

P. I's. COURSE
MAY – AUG: 1931.

FROM one of 34 Probationary Inspectors, successful candidates at the December 1930 Examination, a few impressions of the first period of training may be of interest.

All had received the official notification of success and had been ordered to report for training at the Engineer-in-Chief's Training School, situated at the Research Station, Dollis Hill. A considerate School Staff had arranged for one of its members to meet us at the main gate of the station and escort us to the lecture hall where we proceeded to make each other's acquaintance. Whilst awaiting the reception lecture, we indulged in a mutual cross-examination, recalling experiences and comparing notes *re* our former occupations. In the course of his official welcome, Captain Cohen gave an interesting lecture dealing with the scope of the Department's activities. He impressed us with the magnitude of the Engineering Department, and did not fail to bring relief to some of our members who had been—as it were—waiting for the dentist.

The main lecture hall, a truly magnificent place, had been allotted to us for our studies during our subsequent stay at Dollis Hill. In it we met our lecturers—specialists in all branches of the Department's work. Each informed us, with a few exceptions, that his particular subject was the most important. We now realise that all are integral parts of a great machine. The writer, although not anxious to tread the same path again, has been greatly impressed by the way in which most lecturers achieved the almost impossible task of creating interest in very "dry" subjects. If the reader of this article will refer to the "Journal" of October 1930, and scan the syllabus laid down for the training of Probationers in the Engineering Department, he will on learning that this syllabus is completed within sixteen weeks, agree that the persons responsible for its completion are worthy of the highest praise.

The proportion of time allowed for the study of different phases of the Department's practice did not always appear satisfactory, but perhaps the writer's interests are biassed in certain directions.

During the period devoted to the study of non-technical subjects, it seemed that an Inspector had at some time or other to check and sign every form devised and issued by the Department, but subsequent lectures showed that not a few are dealt with by other members of the Organisation. Whenever, on future occasions, one of us is called upon to make use of any particular form, a mental picture of the lecture hall at Dollis Hill Research Station will appear and recall occasions when he was led, rather hurriedly, it is feared, through the procedure surrounding innumerable forms. Then perhaps detail which now seems lost under a mass of information acquired since, will return to be of use and he will have cause to bless the lecturers who so valiantly endeavoured to shed some light during the course of training.

To many of us the technical lectures covered new ground, to others they created memories of days of toil and sleepless nights of study. None can say he learnt nothing. The lecturers generally showed themselves to be expert in their subjects and invariably impressed us with their own vast knowledge. The lectures were on the whole interesting and informative, and it is to be regretted that the time allowed for dealing with certain subjects was totally inadequate and prevented a more thorough absorption of the practical details and theoretical considerations involved.

On several occasions arrangements were made for visits to various internal and external works. Here was seen the need for organising along the lines already defined by our lecturers. Although it should not be inferred that conditions of inefficiency were found, close observation showed that a tight grip on departmental matters was vital. These visits certainly are an asset to the Probationer, for by them he is able to observe the methods of applying the many rules of administration and thus to solve any difficulties which may have arisen during his studies.

Towards the end of the course, visits were made to Contractors' Works to witness the manufacture of cable and other telephone plant. These gave excellent opportunities to study first hand the methods adopted on the part of the Contractors to meet the requirements of the rigid Post Office Specifications.

By the time this article is in print we will be engaged in district training, the District in each case having been chosen as far as possible to suit the convenience of the Probationer. This again shows the consideration paid by the Department to the interests of its new officers as well as to its own.

Our experiences in our new sphere are difficult to foretell, but although each one of us will be functioning in a different district in some cases hundreds of miles apart, we may abide in the knowledge that co-ordination and co-operation are the two basic features underlying the success of the Post Office Engineering Department. Mr. C. W. Brown and his School Staff and other members of the Department have, during our stay at the Training School demonstrated this, and the beneficial effects that result.

Upon the even of completion of the course, Captain B. S. Cohen addressed us, and in a few well chosen words wished us success in the future He stressed the inadvisability of losing touch with the rapid progress in Communication Engineering and, in pointing out how easy it is to get into a rut, urged us not to do so. We can assure him that whatever course our future may run the splendid impetus given by the training at Dollis Hill can only reflect to the credit of the School.

It only remains to express the keen appreciation felt by these 34 students of the welcome extended to them by the School Staff and the efforts of the Research Station generally to make them feel at home.

L.R.J.

LONDON DISTRICT.

Growth of Telephone System.—During the quarter ended 30th June, 1931, the nett additions in exchange lines and stations amounted to 4,015 and 7,669 respectively. The total is now 417,097 exchange lines and 703,777 telephone stations.

The total loop mileage of telephone wire, including trunks and junctions, is 1,548,428. An additional 155 kiosks were erected during the quarter.

New Manual Exchanges.—Two further manual exchanges to cater for the increasing demand for telephone facilities in the outlying suburbs were opened in July.

Sanderstead exchange, installed by the General Electric Company, Limited, with an initial multiple capacity of 1800 and ultimate of 10,000, was opened on July 15th by the transfer of 757 subscribers from the Purley, Croydon and Upper Warlingham exchanges.

On July 29th, Downland Exchange, installed by the Automatic Telephone Manufacturing Company, Limited, was opened to serve the rapidly developing neighbourhood around Merstham and Coulsdon. The initial multiple capacity of the exchange is 1,100 and ultimate 5,000; at the opening 477 subscribers' lines from the hypothetical Downland Exchange on Merstham and from Purley and Burgh Heath exchanges were successfully transferred.

L.E.D. Intercommunication P.A.X.—In a complicated telephone network such as that in London it is essential that communication between the various automatic and manual exchanges be effected by other means than the public system for ensuring quick and efficient co-operation in the advising and clearing of faults, especially in the case of major breakdowns.

Since the inauguration of automatic working in London each automatic and C.C.I. exchange has had a private wire to the Tandem exchange terminating on a magneto switchboard and has thus been able to establish connection with any other exchange in the network. It was considered, however, that the magneto system was not entirely satisfactory as regards reliability and speed of connection, so steps were taken to introduce automatic working in the form of a P.A.X. separate from the public system.

This P.A.X. has been installed by the A.T.M. Co. in the Holborn Exchange and comprises the following main items of equipment :—

140 Preselectors with capacity for 200.
25 1st Selectors with capacity for 30.
and 34 Final Selectors with capacity for 60.

Each automatic and C.C.I. Exchange has two stations on the one line to the P.A.X., an indicator and dial on the Test Desk and a telephone in the apparatus room. Party line working is provided by allotting two final selector numbers per exchange on the P.A.X., the X and Y ringing feature being catered for by special jumpering. At present 111 exchanges are connected to the P.A.X. Thorough tests were carried out at each exchange in co-operation with the P.A.X. before the transfer, the receipt of incoming calls, correct dialling out and transmission being verified in every case.

The transfer was effected by the change over of heat-coils on the Holborn frame at 8.15 a.m. on Wednesday, the 19th August. From 8.15 a.m. till 9 a.m. the magneto telephones in the apparatus rooms were changed for automatic type and during the day test calls were passed to neighbouring exchanges to verify the correct conditions.

The introduction of the P.A.X. will enable close and speedy co-operation between all exchanges to be effected and should amply justify the capital cost and maintenance charges involved.

Teleprinter Pool: Tandem Centre.—It may be of interest to some of our readers to learn that a pool of teleprinters and auxiliary apparatus for use at events such as Race Meetings, Regattas, etc., has been formed, and this apparatus is located in the Central Telegraph Office Section.

Teleprinters of varying D.C. voltages, with baseboards having connections which can be utilized to allow of Simplex, Duplex and Omnibus working, are available and rectifiers from A.C. to D.C. are stocked. Ultimately, small petrol electric sets with accumulators will be available in order that Teleprinters of a standard voltage can be used anywhere. The London Centre supplies the needs of the South-Eastern counties.

Pneumatic Perforators.—The last of the pneumatic perforators used in connection with high speed Wheatstone working at the C.T.O. has been recovered. Pneumatic perforators were installed in the News Division in the London Head Telegraph Office over 40 years ago, and were employed chiefly on News transmissions. Changes in their construction have been made from time to time since those early days, the later double type being capable of punching eight Wheatstone slips simultaneously. The withdrawal of the perforator is the result of the general development in the handling of telegraph work by means of Teleprinters.

MR. J. BROWN, M.I.E.E.

Mr. J. Brown, Assistant Superintending Engineer, London Engineering District, who retired on the 30th June, 1931, was one of the band of Scotsmen who invaded the Engineering Department in the "nineties," and whose ability and genius contributed in no small degree to the proud position which the Department occupies at the present time.

Mr. Brown was born and educated at Aberdeen and entered the Post Office Telegraph Service in 1885. Although he was active in most forms of sport he did not neglect technical study, and after numerous successes in this direction he was transferred to the Engineering Department at Liverpool in 1898. A year later he was promoted to Sub-Engineer at Warrington, where he carried out many important engineering works in Lancashire, Cheshire and North Wales. 1903 found him in London as Second Class Engineer engaged with many others in the task of telephoning the Metropolis.

After this he was for several years in the Hornsey Section, first as Assistant Engineer and later as Executive Engineer, leaving there in 1912 to take charge of the Technical Section of the London Engineering District. In this capacity he was responsible for the standardisation of procedure and the co-ordination of the organisation of the National Telephone Company with that of the Department. The organisation set up at this time by Mr. Brown for dealing with the design and lay-out of plant to meet telephone development in London and its suburbs has remained practically unaltered to the present time—a remarkable tribute to the character of his work.

During the war he was placed in charge of the

MR. JAMES BROWN.

Centre External Section, where the promptitude and efficiency with which lines of communication between the nerve centres of the Empire in Whitehall were proved earned high praise from the War Office, Admiralty and other Government Departments. After the war extensive proposals for overtaking telephone development and schemes for the intensive training of the staffs occupied Mr. Brown's attention. In 1927 he was promoted to the rank of Assistant Superintending Engineer and was put in control of external construction. He rendered invaluable service in connection with the fires in the Embankment Subway and the water burst at St. Giles' Circus, where the Department's plant suffered serious damage. The gas explosion in the Post Office Holborn tube provided an opportunity at the close of his official career of proving his capacity for dealing with difficult problems. Practically all the details in connection with the official enquiry and the subsequent settlement claims were dealt with by Mr. Brown. He was a tactful negotiator and carried through successfully many important Wayleave settlements with public authorities in London. In very few cases was it necessary to appeal to the Courts and the Department never lost a court case for which Mr. Brown was responsible.

Sir R. W. Woods, the Post Office Solicitor, in a letter which was read at the official farewell to Mr. Brown, expressed on behalf of himself and his staff their keen appreciation of the invaluable assistance given by him in many important cases and their regret at losing such a pleasant colleague and companion. In Mr. Brown the Department loses a highly efficient engineer, a wise administrator and one who will long be remembered for his fairness and readiness to help others, and who has endeared himself to all by his kindliness and charm of manner. May he have many happy and useful days in his retirement.

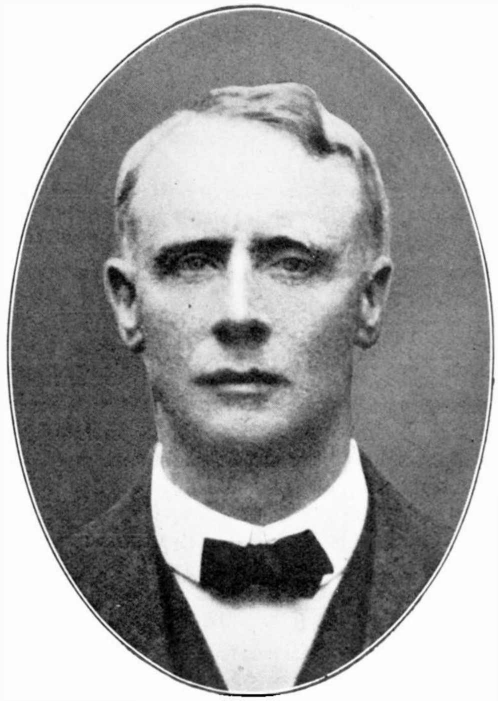
LOCAL CENTRE NOTES.

NORTHERN CENTRE.

SUMMER OUTING, 7/7/31.

The above photograph was taken on the occasion of the Sixth Annual Summer Outing of the Northern Centre, when a party of 66 members and friends, retired officials and representatives of the Commercial Staff visited Cragside Rothbury, where tea was served by kind permission of Lord Armstrong.

RETIREMENT OF MR. J. D. TAYLOR.



MR. J. D. TAYLOR.

MR. JOHN DEAN TAYLOR, for 19 years Superintending Engineer of the Scotland East District, retired from the service on 15th August, 1931, on attaining the age of 60.

Mr. Taylor was born at Scarborough, but his parents removing to Leeds he entered the Post Office there in 1886, and this enables him to tell some amusing stories of those "sixpenny tariff" days in which the late Mr. E. Trenam figures pleasantly—and, as a rule, effectively! In 1891, after a period of temporary duty in the Engineering Department, he was transferred to the clerical staff of the Superintending Engineer, Mr. J. C. Chambers; and two years later he was promoted and transferred to Cardiff as a 1st Class Junior Clerk.

The acquisition of the telephone trunk lines from the National Telephone Company, in 1896, provided an opportunity for temporary employment on engineering duties, followed by promotion in 1897 to a 2nd Class Engineership at Manchester: two years later, Mr. Taylor was transferred to the Engineer-in-Chief's Office as one of the group of engineers selected by Mr. (afterwards Sir) John Gavey to make the survey of the underground plant necessary to the "Telephoning of London" by the P.O. His association with this important instalment of the State telephone service continued for eight years and the knowledge thus gained of the economic principles governing the lay-out of "local" underground plant and of the difficulties encountered in congested areas, proved of great value later.

In 1907 Mr. Taylor returned to Leeds as Assistant (Superintending Engineer) to the late Mr. G. M. Carr; and in 1912, after a strenuous terminal period of detached duty connected with the inventory and valuation of the National Telephone Company's plant, he crossed the Border—in a direction not regarded as normal—and, with headquarters at Edinburgh, entered on the last stage of his official career.

The changes and advances which have taken place in the electrical communication network of the east and north of Scotland during Mr. Taylor's régime are of great significance, whether expressed statistically or in other ways: the most important, perhaps, from one standpoint, has been the extension of the telephone trunk system northwards from Tain to Wick, Thurso and the Orkneys; from another, the tripling of the mileage of underground conductors; and, from yet another, the entirely successful conversion, in 1926, of the Edinburgh telephone exchange system from manual to automatic working—at that date, the largest scheme of the kind which had been undertaken and one with which, as Mr. Taylor is first to acknowledge, the name of the late Mr. R. Alexander will always be associated.

On the economic side, there are few—if any—laurels which during the past 10 or 12 years have not been gained by the Scotland East District; and the success achieved may rightly be attributed to Mr. Taylor's unremitting efforts to secure "good work in good time." In some of his views on procedure he inclined towards a drastic curtailment of checks and safeguards; and time may show that his assessment of the risks was accurate or, in other words, that his judgment was sound.

Mr. Taylor was a member of the Committee of Superintending Engineers and also the Committee of the Scottish Centre of the Institution of Electrical Engineers: in these capacities he rendered the same good service as in the discharge of his main responsibility.

It is frequently both easy and convenient, in a notice of this kind, to distinguish between the official and the man: in this instance, such a distinction is impossible. Mr. Taylor's outlook on life is uniform in all directions and comes of his qualities—honest; sincere; strong: such a man expects efficiency from his staff and, better still, he stimulates it—when a mistake occurs, he aims to correct it, but he aims also to locate the cause, believing that in realisation of the cause lies the best chance of preventing recurrence. A deep sympathy with those in trouble, a well-marked sense of humour and a life-long and active interest in healthy sport are other components of the man.

Mr. Taylor may feel assured that, in leaving the official circle, he takes with him the best wishes of his many friends, both within and without the Scotland East District. J.W.A.

COMMONWEALTH OF AUSTRALIA.

POSTMASTER-GENERAL'S TWENTIETH ANNUAL REPORT, FOR YEAR ENDING 30th JUNE, 1930.

THE following extracts from the above report will be of interest to communication engineers :—

CAPITAL INVESTMENT.

The total amount debited to Capital Account for fixed Assets and Plant at the commencement of the year 1929-30 was £49,265,641.

The Capital expenditure during the year totalled £3,509,652 under the following headings :—

	£
Telephone Lines and Equipment (excluding Trunk Lines) ...	2,539,013
Telegraph Lines and Telephone Trunk Lines	490,198
Telegraph Equipment	104,494
Postal Equipment	85,791
Miscellaneous Plant and Equipment	45,885
Sites, Buildings, Furniture, and Office Equipment	244,271
Total	3,509,652

TELEPHONE SERVICE.

As a result of the adverse business and financial conditions, the telephone service did not progress at the same rapid rate as in former years. 11,567 lines and 14,890 telephones were added during the year, bringing the total lines and stations in use to 395,812 and 520,169 respectively. Australia has now an average of 8.08 telephones per hundred people and occupies sixth place in the list of countries having the greatest telephone density.

183 new telephone exchanges were brought into service and there are now 6,094 exchanges in operation. 5,946 of the exchanges are in areas outside the capital cities, and they serve nearly 44 per cent. of the total telephones connected throughout the Commonwealth.

The abnormal conditions also affected telephone traffic and the increase in business was not so great as in previous years. During 1929-30 420,639,538 effective paid local calls were made, an increase of 14,685,900 on the preceding year. 35,388,715 trunk line calls were also effected in comparison with 34,741,671 in 1928-29.

171,557 miles of wire were added, bringing the total length of telephone wire to 2,482,149 miles.

Rural Automatic Exchanges.—The trials with automatic equipment designed to meet the conditions peculiar to rural areas have continued. Unfortunately, the financial position renders it necessary to defer for the time being the installation of additional units.

Long Distance Service.—Not only were 8,759 miles of telephone trunk line added to the system during the year, but extra channels on many important routes were secured by the installation of the carrier system. There are now thirty-two carrier telephone systems in operation in Australia, giving a total of sixty channels, with an aggregate channel mileage of approximately 19,000 miles.

The completion during the year of carrier telephone systems from Brisbane to Townsville and from Townsville to Hughenden, has extended the long distance communication system to Northern Queensland. Telephone calls from Adelaide are now possible to Hughenden and Cairns.

The work of providing a telephone link between Adelaide and Perth, a distance of 1,700 miles, is in progress, and it is hoped to inaugurate the service before the end of 1930, when the ideal of a nation-wide telephone service will be within sight of achievement.

Overseas Telephone Service.—Another milestone of telephone progress was passed when commercial telephone service was established during the year between Australia and Great Britain. The inauguration took the form of a conversation between the Prime Minister of Great Britain, the Honorable J. Ramsay MacDonald, and the Prime Minister of Australia, the Honorable J. Scullin, which was held at 5.30 p.m., on 30th April, 1930. Since then, the service has been extended to many other European countries, and to the United States and Canada. It is hoped to open a service with New Zealand shortly and preliminary tests are proceeding.

Whilst the utility of the service with Europe is restricted somewhat because of the differences in time, nevertheless it furnishes an important link in the rapidly growing network of a world-wide telephone system.

New Automatic Exchanges.—Twelve new automatic exchanges were placed in service during the year, with 24,390 lines.

Research.—The Research Section continues to provide expert technical assistance with the developmental and investigatory problems of the telegraph, telephone and radio services of the Department. During the year it was found necessary to acquire additional accommodation for the increased staff and additional equipment.

The total staff at 30th June, 1930, was 22 officers, and the value of the equipment £16,000.

Transmission Section.—During the year a special section was formed to deal with all transmission questions. The specialized treatment of the important technical matters falling under this heading has already had beneficial effects and it may be expected that the Department's plant will function with greater efficiency as a result of the concentrated study given to this vital aspect of the service.

TELEGRAPHS.

Traffic.—The number of telegrams lodged during 1929-30 for transmission to places within the Commonwealth was 15,724,246 as against 16,345,152 for 1928-29, a decrease of 620,906, or 3.80 per cent.

These figures are inclusive of free messages (service, meteorological and shipping), the proportion representing paid traffic being 14,566,965 messages for 1929-30 as against 15,220,947 for 1928-29, a decrease of 653,982, or 4.30 per cent. The receipts from the paid traffic totalled £1,131,249 for 1929-30 as against £1,196,754 for 1928-29, a decrease of £65,505, or 5.47 per cent.

The number of telegrams despatched to places beyond the Commonwealth was 781,982 for 1929-30 as against 808,812 for 1928-29, a decrease of 26,830 or 3.31 per cent. Telegrams received from abroad for delivery in the Commonwealth totalled 718,339 for 1929-30 as compared with 727,256 for 1928-29, a decrease of 8,917, or 1.23 per cent. The Commonwealth earnings on traffic destined for or received from abroad were £205,700 for 1929-30 as against £221,358 for 1928-29, a decrease of £15,658, or 7.07 per cent.

Picturegram Service.—A picturegram service was opened for public business between Melbourne and Sydney during the year. The transmission of a photographic image of 70 square inches, effected over an existing telephone carrier channel 560 miles in length, occupies fifteen minutes only, the image being of good quality. Notwithstanding the severity of the prevailing depression, 400 images were exchanged between the two cities during the year.

Machine Printing Telegraph Systems.—The policy of extending the direct machine printing services wherever economically justified has been pursued throughout the year. The machine speeds have been steadily increased, the systems between Melbourne, Sydney and Adelaide now being operated at 50 words per channel minute.

Telegraph Carrier Outlets.—The financial advantages as well as the stability in performance of carrier wave transmission on well maintained aerial routes are reflected in the rapidly extending use of the carrier system on important traffic routes. The telegraph carrier system between Adelaide and Perth, now nearing completion, will be available for use early in 1931, providing Perth with direct machine-operated outlets to Adelaide, Melbourne, Sydney and, later, Brisbane. On completion of the work, the Department will reap important service and economic advantages.

RADIO SERVICES.

National Broadcasting Service.—The inauguration of the National broadcasting service was made with the transference of the services from station 2FC Sydney on the 17th of July, 1929, and satisfactory progress has been made to date by bringing the following stations within the National scheme on the dates indicated :—

2BL Sydney, 22nd July, 1929.
3LO Melbourne, 22nd July, 1929.
3AR Melbourne, 8th August, 1929.
6WF Perth, 1st September, 1929.
5CL Adelaide, 14th January, 1930.
4QG Brisbane, 30th January, 1930.

The only remaining station to be brought within the National service is 7ZL Hobart, which will be taken over after the expiration of the existing licence on the 13th of December, 1930.

The responsibility for the provision of the programmes over the whole of the National service stations was assumed by the Australian Broadcasting Company under a contract with the Commonwealth Government. At the present time the Company is rendering programmes throughout the Commonwealth covering about 30,000 hours per annum.

The first year of the National broadcasting service has unfortunately been one in which the economic conditions of the Commonwealth have been seriously depressed, but even under the adverse conditions the number of licences has increased from 301,000 to 312,000.

The Post Office is responsible for rendering all the technical services under the National broadcasting scheme, embracing the stations, studios, pick-up equipment, and inter-connecting lines.

FEDERATED MALAY STATES.

EXTRACTS from the Annual Report of the Posts and Telegraphs Department for year 1930 :—

TELEGRAPHS.

During the year 383,887 telegrams were despatched and 412,017 telegrams were delivered, being a decrease of 12 per cent. in the number of telegrams despatched and a decrease of 11 per cent. in the number delivered as compared with 1929. The revenue derived from telegrams was $386,417. The revenue shows a decrease of $58,981 or 13 per cent. compared with that of 1929. The value of telegrams sent free of charge for Government departments was $52,205, an increase of $10,300.

Telegraph facilities were extended to the new post offices at Malim Nawar and Gambang and, as it was not practicable to connect Sungei Lembing with the ordinary telegraph system, a low-powered short-wave Marconi type ZSB 2 station was installed in the post office and opened for traffic on the 3rd of November. A telegraph office was opened at Kuala Pahang on the 20th of August.

The use of typewriters for the reception of telegrams was further extended with satisfactory results.

In conjunction with the Eastern Extension Australasia and China Telegraph Company, Limited, arrangements were again made for the acceptance at any telegraph office in the Federated Malay States of "Christmas and New Year Greeting Telegrams" for many countries, at rates which approximated to one-quarter of the ordinary charges.

Telephones.

The number of direct exchange lines connected to the Federated Malay States telephone system on the 31st December, 1930, was 5,181, an increase of 106 as compared with 1929. In addition there were 2,617 extension lines, extension bells, private lines, private bell or alarm circuits and tell-tale clock circuits maintained by the department in 1930 as compared with 2,403 in 1929.

The revenue derived from telephones was $1,323,437, a decrease of $29,498 compared with 1929. Of this revenue the amount derived from junction and trunk services was $402,894, a decrease of $60,261 below the previous year.

On the 31st December, 1930, 66 public telephone exchanges were in operation in the Federated Malay States. By the end of the year 99 public call offices were available at post offices and postal agencies in the Federated Malay States—an increase of four over 1929.

The approximate total originated telephone traffic during the year 1930 was as follows :—

Local calls	14,247,000
Junction calls	2,061,000
Trunk calls	995,000
Total originated traffic ...	17,303,000

The installation of the new automatic exchange for Kuala Lumpur was commenced by Messrs. Ericssons Telephone Manufacturing Company, Limited, on the 3rd July, 1930, and was nearing completion by the end of the year.

The question of utilising automatic exchange equipment in rural areas has continued to occupy the attention of the department during the year, and two additional "Rural Automatic Units" have been ordered for trial under service conditions—one at Gap and one at Temerloh.

The scheme under consideration in 1929 for the provision of "Carrier Current" speech channels between Singapore and Kuala Lumpur, Singapore and Bukit Mertajam, Kuala Lumpur and Bukit Mertajam, and Ipoh and Bukit Mertajam (to which has been added a single channel system between Singapore and Tampin) was authorised by the Straits Settlements and Federated Malay States Governments during the year and a contract for the necessary equipment was placed with Messrs. Standard Telephones and Cables, Limited, of London, on the 24th May, 1930, and the contractors had commenced installation on site by the end of the year.

Wireless.

One hundred and seventy-nine temporary licences for the use of wireless receiving apparatus were issued during the year and two experimental transmitting licences. The British official news broadcast from the wireless station at Rugby in England, received at Penang wireless station and retransmitted from Penang by land-line for delivery to local newspapers on payment of a monthly fee, averaged 26,245 words a month.

A Marconi type U. ½ K.W. telegraph-telephone transmitter was reconstructed and re-modelled as a broadcast transmitter to operate upon 325 metres and installed in the Petaling Hill Station.

A low-power short-wave Marconi type ZSB 2 station was installed at the Post Office at Sungei Lembing and opened for traffic on the 1st of November.

Two Marconi ¼ K.W. type XMD 1 sets were sold to the Kedah Government and installed by this department at Alor Star and Pulau Langkawi. The service was opened in July and is reported to be satisfactory.

BOOK REVIEW.

"Examples in Power Distribution and Electric Traction." By A. T. Dover, M.I.E.E., A.Am.I.E.E. (Sir Isaac Pitman & Sons, Ltd.). Pp. 80. Price 3/6.

This book deals briefly with the more important theorems and formulæ relating to Power Distribution and Electric Traction, supplemented by typical questions, set by the University of London, the C. and G. Institute, and the I.E.E., to which answers are given. It will prove useful chiefly to students preparing for the higher examinations set by these bodies.

J. McG.

I.P.O.E.E. PROGRAMME, 1931-32.

PROVISIONAL PROGRAMMES OF LOCAL CENTRES.

LONDON CENTRE.

1931.
6 Oct. J. S. Elston, A.M.I.E.E.
"Trunk Telephone Re-organisation Plan."
10 Nov. W. T. Palmer, B.Sc., Wh. Ex., A.M.I.E.E., and E. H. Jolley, A.M.I.E.E.
"Telephone Cable Testing."
8 Dec. G. J. S. Little.
"Electric Wave Filters."
1932.
12 Jan. W. E. H. Kennedy.
"Industrial Psychology and its possibility in the P.O.E.D."
9 Feb. F. H. Buckland and R. H. Franklin.
"Cable Manufacture."
8 Mar. R. T. A. Dennison.
"P.B.X. Installation, requirements governing design of auto equipment and their practical applications."
10 May G. F. O'Dell, B.Sc. (Eng.), M.I.E.E.
"Standardisation."

Informal Meetings.

1931.
27 Oct. R. E. Soper.
"Special features in U.G. contract work."
24 Nov. H. T. Roberts.
"Engineering Repair Service."
1932.
26 Jan. G. Evans and S. W. Broadhurst.
"The By-path System of Automatic Telephony."
23 Feb. Harvey Smith.
"Something new in Cabling and Jointing work."
22 Mar. *To be arranged.*
26 Apr. E. J. Wilby, M.I.E.E.
To be announced later
Visits:—
P.O. Research Station, Dollis Hill.
B.B.C. Broadcasting House.

EASTERN CENTRE.

1931.
29 Sept. N. F. Cave-Browne-Cave, B.Sc., M.I.E.E.
"Sound and Hearing."
24 Nov. J. S. Elston, A.M.I.E.E. (*E.-in-C.O.*).
"Trunk Telephone Re-organisation Plan."
1932.
W. E. H. Kennedy (*E.-in-C.O.*).
"Industrial Psychology and its possibilities in the P.O.E.D."
16 Feb. C. J. Jones.
"Fenny Stratford Repeater Station."
15 Mar. T. Fewster (*Northern*).
"District Accounting."
12 Apr. L. G. Semple, B.E.
To be arranged.

NORTHERN CENTRE.

1931.
7 July Summer Visit.
21 Oct. J. S. Elston, A.M.I.E.E. (*E.-in-C.O.*).
"Trunk Telephone Re-organisation Plan."
18 Nov. T. Fewster.
"District Accounting."
16 Dec. A. O. Gibbon, M.I.E.E. (*E.-in-C.O.*).
"The Control of Electrical Time Services in the British Post Office."

NORTHERN CENTRE—*continued.*

1932.
30 Jan. Prof. W. M. Thornton, O.B.E., D.Sc., D.Eng. M.I.E.E.
"Transients."
17 Feb. *To be arranged.*
20 Apr. N. F. Cave-Browne-Cave, B.Sc., M.I.E.E. (*Eastern Centre*).
"Non-Metallic Materials and their characteristics."

NORTH EASTERN CENTRE.

1931.
— *To be arranged.*
10 Nov. J. S. Elston, A.M.I.E.E. (*E.-in-C.O.*).
"Trunk Telephone Re-organisation Plan."
— *To be arranged.*
— *To be arranged.*
— *To be arranged.*

NORTH WESTERN CENTRE.

1931.
— Sept. Visit to North Regional Station (B.B.C.).
26 Oct. J. M. Shackleton, M.I.E.E., and J. K. Murray, M.I.E.E.
"Co-operation."
8 Dec. J. S. Elston, A.M.I.E.E. (*E.-in-C.O.*).
"Trunk Telephone Re-organisation Plan."
1932.
11 Jan. G. S. Sunley.
"Postal Organisation."
15 Feb. T. E. Tootell.
"Transmission Testing in Telephone Exchanges."
14 Mar. J. D. Tough.
"Preliminary work in connection with the transfer of Exchange Systems."

SOUTH LANCS. CENTRE.

Not yet available.

NORTH MIDLAND CENTRE.

1931.
29 Sept. "Long Distance Radio Telegraphy" (at Rugby Wireless Station).
2 Nov. J. S. Elston, A.M.I.E.E. (*E.-in-C.O.*).
"Trunk Telephone Re-organisation Plan."
7 Dec. H. Green, A.M.I.E.E. (*Standard Telephone & Cables, Ltd.*).
"The Installation of the London-Liverpool Cable."
1932.
4 Jan. F. Coote.
"The work of the Maintenance Staff."
W. Dixon.
"Teleprinters."
J. R. Milnes.
"Secondary Cells."
1 Feb. W. E. Gill.
"Voice Frequency Work."
7 Mar. T. S. Skeet.
"Tuning Iron-cored Inductances. Energy Reflection in Telephone Circuits with special reference to Multiple Way Repeaters."

NORTH WALES CENTRE.

1931.
— E. Redpath (*Technical Staff, B.B.C.*).
"Short Wave Transmission."
— Capt. N. F. Cave-Browne-Cave, B.Sc., M.I.E.E. (*Eastern Centre*).
"Characteristics of some Non-Metallic Materials."
— H. P. Lloyd.
"Birmingham Auto Scheme External."
— C. V. Law.
To be arranged.
— G. H. Carrier.
"Protons."
— J. S. Elston, A.M.I.E.E. (*E.-in-C.O.*).
"Trunk Telephone Re-organisation Plan."

SOUTH WALES CENTRE.

1931.
12 Oct. Visit to Messrs. Burt & Co., Newport, Pole Creosote Yard.
9 Nov. W. Day, A.M.I.E.E.
"The Philosophy of Engineering."
15 Dec. J. S. Elston, A.M.I.E.E. (*E.-in-C.O.*).
"Trunk Telephone Re-organisation Plan."
1932.
11 Jan. R. E. Soper (*E.-in-C.O.*).
"Special features of Underground Contract Works."
8 Feb. B. Lynn (*E.-in-C.O.*).
"Voice Frequency Key Sending at Automatic Exchanges."
14 Mar. *To be arranged.*

SOUTH MIDLAND CENTRE.

1931.
7 Oct. *To be arranged.*
4 Nov. J. S. Elston, A.M.I.E.E. (*E.-in-C.O.*).
"Trunk Telephone Re-organisation Plan."
2 Dec. E. J. S. Roberts.
"Unit Maintenance Costs."
1932.
6 Jan. E. Clifford Harris.
"Cabling Economics."
3 Feb. R. J. S. Gold (*E.-in-C.O.*).
"Re-Valuation of the Department's External Line Plant."
2 Mar. H. G. Yeatman.
"Development."

SOUTH WESTERN CENTRE.

1931.
13 Oct. Major W. M. Batchelor, D.S.O., M.C.
Chairman's Address.
10 Nov. W. Ware.
"Radio Station—Portishead."
8 Dec. *To be arranged.*
1932.
12 Jan. J. S. Elston, A.M.I.E.E. (*E.-in-C.O.*).
"Trunk Telephone Re-organisation Plan."
9 Feb. *To be arranged.*
8 Mar. S. Preston and P. G. Treglown.
"Bristol Auto Transfer."

SCOTLAND EAST CENTRE.

Not yet available.

SCOTLAND WEST CENTRE.

1931.
5 Oct. F. W. Turner.
"Wayleaves."
2 Nov. A. McNeill.
"Ayr Automatic Transfer."
7 Dec. Informal.
1932.
18 Jan. M. Beattie.
"Telephones, Past and Present" (Glasgow particularly).
1 Feb. R. Milne.
"Some remarks on Records."
7 Mar. Informal.

NORTHERN IRELAND CENTRE.

1931.
6 Oct. T. Rodger (*District Manager, Belfast*).
Opening Address.
3 Nov. J. S. Elston, A.M.I.E.E. (*E.-in-C.O.*).
"Trunk Telephone Re-organisation Plan."
— Dec. A. S. Colston.
"Belfast Special Underground Construction."
1932.
— Feb. A. H. Jacquest, A.M.I.E.E.
"Frequency—its bearing on Communication Channels and Rentals."
— Mar. F. Gallagher.
"Works estimates from the Records standpoint."
— Apr. *To be arranged.*

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South Rhodesia.

ESSAY COMPETITION.

The Council has decided to offer five prizes of two guineas each for the five most meritorious Essays submitted to it by employees 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 candidate who has won a prize shall not be eligible to enter for this competition, but this restriction shall not apply to a candidate who has been awarded a certificate only.

Each competitor may choose any subject relevant to current telegraph or telephone practice. It is thought that the list given below of suitable subjects for Essays, though not exhaustive, will prove of assistance to competitors. The subject need not, however, be chosen from this list, but it must be relevant to current telegraph or telephone practice.—

A Long-distance Conversation.
A Practical Analysis of Characteristic Faults at Automatic Exchanges.
A Short History of Telephony.
A Telephone Man's attitude to the Subscriber.
Advice Note Procedure.
Aerial Cables.
Automatic Private Branch Exchanges.
Automatic Telephony.
Cable Balancing.
Cable Drawing.
Capacity Effects in Telephony—Wired or Wireless.
Carrier Wave Telegraphy and Telephony.
Change Over from an Old to a New Exchange Equipment.
Common Battery Manual Telephone System.
Conveyors—their Installation and Maintenance.
Cord Circuit Repeaters.
Corrosion of Lead Covered Cables.
Departmental Methods of Costing.
Electrical Clocks.
Electric Light and Power Installations.
Emergency Arrangements.
Extension of Large Telephone Exchange Multiples.
Fault Procedure at Automatic and Manual Exchanges.
Fire Alarm Systems.
Insulation.
Internal Combustion Engines.
Jointing.
Lifts—their Installation and Maintenance.
Lineman's Maintenance Load.
Live Wires.
Long Distance Wireless.
Manual versus Automatic.
Methods of increasing Output.
Modern Aspects of Electricity and Magnetism.
Modern Telephone Practice.
Multi-Office Automatic Telephony.
Oscillographs.
Overhead Construction—Precautions to avoid Interference with Working Circuits.
Overhead Line Construction.
Overhead Line Maintenance.
Practical and Theoretical Training.
Precision Testing of Underground Cables.
Preparation of Development Schemes.
Primary Batteries.
Radio Communications—any phase of.
Routine Testing in Automatic Exchanges.
Rural Automatic Exchanges.
Secondary Batteries.
Sound and Hearing.
Specialization—advantages and disadvantages.
Stamping Machines.
Store Keeping.
Subscribers' Switchboards.
Technical Education in Practice.
Telegraph Printing Apparatus.
Telegraph Working with Batteries.
Telephone Buildings.
Telephone Development.
Telephone Fitting.
Telephone Line Construction.
Telephone Repeaters.
Telephone Transmission.
Telephony Considered from a Subscriber's point of view.
Television.
The Construction of a Modern Balanced Cable.
The Economy of the Leclanché Cell.
The Economical Lay-out of Construction Work, etc.
The growth of the Trunk Service.
The Installation of a New Telephone Exchange Equipment.
The Laying of Pipes and Ducts.
The Loading of Telephone Circuits.
The London Trunk Exchange.
The merits of Overhead and Underground Distribution, with particular reference to costs.
The Telephone System of the British Post Office.
The Thermionic Valve.
The Theory of the Accumulator.
The Training of Youths.
The Use of Motor Transport in the Telephone business.
The Value of Private Study.
The Ventilation and Heating of Automatic Exchanges and Repeater Stations.
The Wiring of Large Buildings.
Traffic Recording in Automatic Exchanges.
Trunk and Junction Testing.
Trunking in Automatic Exchanges.
Underground Cables.
Underground Line Construction.
Voice Frequency Signalling Systems.
Wireless. Investigation of Broadcast Interference.

Each Essay must be written on foolscap on one side of the paper only, and must not exceed 5,000 words. A quarter margin to be left on each page. A certificate is required to be furnished by each competitor, at the end of the essay, in the following terms:—

"In forwarding the foregoing essay of..............words, I certify that the work is my own unaided effort both as regards composition and drawing."

Address.............................. *Signature*.....................

Date........................ *Rank*...........................

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, 1931.

The Council reserves the right to refrain from awarding the full number of prizes or certificates if, in its opinion, the Essays submitted do not attain a sufficiently high standard.

J. J. McKichan,
Secretary.

OUTLINE NOTES ON TELEPHONE TRANSMISSION THEORY.

W. T. PALMER, B.Sc., Wh.Ex., A.M.I.E.E.

SECTION 10—*continued.*

(1) Volume Efficiency.

Three principal units have been used to express this factor :—

(*a*) The " natural " attenuation unit.
(*b*) The " mile of standard cable " or M.S.C. unit.
(*c*) The " decibel "—sometimes referred to as the " TU " or " Transmission unit."

The decibel is the unit now used in America and by the British Post Office. The " natural " unit (the neper) is used by most other Continental administrations.

(*a*) *The Natural Attenuation Unit.*—This is known variously as the napier, neper or hyp.

If I_r = received current of a given system
I_s = sent current of the system.

then *if each of these currents is flowing into equal impedances* (as would be the case for a uniform line closed at the receiving end by the characteristic impedance Z_0) we can consider the ratio $I_r : I_s$ to represent the " volume " efficiency of the system. Since in the case of the infinite uniform line the ratio $\frac{I_r}{I_s}$ is of exponential form it has naturally become the practice to write—

$$\frac{I_r}{I_s} = e^{-\gamma l} \quad \text{(See Section equation).}$$

and to base the natural unit of attenuation on this formula.

In general γ is a complex quantity $= \beta + j\alpha$ and it is only necessary to consider the real part β since this alone determines the relative *magnitudes* of the two currents. Hence for scalar values of I_s and I_r :—

$$\frac{I_r}{I_s} = e^{-\beta l}$$

$$i.e., \ \beta l = \log_e \frac{I_s}{I_r} \doteqdot 2.303 \log_{10} \frac{I_s}{I_r} \quad \text{............(1)}$$

Thus if $\frac{I_s}{I_r} = e$

then βl = unity, *which defines the neper* as the attenuation of a system with the ratio $I_s : I_r$ equal to $\epsilon \doteqdot 2.718$.

Example.—If in a uniform line of 50 miles closed by Z_0 the sent current is 20 and the received current is 2 mA, then the total attenuation is given by equation (1) :—

$$\beta l = \log_e \frac{20}{2} \doteqdot 2.3 \text{ nepers.}$$

Since $l = 50$ then it can be written that the *attenuation constant* of the line $= 2.3 \div 50 = 0.046$ *neper per mile.*

If P_s and P_r represent the corresponding powers required I_s by and I_r *flowing into equal impedances* Z_0, then—

$$P_s = I_s^2 Z_0 \text{ and } P_r = I_r^2 Z_0$$

$$\therefore \ \log_e \frac{I_s}{I_r} = \log_e \sqrt{\frac{P_s}{P_r}} = \tfrac{1}{2} \log_e \frac{P_s}{P_r}$$

∴ Equation (1) becomes : —

$$\beta l = 1.151 \log_{10} \frac{P_s}{P_r} \quad \text{....................(2)}$$

Example.—If in the foregoing example the currents were flowing into 1000 ohm impedances then—

$P_s = 0.4$ millowatt
$P_r = 0.004$ millowatt

Using equation (2)

$$\beta l = \tfrac{1}{2} \log_e \frac{P_s}{P_r} = \tfrac{1}{2} \log_e \frac{0.4}{0.004}$$

$= 2.3$ nepers as before.

(*b*) *The Mile of Standard Cable (M.S.C.).*—This unit is now rarely used, having been replaced by the decibel. The M.S.C. is approximately one-tenth the magnitude of the neper and is thus of more convenient size for ordinary practical use. The volume efficiency of a line or piece of apparatus is then expressed by stating the number of miles of standard cable which gives the same ratio of received to sent currents. In England the standard mile is defined as a cable having the following constants :—

R = 88 ohms per mile loop
L = 1 mH per mile loop
G = 1×10^{-6} mho per mile loop
C = 0.054 μF per mile loop
} Standard mile.

The attenuation constant of such a mile can be calculated from equation (18) of Section 2, and comes to *0.106 neper* at 800 periods per second. Hence if a cable has a total attenuation length of βl = 2.12 nepers at 800 p.p.s. then its **S.C.E.** (Standard cable equivalent) is 2.12 ÷ .106 = 20 M.S.C.

In general for a cable of S.C.E. = M mls. :—

$$\beta l = \log_e \frac{I_s}{I_r} = 0.106\ M$$

$$i.e.,\ \beta l \fallingdotseq \frac{1}{10} M$$

In other words, the M.S.C. unit (at 800 p.p.s.) is nearly one-tenth the neper or natural unit. From equation (1), M (M.S.C.) = (2.303 ÷ 0.106) $\log_{10} \frac{I_s}{I_r}$

$$\therefore\quad M\ (M.S.C.) = 21.72 \log_{10} \frac{I_s}{I_r} \quad \text{...........(3)}$$

If P_s and P_r represent the sent and received powers respectively sent into equal impedances then as in pp. (*a*) it can be shown that—

$$M\ (M.S.C.) = 10.86 \log_{10} \frac{P_s}{P_r} \quad \text{..............(4)}$$

The American Standard Cable (800 cycle-mile) has

R = 88 ohm per mile loop
C = 0.054 μF per mile loop

and L and G are neglected. Hence the attenuation constant at f = 800 p.p.s. is *0.109 neper* (as compared with the English Standard cable value of 0.106. The difference is chiefly due to the absence of inductance in the American Standard).

(*c*) *The Decibed (db) or Transmission Unit (TU).*—It is clear that the attenuation constant of the M.S.C. is dependent on frequency,—See equation 18, Section 2, and hence the standard cable equivalent of a system will be

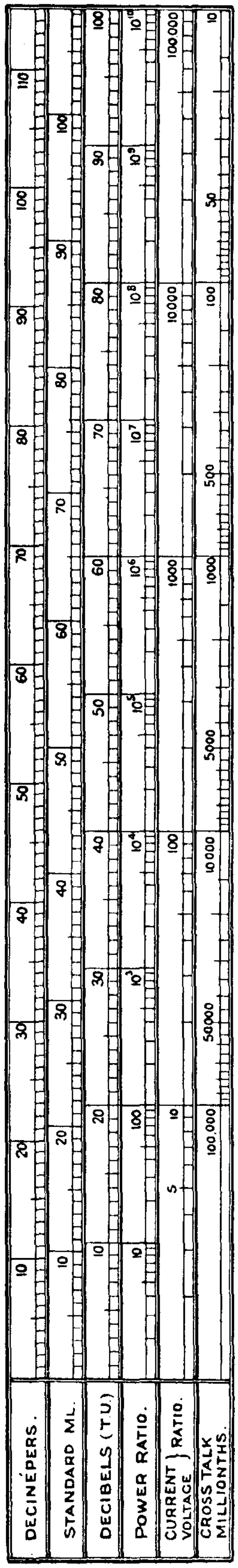

FIG. 28.—A SCALE GIVING THE RELATIONSHIP BETWEEN THE UNITS GENERALLY USED IN TELEPHONE ENGINEERING.

CONVERSION TABLE.

Decibel.	M.S.C. (Miles of Standard Cable).	Neper.
1.0000	1.0846	0.11513
0.9221	1.000	0.10616
8.686	9.420	1.00000

different for different frequencies. Due to this variation, and because 800 p.p.s. as a standard mean speech frequency is not universally accepted, there has been adopted a distortionless transmission unit (TU) referred to as the *decibel* and is defined so that (using the nomenclature of pps. (*a*) and (*b*)) the number of decibels (N) to which a system is equivalent is given by—

$$N = 10 \log_{10} \frac{P_s}{P_r} \qquad (5)$$

The function $\log_{10} \frac{P_s}{P_r}$ is said to represent the volume efficiency of the system in bels.

Comparing (4) with (5):—

$$\log_{10} \frac{P_s}{P_r} = \frac{M}{10.86} = \frac{N}{10}$$

i.e., 1 M.S.C. = .922 db.

Comparing (1) with (5):—

1 neper = 8.686 db.

i.e., the decibel is very approximately of the same magnitude as the M.S.C. at 800 p.p.s. and nearly one-tenth the size of the neper.

Hence the following advantages are claimed for the decibel—

(α) Of convenient size and is a fundamental unit.

(β) Independent of frequency.

(γ) As simple a physical significance as the M.S.C. and can be easily constructed.

(δ) Common log tables only required for calculation purposes.

From equation (5) the decibel is defined as the attenuation of a system with the ratio $I_s : I_r$ equal to $10^{0.05} \fallingdotseq 1.12$.

See Fig. **28**, which shows a useful conversion Scale and has been reduced to a size suitable for fixing on the back of an ordinary 10″ slide rule.

Example.—From the foregoing notes it will be seen that the transmission equivalents required in Example 2 in Section 9 are found as follows:

Before loading calculate β in nepers from equation (18) of Section 2, but putting L = 0.001. Then the transmission equivalent is $(8.686 \times \beta)$ in decibels.

β will be found to be 0.107 nepers
= 0.93 db. per ml., giving a total equivalent of 50 × 0.93 db. = *46.5 db*.

After loading, the attenuation, β in nepers, can be found from equation (18), Section 2, and is equivalent to

= 8.696 × 0.02 db. per ml.
= 0.17 db. per ml., giving a total equivalent of 50 × 0.17 db. = *8.5 db*.

(*a*) Articulation Efficiency.

Articulation tests were proposed by Campbell in 1910, but it is only during the last few years that the technique of making such tests has been sufficiently well developed to ensure accuracy of results.

The tests are carried out by trained speakers reading aloud, into the sending end of the system, a number of groups of meaningless monosyllables and the percentage of these sounds correctly received, by trained listeners at the receiving end, is computed.

In the special cases of standard systems (using reference transmitters, reference artificial lines and receivers—See Section 11 of Notes) used in the laboratory for investigating the articulation may reach as high as 98%, but in the average system using ordinary commercial apparatus it is much lower, being of the order of 60% to 70%.

To-day, when any new piece of telephone apparatus is developed, it is usual during testing to include both volume and articulation tests and to determine the suitability of the new apparatus by a comparative study of the results of these tests.

Recently, further tests of the "*intelligibility of words*" and "*intelligibility of phrases*" have been made from which the "intelligibility" of the system may be estimated.

A relation between articulation efficiency and intelligibility is indicated in Fig. **29**, taken from a paper by B. S. Cohen in the J.I.E.E., Vol. 66, p. 169.

(Section 10 to be continued.)

References for Section 10:—

Journal I.E.E., Vol. 66, p. 165.—"Apparatus Standards of Telephonic Transmission," by B. S. Cohen.

Journal of the Franklin Institute, June, 1922.—"The Nature of Speech and its Interpretation," by Harvey Fletcher.

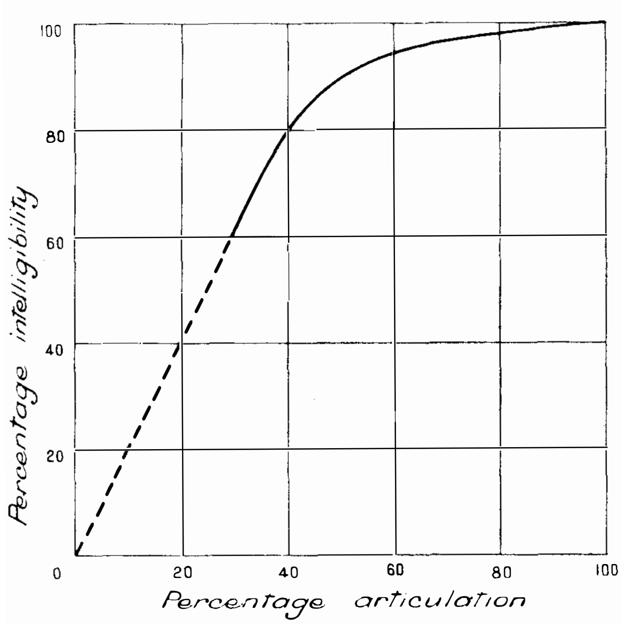

FIG. 29.

Elek. Nachrichten, Vol. 4, p. 184.—"Articulation Tests in Telephone Transmission Systems," by H. F. Mayer.

Electrical Communication, Jan., 1929.—"A Theoretical Study of Articulation and Intelligibility of a Telephone Circuit," by John Collard.

"Speech and Hearing," by H. Fletcher. Published by D. Van Nostrund Co. Inc.

NOTES FOR ADDITION TO SECTION I :—

(h) Solution of Network Problems.

For this purpose there are three main methods of attack, viz. :—

(1) **By means of Kirchoff's Laws** and use of Maxwell's cyclic currents to obtain a number of simultaneous equations which are solved by the use of Determinants. This is probably the best known method and is not dealt with more fully here. References are given at the end which will be found useful.

(2) **By the "Network" Theorem** or Star-Mesh Transformation Theorem. This theorem states :—

In any network a star of n rays, OA = *a*, OB = *b*, OC = *c* . . . . ON = *n* (See Fig. **30** (*a*)) *may be replaced by a mesh* (Fig. **30** (*b*)) *of* $\frac{1}{2}\,n\,(n-1)$ *conductors joining every pair of points.* A, B, C . . . N(*O being eliminated*) *without affecting the rest of the network: and then for conductance operators :—*

$$AB = \frac{ab}{\Sigma a},\quad BC = \frac{bc}{\Sigma a},\quad CD = \frac{cd}{\Sigma a},\ \text{etc.}\ldots\ldots\ldots(1)$$

where $\Sigma a = a + b + c + \ldots n$

For impedance operators :—

$$AB = ab\sum\frac{1}{a},\quad BC = bc\sum\frac{1}{a},\quad CD = cd\sum\frac{1}{a}\quad \text{etc.}\ldots\ldots\ldots(2)$$

where $\sum\frac{1}{a} = \frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \ldots \frac{1}{n}$

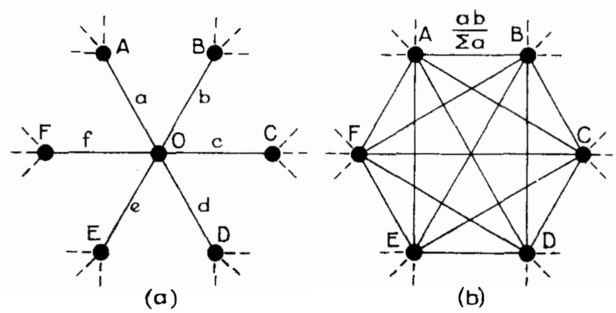

FIG. 30.

Note.—(*a*) In general the number of mesh conductors is greater than the number of rays in the corresponding star and hence the general theorem is not reciprocal (*i.e.*, no mesh in which the members are arbitrary can be converted into a star). *One exception*, however, arises when $n = 3$ in which case the number of mesh conductors equals the number of rays and a *triangular mesh* can always be replaced by an equivalent star. (Fig. **32**).

(*β*) Another particular case of the general theorem arises when $n = 2$ which represents two conductors in series (Fig. **31**), wherein the 2-ray star OA, OB transforms to $AB = \frac{ab}{a+b}$

Using impedance operators—

$$AB = ab\left(\frac{1}{a} + \frac{1}{b}\right) = a + b.$$

Except in this simple case the impedance operators are not so convenient to use on account of the frequent addition of conductors in parallel and in the following example conductances or admittances are employed :—

Example.—To find the effect on the balance of a Wheatstone bridge of earth admittances located at the four corners of the bridge A, B, C, D. (Fig. **33** (*a*)).

Applying the transformation theorem to the 4-ray star AE, BE, CE, DE, the new condition for balance can be written down directly. (Fig. **33** (*b*)).

$$\left(w + \frac{ac}{\Delta}\right)\left(y + \frac{bd}{\Delta}\right) = \left(x + \frac{bc}{\Delta}\right)\left(z + \frac{ad}{\Delta}\right) \ldots\ldots(1)$$

Where D = $a + b + c + d$.

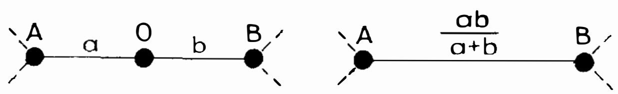

Fig. **31**.

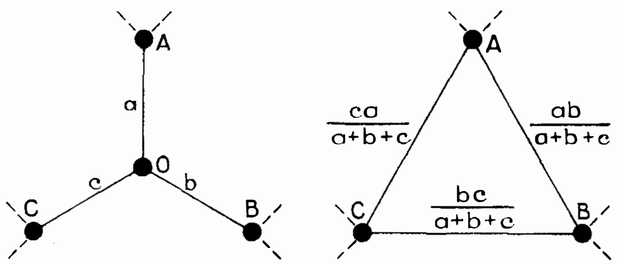

Fig. **32**.

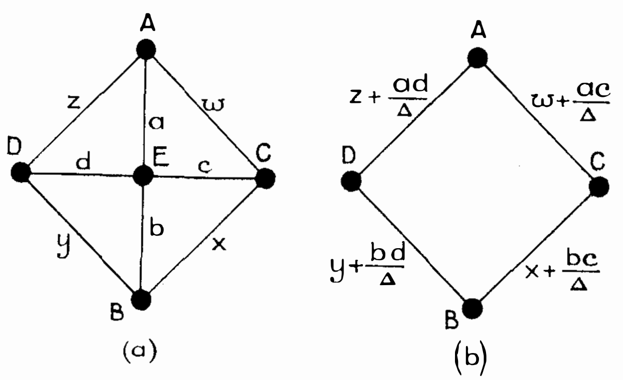

Fig. **33**.

The admittances $\frac{cd}{\Delta}$ and $\frac{ab}{\Delta}$ which would appear across CD and AB respectively by the transformation are not shown as they appear across either the source or the detector and do not affect the condition for balance given in equation (1).

(3) **By Thevenin's Theorem** certain classes of network can be very quickly solved. This theorem states :—

In any system of arbitrary linear conductors (in which the current in every branch is proportional to the impressed voltage) the current in any branch is that which would result should an E.M.F., equal to the p.d. which would appear across the break were the branch opened, be introduced into the branch and all other E.M.F.'s be removed.

In other words, the theorem can be stated :—

The current in any branch, z, of a network may be determined by replacing the remainder of the network by a generator whose E.M.F. is V and internal impedance Z where V and Z are the values measured at the terminals of z when that branch is opened, i.e., the generator is an open circuit. The current in the branch z is then given by $\frac{\mathbf{V}}{\mathbf{Z} + \mathbf{z}}$.

An example of the use of this theorem occurs in Section 10, pp. (*c*) and the following example is given here for comparison of this method (3) with method (1) :—

Example.—To find an expression for the current in the galvanometer branch of a Wheatstone bridge and the condition for balance.

Using Method (1).—By applying Kirchoff's Laws and Maxwell's cyclic currents (Figs. **34** and **35**) the required current x can be found from the equations :—

$$\left.\begin{aligned} (a + b + g)(x + y) - gy - bz &= 0 \\ (f + g + d)\, y - g(x + y) - dz &= 0 \\ (b + d + h)z - b(x + y) - dy &= e \end{aligned}\right\} \quad (1)$$

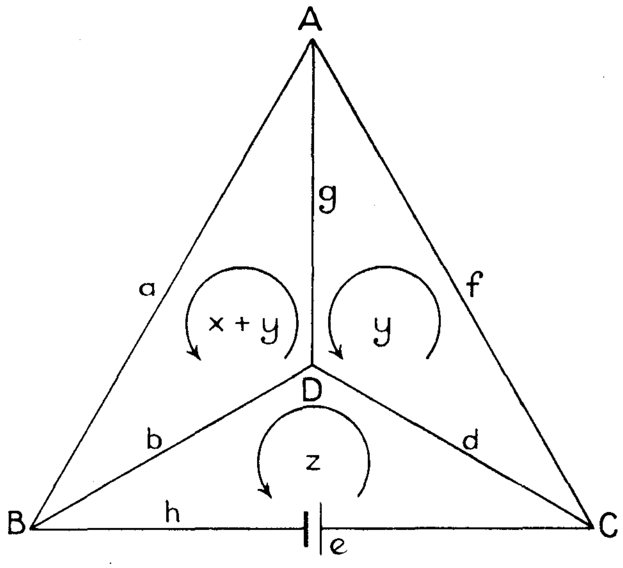

FIG. 34.

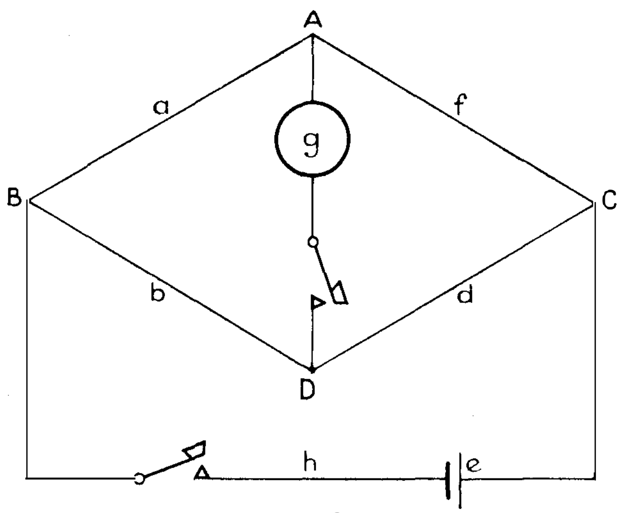

FIG. 35.

By rearrangement :—

$$\left.\begin{aligned}(a + b + g)x + (a + b)y - bz &= 0\\ -gx + (d + f)y - dz &= 0\\ -bx - (b + d)y + (b + d + h)z &= e\end{aligned}\right\} \qquad (2)$$

Hence by the Theory of Determinants :—

$$x = \frac{\begin{vmatrix} 0 & (a + b) & -b \\ 0 & (d + f) & -d \\ e & -(b + d) & (b + d + h) \end{vmatrix}}{\begin{vmatrix} (a + b + g) & (a + b) & -b \\ -g & (d + f) & -d \\ -b & (b + d) & (b + d + h) \end{vmatrix}}$$

$$\therefore\ x = e\,\frac{\begin{vmatrix} (d + f) & -d \\ (a + b) & -b \end{vmatrix}}{\Delta} = \frac{e(bf - ad)}{\Delta}$$

For a balance $x = 0$

$\therefore$ *$bf = ad$ is the required condition.*

Using Method (3).

Let *p.d.* between B and C be E when the galvanometer branch is opened (Fig. **34**).

Then *p.d.* between B and A is $\dfrac{a}{a + f} \cdot \mathrm{E}$

and ,, ,, B and D is $\dfrac{b}{b + d} \cdot \mathrm{E}$

$\therefore$ *p.d.* across the open salvo branch AD is

$$\mathrm{E}\left(\frac{b}{b + d} - \frac{a}{a + f}\right)$$

If R = external resistance to an E.M.F. in the galvanometer branch then *by Thevenin's Theorem* the current, x, in the branch when the circuit is closed is :—

$$x = \frac{\mathrm{E}}{g + \mathrm{R}}\left(\frac{b}{b + d} - \frac{a}{a + f}\right)$$

i.e., $x = \dfrac{\mathrm{E}}{(g + \mathrm{R})(b + d)(a + f)}(bf - ad)$

$\therefore$ *The condition for balance ($x = 0$) is $bf = ad$.*

Note.—Fig **25A** below refers to Section 9 of the last issue.

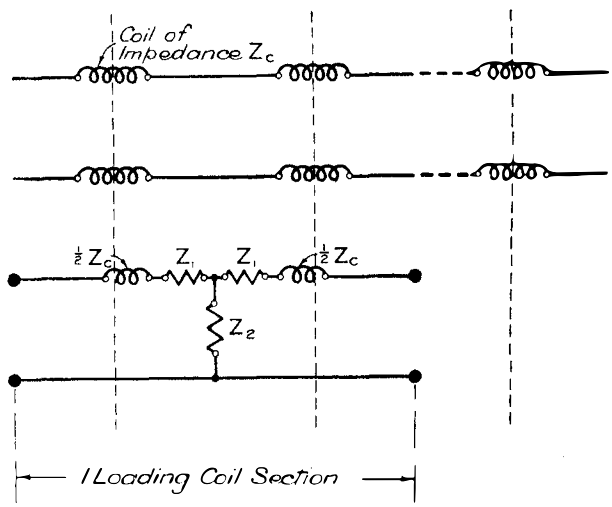

FIG. 25A.

Useful References for the foregoing Additional Notes to Section 1.

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"A New Network Theorem," by A. Rosen. J.I.E.E., Vol. 62, p. 916.

"Direct Capacity Measurement," by G. A. Campbell. Bell System Tech. Journal, July, 1922.

"The Equivalence of Triangles and Three Pointed Stars in Conducting Networks," by A. E. Kennelly. Elec. World, 1890, Vol. 34, p. 413.

Discussion of "New Network Theorem," by A. Morris. J.I.E.E., p. 303, Vol. 63.

"A Principle Governing the Distribution of Current in Systems of Linear Conductors," by Dr. F. Wenner. Proc. Phys. Soc., p. 124, Vol. 39.

"Transmission Circuits for Telephonic Communication" (p. 79), by K. S. Johnson. Published by Library Press, Ltd., London.

[*This series of papers when completed will be published in book form.—Eds. P.O.E.E. Jnl.*]

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Strachan, L. D.	Staff Officer, Stores Dept.	Motor Transport Officer, Cl. II., E.-in-C.O.	1-7-31
Benzies, A.	Staff Officer, Stores Dept.	Motor Transport Officer, Cl. II., E.-in-C.O.	1-7-31
Robinson, R. T.	Assistant Engineer, E.-in-C.O.	Motor Transport Officer, Cl. II., E.-in-C.O.	1-7-31
Wood, P. T.	Assistant Staff Engineer, E.-in-C.O.	Suptg. Engineer, S. West District.	1-11-31
Kitchen, H.	Assistant Staff Engineer, E.-in-C.O.	Suptg. Engineer, Scot. East District.	23-8-31
Smart, E. V.	Executive Engineer, London District.	Assistant Suptg. Engineer, London. District.	1-7-31
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Johnson, A. S. A.	Executive Engineer, E.-in-C.O.	Assistant Staff Engineer, E.-in-C.O.	1-11-31
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Vernon, R. J.	Chief Inspector, E.-in-C.O.	Assistant Engineer. E.-in-C.O.	To be fixed later.
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Allsop, E.	Inspector, N.E. District.	Chief Inspector (Allocation to be fixed later).	To be fixed later.

Name.	From	To	Date
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Bevis, W. F.	Repeater Officer, Cl. II., E. District.	Chief Inspector, E.-in-C.O.	5-9-30
Peirce, J. G.	Unest. Skilled Workman, Testing Branch.	Inspector, Testing Branch.	To be fixed later.
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Scott, D. W. R. ... ... Jenkinson, T.	Skilled Workmen, Cl. I., S. West District.	Inspectors, S. West District.	To be fixed later.
Baker, J.	Skilled Workman, Cl. I.,	Inspector, S. Wales District.	To be fixed later.
Tolhurst, S. ... ... Crofts, A. A. ... ... Rockall, A. G.	Skilled Workmen, Cl. I., Testing Branch.	Inspectors, Testing Branch.	To be fixed later.

Death.

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TRANSFERS.

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Paterson, J. S.	Assistant Engineer.	E.-in-C.O.	30-6-31
Bytheway, P. C.	2nd Cl. Engineer.	Scot. West.	1-9-31
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Kennedy, H.	Inspector.	Scot. West.	30-4-31
Earp, E.	Inspector.	N. Mid.	31-7-31
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Clatworthy, F. H.	Inspector.	Testing Branch.	2-9-31
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Bullimore, G.	Inspector.	London.	31-5-31

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Morrison, G. E. N.	Higher Clerical Officer.	Scot. West.	1-7-31
Cross, W. H.	Higher Clerical Officer.	N. Mid.	31-7-31
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Brown, C.	Higher Clerical Officer.	S. West.	31-7-31
Hemming, J. G.	Higher Clerical Officer.	N. East.	11-9-31
Smith, J. R.	Higher Clerical Officer.	Eastern.	24-9-31
Cole, G. G.	Executive Officer.	London.	30-9-31

TRANSFERRED.

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Wilson, E.	Higher Clerical Officer.	Eastern District.	S. Mid. District.	4-8-31

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Name.	From	To	Date.
Scott, W. H.	Clerical Officer, London District.	Higher Clerical Officer, London District.	13-6-31
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Smerdon, J.	Clerical Officer, London District.	Higher Clerical Officer, London District.	1-8-31
Jones, F. E.	Clerical Officer, S. West District.	Higher Clerical Officer, S. West District.	1-8-31
Calderwood, R. H.	Clerical Officer, Scot. West. District.	Higher Clerical Officer, Scot. West District.	2-7-31
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Hinks, G. W.	Clerical Officer, N. Mid. District.	Higher Clerical Officer, Eastern District.	4-8-31
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Fryer, G. Y.	Clerical Officer, N. East District.	Higher Clerical Officer, Eastern District.	9-8-31

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