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A Trailer Motor Desiccator employing Silica Gel

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A description is given of a petrol-engine-driven desiccator in which the drying agent, silica gel, can be reactivated periodically by heat supplied from the engine exhaust gases. The complete equipment is trailer-mounted and has proved to be a valuable maintenance aid in effecting rapidly the temporary restoration of cables affected by the ingress of moisture.

Introduction.

WITH the existing multiplicity of circuits provided by air-spaced paper-core cables and coaxial cables, the risk of considerable dislocation of traffic exists through the failure of such cables. Failures may arise from various causes, prominent amongst which is the penetration of water through cracks or punctures in the cable sheath. When such conditions develop, the first intimation that is received may be that the electrical characteristics of the cable have fallen to such a level as to make the circuits unworkable. Permanent restoration of the cable generally necessitates renewal of the faulty length, but there are occasions when very real economies can be effected and much inconvenience saved if the cable can be restored to service by desiccation and the main repair work carried through later when the stress and urgency of breakdown conditions have been removed.

Restoration of the existing, but faulty, cable may often be accomplished by passing dry gas through the cable and removing the offending moisture. While carbon dioxide or dry air are so employed to-day, the former, although conveniently supplied from the familiar gas cylinders, collects in jointing chambers at the discharge points and requires to be dispersed before permanent repairs are completed. The second alternative generally involves the use of calcium chloride for drying the air before it is pumped through the cable, a method which has a number of disadvantages, particularly when viewed under breakdown conditions. The motor-driven desiccator, described below, uses silica gel as the adsorbent material and is considered to possess advantages over the usual methods of desiccation.

General Description.

The petrol-engine-driven desiccator which forms the subject of this article is based upon the principle of using silica gel as the moisture-adsorbent material and employing the waste heat in the engine exhaust gases to reactivate the silica gel when it becomes saturated. The practicability of this principle was established by P.O. Research Report No. 7612. By the use of two beds of silica gel—one drying the air while the other is being reactivated—the operation of the unit may be continued without interruption as long as the engine is supplied with fuel. The system is shown schematically in Fig. 1.

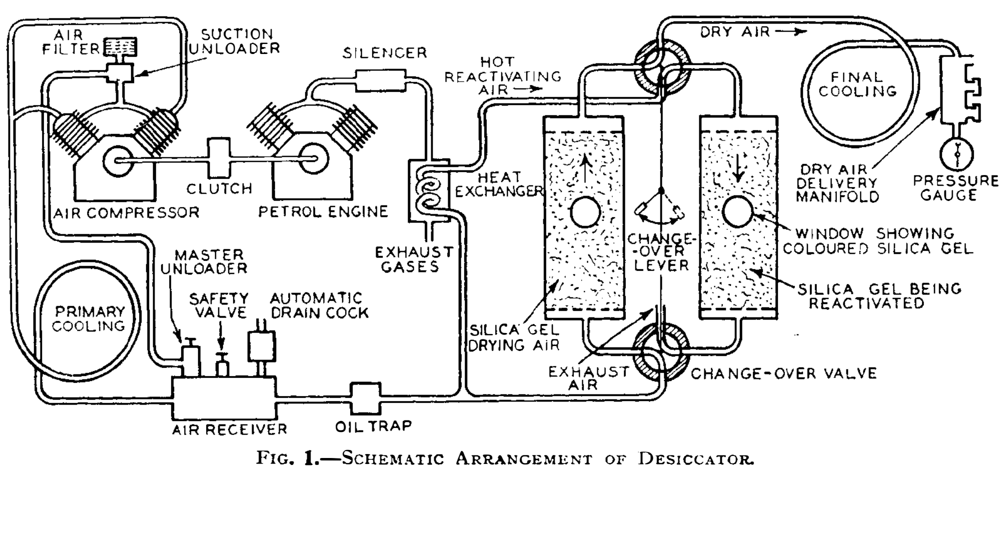

FIG. 1.—SCHEMATIC ARRANGEMENT OF DESICCATOR.

The trailer-mounted apparatus is constructed to meet the Departmental requirements and consists of an air-cooled petrol engine driving an air compressor. The bulk of the compressed air passes through one of the silica-gel beds and thence to the cables, while the remainder is heated by a heat-exchanger and is then fed through the second bed of silica gel to blow-off the water vapour liberated from the silica gel by virtue of the heat in this air. After one bed has been used as the drier for a time, the change-over of action is effected rapidly by a single lever connected to a pair of double-port valves. A number of accessories are also incorporated, e.g. automatic unloader, automatic drain cock, safety valve, etc., enabling the units to be operated with the maximum efficiency by staff that have not been specially trained in the use of the equipment.

Prime Mover.

The prime mover is a standard commercial twin-cylinder, air-cooled petrol engine developing approximately 10 h.p. at 1,000 r.p.m. Although this type of engine is normally governor controlled, a means is provided of reducing the engine speed to a minimum of approximately 800 r.p.m. in order that the power used may be approximately in proportion to the dry air consumed. Reduction in the engine speed below 800 r.p.m. is not practicable, because of the difficulties that arise through ineffective cooling and lubrication. A fan is provided on the engine for cooling purposes.

The output drive is transmitted via a spring-loaded centrifugal clutch to enable the mechanical load from the compressor to be excluded until the engine has been started and has gathered speed. The clutch engages at approximately 200 r.p.m.

Air Compressor.

The air compressor (see Fig. 2) is of the twin-cylinder, air-cooled type and is fan-cooled. The atmospheric air passes through an air filter before being compressed. The compressor employed is the nearest suitable commercial size to give the required output of 10 cu. ft. of air per minute at 30 lb. per sq. in.

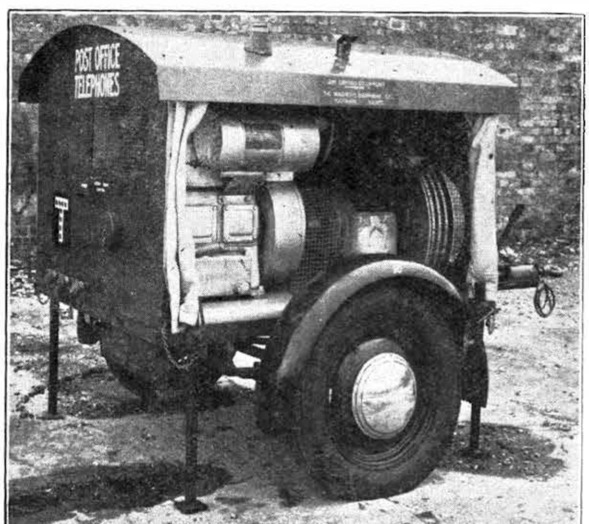

FIG. 2.—ENGINE AND COMPRESSOR SIDE OF THE DESICCATOR.

Air Receiver.

An air receiver of welded construction is employed which conveniently provides a means of mounting an automatic unloading valve, set to operate at 35 lb. per sq. in., and a safety valve which operates and releases at 30 ± 2 lb. per sq. in. The function of the automatic unloader is to trip a valve in the compressor and so relieve the load on the engine when the volume of air used is less than the volume of air compressed.

Silica-Gel Beds.

Each of the two silica-gel beds (see Fig. 3) consists of a cylindrical mild steel drum with a small glass window at a central position. Each bed contains 70 lb. of plain silica gel and also, in a perforated container behind the small window, 1 lb. of silica gel that is coloured, for indicating purposes, with cobalt chloride. When dry, the familiar cobalt blue colour is visible through the window, but as the silica gel adsorbs moisture the colour changes to pink. A colour-comparison guide is provided adjacent to the window as a safeguard to indicate when the bed should be reactivated. The colour guide is divided into four areas, ranging from blue to pink and clearly showing the safe and unsafe colour tints.

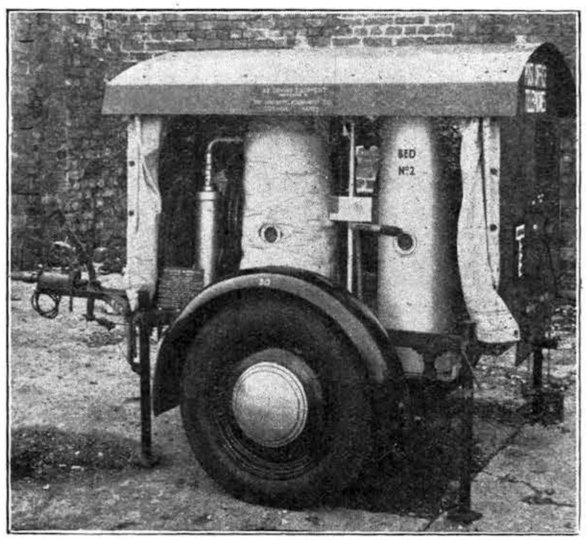

FIG. 3.—SILICA-GEL BEDS SIDE OF THE DESICCATOR.

Although each bed has been designed to cater for the maximum volume of air that may be passed through it in a continuous run of eight hours, considerable periods may elapse between occasions of use and the particular moisture content of either bed may be unknown to an individual user. Hence, the provision of colour-indicating windows is considered to be a justifiable precautionary measure.

During the air-drying cycle of operation the air passes through each bed from the bottom to the top, while during the reactivating cycle the direction is reversed. This ensures that the air, immediately before its entry into the cable, emerges from that part of the silica-gel bed which has received the most thorough reactivation and so minimises the risk of passing even a relatively small volume of damp air into the cables.

Change-over Valves.

The change-over valves consist, in essence, of a cylindrical block of mild steel containing two passage-ways and housed within a casing provided with four suitably disposed ports. The two valves are coupled together and operated by a single change-over lever that swings through an arc of 90°.

Heat-Exchanger.

Although the reactivation of the adsorbing agent could be achieved by the direct use of the engine exhaust-gases, numerous deleterious effects would result. The employment of a simple heat-exchanger overcomes this major disadvantage without appreciable loss of efficiency.

The heat-exchanger, which is illustrated in Figs. **4** and **5**, consists of a pack of copper plates clamped between cast iron headers which incorporate the inlet and outlet ports. Each plate has grooves cut in both faces, the grooves in one face being at right-angles to those in the other face. Each set of grooves terminates in marginal slots, one on each side of the plate, which, as the plates are assembled, form four separate passages connected into pairs by the grooves. The hot exhaust gases pass into one such passage, through the grooves in the plates, heating the plates in passing, and then to the other passage and out. The air to be heated is fed into the third passage, through the transversely cut grooves, receiving heat from the plates, and thence to the fourth passage and out. Fig. **4** shows the various components and the routes taken by the two gases. All the plates are marked to ensure replacement in the correct position and sequence, should the heat exchanger be dismantled for maintenance or cleaning.

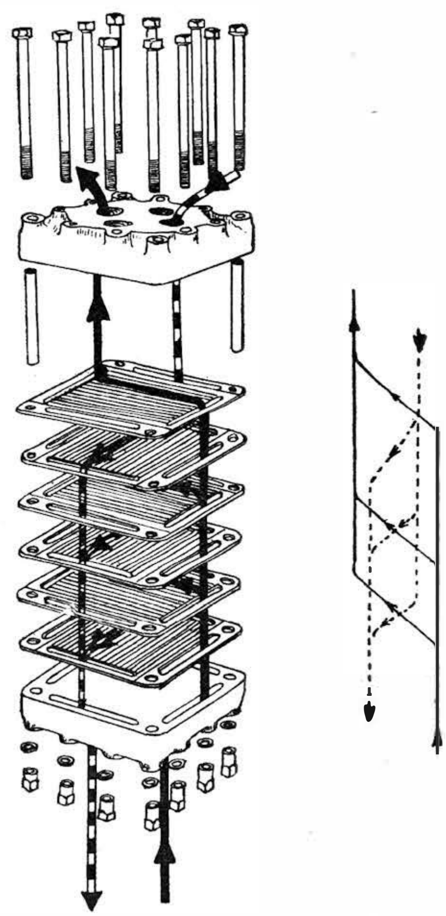

FIG. 4.—EXPLODED SKETCH OF HEAT-EXCHANGER.

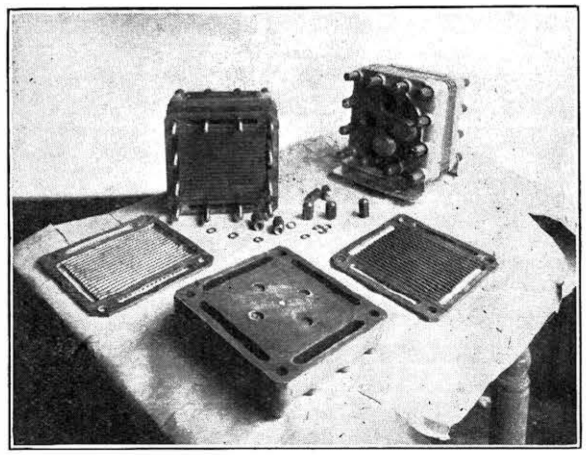

FIG. 5.—THE HEAT-EXCHANGER COMPONENTS AND ASSEMBLY.

To ensure the minimum loss of heat during the reactivation cycle, the hot pipes are permanently wrapped with asbestos tape and a heat-retaining jacket is provided around one of the silica-gel beds (see Fig. **3**). The jacket is changed over to the other silica-gel bed when the latter commences its re-activation cycle.

After-Coolers.

To increase the relative humidity of the compressed air and so facilitate its drying, the air is cooled immediately after being compressed by being passed through a coil of gilled tubing mounted on the compressor and around the fan. A further cooling coil of copper tubing ensures that even after the apparatus has been running for several hours the temperature of the air delivered to the cables is not appreciably higher than the ambient temperature.

Performance.

The moisture-adsorbing performance of the unit is shown in Fig. **6**, and while this possibly may be regarded as a laboratory result, a series of practical tests was also made. The performance of the units under these critical, but practical, conditions was ascertained by the following test. The conductors in a 157-yd. length of 104 pr./10 lb. P.C.Q.T. cable were joined together in series and connected to a high-voltage megger and insulation resistance measure-

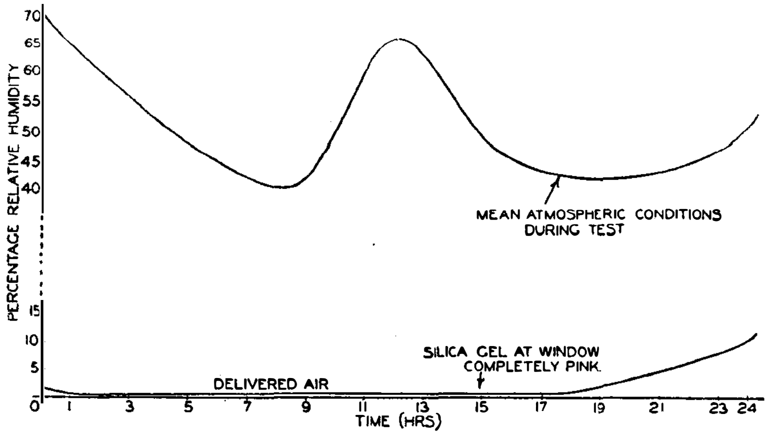

FIG. 6.—MOISTURE ADSORBING PERFORMANCE AS INDICATED BY VARIATION OF RELATIVE HUMIDITY OF AIR DELIVERED WITH RUNNING TIME.

ments taken. A carefully measured quantity of water was then injected into the centre of the cable through a suitable orifice. The dry air from the desiccator was then fed into one end of the cable and allowed to escape to atmosphere at the other. The results of a series of such tests are shown in Fig. 7. Although the volumes of water injected into the cable are probably very much greater than would be expected to be present under breakdown conditions, it is considered that the results clearly indicate the performance that may be achieved by the employment of such a desiccator in temporary restoration of faulty cable.

Conclusions.

The delivery capacity of the desiccator is calculated to be adequate for drying out in a minimum amount of time, either a 6-tube coaxial-type cable or two carrier or three air-spaced paper-core-type cables of the largest size. The time factor is governed primarily by the pneumatic resistances of the cables, together with the need to maintain the pressure at a fairly low value. It is concluded, however, that desiccators with a smaller output would produce further economies by catering for the average requirements rather than for the worst conditions.

Acknowledgments.

It is desired to express appreciation of the co-operation given by the Magnetic Equipment Co., Cosham, Hants., in the production and manufacture of these units which are believed to be the first of their particular type, and for the many suggestions made in connection with them.

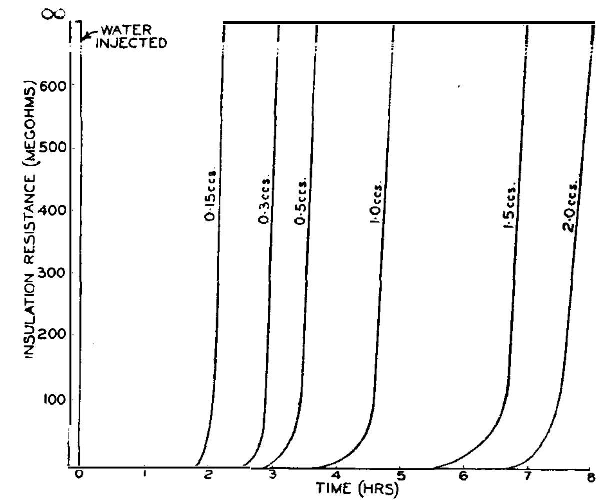

FIG. 7.—VARIATION OF INSULATION OF CABLE WITH RUNNING TIME OF DESICCATOR DURING TESTS.

Book Review

" Television Explained." Third Edition. W. E. Miller, M.A.(Cantab.), M.Brit.I.R.E. The Trader Publishing Co., Ltd. 104 pp. 75 ill. 5s.

This is a revised and enlarged edition of the handy little book first reviewed in this Journal some two years ago (Vol. 40, p. 178). Some of the earlier shortcomings of the book have been rectified ; in particular, receiver maladjustments are now illustrated by means of an excellent series of photographs of the television screen under various conditions. The picture with the controls said to be correctly set may be criticised, however, on the grounds that it is too deep and too wide, the black and white edging to the picture being obscured by the mask. Although, in fact, many viewers adjust their receivers in this way so as to enlarge the centre of the picture, it is not correct to do so and may lead to the loss of important parts of the picture such as the sub-titling on foreign films.

The major part of the additional space available in this edition has been used to allow a larger and more easily readable type, but many sections have also been expanded and new material has been added. In particular, the text now deals with the reception of signals from the Birmingham transmitter as well as Alexandra Palace. The vestigial sideband characteristic of the transmission from Sutton Coldfield is explained ; this shows a saving of about 2 Mc/s in the bandwidth of the transmitted R.F. spectrum as compared with the double sideband transmissions from Alexandra Palace. The modified form of receiver characteristic necessary for dealing with the vestigial sideband transmissions is also fully explained.

Up-to-date additions to the text include a brief description of a projection type receiver and the latest methods of generating the E.H.T. supply for the cathode ray tube. A very useful Appendix describes the " Test Card C " radiated daily by the B.B.C., and the way in which it can be used to check the performance of a receiver in respect of frequency response, linearity of scan, uniformity of focus, etc.

Those who found the earlier edition useful and who wish to bring their knowledge of the subject up to date will do well to study this new edition ; those who are new to the subject will find the book a valuable foundation upon which to base their studies.

T. K.

National Trunk Dialling

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This article discusses the dialling problems arising from the mechanisation of national trunk switching centres, and proposals for the routing of trunk traffic are advanced. A résumé of the existing national trunk network is given and the principles to be employed under trunk mechanisation are described.

Introduction.

A TRUNK call may be defined as any connection for which the normal charge is greater than 4 unit fees. It is usual, within the Post Office, to distinguish between two types of trunk call, namely, demand or long-distance calls which are controlled only at trunk exchanges, and toll or short-distance calls which may be controlled at any exchange.

While some trunk traffic is at present completed automatically, the objective of trunk mechanisation is that a controlling operator at a trunk exchange shall be able to complete any connection by dialling and without the assistance of any other operator. This objective calls for a considerable extension of the present trunk dialling facilities, and as some connections may involve two or more trunk circuits, it also requires the provision of tandem dialling facilities.

Outline of the Existing National Trunk Network.

The existing national trunk network is based on the division of the country into a number of basic areas, termed Group Areas. One exchange in each of these areas, usually the largest or most centrally situated, is selected as the Group Centre. This Group Centre acts as a collecting and controlling centre for all trunk traffic originating in the area and, in general, all trunk traffic incoming to subscribers in the area is routed through the Group Centre. Ultimately it is envisaged that there will be some 300 Group Areas, each of approximately 15 miles radius round the Group Centre. When all local exchanges in the area have been converted to automatic working there will normally be only one manual board in the area, namely that at the Group Centre. Thus, in addition to handling trunk traffic, the Group Centre manual board will also be used for assisting subscribers on their local calls.

The remaining exchanges in a Group Area are known as Minor or Dependent exchanges. A Minor exchange is one which has a direct route to the Group Centre, while a Dependent exchange obtains access to the Group Centre via a Minor exchange. Thus any subscriber in the area may be connected to the Group Centre over a routing involving not more than two junctions. Further, although it is impracticable to provide direct junctions between all Minor and Dependent exchanges, the interconnection of any two subscribers is readily achieved. Thus, in addition to acting as a controlling centre for trunk traffic, a Group Centre also serves as a switching centre for traffic circulating within the area. Ultimately, when all exchanges have been converted to automatic working, a large proportion of this traffic will be completed automatically by subscribers, and the appropriate fee recorded by the use of multi-metering equipment.

The large number of exchanges involved makes it uneconomical and impracticable to provide direct connections between all Group Centres. Thus larger units, termed Zones, are formed, each consisting of a number of Group Areas. One Group Centre, suitably situated, is selected in each Zone to serve as a trunk switching centre. These exchanges are known as Zone Centres. Direct connections are provided between a Zone Centre and all Group Centres in the Zone, and Zone Centres, with few exceptions, are fully interconnected with each other. In those cases where the Zone Centre is not fully interconnected, the Group Centres in such Zones will have access to a fully interconnected Zone Centre in addition to the normal home Zone Centre. Thus a Zone Centre acts as a switching centre for trunk traffic circulating within the Zone and also for traffic passing from one Zone to another. In addition, a Zone Centre functions also as a Group Centre for traffic originating or terminating in its own Group Area.

The division of the national network into Groups and Zones readily permits the interconnection of any two subscribers on a link-by-link basis, the fundamental routing being: Minor—home Group Centre—Zone Centre—Zone Centre—terminal Group Centre—Minor. In the extreme case two further links, Minor—Dependent, may be included. The present transmission plan is based on the following standards of transmission performance: Dependent or Minor—Group, 4·5 db. loss; Group—Zone, 3 db. loss; and zero loss between Zone Centres. With such a transmission plan, the overall transmission loss between terminal exchanges in any trunk connection should not exceed 15 db.

Present National Trunk Dialling Facilities.

At present, the only standard signalling system available within the P.O. network for providing dialling facilities on circuits routed via H.F. lines, is the P.O. 2 V.F. system. This is, in principle, a "signalling on speech path" system. It employs signalling frequencies in the voice range which are transmitted over the speech path, and may be used on any circuit, physical or H.F., which meets normal transmission requirements. The application of 2 V.F. working has so far been confined to circuits interconnecting Zone Centres, and the majority of such circuits employ this method of working.

With the original design of 2 V.F. equipment, the time required to effect the seizure of an incoming relay set and set up circuit conditions to accept impulses, precludes selector level access to a 2 V.F. link, as in this case the major part of the available inter-train pause period is taken up by the rotary search time of the selector. Hence, with the original design of 2 V.F. equipment, tandem dialling

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is not possible over connections involving more than one 2 V.F. link, and present dialling facilities are confined to circuits outgoing from a Zone Centre manual board, with limited access to the local automatic network beyond the terminal Zone switching centre.

For short-distance trunk circuits routed via audio cables, dialling facilities may be provided by loop or battery dialling. Battery dialling, however, is unsatisfactory over 4-wire amplified circuits, due to the relatively high capacitance of the signalling path, and is generally regarded as obsolescent. The dialling range with loop dialling is restricted, and although the range may be increased by the use of impulse regenerative relay sets at switching centres, its application in the trunk network is limited and mainly confined to single-link working, such as Group-Zone and Zone-Group connections. Loop dialling, however, is the standard method of signalling for local junction networks, namely Dependent-Minor-Group routings.

For the longer audio circuits, a long distance, direct current impulsing system, known as L.D.D.C. or system D.C.1, was developed.[1] The application of this system was mainly confined to the London Toll network, and for new work will be superseded by the single commutation, direct current impulsing system, known as S.C.D.C. or System D.C.2.[2]

Generally speaking, trunk dialling facilities are at present restricted to connections involving a single trunk link, and connections involving more than one trunk link are established on a link-by-link basis with the assistance of operators at the intermediate switching centres.

Routing Principles under Trunk Mechanisation.

It has been decided that, under trunk mechanisation, the present principle of link-by-link working will be retained and, as demand traffic will continue to be originated and controlled by an operator—normally at a Group Centre—the fundamental trunk routing will remain as at present, namely, originating Group Centre—Zone Centre—Zone Centre—terminal Group Centre. For large cities, the volume of originating trunk traffic may make it advantageous to provide more than one manual board and traffic will then be handled at suitably situated exchanges, termed Control Centres. Each Control Centre will be directly connected to the main trunk switching centre, normally a Zone Centre, and thus the fundamental trunk routing in these cases becomes: Control Centre—Zone Centre—Zone Centre—terminal Group Centre.

With the retention of link-by-link working it becomes necessary to route trunk traffic automatically through the intermediate switching centres. This may be effected by using either a translator or non-translator system, which are analogous to the director or non-director system of local automatic working. It has been decided to adopt a non-translator system. Thus traffic will be routed on a non-director switching basis, and controlled directly by the routing digits dialled by the controlling operator.

The numbering schemes to be employed for the routing of operator-controlled traffic under trunk mechanisation will be individual to the trunk switching centres and not form part of a national numbering scheme.

If, at some future date, subscriber-to-subscriber trunk dialling is introduced, a national numbering scheme and a translator trunk dialling system may be introduced. Their introduction, however, will not be prejudiced by the arrangements adopted for operator trunk dialling.

Signalling Systems under Trunk Mechanisation.

To meet the requirements of trunk mechanisation, the signalling systems used on trunk circuits must meet the following basic requirements:—

(i) The system must permit of seizure from a selector level.

(ii) The seizure time must be small, in order that the controlling operator may dial at normal speed without excessive pauses between digits.

(iii) The system must provide tandem-dialling facilities.

The systems which will be used initially to provide dialling facilities under trunk mechanisation are as follows:—

(*a*) 2 *V.F.* (*System A.C.*1).—Two types of equipment may be used, namely, equipment of existing design and type as at present in service, and a later design[3] which has been developed primarily to provide selector level access. An important difference between the two types of equipment is the inclusion of an impulse regenerator in the outgoing selector level relay sets of the later design, primarily to reduce the effective seizure time of a 2 V.F. link when seized from a selector level, where the major part of the inter-train pause is taken up by the rotary search time of the selector.

(*b*) *Single Commutation Direct Current Impulsing* (*S.C.D.C., System D.C.*2).—The application of this system is confined to audio circuits. Briefly, impulsing is effected by the transmission of double current signals, and supervisory signalling by earth return leg signals. Impulse distortion correcting elements are included in both the outgoing and incoming relay sets, and these are manually adjusted to take up the distortion introduced by relay contact transit times, and also by local impulse repetition at switching points. Within the limits of testing error S.C.D.C. may be termed a "controlled distortion" impulsing system.

(*c*) *Long Distance Direct Current Impulsing* (*L.D.D.C., System D.C.*1).—Where already existing, L.D.D.C. working may be retained, but this system is now obsolescent and will be replaced for new work by S.C.D.C.

(*d*) *Loop Dialling*.—The use of loop dialling will be confined to the shorter distance Group or Control Centre—Zone and Zone—Group circuits, routed via audio pairs.

Ultimately, it is envisaged that trunk dialling facilities will be provided by an A.C. signalling system for long-distance circuits routed via carrier or

[1] I.P.O.E.E. Printed Paper, No. 178.
[2] To be described in the next issue.
[3] To be described in a forthcoming issue.

coaxial cables, and by S.C.D.C. for the longer audio circuits and short-distance audio circuits routed via amplified circuits. The use of loop dialling will thus be confined to short distance unamplified circuits and the local junction networks. As stated previously, dialling facilities will be provided initially over H.F. circuits by 2 V.F. equipment, the outgoing selector level relay sets of which will include an impulse regenerator. Consideration is being given, however, to the possibility of obviating the need for this regenerator, in which case the ultimate A.C. signalling system may take the form of a "controlled distortion" system.

The Impulsing Problem.

With the decision to route national trunk traffic on a non-director switching basis, the fundamental impulsing problem is the response of the selector switching equipment—at all exchanges involved in a connection, from the first trunk switching centre down to the terminal Minor or Dependent exchange in the local network—to the routing digits dialled by the controlling operator at the originating Group Centre.

A known maximum amount of impulse distortion may be introduced between the output of a dial and the output of the A relay of a final selector, and this margin may be distributed over the trunk and local junction networks. The impulsing problem thus resolves into an examination of the available distortion margin; the distribution of this margin over the various links involved in a trunk connection; and, if the margin is insufficient to ensure reliable operation of all equipment, the impulsing aids, such as impulse regeneration or correction, that must be introduced and the siting of such equipment to the best advantage.

With link-by-link working, and when the method of signalling is other than loop dialling, line impulses are converted at the incoming trunk relay sets at each switching point to loop impulses which control the selector equipment at the switching centre. The loop impulses are re-converted to the appropriate line signals at the outgoing relay set associated with the following link. Thus the impulse distortion introduced by a trunk connection obviously depends on the number of links involved in the connection. While the fundamental routing under trunk mechanisation involves three trunk links, namely Group—Zone—Zone—Group, an analysis of trunk demand traffic has shown that some 53 per cent. of the traffic involves only one trunk link and some 3 per cent. is completed over two trunk links. On the other hand, the objective of trunk mechanisation is that ultimately all connections be established automatically, and thus connections involving three trunk links must be considered, even although the actual volume of traffic concerned is small. Further, the present arrangements for alternative routing will be retained under trunk mechanisation, whereby, if a call cannot be established over the recognised primary routing, due to congestion of any trunk link, the controlling operator may attempt to set up the connection over an alternative or secondary routing. Under these conditions the routing may involve four trunk links, namely Group—Zone—Zone—Zone—Group, and this present study of the trunk dialling problem has been based on this condition.

Trunk traffic to Minor or Dependent exchanges in the terminal Group area may involve a maximum of two local junctions, namely Group-Minor-Dependent routings.

The Available Impulse Distortion Margin.

The maximum amount of impulse distortion that may be allowed to occur on any connection is the difference between the output of the impulse sender and the operating requirements of the terminal selector equipment. In the problem under consideration the impulse source will be the controlling operator's dial, or equivalent impulse sender, with normal limits of 9-11 i.p.s., 63-70 per cent. break, and the terminal equipment will be a final selector at the objective Dependent exchange, which may incorporate equipment of any type.

Typical impulsing elements of 3,000-type selector equipment (equipment incorporating 3,000-type relays and pre-2,000-type selector mechanisms) and 2,000-type selector equipment (equipment incorporating 3,000-type relays and 2,000-type selector mechanisms) are illustrated by Fig. 1. Pre-3,000-type equipment

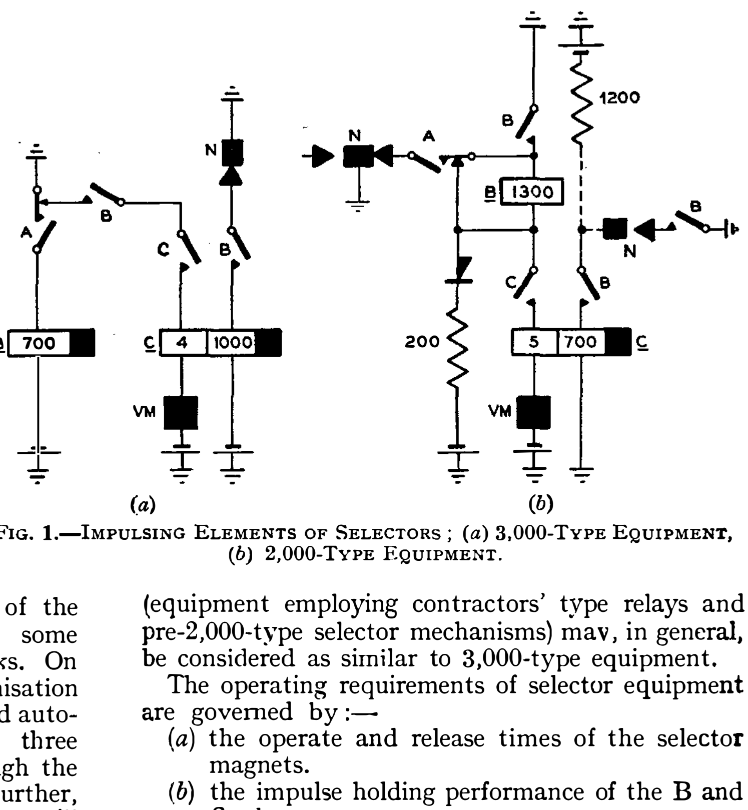

FIG. 1.—IMPULSING ELEMENTS OF SELECTORS; (a) 3,000-TYPE EQUIPMENT, (b) 2,000-TYPE EQUIPMENT.

(equipment employing contractors' type relays and pre-2,000-type selector mechanisms) may, in general, be considered as similar to 3,000-type equipment.

The operating requirements of selector equipment are governed by:—

(a) the operate and release times of the selector magnets.

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

The performance of these items, in terms of the selector A relay output, together with the limits of impulse output for an operator's dial, are illustrated by the target diagram of Fig. 2, from which it will be

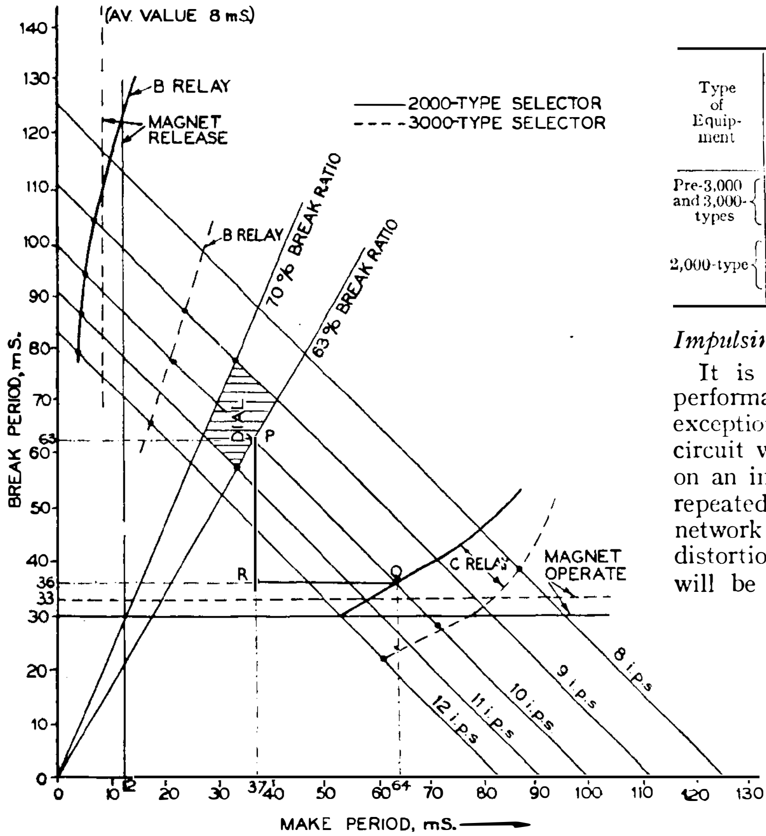

FIG. 2.—SELECTOR TARGET DIAGRAM.

seen that, within the limits of 9-11 i.p.s., the response of selector equipment is governed by the following :—

2,000-type equipment—magnet release time and C relay impulse holding performance.

3,000-type equipment—B relay impulse holding performance and magnet operate time.

The distortion that may be introduced between the impulse source and the terminal selector equipment may be readily obtained from the target diagram. For example, consider an impulse speed of 10 i.p.s. The co-ordinates of the point P, 63 mS break period, 37 mS make period, represent the output of the impulse source, and the co-ordinates of the point Q, 36 mS break period, 64 mS make period, represent the operating requirements of 2,000-type selector equipment. Hence the distortion margin, in terms of the amount by which the make impulse output of the source may be increased, is given by RQ, namely $64 - 37 = 27$ mS. It is usual to express the distortion margin as positive or negative, representing the amount by which the make impulse output of the source may be increased or decreased.

From Fig. 2 it will be seen that, within the limits of 9-11 i.p.s., the margin is least at 11 i.p.s. and also that on the negative side it is governed by the requirements of 3,000-type equipment and on the positive side by 2,000-type equipment. The distortion margin is summarised in Table 1, the limiting values being shown in bold type.

TABLE 1
Overall Impulse Distortion Margin.

Type of Equipment	Dial, Speed, i.p.s.	Maximum Make, mS.			Minimum Make, mS.		
		Dial Output	Selr. Requirements	+ve Distortion Margin	Dial Output	Selr. Requirements	−ve Distortion Margin
Pre-3,000 and 3,000-types	11	33·5	58	+24·5	27·5	19	− **8·5**
	10	37	67	+30	30	21·5	− **8·5**
	9	41	78	+37	33·5	24·5	− **9**
2,000-type	11	33·5	58	**+24·5**	27·5	12	−15·5
	10	37	64	**+27**	30	12	−18
	9	41	71	**+30**	33·5	12	−21·5

Impulsing Performance of Local Junction Networks.

It is now necessary to examine the impulsing performance of local junction networks. With the exception of circuits employing loop dialling, a trunk circuit will terminate at the terminal Group Centre on an incoming relay set, and loop impulses will be repeated from this relay set over the local junction network to the objective exchange. The impulse distortion occurring at the terminal Group Centre will be least when forward-holding principles are employed at this exchange, as this avoids a further impulse repetition stage between the incoming trunk relay set and the local junction network. On the other hand, many Group and Zone Centres will employ backward-holding, and thus this condition dictates the performance and has been assumed.

In the local network, impulse distortion may be introduced at each impulse repetition stage, the magnitude and sense depending on such factors as relay adjustment, battery voltage and junction characteristics, namely resistance, leakance and mutual capacitance, and also on whether the junctions are amplified or unamplified circuits. A detailed examination of the factors affecting impulse distortion will not be considered here as this has been fully covered elsewhere.[4]

As later considerations suggest that it may be advantageous to replace loop dialling on amplified circuits by a system in which the distortion is controlled, separate consideration will be given to the distortion introduced by local junction networks with :—

(*a*) Loop dialling over both amplified and unamplified circuits.

(*b*) Loop dialling over unamplified circuits only.

Also, it is convenient at this stage to consider the distortion occurring with a single loop-dialling junction and also with no junction, i.e. the distortion introduced by the A relay of a final selector or impulse regenerative relay set situated at the terminal trunk exchange.

The distortion introduced by local junction networks is given in Table 2, and for the purpose of this

[4] I.P.O.E.E. Printed Paper, No. 184.

table it has been assumed that impulses are repeated from an incoming trunk relay set with a 2 μF + 100 ohms spark quench across the impulse repeating contact.

TABLE 2

Local Network Distortion.

Type of Junction and Resistance	Adverse limits of distortion introduced by the local network, mS.	
	+ ve	− ve
No Junction	+ 3	+1
Single Junction (0-1,500 ohms)		
(*a*) Amplified only	+18	—
(*b*) Unamplified only	+13	−5·5
(*c*) Amplified and Unamplified	+18	−5·5
Two Junctions (0-800 plus 0-800 to 3,000-type terminal exchange) (0-800 plus 0-1,500 to 2,000-type terminal exchange)		
(*a*) Amplified only	+21·5	—
(*b*) Unamplified only	+16·5	} −5·5 for 3,000-type −8 for 2,000-type terminal exchange
(*c*) Amplified and Unamplified	+21·5	

For a routing involving junctions of 0-800 plus 0-1,500 ohms to a 2,000-type terminal exchange, the higher negative distortion (−8 mS.) resulting from the greater resistance of the second junction, is more than offset by the wider distortion margin available with 2,000-type selector equipment.

Possibility of Straightforward Dialling System.

A straightforward dialling system involves the direct repetition of impulses at each switching point, without impulse regeneration or correction. Thus the distortion margin available to the trunk network will be that remaining after the requirements of the local junction network have been satisfied. From the values given in Tables 1 and 2, it will be seen that :—

The minimum overall distortion margin available	= +24·5 to −8·5 mS.
Local network distortion, 2-junction route, amplified/unamplified condition	= +21·5 to −5·5 mS.
Distortion margin available for the trunk network	= +3 to −3 mS.

If, however, loop dialling in the local network is restricted to connections involving only unamplified junctions, the distortion margin available for the trunk network is increased to +8 to −3 mS. As mentioned previously, a maximum of four trunk links may be involved in a trunk connection, and the question arises whether it is possible to design and maintain trunk signalling equipment to meet such narrow margins of distortion.

It is possible, by the use of suitable components, together with adjustable corrector elements which can be arranged to decrease or increase the impulse make period within certain limits, to design equipment such that, within the limits of testing error and assuming constant exchange battery voltage, no distortion is introduced at the local impulse repetition stages. Signalling systems designed on these lines may be termed " controlled distortion " systems. On the other hand, there will always be variations in the impulsing performance of equipment due to the effect of a number of variables, such as drift of adjustments, variations of voltage supplies and, for A.C. signalling equipment, variations of signal level and frequency. Modern V.F. receivers, however, are capable of giving an impulsing performance of the order of ± 1 mS. distortion over the normal ranges of line T.E., voltage and tone supplies.

Allowance must also be made for the tolerances for maintenance testing. It is desired to test equipment *in situ*, and thus the routine test limits must take into account the change in impulsing performance resulting from a change of battery voltage, or otherwise, readjustment of equipment would be necessary if maintenance testing happened to coincide with periods of adverse voltage. With regard to the latter, it is usual at Zone Centres to have " Divided Battery Float " power plant which gives a comparatively stable voltage, but at many Group Centres C.E.M.F. cell switching schemes are employed, with which voltage variations occur quite frequently.

An approximate estimate of the distortion likely to occur on a trunk connection, assuming straightforward dialling with " controlled distortion " impulsing systems, is given in Table 3. For the purpose of this table, advantage has been taken of the closely controlled voltage conditions at Zone Centres, but any characteristic bias, that is bias due to the characteristics of signalling systems, has been ignored.

TABLE 3

Trunk Network Distortion with Straightforward Dialling.

Trunk Routing	Distortion, mS.			Overall Distortion Range, mS.
	Line Relay	Group Centre D.C. Repetition	Zone Centre D.C. Repetition	
G-G	±1	±2	—	6
G-Z-G	±2	±2	±0·5	9
G-Z-Z-G	±3	±2	±1	12
G-Z-Z-Z-G	±4	±2	±1·5	15

As shown previously, the distortion margin remaining for the trunk network, after meeting the requirements of a 2-junction local network routing, involving both amplified and unamplified junctions, is +3 to −3 mS., i.e., an overall range of 6 mS. It will be seen from Table 3 that this precludes dialling over two or more trunk links on a straightforward dialling basis. Further, even assuming that loop dialling in the local network is restricted to unamplified junctions, the distortion margin available to the trunk network is +8 to −3 mS., an overall range of 11 mS., and this is insufficient to meet the requirements of a 4-link trunk connection, which requires an overall range of 15 mS.

Summarising, it will be seen that the impulsing requirements of junctions, selectors and impulse repeating equipment in existing local networks preclude the use of a straightforward dialling system for the trunk network. Dialling over one trunk link may be possible, but to permit dialling over two or more trunk links some reduction is necessary in the distortion introduced by the local networks. This may be achieved ultimately by confining loop dialling in the local network to routings involving a single unamplified junction, and employing a controlled-distortion D.C. impulsing system on all amplified circuits and routings involving two junctions. In the meantime it would be necessary to restrict the trunk dialling range to connections involving a single loop dialling junction beyond the terminal trunk switching centre.

Alternatives to Straightforward Dialling.

A straightforward dialling system being impracticable, it is obvious that some form of impulsing aid must be introduced at some or all of the switching points involved in a trunk connection. These impulsing aids may be either impulse regenerators or impulse correctors. With impulse regeneration, the speed and ratio of the transmitted impulses are independent of that of the received impulses. As the speed of the received impulses may be greater than that at which they are transmitted, impulse storage is necessary, and it is the usual practice to store a complete impulse train.

With impulse correction, impulses are transmitted, with negligible delay, at the same speed as that at which they are received, but with corrected impulse ratio or corrected make or break pulse periods. In the simplest form of impulse corrector a fixed impulse speed is assumed, and the duration of the transmitted make or break pulse periods is controlled to relatively close limits. This type of fixed time base corrector suffers from the disadvantage that the ratio of the transmitted impulses varies at different impulse speeds. It is possible, for example, by measuring the total break plus make period of the received impulses, to design a corrector such that the ratio of the transmitted impulses is independent of the impulse speed, but such correctors are relatively complex and costly items. Under the conditions existing in the Post Office network, impulse regeneration, with the complete storage of an impulse train, is preferred to the use of impulse correctors. A description of the present standard impulse regenerator has been given in a previous article.[5]

The need for some form of impulsing aid in the trunk network having been established, it is now necessary to consider the siting of such equipment to the best advantage.

Impulse Regeneration at all Intermediate Trunk Switching Centres.

The inclusion of an impulse regenerator in all trunk circuit relay sets outgoing from selector levels is attractive from the signalling and impulsing aspect in that it offers the following advantages :—

(*a*) The impulse distortion introduced by a trunk circuit routed via an outgoing relay set with regenerator will be independent of that introduced by any preceding circuit. Thus any number of links may be connected in tandem and yet each link may be considered as a self-contained circuit from the impulsing aspect.

(*b*) It permits the major portion of the available inter-train pause period to be taken up by preceding switching operations, as the delay introduced by the regenerator between the receipt and transmission of the first impulse train is available for the seizure of a 2 V.F. link and the preparation of the distant equipment to receive impulses. This is an important advantage in relation to the existing 2 V.F. signalling system in which the time taken to seize the distant equipment and set up impulsing conditions leaves insufficient time for selection over large groups of trunk circuits. For this reason a regenerator has been included in the outgoing selector level relay sets of the equipment which will be used under trunk mechanisation.

On the other hand the fitting of regenerators at all intermediate trunk switching centres is open to objection on the following grounds :—

(*a*) It increases the maintenance attention required on the outgoing trunk relay sets.

(*b*) The present impulse regenerator is inferior to an operator's dial as an impulse source, its upper speed limit being 12 i.p.s. The effect of this is to reduce the distortion margin given in Table 1 from −8·5, +24·5 mS. to −7, +19·5 mS. It may be possible to overcome this particular difficulty by reducing the nominal speed to 9 i.p.s. so as to reduce the upper limit to 11 i.p.s.

(*c*) Delay is introduced in setting up a connection The greatest delay will be introduced by the first regenerator in the connection when dialling is carried out quickly, due to the lengthening of the inter-train pause periods. This may amount to 0·5 seconds per digit, say 4 seconds for an average of 8 digits. To this must be added the delay between receipt and transmission of the first digit, approximately 1·5 seconds, which is introduced by each subsequent regenerator in the connection. This delay of 1·5 seconds may be reduced by eliminating the initial inter-train pause before sending. The importance of the overall delay is minimised if allowance is made for the fact that some 53 per cent. of the trunk traffic passes over only one trunk link, and hence will encounter only one regenerator in the trunk network. Also, as long as cord-type switchboards remain in use, there will be a proportion of direct circuits available, and these need not include regenerators. Ultimately, cordless type switchboards will be employed and a greater use will be made of key-senders instead of dials, on which the pause between digits can be made sufficiently long to permit switching and signalling operations to be effected without artificially lengthening the pause. Under these conditions the delay introduced by regenerators between the receipt and transmission of the first digit may not be noticed.

The inclusion of a regenerator in all outgoing trunk circuit selector level relay sets, however, does not of itself offer a solution to the trunk dialling problem. As shown previously, an overall distortion margin of only 6 mS. remains for the trunk network after the requirements of a local junction routing involving two junctions, amplified or unamplified, have been met. This margin is available to each link involved in a trunk connection, as the inclusion of a regenerator

[5] *P.O.E.E.J.*, Vol. 30, p. 261.

in the outgoing relay sets results in each link becoming, from the impulsing aspect, a self-contained circuit. To meet the requirement, however, that the distortion introduced by a trunk link should not exceed a range of 6 mS, it would be necessary to employ "controlled distortion" impulsing systems on all trunk circuits. Failing this, further impulse regeneration will be necessary, either at the terminal trunk switching centre or at some subsequent stage in the local network.

Impulse Regeneration at Terminal Trunk Switching Centres.

It is apparent that the maximum advantage will be obtained from impulse regeneration if the equipment is sited so that the distortion introduced by the local junction networks is not additive to that introduced in the trunk network.

It follows, therefore, that the ideal siting of impulse regenerators is on all local junction levels at terminal trunk switching centres, as this makes the whole of the impulse distortion margin available for the trunk network.

This siting of impulse regenerators has the added advantage of fitting in with the impulsing requirements of the local junction networks. In this connection, it is desired, as far as possible, to avoid the use of impulse regenerators at Minor exchanges, especially those of the U.A.X.7, 13 and 14 types, but the impulsing performance of the present type of auto-auto impulse repeating relay sets is such that some impulsing aid is necessary for connections involving three or four junctions. With the exception of Dependent-Dependent routings via a Minor exchange, all three- or four-junction routings in the local network would be assisted by impulse regeneration at the Group Centre.

Thus, while the fitting of impulse regenerators on all local junction levels at terminal trunk switching centres is attractive, it remains to be considered whether the distortion margin made available to the trunk network is sufficient, having regard to the performance of the signalling systems that may be used, to meet the most onerous routing conditions that may arise under trunk mechanisation without the need for impulse regeneration at any other trunk switching centre.

The signalling systems that will be available initially under trunk mechanisation have been discussed previously, and for Zone-Zone circuits are the 2 V.F. system and S.C.D.C. equipment. The use of the latter is confined to audio circuits, and as many of the Zone-Zone circuits at present routed via audio cables may be converted to H.F. working in the near future, the use of S.C.D.C. equipment on Zone-Zone circuits is unlikely, as early conversion to 2 V.F. working may be necessary. For 2 V.F. equipment, the outgoing selector level relay sets will incorporate an impulse regenerator, which, as stated previously, has been included primarily to reduce the effective seizure time of a V.F. link and not for reasons of impulsing performance. While this regenerator offers advantages from the impulsing aspect, in that each link may be considered as a self-contained circuit, future developments may obviate its need. In this event a non-regenerative, controlled distortion, V.F. impulsing system may be developed, and in order not to prejudice the introduction of any new signalling system developed on these lines, allowance should be made for the impulse distortion which may be introduced in the trunk network with such a system.

For Group-Zone and Zone-Group circuits, the signalling systems initially available will be 2 V.F., S.C.D.C., L.D.D.C. and loop dialling. The greatest distortion will be introduced when loop dialling is employed, and will be a maximum under amplified line conditions. Ultimately, it is hoped that S.C.D.C. working will be employed on all amplified circuits, but due to the large number of circuits involved it is impracticable at the present time to convert all loop dialling circuits to S.C.D.C. working. Further, in many cases, the additional accommodation required and power plant capacity, makes such conversion impracticable. Thus, it is essential to permit as extensive a use as possible of loop dialling on Group-Zone and Zone-Group circuits in order that existing dialling facilities and methods of working may be retained.

The distortion margin remaining for Group-Zone and Zone-Group circuits, after allowance has been made for the distortion that may be introduced by Zone-Zone circuits routed via a non-regenerative controlled distortion impulsing system, is insufficient to permit loop dialling over both Group-Zone and Zone-Group circuits should both be amplified. The margin does, however, permit loop dialling over a Group-Zone circuit, amplified or unamplified and of resistance up to 1,500 ohms, together with loop dialling over an unamplified Zone-Group circuit of resistance up to 800 ohms. Loop dialling is also permissible over circuits to the above limits when S.C.D C. or 2 V.F. working is employed on the Zone-Zone circuits.

Where loop dialling is required on Zone-Group circuits which either have a resistance greater than 800 ohms or are amplified, impulse regeneration at the Zone Centre, in addition to the terminal Group Centre, will be necessary. With this exception, it is seen that the fitting of impulse regenerators on all local junction levels at terminal Group Centres offers an attractive solution to the trunk dialling problem, inasmuch as it permits the most onerous routing conditions that may arise under complete trunk mechanisation to be met with a non-regenerative trunk dialling system. Also, besides fitting in with the impulsing requirements of local junction networks, the proposal has the added advantage that ultimately no call, either trunk or local, need encounter more than one impulse regenerator on any connection.

Conclusion.

The objective of trunk mechanisation, namely that an originating operator at a Group Centre shall be able to establish any connection by dialling and without the assistance of another operator at any intermediate switching centre, calls for a considerable extension of the present National trunk dialling facilities. A straightforward dialling system, with the direct repetition of impulses at all switching points, is not a practical proposition, as the character of existing local junction networks takes up the major portion of the available impulse distortion margin

The inclusion of impulse regenerators in all outgoing trunk circuit selector level relay sets is attractive It permits any number of trunk links to be connected in tandem, but does not offer a complete solution to the problem as further impulse regeneration, either at the terminal trunk switching centre or at some subsequent point in the local network, is still required.

The most satisfactory solution to the National trunk dialling problem is given by fitting impulse regenerators on all local junction levels at terminal Group and Zone/Group centres. By this means the impulse distortion introduced by the local junction networks is not additive to that introduced by the trunk network, and hence the maximum possible margin of impulse distortion is made available to the trunk network. This margin is sufficient to permit the most onerous routing condition that may arise under complete trunk mechanisation to be met with a straightforward trunk dialling network. At the same time, it permits the retention of loop dialling on circuits interconnecting Group and Zone Centres, which is an advantage from an economic point of view.

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Book Reviews

"Cathode Ray Tube Traces." Hilary Moss, Ph.D., A.M.I.E.E. *Electronic Engineering*, London, 1949, 66 pp. 52 ill. + 180 traces. 10s. 6d.

A series of articles, which appeared in *Electronic Engineering* some five years ago, forms the basis of this book. In it the author stresses the importance of the geometrical theory of the patterns which users of oscilloscopes have found of value; the means of production of time bases, linear or otherwise, are largely left to other books.

The Lissajous figure is well explained in the first chapter, but the rules given for determining the ratio of the frequencies of the two waveforms giving the figure could be improved. They admit of exceptions, where another does not, and the word "intersection" is used in one rule, where in practice it will be found to apply only to a line touching a curve. The chapter points out many interesting features of complex Lissajous figures, whose interpretation has several pitfalls, and concludes with the effect of pulse injection into one of the waveforms generating a Lissajous figure.

Linear time bases, so widely used in commercial C.R. oscilloscopes, provide the horizontal deflections in the second chapter, but even the most experienced users of commercial instruments can expect to find new features in the patterns shown.

Circular and spiral time bases are well dealt with; limitations in their production are not overlooked. The patterns show that radial deflection of circular time bases offers new possibilities in the presentation of some recurrent waveforms.

Complex waveforms are next considered and deductions made from symmetry conditions. Extensive series of patterns using a linear time base show 2nd, 3rd, 4th and 5th harmonic distortion. The same chapter gives "beat" waves very good attention, and lists expressions for some waveforms often met with in pulse communications. The last chapter deals with amplitude-modulated waves, and again introduces new presentations. Here, perhaps more than anywhere else, the reader will ask whether full advantage is always taken of the oscilloscope in examining waveforms so often met in telecommunications.

The book concludes with some worthwhile though simple appendices on the transient response of networks, the use of C.R.T.s and the production of the waveforms shown. The book is readable and instructive. It is well produced, except for the cover and, in all, justifies the bringing together of the otherwise separated articles.

J. R. T.

"Electronic Time Measurements." Massachusetts Institute of Technology. McGraw-Hill Publishing Co., Ltd, London. 538 pp. 383 ill. 42s.

This book, Volume 20 of the Radiation Laboratory Series, deals with systems for the accurate measurement of small repetitive time intervals, such as are required in precision ranging radar equipments and certain types of radio navigational aid, for example, Gee and Loran. Although most of the systems discussed are American, there are several descriptions of British, and one or two mentions of German equipment.

After a brief introduction, Chapter 2 summarises the various methods of distance and speed measurement using pulse-, phase-, and frequency-modulated waves, and also continuous waves. The next chapter reviews the technique of pulse time measurements.

Chapters 4 and 5 cover in rather more detail the production and measurement of fixed and movable time-markers.

Chapter 6 is concerned with the application of these circuits to systems, and describes a widely-used precision ranging system. The direct-reading Loran Indicator is also discussed.

Chapter 7 deals with manual measurements, in which the operator sets a marker to coincide with the incoming signal, and discusses the different types of marker and the errors involved. In the next two chapters automatic methods of performing the same task are considered, including the provision of "search and lock on" facilities for radar equipments.

Chapters 10 and 11 are concerned with special systems for the transmission of range and bearing information, principally by radio, using pulse-position modulation and tone-modulation techniques.

The last chapter discusses at length the technique of cancelling-out the unchanging part of a slowly-changing recurrent waveform. This has practical application in the detection by a radar system of a moving target in the presence of fixed targets.

Two features of the book which make reading somewhat difficult are the multiple authorship which results in some repetition and discontinuity and the highly specialised terminology.

The emphasis throughout the book is on complete systems, the principles of operation of the individual circuits employed to make up these systems being only briefly described; reference is frequently made to Volume 19 of the Radiation Laboratory Series on "Waveforms," for detailed information on the latter. For this reason the book will be of value chiefly to those concerned with the operation and design of the systems described, rather than to those interested in using similar techniques for other purposes.

A. H. F.

Introduction to Electronic Automatic Telephone Exchanges: Register-Translators

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U.D.C. 621.395.34 : 621.38 : 621.395.636.3

The operations of remembering an instruction and converting the instruction into an action to be performed are inherent in all telephone switching systems. In automatic telephone systems these actions are performed in a number of ways by a variety of different forms of apparatus, one of which is the register-translator which takes in a number of several digits, and sends out a number which may be different in one or more of its digits. This article describes some of the possible forms of all-electronic register-translators which can register, translate and send numbers. The next article will discuss trunking and selecting systems.

General.

A PREVIOUS article[1] has considered speech path switches in a fully electronic exchange system and the controlling signals which may be passed through them. It was assumed that a number of ranks of switches would be provided in each exchange, connections being made through the exchange by switches in each rank. Before discussing the setting of the switches it is preferred to consider (as is the purpose of this article) some possible forms of register-translator from which, in some selecting systems, the setting of the switches may be considered to start. Register-translators, as generally understood, are not essential to an automatic telephone system, and where used, they may differ widely in their design and perform a variety of different functions. Hence, generalisation is difficult, but it is thought the examples given in the following descriptions will convey some of the more general ideas and possibilities of all-electronic apparatus.

Preliminary Outline and Definitions

It is necessary first of all that the terms such as register and translator should be clearly understood. It is thought that this may be best accomplished by referring to the analogy between manual operating and the equivalent functions performed by a machine.

An operator, whether at an originating, a transit, or a terminal exchange, performs operations which may be regarded as divided into three categories :—

(*a*) The operator first of all registers in her mind an instruction which is given to her verbally by a subscriber or another operator. This memorising of an instruction, which is to be forgotten when acted upon and is therefore temporary, will be identified as the register function.

(*b*) The operator compares the instruction (*a*) with a set of permanent instructions, some of which are recorded in her own memory, some perhaps in printed form on a card index on her position, and in various other ways. From this comparison the operator derives the information concerning the next action which she must take. The combined comparison of the temporary with the permanent instruction to derive the next action to be taken will be defined as the translating function. The permanent instructions are permanent in the sense that they remain in existence until deliberately altered or destroyed by the Administration. The permanent instruction is the means by which the Administration controls the telephone service.

(*c*) The operator takes the action indicated in (*b*) and this is identified as the sending function.

No matter how a telephone system works, with operators or any kind of a machine, these operations can be traced to exist. When they are performed by a single piece of apparatus in an automatic exchange, that apparatus may be called a register-translator-sender, but is more commonly called a register-translator.

Machine operation has an influence on the basic operations which will now be examined. An operator can remember names as well as, and perhaps better than, numbers but a machine can conveniently remember only numbers. One of the first stages, therefore, in the conversion of a manual system to an automatic system is to convert all the subscribers' instructions into numbers. Secondly, an operator can use her intelligence to decide what action to take in abnormal circumstances. A machine has no intelligence, and the instructions for every possible circumstance must be built into the machine at the outset. Again, the action which an operator may take is largely based on information in the form of a number, but also includes communicating exchange names and taking other actions which are not in numerical form. The machine acts most readily by numerical information and the sending function of a register-translator is most conveniently arranged in that form.

What has been said so far can be illustrated from current practice by considering the familiar director as a register-translator. A director is given the wanted subscriber's exchange code and number, which it registers on mechanical switches, digit by digit, by the distinctive position of the wipers of each switch. The instructions which are permanently stored in the register are in the form of permanent wiring and refer only to the exchange code digits recorded on the register. The comparison between the registered digits and the "memory" is made by metallic contact between the register switches and the permanent wiring memory, and the translation is communicated directly in the form of digits which are sent out. The director is, therefore, a

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[1] T. H. Flowers. "Introduction to Electronic Automatic Telephones Exchanges: Speech Path Switches and Line Signalling." *P.O.E.E.J.*, Vol. 43, p. 61.

register and translator of the code digits ; but instructions regarding the numerical digits have to be stored somewhere in the switching machine in order to cover the action to be taken, for example, when the numerical digits which have been stored correspond to an unallotted number. In this case, the director sends out stored numerical digits in the same form in which they were received and it is the switches that supply the information, by permanent wiring to N.U. tone on their banks, that the recorded number has not been allotted. It is interesting to note that the operator behaves in practically the same way in these circumstances ; she proceeds to set up the call as if the number were working and finds from the marking on the multiple that the number is unobtainable. This example illustrates the important point that translation even in one system may take more than one form and it is not possible to give a generalised statement of the form of translation for each operation in every system.

In this article only number translators will be considered, that is, register-translator-senders which take in a number, translate it to, and send out, another number. It is difficult to see how some such apparatus can be avoided in any new system for reasons which are given in the next section, which also indicates the scale of the register-translator problem.

National Automatic System With National Numbering.

Many years must inevitably elapse before any new system could be installed in this country in any appreciable quantity, and many years of service would be expected from such equipment. It must, therefore, follow that any new system must be capable of satisfying the needs of a national telephone network for several future decades. These needs may not at this moment be known in detail but, to be sure that future development will not be handicapped, any new system must be capable of giving automatic service on a national basis, that is, it must at least be capable of subscriber-to-subscriber national dialling, with the cost of the calls determined at the time the calls are made.

In this country there are about 6,000 exchanges and the problem of connection between these exchanges by subscriber-controlled signals is clearly of a much larger order than that of the director which is limited to a maximum of 100 exchanges but, in practice, is rarely concerned with more than 30 exchanges. The problem is further complicated by the fact that, in order to identify the 6,000 exchanges, 5-digit exchange codes will probably be necessary. Since a machine exchange must have an instruction built into it for every possible circumstance, it appears that it must be capable of recognising 100,000 numbers. This problem occurs, of course, with the present type of exchanges, and means of reducing the amount of recognition to a much smaller number of items have already been devised. The general principle adopted is that of the allocation of exchange codes according to some system by which whole blocks of exchange numbers can be recognised, each by a single number.

One general principle of numbering is that the whole network is divided into large areas, the exchanges within each of which have codes all beginning with the same first digit, different areas having different first digits. Each large area is then further sub-divided into areas within which the exchanges bear codes having the same first and second digits. Further subdivision of the areas may be necessary, depending on the size of the network but, in the final areas, the exchanges are allocated different digits for the final digits of their codes. For a variety of reasons, only a small number of the available numbers are taken up as working exchange codes ; as already mentioned, in this country 5-digit exchange codes will probably be needed for 6,000 working exchanges. It will be apparent, however, that starting from any point in the system the route to be taken and the charge for the longest-distance calls will be defined by the first code digit. Similarly, some not so distant calls will be defined by two digits and so on, and only in the shortest distance calls will 5-digit codes have to be recognised in full. In this way, the number of numbers which must be individually recognised may be reduced for a country of this size to perhaps 1,000. This is a great reduction, but it still means the recognition of 1,000 numbers having from 1 to 5 digits and the provision of a large number of translations. It is possible to arrange the switching systems so that 5-figure codes are translated in two stages, but however the problem is solved, it is economically difficult to avoid the recognition of at least several hundred numbers having from 1 to 3 digits, and the provision of a corresponding number of translations.

Electronic Registers

It is well known from current practice that numbers may be transmitted, received and registered by a variety of methods and these methods can be reproduced electronically. In one method, exemplified by dialling, a train of impulses is sent for each digit of the number, the number of impulses in each train being equal to the value of the digit which it represents. In another method, each decimal digit is coded into a binary number, the digits of which are sent simultaneously, e.g., multiple frequency key impulsing. In a further method, exemplified by teleprinter code, each decimal number is coded into a binary number, the digits of which are sent in time sequence. Reception is a question of recognising the incoming signals and converting them into a form suitable for the registering equipment. The registers may be, for example, switches with 10 positions into one of which each switch may be set to indicate a number directly ; or, again, four relays operated according to the binary code of the number represented. Some electronic versions of familiar registers will now be described together with some registers which are peculiar to electronic technique.

Dialled Impulse Register.

Fig. 1 shows a register suitable for storing dialled impulse trains which are assumed to consist of positive-going impulses of about 40V amplitude from a low impedance source R1. The cold-cathode-tube counting chain of valves D1, D2...forms a distributor which distributes the trains one each to a counting chain, one counting chain being indicated by the cold-cathode tubes N1, N2....

The cold-cathode tubes each have an anode, a cathode and a primer. When the primer potential is positive with respect to the cathode by a critical amount called the striking voltage, it initiates an

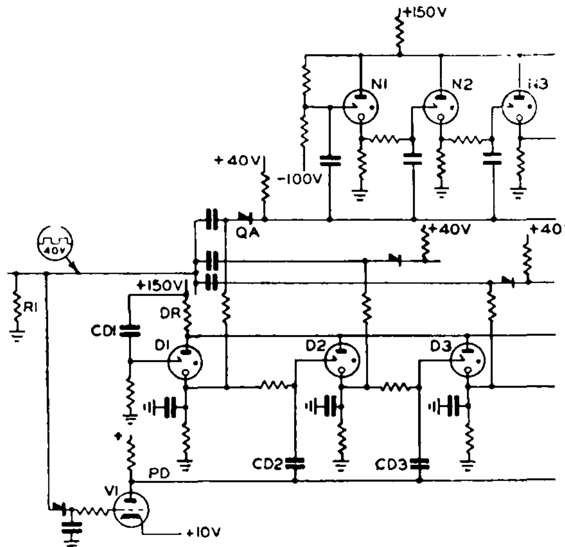

FIG. 1.—A DIALLED IMPULSE REGISTER.

electric current through the gas, which then starts a current between the cathode and anode. The anode current can be stopped only by reducing the anode/cathode voltage below a critical value called the sustaining voltage. In these examples it is assumed that the primer striking voltage and the anode sustaining voltage are both about 70V.

Taking the distributor first, initially the anode voltage is zero, so that no tubes are struck. When the register is taken into service, the anode voltage is applied and this, operating through capacitor CD1, causes the first tube, D1, in the chain to pass anode current. In doing so, it raises the potential of the cathode of D1 by about 40V and thus that of the primer of tube D2 by a similar amount. A positive-going impulse of about 40V applied to the distributor impulse lead PD when added to the cathode potential of tube D1 will cause tube D2 to fire. The capacitors connected between earth and the cathodes of the counting tubes prevent the cathode potentials from changing quickly. When tube D2 fires, therefore, its cathode potential remains momentarily at earth potential, and its anode, therefore, at the sustaining voltage above earth potential. The cathode potential of tube D1 remains momentarily constant, but its potential is reduced by tube D2, and this extinguishes the glow in tube D1. D2 will prime D3, but not until the impulses through the capacitors CD2, CD3 . . . have died away. Further impulses will operate in a similar manner to advance the glow along the chain. The glow is advanced one step for each incoming train of digits by the hot-cathode valve V1, and its circuit. The anode current of valve V1 is normally cut-off. The first impulse of a train of impulses causes the valve to conduct and remain conducting until the impulses stop. This result is produced by the rectifier and capacitor in the grid circuit of the valve. When the impulses stop, the charge across the capacitor leaks away until the valve V1 again cuts off its anode current. In doing so, it applies to the distributor the positive impulse necessary to advance the glow.

Each distributor tube when fired operates a rectifier switch to allow a train of incoming impulses to pass to a counting chain similar to that of the distributor. When tube D1 is fired, for example, the rectifier QA, which is normally biased to its high resistance direction by an amount about equal to the voltage of the incoming impulses, becomes conducting. The incoming impulses are, therefore, communicated to the counting chain which includes tubes N1, N2. . . . The first tube N1 is primed from the anode supply voltage until a tube fires and reduces the tube anode voltage. The first impulse thus operates tube N1, and subsequent impulses operate the tubes in turn as described for the distributor chain.

Coded Impulse Register.

Fig. **2** shows part of an array of gas-discharge tubes

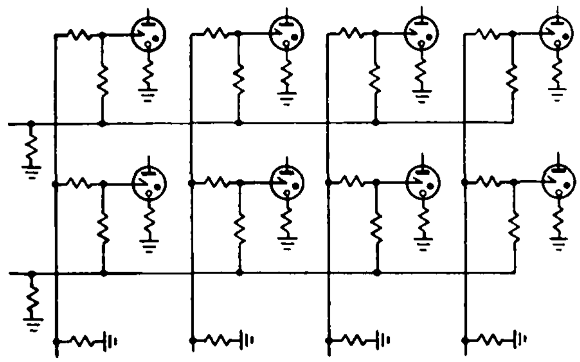

FIG. 2.—A CODED IMPULSE REGISTER.

which is suitable for registering coded impulse numbers. Each row of tubes registers a decimal digit in four-digit binary code. The primer of each tube is connected through two resistors, one to a column common, and the other to a row common. The distributor applies 80V positive to each row common in turn as digits are received. As each digit comes in, a signal receiver applies 80V positive to the column commons according to the value of the digit. As a tube will fire only when its two resistors are at 80V positive, tubes will glow and register the digits which are received. The digits may be received in coded form, for example, by multi-frequency key impulsing, or in any other form and be coded at the receiving point. For example, if the number of dialled trains to be registered is large, it is more economical to code them into binary form before registering than to register them in decimal form, as in Fig. **1**.

Supersonic Delay Line Register.

Supersonic delay line registers have been invented as memory units for automatic computors.[2] Fig. **3**

[2] T. K. Sharpless. "Design of Mercury Delay Lines." *Electronics*, November, 1947, p. 134.

shows one form of delay line. A steel tube is closed at its ends with insulating discs. Let into the inner face of each disc is a metal electrode connected through the disc to an external terminal. Stuck or in some way pressed against each electrode is a quartz crystal.

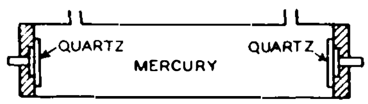

FIG. 3.—A FORM OF DELAY LINE.

After assembly the tube is filled with methylated spirit or other liquid which wets the surface of the crystal, and the liquid is then displaced by mercury until the whole tube is full of mercury. The crystals are X-cut so that they vibrate in thickness when an alternating voltage is applied across them. A natural frequency of vibration of the crystals of 10 to 15 Mc/s is often used, but the damping by the mercury load and other effects can be made to produce a frequency response which is flat over a bandwidth of several megacycles about the crystal's natural frequency. The mercury is prevented from making contact with the electrodes by making the crystal diameters greater than that of the electrodes. An alternating voltage may be applied to one of the crystals by applying the voltage to the mercury and external electrode terminal. An alternating voltage of suitable frequency applied in this way causes the crystal to vibrate mechanically, and thus to communicate pressure waves to the mercury. The waves travel along the column and in impinging on the crystal at the other end, produce a voltage similar to that at the sending end, but delayed and greatly attenuated. The frequency of the A.C. applied may be about 10 to 12 Mc/s, and the propagation speed of the waves in the mercury is about 1·5 metres per milli-second. If an impulse of, say, 12 Mc/s for one microsecond is transmitted into the delay line, it will come out of the other end the delay time later. If an impulse issuing from the delay line is used to gate a new time-corrected impulse into the delay line, an impulse once started can be made to circulate indefinitely. Impulses may be injected at intervals down to one microsecond, or even less, and all circulated together. In this way capacity for 1,000 impulses has been provided in a delay line about 1·5 metres long. For a telephone exchange register **a** capacity of about 100 impulses would suffice.

Fig. **4** (*a*) shows the circulation system schematically. A gate G1 has connected to it a pulse source which, because it controls the timing of the circulating system, is called the "clock" pulse. It is common for the impulses of the clock pulse to be 0·2 microsecond long and spaced one microsecond apart. The gate G1 lets a clock impulse through to a second gate, G2, if when the clock impulse occurs, there is a signal on either of the two leads A or B. The gate G2 also has connected to it an A.C. generator, FX of frequency about equal to the natural frequency of the quartz crystals in the delay line. The action of the gate G2 is that when it receives an impulse from the gate G1 it allows the generator current to flow to the delay line input for a fixed time, say one microsecond. An A.C. impulse thus passed into the delay line will emerge after the delay time. After amplification the impulse is passed to the lead B and thence to gate G1, where it will gate a clock pulse to gate G2 and thus start a new impulse

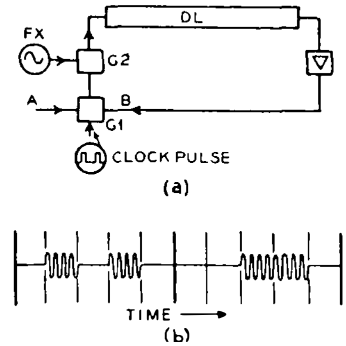

FIG. **4**.—SUPERSONIC DELAY LINE REGISTER—(a) SCHEMATIC OF CIRCULATION SYSTEM. (b) PORTION OF CYCLE AS INDICATED BY A CATHODE-RAY TRACE.

into the delay line. Initially there are no circulating impulses, and impulses are registered by an impulse generator which generates them at the right time and passes them into the system over lead A, after which they continually circulate as described.

Fig. **4** (*b*) shows a portion of the cycle as it would appear on a cathode ray tube connected to any part of the circulation system. It shows two 5-binary digit numbers registered, the first with impulses in the second and fourth digit places, the second with impulses in the third and fourth digit places, each impulse being an A.C. impulse at the frequency of the generator FX. These impulses are cyclically repeated at intervals equal to the cycle time of the circulating system which is controlled by the clock impulses. A second clock pulse gives out impulses to mark the beginning of each cycle. The whole of the recorded information appears cyclically as impulses at a single point anywhere in the circulating system, and use can be made of this feature in translating operations. The significance of any impulse is dependent on its time position in the cycle. Registering and "reading" digits is thus a matter of controlling and measuring impulses in time. This needs somewhat complicated apparatus which, however, is independent of the number of impulses in the cycle. Hence the system may be very economical for registering a large number of digits.

Cathode-Ray Tube Register.

Electro-mechanical registers have been made with capacitors as register elements, the charges on the capacitors constituting the record of the numbers received. Fig. **5**, which illustrates this system, shows capacitors in four columns and two rows although many more rows usually are necessary. Each capacitor is shown with a leak resistor which in most cases is the insulation resistance. For each number received capacitors in one row are charged according to a code and constitute a record of the numbers received for so long as the charges on the capacitors persist. The record can be maintained indefinitely by an arrangement which tests each capacitor in turn at frequent intervals and "tops up" the charged ones to a standard charge. This is a very economical system when the storage required is large.

A cathode-ray tube can be made to operate in roughly the same way even more economically when a very great amount of storage is required.[3] The beam

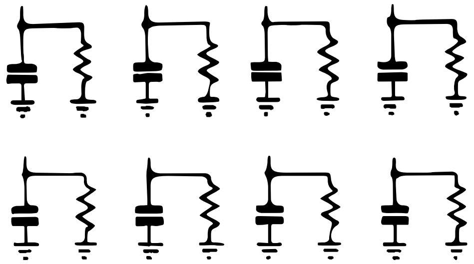

FIG. 5.—CAPACITORS USED AS A REGISTER.

of a cathode-ray tube when suitably controlled can leave the part of the insulating screen on which it impinges charged to one of two potentials. If the beam is caused to travel over the screen in a line, and during the passage over the line the beam is modulated according to the digits of a binary number to be stored, charges representative of the digits can be left on the screen. This is called "writing" on the screen. These charges will soon disappear if no further action is taken. The line is, therefore, scanned at frequent intervals and the charges renewed. Many different numbers are recorded in straight lines parallel to one another and continuously scanned in television picture fashion. In this way a very large amount of number information can be registered and held indefinitely. The amount of common apparatus needed to write the information in the right places, to "read" and to renew the charges is fairly substantial, so that the system shows up to its best advantage when there is a great amount of information to be stored, as there is in the automatic computers for which the system was originally invented. The continuous and cyclic scanning results in the registered information being reproduced, as in delay line registering, in a repeating sequence of timed impulses.

ELECTRONIC TRANSLATORS

The translator function will be approached by way of some practical examples which illustrate three main types of translator.

Static Register-Static Translator.

In Fig. 6, three groups of ten wires each are shown on the left of the figure and represent a three decimal-digit register. Each wire is connected, for example, to the cathode of a register gas discharge tube ; it is normally at earth potential, but when marked by the register takes a positive potential. Any combination of one wire marked in each group can be made to operate a three-electrode gas discharge number tube. The figure shows one such tube operating via rectifiers to the number 142, and marking, through 2 two-electrode gas discharge tubes, one wire in each of two groups of ten wires on the right of the figure. The rectifiers act so that the primer of a tube to which a group of the rectifiers is connected takes up a positive potential only if all the wires to which the group of rectifiers is connected have a positive potential. With this arrangement a large number of such groups of rectifiers are operable with low power consumption from the wire-marking sources. When a tube is fired, its cathode takes a positive potential which causes discharges through the two-electrode marking tubes connected to it, and thus marks a wire in each group, in this example 23. It will thus be seen that number 142 is translated into number 23. It will also be realised that any number of numbers, each of any number of digits, can be translated to other numbers, each of any number of digits, by the provision of sufficient apparatus. The amount of apparatus is clearly considerable even for a relatively simple piece of apparatus like a two-digit director. The natural development to reduce the cost is to make the translator common to a number of registers. The broken line drawn across Fig. 6 shows the division between

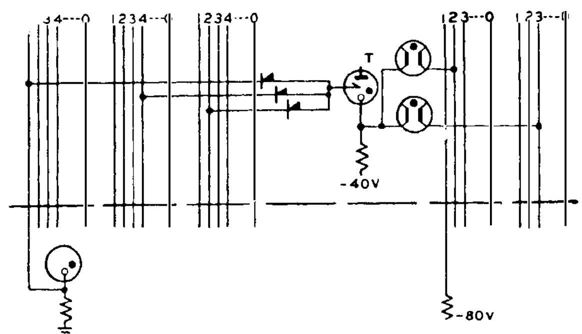

FIG. 6.—THE ELEMENTS OF A STATIC REGISTER-STATIC TRANSLATOR.

the individual register and the common translator. It is obvious that no two registers should be connected simultaneously to the translator. Some means must, therefore, be employed to connect the registers one at a time to the translator. One method is to let each register, when it requires a translation, apply for connection to the translator through a switch which permits only one such connection at a time. The disadvantage of this method is that reference to the translator must be made after a fixed number of incoming digits. This difficulty is surmounted by connecting each register to the common translator after each digit which is received. However, complication still remains in the means for determining that a digit has been received. A further method is to connect each register to the translator in sequence and independently of the incoming digits. By whatever method the translator is made common to the registers, no register should hold the translator for more than the briefest necessary time, which is the time to operate a memory, e.g. a gas discharge tube ; each register then has to have a memory for the translation as well as the incoming digits. For this reason, it is sometimes economical to read the translator digits out of the translator one at a time. This may readily be achieved by adding to the code digits an

[3] F. C. Williams and T. Kilburn. "A Storage System for Use With Binary Digital Computing Machines." *J.I.E.E.*, 96, p. 81 (Part III, March 1949).

extra digit which records the number of translation digits read out. By this method, the translator is made more complicated, but the register less so. In the example given in Fig. **6**, instead of one tube T, operated by the received code and giving all the translation digits, there would be a number of tubes T, each operated by the same received code plus a different digit recording the numbers of translation digits read out, and each providing one translation digit. The number of tubes T required in the common translator is increased from the number of codes requiring translation to the number of codes requiring translation multiplied by the average number of translation digits per code, but the economy in the register may easily offset the extra expense in the common translator.

Static Register-Pulse Translator.

In Fig. **7** (*a*), the lower portion of the figure is

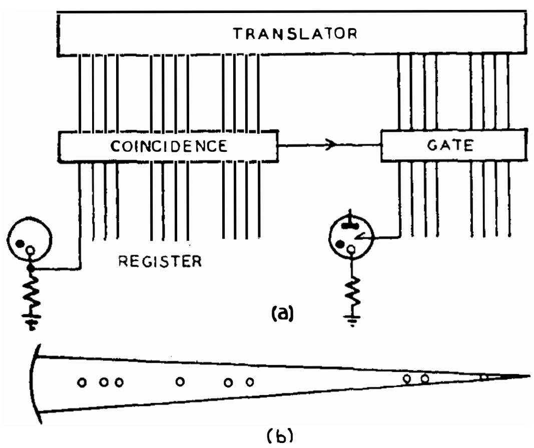

FIG. **7**.—THE ELEMENTS OF A STATIC REGISTER-PULSE TRANSLATOR.

concerned with the register and the upper portion with the translator. On the left are three groups of four wires below the apparatus marked "coincidence." These wires are marked according to the binary code, by the register gas discharge tubes. On the right are two groups of four wires; each wire has one end connected to a gate apparatus and the other terminated on a gas discharge tube which is fired when the wire is marked with a suitable potential. For each wire connecting the register to the coincidence apparatus, there is a corresponding wire joining the coincidence apparatus to the translator, and similarly for the gate apparatus. The translator presents in cyclic order to the coincidence apparatus all the incoming numbers for which a translation is required, each number being presented as markings, in binary code, of the wires to the coincidence apparatus. Thus, in an extreme case, one thousand codes corresponding to all the numbers from 000 to 999 would be presented to the coincidence apparatus. For each number which is thus presented the corresponding translation in coded numbers is at the same time presented to the gate apparatus. When a translator incoming number coincides with the incoming number registered in the register, the coincidence apparatus operates the gate, which is normally "closed," and allows the translation numbers to be passed to the register and there stored. The speed at which electronic apparatus can work makes presentation of a great number of different translations in a short interval of time relatively easy.

The translator is a variable pulse generator which may take various forms. One is indicated in Fig. **7** (*b*), which shows a sector of a disc. Each sector corresponds to one "entry" in the translator, the entry taking the form of holes punched in the disc in positions corresponding to the required wire markings. The disc on being rotated between a light source and an appropriate number of photocells, causes the required pulses to be generated in the photocells. There are other and better methods of generating the pulses, but all are too expensive to be individually provided for each register. There is no difficulty, however, in one translator serving a number of registers. Each register, if connected to the translator through its own coincidence and gate circuits, can operate quite independently of the others, and by adding an extra digit to the code digits, as described for Fig. **6**, the translation digits can be extracted one at a time to save translation registers.

Pulse Register-Pulse Translator.

Fig. **8** shows schematically the further development of the previous register-translator in which both the register and translator operate with pulses. The register may be of the supersonic delay line or cathode-ray tube type, or any type giving the registered information in a cycle of pulses synchronised by a "clock." In Fig. **8**, this is represented by the circle marked "register cycle." The translator has a code cycle similar to, but much longer than, the register cycle, and synchronised by the same "clock." Written into the translator code cycle are all the codes for which translations are needed, these codes being written into the cycle in positions such that the impulses of a code will appear at the output of the cycle at the same time

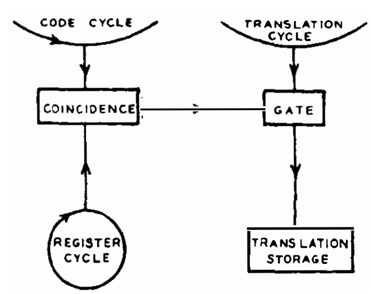

FIG. **8**.—THE ELEMENTS OF A PULSE REGISTER-PULSE TRANSLATOR.

as the impulses of the same code written into a register cycle will appear at the output of the register cycle. An impulse code coincidence detecting circuit connecting the outputs of the code and register cycles operates a gate circuit for a given time after detecting coincidence between a registered number and a code cycle number. During the time the gate is operated, the translation in coded impulses is given out from a translation cycle in the translator, and will pass into the register and be stored there.

With this method the coincidence and gate circuits can be very simple. The registered numbers must be in pulse form, which in practice limits the method to delay line and cathode-ray tube registers. The code and translation cycles in the translator have to be very long, many thousand of pulses in some cases; this requires a high-speed technique with impulses of the order of one microsecond in length. In general, the method shows up to best advantage when the number of translations is very large.

Electronic Senders

Registering a number consists of detecting or receiving the number, converting it if it is not already in a form suitable for registering, and finally registering the number. Sending is the reverse process. Given a registered number, this has to be converted, if not already suitable, into a form suitable for transmitting, and finally transmitted in the required form.

The number of forms that sending may take is very large, being equal to the number of combinations of ways in which numbers may be registered with the ways in which numbers may be transmitted. Nevertheless, the sending problem is a relatively simple one and a single illustration will suffice to show the type of operation involved. In general, numbers are transmitted either by a train of impulses or by binary code impulses. In the following example, registered decimal numbers are sent out in two-out-of-five binary code.

Fig. **9** shows the elements of a sender designed to

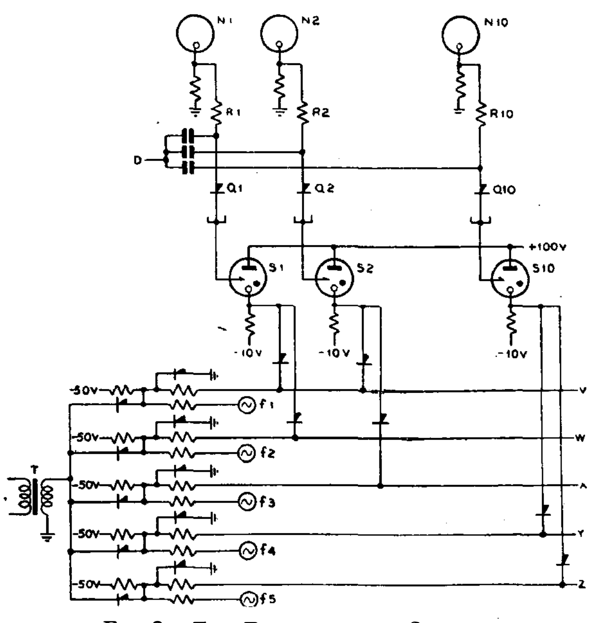

Fig. 9.—The Elements of a Sender.

read out from decimal static registers, convert to combinations of two-out-of-five frequencies and transmit the frequencies to a transmission channel. This is a common arrangement for sending from one register to another over a junction or trunk circuit. One decimal register is represented by the row of cold-cathode gas tubes N1, N2 . . . N10. These may, for example, be tubes N1, N2 . . . in Fig. **1**, with the addition of the circuit elements about to be described. The cathode of each tube N is connected through a resistor R and rectifier Q to the primer of a gas discharge tube S; the junction between each resistor R and rectifier Q is connected through a capacitor to a lead D. There will be a number of decimal registers each as shown in the diagram, and commoned to the primers of the tubes, S.

The lower portion of Fig. **9** shows the frequency-sending arrangements. The five frequencies are produced by the generators f_1, f_2 . . . f_5, and these are connected through rectifier switches to the output transformer T. Normally the rectifier switches produce high attenuation between the generators and the output, but any wire V, W, X, Y or Z, the potential of which is raised substantially above earth potential, will bias its associated rectifier switch into the low attenuation condition and thus send one of the frequencies. The conversion from decimal to two-out-of-five code is performed by the rectifiers which connect the cathodes of the valves S to the wires V, W, X, Y, Z.

Before sending commences, one tube in each decimal register will be glowing, but none of the tubes S will be struck. When sending is to commence, a positive-going impulse will be applied to the lead D of the first decimal register. This impulse will raise the potential of the primers of all the tubes S, but one primer, the one connected to the glowing valve N, will be raised more than the others and its tube will be the only one to glow. The potential of the cathode of this tube will become positive with respect to earth, and the current through the two rectifiers connected to the cathode will cause two of the five frequencies to be transmitted. To terminate the sending, the anode voltage of all the S tubes is reduced so that the one tube struck ceases to conduct. To send the next digit, an impulse is applied to the D lead of the second decimal register tubes N, and the process described is then repeated.

Conclusion

It is hoped that the description and examples given will convey the future scope of the register-translator problem and some of the possibilities of all-electronic solutions to the problem. It will be appreciated, of course, that the register-translators described do not apply only to fully electronic exchanges. Partially or fully electronic register-translators, or register-senders without translation, may very likely find their way into existing systems. For a possible all-electronic automatic exchange system, however, the existence of an all-electronic register-translator-sender means that the speech path switches can be connected and controlled according to any of the well-known trunking and selecting systems, which will form the subject of the next article.

A Drawing Office Aid in Isometric Projection

R. H. CHAPMAN, B.Sc., A.M.I.E.E., and E. C. SHIPLEY†

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The article describes a novel machine which enables views in isometric projection to be easily traced from conventional orthographic engineering drawings. Some examples are given of its application to P.O. Engineering Department work.

Introduction.

THE majority of Departmental Technicians are electrical rather than mechanical specialists; moreover, as they are, generally, more concerned with maintenance than with the manufacture of mechanical or electro-mechanical equipment, they do not normally have the opportunity of becoming so familiar with reading and interpreting conventional mechanical drawings as do their colleagues in workshop or drawing office. In preparing instructions for installation and maintenance, particularly when dealing with detailed mechanical features, there is, therefore, a considerable demand for semi-pictorial views of items, but the production of drawings of this type has been restricted owing to the high cost in drawing-office man hours.

For these reasons, a drafting machine, known as the Parallel Perspector and constructed on pantographic principles, has been obtained from Isometric Projections, Ltd., Bucks., which enables isometric views to be traced readily from conventional orthographic drawings. Experience with the machine has shown that a reasonably experienced operator can produce a complicated isometric view in a fraction of the time taken by normal drafting methods. It is hoped that the acquisition of this machine will enable the usefulness of the semi-pictorial nature of isometric views to be more widely exploited by the Department than has been possible in the past.

Principles of Isometric Projection.

To enable the functioning of the machine to be better understood it may be desirable to reconsider some of the principles of isometric projection. An isometric view is a plane view in which the three rectangular dimensions (length, breadth, and height) are drawn parallel, respectively, to three main axes which are equiangularly spaced, the one axis being vertical and the other two making angles of 120° with it. The object is viewed from such an angle that the item is symmetrically disposed and the apparent lengths of dimensions parallel to the three main axes are equally foreshortened.

A cube of unit side is represented isometrically by Fig. **1**. BD is evidently a true length ($=\sqrt{2}$), from which it follows that side AB $= \sqrt{2}/2 \cos 30° = 0{\cdot}816$.

If Fig. **2** represents an orthographic elevation and plan of the cube, and α is the angle of vision from which the cube is viewed to obtain the isometric projection on a plane at right angles to the line of vision, the apparent length of AE (i.e. length AF in Fig. **1**) is AH ($= 0{\cdot}816$), therefore, $\cos \alpha = 0{\cdot}816$ and $\alpha = 35° 16'$.

A circle tangential to each of the four sides of any face of the cube has a diameter of unity and, in the isometric view, becomes an ellipse whose major axis is also unity and whose minor axis is $\sin 35° 16'$ (i.e. $0{\cdot}577$).

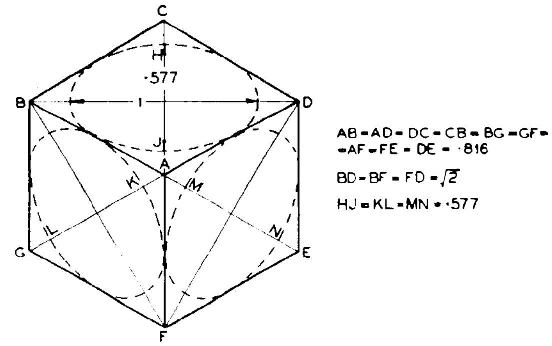

FIG. 1.—PRINCIPAL DIMENSIONS ON ISOMETRIC VIEW OF CUBE OF UNIT SIDE.

Basic Principles of the Perspector.

From the foregoing the two main requirements for an isometric drafting machine are therefore :—

(1) A means of producing from a circle an ellipse

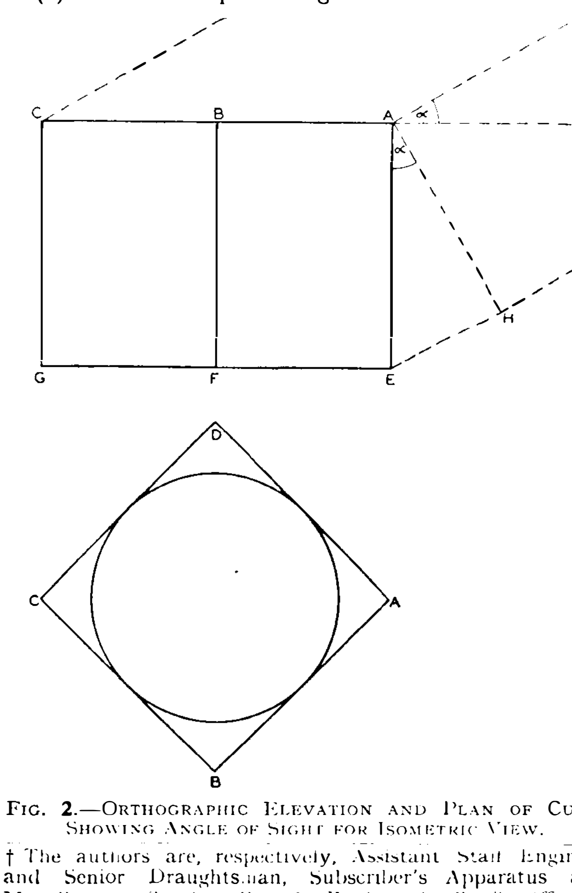

FIG. 2.—ORTHOGRAPHIC ELEVATION AND PLAN OF CUBE, SHOWING ANGLE OF SIGHT FOR ISOMETRIC VIEW.

† The authors are, respectively, Assistant Staff Engineer and Senior Draughtsman, Subscriber's Apparatus and Miscellaneous Services Branch, Engineer-in-Chief's Office.

in its appropriate position with an axis ratio of 0·577 to 1.

(2) A method of setting off the various lengths in an orthographic drawing to a scale of 0·816 to 1 on the isometric drawing.

For the perspector, the first requirement is met by means of a double pantograph mechanism, enabling an ellipse of the correct size and location to be drawn by tracing over the equivalent circle on the orthographic master drawing. The second requirement is met by moving the isometric drawing board crosswise in relation to the board carrying the orthographic drawing, the movement being made according to any particular scale selected by the operator as being appropriate to the drawing being dealt with.

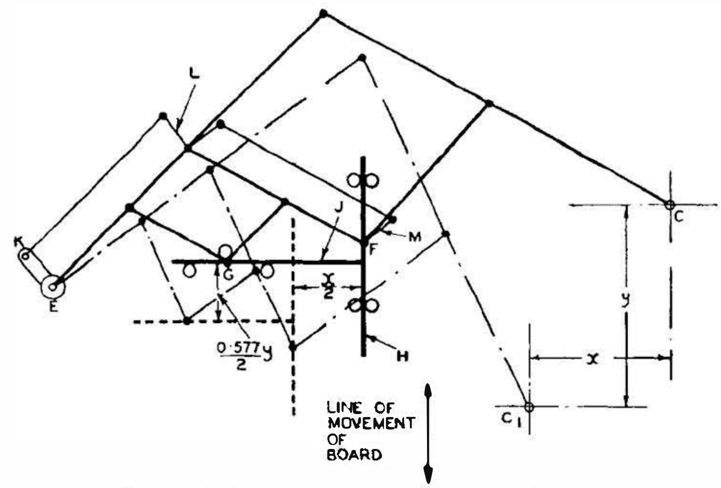

FIG. 4.—SCHEMATIC DRAWING OF PARALLEL PERSPECTOR.

Outline of Constructional Features and Principles of Operation.

Fig. 3 shows a general view of the machine, while Fig. 4 gives the skeleton schematic equivalent. The orthographic master drawing is affixed to board A (Fig. 3) and the isometric view is produced to half normal isometric scale on paper pinned on board B (Fig. 3) which is movable transversely relative to board A. C is the orthographic tracing point, D the isometric drawing point, and E the main pantograph linkage pivot. F and G are further pantograph linkage pivots, F giving a 1 : 2 reduction of the motion of C, and G giving a 0·577 : 1 reduction of motion of F, i.e. 0·577/2 : 1 reduction of the motion of C. The pantograph link arrangement is such that the points C, F, G, and E always lie on a straight line.

Referring to Figs. 3 and 4, the pencil D is carried on a spider, to the underside of which are fixed hardened and ground steel straight-edges H and J forming a ⊥ shaped member. Straight-edge H slides between two pairs of guide rollers on a carriage integral with the pivot pin at F, whereas J is similarly constrained by three rollers on a carriage integral with pivot pin G. The ⊥ member is maintained always parallel/normal to the line of motion of the left-hand board (Fig. 3) by a subsidiary linkage KLM, coupling the 4-roller guide carriage to a fixed point K on the main pivot bearing housing.

Referring to Fig. 4 it will be evident that if C is moved to C_1 (i.e., a distance y parallel to the direction of motion of the left-hand board and x at right angles to it) the ⊥ member and tracing pencil D move $0{\cdot}577y/2$ and $x/2$, respectively, parallel to these two directions.

The motion of the left-hand board is separately controlled by hand wheel R (Fig. 3), the system of transmission consisting of steel wire stretched over guide pulleys, giving smooth and easy movement without backlash.

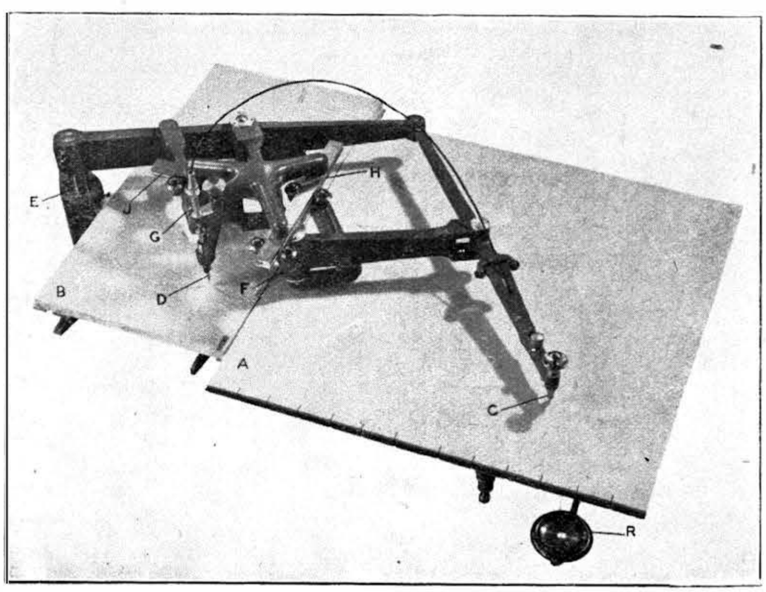

FIG. 3.—GENERAL VIEW OF THE PARALLEL PERSPECTOR.

The machine is precision finished and all pivots are fitted with ball bearings. By means of a bowden wire control, operated from the tracing point C, the pencil at D can be made operative or non-operative at will.

Making a Drawing.

Referring to Fig. 5, in which a simple example is taken to demonstrate the principle, the orthographic plan and elevation drawing is pinned to the fixed board of the perspector so that the axis of the drawing is at an angle of 45° with the edge of the board. The points ABCDEF where abrupt changes in level occur in the orthographic elevation, are marked off and reproduced along the edge of the fixed board, the distances between the points being scaled down to 0·816/2 of the original value. (A standard conversion chart is issued to facilitate this.)

With the movable board located so

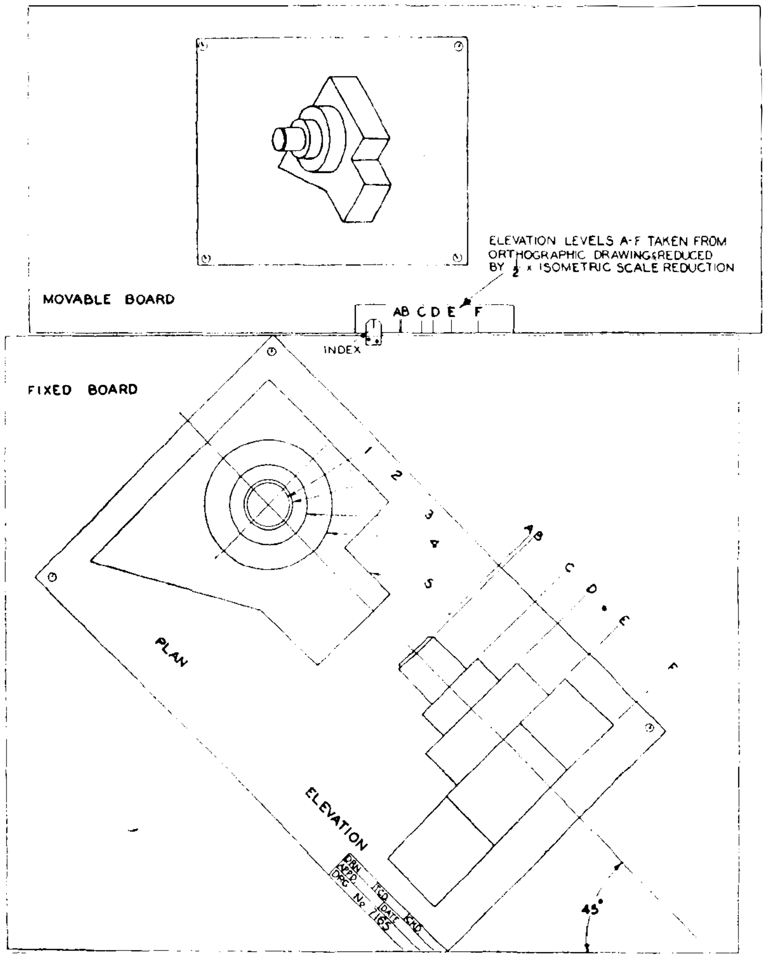

FIG. 5.—SIMPLE EXAMPLE OF THE METHOD OF CONSTRUCTION.

that the index pointer covers A on the scale, an ellipse is traced by tracing over plan circle 1 (the small ellipse at the extreme left of the isometric view). The movable board is then shifted so that the pointer covers point B on the scale and as much as is required is traced from plan circle 2. The movable board is then shifted on to point C and a

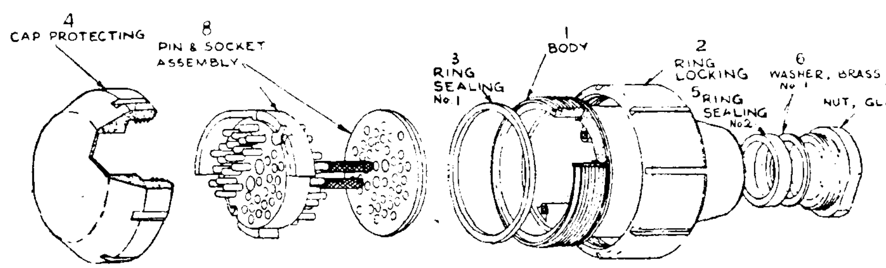

FIG. 6.—EXPLODED VIEW OF A CABLE CONNECTOR PRODUCED ON THE PARALLEL PERSPECTOR.

semi-ellipse is reproduced by again tracing over half of plan circle 2.

With the tracing point held stationary at one extreme of the latter half circle and with the tracing pencil depressed, the movable board is retracted back to B. This motion is repeated with the tracing point held stationary at the other extreme of the half circle. These two operations draw in the two horizontal lines outlining the small diameter pin, or shaft, in the isometric view. The reproduction of the two other portions of wider diameter is carried out similarly.

The movable board is then shifted so that the index pointer registers with point E and, with the pencil depressed, the tracing point is run over as much of the main outline (5) of the plan as is required. This operation is repeated after shifting the movable board to point F. The corresponding corner points are then joined by straight lines and the isometric view is thus completed.

To facilitate tracing, the machine is supplied with a number of drawing aids and accessories for the operator, e.g. radius arms for tracing circles, set squares suitably grooved for tracing straight lines and also grooved for tracing circles of small diameter. All tracing from the orthographic drawing is made by fitting a suitable groove over the desired line and drawing the orthographic tracing point along it.

Exploded Views.

An example of an exploded view produced with the aid of the perspector is given in Fig. **6**. The exploded view drawing is particularly useful for showing, not only the detailed piece-part make up of a complex item, but also the order of assembly. This type of view is also an instance where the facility of the separate control of the traverse of the movable board is used—in this case, to space out the separate piece parts to the distance required.

Conclusion.

The results obtained from the use of the machine have so far been encouraging, savings of as much as 85 per cent. in drafting time having been obtained in particular instances; also, no doubt with further experience, new applications will be found for the machine.

Finally, the authors wish to extend their thanks to Isometric Projections, Ltd., for supplying the photograph used for Fig. **3**.

A Survey of Modern Radio Valves

W. J. BRAY, M.Sc.(Eng.), A.C.G.I., D.I.C.†

Part 6(b).—Valves for Use at Frequencies Above 3,000 Mc/s

U.D.C. 621.385 : 621.396.615.14

In this concluding part of the series*, the principles of operation, methods of construction and characteristics of low-power oscillator and amplifier valves suitable for use in radio and wave-guide relay systems operating at frequencies above 3,000 Mc/s are described. The valves referred to include klystron amplifiers, travelling-wave and electron-wave amplifiers, grounded-grid triode amplifiers, klystron oscillators and continuous-wave magnetrons. The suitability of the oscillators for amplitude, frequency or pulse modulation is discussed.

(*Continued from previous issue*)

OSCILLATORS

Double-resonator Klystron Oscillator.

IF the buncher and catcher resonators of a double-resonator klystron amplifier are coupled by a feed-back path as shown in Fig. **8**, oscillation will occur if the phase-shift round the complete loop is an integral multiple of 2π radians and the small-signal

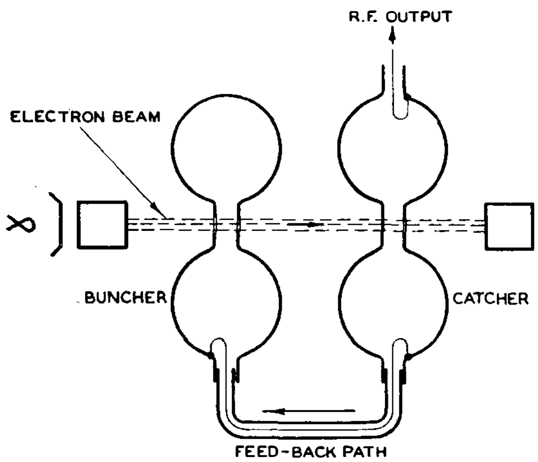

FIG. 8.—SIMPLIFIED SKETCH OF DOUBLE-RESONATOR KLYSTRON OSCILLATOR.

gain through the valve exceeds the loss in the feed-back path. The resonators and the feed-back loop behave as a pair of coupled tuned circuits and the frequency of oscillation adjusts itself until the required phase conditions are satisfied. If the beam voltage is varied the transit time of the electrons and therefore the phase-shift in the drift space also vary, and the frequency changes to a new value such that the total phase shift is once again an integral multiple of 2π. If the resonators are under-coupled the frequency of oscillation varies as an approximately linear function of the beam voltage over a limited range; this characteristic may be used for automatic frequency control or for frequency-modulation but with the disadvantage, as compared with the reflex klystron referred to below, that appreciable modulating power is required, and the linear range of frequency control is usually limited to a few megacycles per second. There is the additional disadvantage that both resonators must be adjusted if the mean frequency is to be shifted manually, as compared with the one adjustment needed in a reflex klystron.

Reflex (single-resonator) Klystron Oscillator.

For many purposes the single-resonator reflex (or reflection) klystron oscillator[18, 19] is preferred to the double-resonator klystron because of the ease of tuning and simplicity of construction. In a reflex klystron oscillator the electron beam traverses the resonator gap twice, first in a forward direction from the cathode, after which the beam is returned from a reflector electrode held at a negative potential with respect to the cathode and crosses the gap again in the reverse direction. The beam becomes velocity modulated in the first transit and subsequently develops bunches in the retarding field region around the reflector electrode. The drift time is determined by the anode; i.e. the resonator, voltage, and by the reflector voltage relative to the cathode since the former determines the electron velocities and the latter the distance they travel in the drift space. By suitable adjustment of these voltages the drift time can be made such that each bunch arrives in the correct phase to give up energy to the resonator, a condition which is fulfilled if the drift time is $n + \frac{3}{4}$ periods of the oscillation, n being an integer usually in the range 2 to 10. Oscillation occurs if the energy extracted from the beam is equal to, or exceeds, the losses in the resonator and the load circuit.

Since the frequency of oscillation can be varied over a limited range by adjustment of the reflector-cathode voltage and the reflector current is negligible, the reflex klystron is particularly useful as an electronically-tuned beating oscillator in a receiver, or as a low-power frequency-modulated source for a transmitter.

The VX5026 valve is a typical low-power reflex klystron oscillator developed in the Research Laboratories of Electric and Musical Industries, Ltd., for use in the frequency range 3,900 to 4,200 Mc/s. The valve is shown in section in Fig. **9** and its general

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* Because of a dispute in the printing trade it was necessary to split Part 6 of this series at a late stage. Part 6(a) in the previous issue introduces the subject and deals with Amplifier valves.

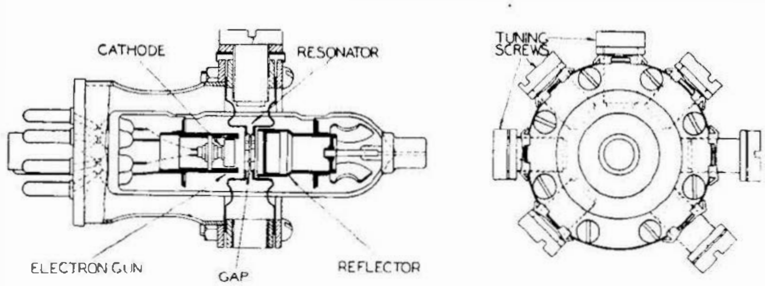

FIG. 9.—SECTION OF SINGLE-RESONATOR REFLEX KLYSTRON OSCILLATOR.

appearance can be seen from the photograph, Fig. **10**. Typical operating conditions are set out below.

Anode (resonator)-cathode voltage	+ 250 V
Reflector-cathode voltage	0 to −200 V (depending on mode of operation)
Cathode current	27 mA
Maximum R.F. power output	160 mW
Efficiency	2·4%

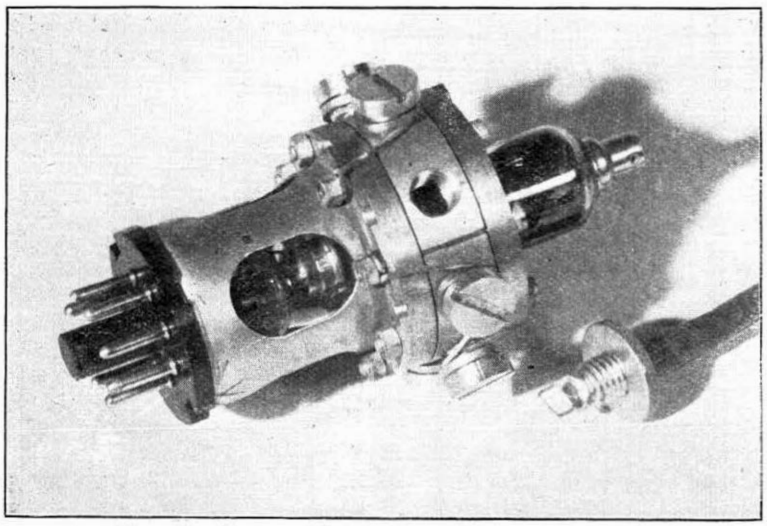

FIG. **10**.—REFLEX KLYSTRON OSCILLATOR, VX 5026.

The variation of frequency with reflector-cathode voltage is shown in Fig. **11**, together with the corresponding variation of R.F. power output. Two different modes of operation are shown, corresponding to different values of the integer *n* mentioned above. It is evident that a nearly linear variation of frequency of some ±5 Mc/s for ±5 V variation of the reflector-cathode voltage can be achieved with little variation of output; the loading of the valve must, however, be adjusted to a suitable value if optimum linearity is to be obtained. Measurements of the modulating voltage required at various frequencies for constant frequency deviation show that modulating frequencies up to at least 10 Mc/s can be accommodated with a variation of response not exceeding 1 db.

Coaxial-line Oscillator.

The coaxial-line type of valve[5] was developed in the Research Laboratories of Standard Telephones & Cables, Ltd., as an oscillator for use in low-power transmitters or as a beating oscillator in superheterodyne receivers.

The valve consists essentially of a short length of coaxial line, short circuited at one end and open at the other, as in the CV230 valve shown in Fig. **12**. The tubular inner conductor is capacitively coupled at one end to a short antenna for feeding an external circuit such as a resonant cavity or wave-guide. The coaxial line is slotted at about one-quarter wavelength from the closed end to permit an electron beam to pass through it, thus forming two gaps (*a*) and (*b*) analogous to the buncher and catcher gaps of a two-resonator klystron. The electron beam is formed by a cathode and control grid together with a screen grid acting as a primary accelerator, and is collected on an anode on the side of the coaxial line opposite to the gun assembly. A magnetic field of at least 1,000 oersteds is necessary to prevent spreading of the electron beam, the field being provided by a permanent magnet.

The coaxial line oscillator operates in a somewhat similar manner to the double-resonator klystron oscillator; the first gap (*a*) produces velocity modulation and hence bunching in the "drift-space" formed by the inner conductor, and the second gap (*b*) functions as a catcher gap. The electric fields across the two gaps are equal in magnitude and differ in phase by 180°, since the buncher and catcher resonators are in fact a single resonator or may be regarded as two resonators with unity coupling. The operating frequency is adjusted manually by tuning the wave-guide cavity but the beam accelerating voltage, which is applied between the coaxial line and the cathode, must also be varied according to the operating frequency, since the accelerating voltage controls the drift-time and, therefore, the phase of the electron bunches relative to the R.F. field across the second gap.

Typical characteristics for the CV230 valve are given below.

Frequency range	2,960-3,000 Mc/s
Resonator-cathode voltage	+ 265 V
Anode-cathode voltage	+ 275 V
Anode current	33 mA
Cathode current	60 mA
Electronic tuning range (for 3 db. decrease of R.F. power)	20 Mc/s
R.F. power output	350 mW
Efficiency	2%

Similar valves have been designed for use in the frequency range 3,600 to 4,200 Mc/s and these valves are suitable for linear frequency modulation with a deviation of up to ±5 Mc/s.

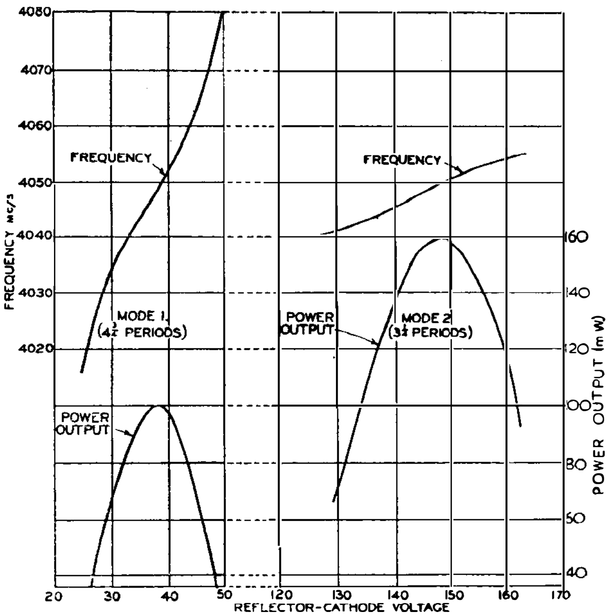

FIG. 11.—VARIATION OF R.F. POWER OUTPUT AND FREQUENCY WITH REFLECTOR-CATHODE VOLTAGE FOR REFLEX KLYSTRON OSCILLATOR, VX 5026.

Magnetron Oscillator.

Magnetron oscillators are of interest because of their high efficiency compared with other sources of centimetre waves and their ability to deliver very large R.F. peak-power outputs. The latter feature, although of great importance in radar, is of less interest for communication systems since the transmitted power required in such systems is relatively small.

The main feature of the magnetron oscillator[20] for centimetre waves is the use of an anode block consisting of a ring of resonant cavities or slots, as shown in Fig. 13 (*a*). An oxide-coated cathode is arranged axially in the centre of the anode block, the whole being enclosed in a sealed-off metal or glass envelope forming a vacuum enclosure. An axial magnetic field is provided from an external permanent magnet or an electro-magnet. A large direct voltage

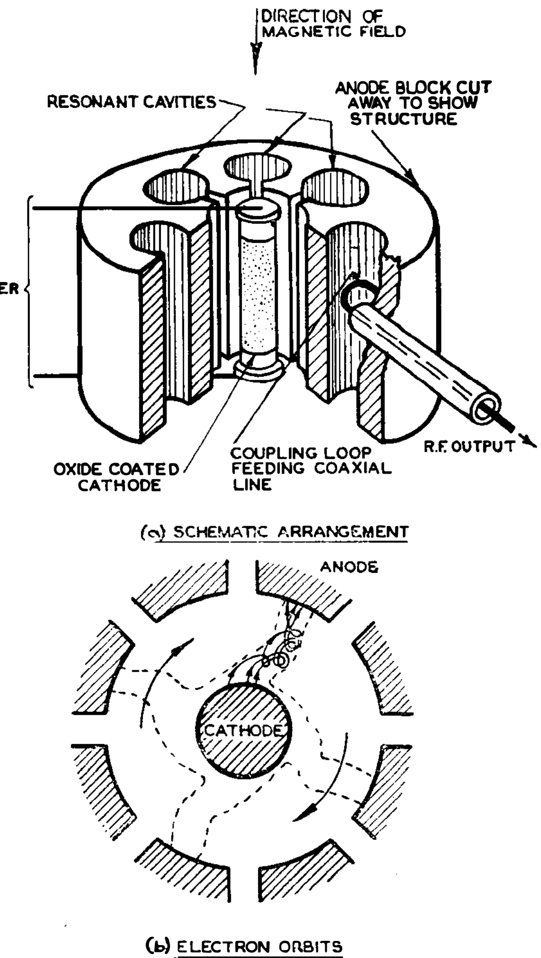

FIG. 13.—MAGNETRON OSCILLATOR.

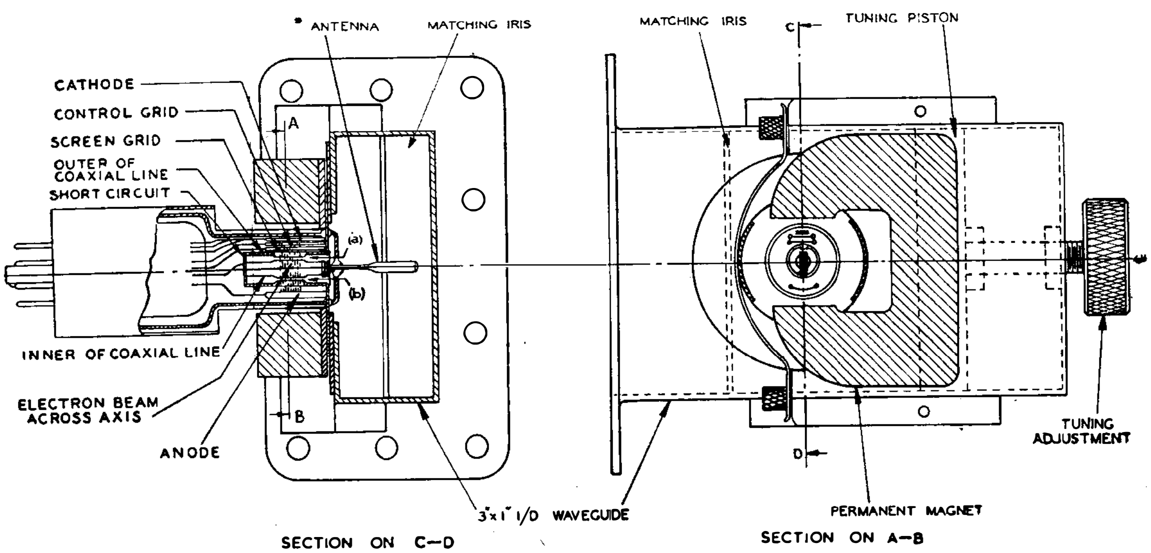

FIG. 12.—SECTION OF COAXIAL LINE OSCILLATOR, CV 230, OPERATING INTO WAVEGUIDE.

is applied to the anode block with the result that electrons flow from the cathode to the anode. In the normal mode of operation the electric fields across the gaps of the cavities differ by 180° or π radians at adjacent gaps—this is known as the "π mode". Other modes of oscillation can exist, and since they may cause frequency instability, arrangements are often made to inhibit such unwanted modes by strapping together the segments that should oscillate in phase; alternatively, the dimensions of alternate cavities or slots may be so proportioned that the frequencies of unwanted modes are well removed from that of the wanted mode—this is known as the "Rising Sun" technique from the appearance of the modified anode block.

The simultaneous action of the constant axial magnetic field and the oscillatory electric field due to the resonant cavities causes the electrons to follow complex paths, as indicated, for example, in Fig. **13** (*b*). Some electrons are returned to the cathode and give up their energy as heat, but the majority of the electrons travel towards the anode and transfer their energy to the oscillating system of cavities. The electrons moving across to the anode tend, by the combined action of the direct magnetic field and the R.F. electric field of the oscillating system of cavities, to be concentrated in radial spokes of space-charge within the limits shown by the dotted lines in Fig. **13** (*b*). These radial spokes of space-charge rotate in synchronism with the R.F. electric field and maintain the state of oscillation by giving up energy to the field. R.F. power can be abstracted from a magnetron by means of a small loop coupling with the R.F. magnetic field within one of the cavities, or by a probe coupling with the R.F. electric field.

Amplitude modulation characteristics.—The oscillating magnetron is not very suitable for amplitude modulation, e.g. by varying the anode voltage, since the relation between the R.F. output and anode voltage is generally non-linear and appreciable unwanted frequency modulation usually occurs.

An arrangement in which a non-oscillating magnetron is used to amplitude-modulate a R.F. carrier flowing along a wave-guide has been described by Gutton and Ortusi.[21] In this arrangement the impedance presented by the magnetron to a coaxial cable is varied by varying the anode voltage; the impedance variations in the coaxial cable are transferred to a wave-guide and thus modulate the amplitude of a wave flowing along the guide. A 100 W carrier at 1,500 Mc/s was linearly modulated up to 80 per cent. at frequencies up to 10 Mc/s, the R.F. power loss in the magnetron being only 1 W.

Frequency modulation characteristics—The Radio Corporation of America has produced a C.W. magnetron[22] suitable for frequency modulation, the mean operating frequency being 4,000 Mc/s. The valve has 12 vane-type cavities through one or more of which an auxiliary electron beam is passed (Fig. **14**), so introducing an admittance across the cavity, the magnitude of which depends on the amplitude of the beam current. Thus, if the beam current is varied by a control grid, the frequency of oscillation can be varied over a limited range. The

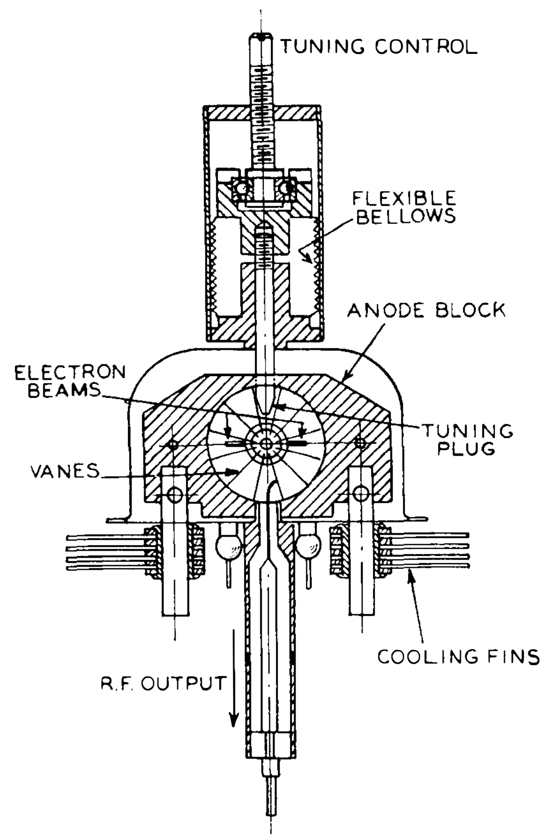

FIG. **14**.—CW MAGNETRON, ARRANGED FOR FREQUENCY MODULATION BY ELECTRON BEAMS.

characteristics of a typical valve are given below:

Operating frequency	4,000 Mc/s
R.F. output	25 W
Efficiency	50%
Anode-cathode voltage	850 V
Anode current	60 mA
Frequency deviation (with two electron beams)	± 2·5 Mc/s

Pulse modulation characteristics.—An example of a low-power pulse-modulated C.W. magnetron for a multi-channel telephony radio link is that used in the Wireless Set No. 10,[23] developed by the Signal Research and Development Establishment during the war. Magnetrons CV79 and 89 used in this equipment produce R.F. power outputs of 300 mW at 4,550 and 4,750 Mc/s respectively. The magnetron is inserted with the anode axis across the shorter dimension of a wave-guide and an $H_{0,1}$ wave is launched into the guide by direct radiation from the anode. Pulse modulation is produced by changing the anode voltage from 450 V (non-oscillating) to 600 V (oscillating), the intelligence being transmitted by variation of the pulse length.

Conclusion.

It is evident from this account that many of the valves for use at frequencies above 3,000 Mc/s are in the early stages of development and that new techniques may be expected to appear in the next few years. Considerable attention has been paid to achieving the required performance characteristics in terms of gain, power output and noise factor, but it is clear that valve life, stability of performance and cost of production will need greater attention in the future. Nevertheless, a number of valves for use at frequencies around 4,000 Mc/s are now reaching the stage where their use in radio relay systems for commercial operation can be envisaged. Valves will probably be required in the future for radio relay systems operating at frequencies in the range 5,000 to 7,000 Mc/s, and it is likely that techniques similar to those used at 4,000 Mc/s can be employed in this frequency range. Valves for use in wave-guide relay systems above 30,000 Mc/s will probably require appreciably different techniques; however, there is now experimental evidence that both oscillator and amplifier valves for such frequencies can be made.

Several of the valves described for use in communication systems were originally designed for use in radar systems and it is clearly desirable to co-ordinate valve development in these two fields; this is ensured by the Co-ordination of Valve Development Committee (Admiralty) which is responsible for the development of valves both for the Services and for certain civil applications.

Acknowledgments.

The author is indebted to Standard Telephones & Cables, Ltd., Electric & Musical Industries, Ltd., the Admiralty Signal and Radar Establishment and the Services Electronic Research Laboratory for supplying data and samples of the valves described. The permission of the Co-ordination of Valve Development Committee (Admiralty) to publish some of the material contained in this article is acknowledged with thanks.

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[18] "Reflex Oscillators," J. R. Pierce and W. G. Shepherd, *Bell System Technical Journal*, Vol. 26, p. 460, July, 1947.

[19] "The CV35—A Velocity Modulation Reflection Oscillator for Wavelengths of About 10 cm," A. F. Pearce and B. J. Mayo, *J.I.E.E.*, Vol. 93, Part IIIA, No. 5, p. 918, 1946.

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[21] "Ultra-High Frequency Modulation on Wave-Guides," H. Gutton and J. A. Ortusi, *J. Brit. I.R.E.*, October, 1947.

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[23] "Low-Power Resonant-Segment Magnetrons for Centimetre Waves," J. C. Dix and E. C. S. Megaw, *J.I.E.E.*, Vol. 93, Part IIIA, No. 10, p. 1585, 1946.

Book Reviews

"Communication Circuit Fundamentals for Radio and Communication Engineers." Carl E. Smith, B.Sc., M.S., E.E. McGraw-Hill Publishing Co., Ltd., London. 401 pp. 190 ill. 42s. 6d.

This book was written to assist American students who are reading by means of home study courses for the more advanced telecommunication examinations. In the U.S.A., correspondence courses are used more extensively than in this country. The author, Carl E. Smith, who has had many years of experience in this aspect of teaching, has clearly given much thought to the best methods of arranging and presenting his subject—one which in the hands of a poor exponent can make dreary reading—in a manner likely to attract and encourage home students. The book was not compiled to fit the English system of technical education, but does, in fact, cover much of the network and thermionic valve theory for the syllabus of the City and Guilds of London Institute examinations in Telecommunications (Principles) up to, and including, the fourth year. The physical aspects are emphasised wherever possible, usually by short illustrated accounts of practical applications of theoretical results.

The first four chapters are comparatively elementary and deal with electrical quantities and their use in D.C. circuits. Chapter 6, entitled "Generator and Motor Action," is the least satisfactory in the book as the field it attempts to survey is too wide. Types of D.C. measuring instruments, relays, and D.C. generators and motors—omitting the essential concept of "back E.M.F."—are all discussed in this one short chapter. A more thorough treatment of instruments alone would have been of more value to most students. From Chapter 7 the author settles to a steady development of network theory, which culminates in Chapter 15 in the classical theorems of Thevenin, Norton, the Reciprocity theorem and Maximum Power Transfer theorems. It is invigorating to find considerable care devoted to the sketching of reactance curves of complex series-parallel networks, a rough method of analysis most useful in more advanced network investigations.

The last five chapters are devoted to thermionic emission and its applications. The diode, the triode, various multi-element tubes and the cathode ray tube are discussed in turn. This section of the book is intended to form a link with a later volume on radio aspects of telecommunications.

Students will appreciate the summary at the end of each chapter, and the exercises (to which skeleton answers appear at the back of the book).

The book is produced in the excellent manner usually associated with the McGraw-Hill Company, and would form a valuable addition to the library of most students of telecommunications. C. F. F.

"Workshop Engineering Calculations and Technica Science." Vol. 2. J. T. Stoney, B.Sc English Universities Press Ltd., London. 212 pp. 177 ill. 12s. 6d.

This, the second volume of this work, completes the second and third years' course in workshop engineering, as required by the City and Guilds and other technical institutes. The book contains 16 chapters followed by tables, logarithms and trigonometrical ratios. The chapters deal principally with materials, simple machines, forces, motion, energy, heat treatment and elementary geometry, trigonometry and algebra, but the arrangement of the material is open to criticism. For example, it seems odd that a chapter on Heat Treatment of Metals should be preceded by one on Velocity and followed by one on Logarithms. Two excellent features of the book, of particular value to students, are the large number of worked examples and the exercises that follow each chapter. The answers to the numerical exercises are given at the end of the book.

The book is written in a simple and clear style, the standard of reproduction is excellent and it will be found very useful by the grade of student for whom it has been written.

R. S. P.

The Use of a Piston Attenuator for Cable Testing in the Frequency Range 1-30 Mc/s

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U.D.C. 621.315.212.001.4 : 621.317.33/34

The piston attenuator has become a familiar tool for use at frequencies of 1,000 Mc/s upwards. This article describes a device which has been developed utilising the same principle for insertion loss measurements on the more recently developed types of high-frequency coaxial cables, in particular the 0·975-in. coaxial pairs of the new London-Birmingham television cable, where it has been used for acceptance testing measurements in the range 1-30 Mc/s. For this purpose, piston attenuators have been incorporated in a portable signal generator providing crystal-controlled spot frequencies in that range.

Introduction.

IN the acceptance testing of completed repeater sections of coaxial cable, the tests made on the coaxial pairs include measurements of attenuation; for this purpose two coaxial pairs are usually connected together at one end of the repeater section and the attenuation* of the loop circuit so formed is measured at the other end of the section. Coaxial pairs of ⅜ in. diameter are utilised and tested at frequencies up to 3 Mc/s, where techniques for measuring attenuation are well established. On the other hand, the 0·975-in. coaxial pairs of the new London-Birmingham television cable[1] may ultimately be utilised at much higher frequencies. It was, therefore, decided to test these coaxial pairs up to 30 Mc/s, and it has been necessary to provide apparatus for the measurement of attenuation at such frequencies. The loss to be measured, for a looped circuit over a repeater section of the maximum permissible length (3·25 miles), increases from about 10 db. at 1 Mc/s to about 58 db. at 30 Mc/s. In considering the method of measurement to be used, it was borne in mind that the measurements have to be made on a routine basis in the field; the apparatus must be portable and easy to operate. The method adopted is based on the use of a calibrated piston attenuator incorporated in a signal generator that has been designed for the purpose. The loss to be measured varies rapidly with frequency, so the frequency of test must be accurately known. To avoid the need for a separate crystal frequency-check unit, the signal generator provides outputs at spot frequencies which are harmonics of the frequency of a crystal oscillator incorporated in it. The principle of operation of piston attenuators will first be briefly described.

Principles and Characteristics of Piston Attenuators

Piston Attenuator as form of Waveguide.

In a piston attenuator a length of waveguide is used as a means of obtaining a known attenuation. The simplest kind of waveguide consists of a metal tube of rectangular or circular cross-section. Electromagnetic fields can exist in such a waveguide in specific configurations or *modes*; these are divided into two main classes, E modes and H modes. In E modes there is a longitudinal component of electric field but no longitudinal component of magnetic field, and conversely for H modes. Within each of the main classes, particular modes are designated by suffixes, for example, $E_{0,1}$, which represents the simplest E mode, and is the one employed in the apparatus to be described. The behaviour of the electromagnetic field in a waveguide varies according to the mode, the frequency and the dimensions of the guide. For each mode in a guide of given cross-sectional shape and dimensions, there is a particular frequency, the critical or cut-off frequency, above which electromagnetic energy is freely propagated in the form of a progressive wave, with a phase shift proportional to distance, as in a transmission line. Ideally, if the walls of the guide had infinite conductivity, there would be no attenuation. On the other hand, at frequencies below the critical frequency the field is rapidly attenuated with increase of distance from the source of excitation. This would be true even if the walls of the guide were perfectly conducting; the attenuation is not primarily due to ohmic losses in the walls of the guide, although the resistance of the walls may contribute a little additional attenuation. The attenuation coefficient, or rate of decay of the field in decibels per unit length, can be calculated from theoretical considerations. In a guide with perfectly conducting walls operated below the critical frequency, the phase of the field components does not change with distance along the guide.

A piston attenuator consists of a length of waveguide with an input element for exciting a field in a particular mode, an output element for extracting power at a point further along the guide, and arrangements for varying the distance between the input and output elements. The dimensions of the guide are such that the operating frequency is below the critical frequency. The nature of the input and output elements depends on the mode; for the $E_{0,1}$ mode in a circular guide, disks are used as shown diagrammatically in Fig. 1. The output element is usually mounted in a tube of smaller diameter than the guide, fitting closely within it like a piston, and this gives the means of varying the distance between the input and output elements and thus varying the

† In the order as listed the authors are: Senr. Exec. Engineer, Radio Experimental and Development Branch; Senr. Exec. Engineer, Research Station; and Assistant Engineer, Radio Experimental and Development Branch.

* "Attenuation" is used as a convenient descriptive term; the quantity actually measured is the insertion loss of the circuit between resistances equal to the nominal characteristic impedance of the coaxial pair (75 ohms in Post Office practice).

[1] "The London-Birmingham Television Cable," H. Stanesby and W. K. Weston, *P.O.E.E.J.*, Vol. 41, p. 183.

attenuation. The input and the output of an $E_{0,1}$ piston attenuator appear as small capacitances ; if it is desired to obtain 75-ohm resistive input and output impedances, 75-ohm resistors may be connected across the input and output circuits near the disks.

Provided that the loss always exceeds a certain minimum value, the change of output in decibels corresponding to a given change in setting can be found by multiplying the constant attenuation

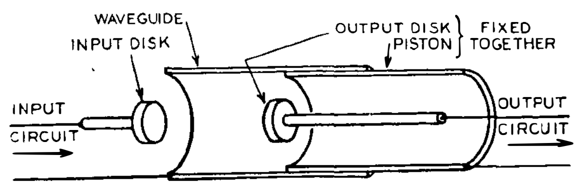

FIG. 1.—BASIC FEATURES OF AN $E_{0,1}$ PISTON ATTENUATOR.

coefficient for the field by the distance through which the piston is moved. This relation does not hold at settings of low loss, when the input and output elements are close together, for two reasons. Firstly, the input element sets up field components in a number of unwanted modes in addition to the intended operating mode, and the different modes have different attenuation coefficients. The operating mode is so chosen, and the input element is so designed, that any other modes likely to be produced have a much higher attenuation coefficient than the operating mode and their effect decreases rapidly with distance along the guide. Secondly, the waveguide operated below the critical frequency is essentially a reactive device, and is necessarily mis-terminated when used to supply power to a resistive load. The piston attenuator, therefore, behaves like any other attenuator that is terminated in impedances not equal to its characteristic impedance ; the actual changes of loss are equal to the nominal changes if the loss is always large, but not otherwise. In any piston attenuator there is thus a minimum loss, below which it is inconvenient to use the attenuator, since the simple relation between loss and piston position no longer holds.

Use of a Piston Attenuator for Loss Measurement.

It is evident that a piston attenuator gives a means of varying the magnitude of a signal by known amounts, but, unlike a resistive attenuator, it does not give an insertion loss of known value variable from zero upwards ; it cannot, therefore, be used for the measurement of insertion loss by direct substitution. It is convenient to combine the source of power and the piston attenuator in a single unit ; the signal generator so formed can then be used, in conjunction with a suitable receiving unit, to measure insertion loss in the following way. The signal generator is first connected through the circuit under test to the receiving unit with the piston attenuator set at minimum, and the indication of the receiving unit is noted. The circuit under test is then removed, and the loss in the piston attenuator is increased so that the receiving unit gives the same indication as before. The loss of the circuit under test can then be calculated from the change in setting of the piston attenuator. It should be noted that the receiving unit is only required to give repeatedly the same indication for the same input ; it is not required to measure the input that it receives. The apparatus to be described operates on these general lines, but, as discussed later, the signal generator has a fixed output from a preset piston attenuator in addition to the variable output from the main piston attenuator, and this simplifies the operating procedure.

DESCRIPTION OF THE EQUIPMENT

Electrical Characteristics of the Piston Attenuator.

The main piston attenuator consists of a length of circular waveguide of $\frac{7}{8}$ in. nominal diameter, which is excited in the $E_{0,1}$ mode by means of a disk at one end. Power is extracted from the guide by a similar disk, whose distance from the input disk can be varied by means of a screw with 24 threads per inch. A 75-ohm resistor is connected between the output disk and the sleeve of the piston to give a resultant output impedance close to 75 ohms.

The critical frequency for the $E_{0,1}$ mode in a $\frac{7}{8}$ in. diameter guide is about 10,000 Mc/s, so the operating frequencies are very much lower than the critical frequency. It can be shown theoretically that under these conditions the attenuation coefficient for the field is 47·744 decibels per inch.

The attenuation per revolution of the screw can conveniently be called the " attenuation factor " of the piston attenuator ; for the $\frac{7}{8}$ in. diameter $E_{0,1}$ attenuator, with a screw having 24 threads per inch, the attenuation factor is 1·9893 decibels per revolution. The attenuation coefficient is inversely proportional to the diameter of the guide, and the figures given must be modified accordingly if the guide diameter differs from 0·875 in.

Provision of Preset Attenuator.

The screw controlling the position of the piston in the main piston attenuator necessarily has a fine pitch to give high setting and reading accuracy, and it follows that the number of revolutions of the driving spindle required to change the output by a given amount is correspondingly large. In the simple method of measuring loss with a piston attenuator, described above, the variable attenuator has to be adjusted through the whole range of loss under test to compare the readings for the receiving unit indicator with the test circuit in series and removed. The measurement of a loss of, say, 40 db., would involve turning the spindle through about 20 revolutions between the two observations and perhaps also repeating this several times to establish confidence in the comparison. This would not only be tedious but the appreciable time interval between the two observations would accentuate the risk of error due to changes in the signal generator output or the receiving unit sensitivity such as can arise from variations in supply voltages.

To avoid these difficulties, the signal generator has a second piston attenuator which can be preset to give an output equal to that of the main attenuator at a particular " reference " setting. The two piston attenuators have the same waveguide diameter and the same arrangement of input and output disks, but whereas the main attenuator has an accurate screw drive giving a large range of movement of the piston, the preset attenuator has only a simple screw adjustment, with a locking arrangement, for a limited range of movement. The input disks of the two attenuators are connected in parallel, so that any change of input affects both outputs equally. The outputs from the main piston attenuator and the preset piston attenuator appear at coaxial plugs marked "variable output" and "fixed output" respectively. The flexible coaxial leads connecting the two attenuators to the associated plugs are made of equal length, so that variation of attenuation with frequency in these leads does not give rise to any error.

With these facilities, the procedure for the measurement of insertion loss is as follows (Fig. 2). The input

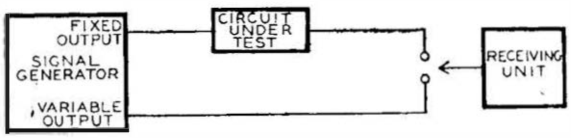

FIG. 2.—ARRANGEMENT FOR MEASURING INSERTION LOSS.

of the circuit under test is connected to the fixed output plug, and with the aid of a receiving unit the main attenuator is adjusted so that the variable output from the signal generator is equal to the output from the circuit under test. To compare the two outputs it is only necessary to change over the lead from the receiving unit from the one to the other, and this can be done very quickly. Repeated change-overs to permit refinement of adjustment and confirm the comparison can be done equally quickly. When the adjustment has been made, the loss of the circuit under test can be found from the reading of the main piston attenuator. It is not necessary to know the actual magnitude of the output from the signal generator, and the latter is not designed to provide an accurately known output.

Circuit Outline of Signal Generator.

The signal generator is designed to operate at any one of twelve frequencies, from 1 Mc/s to 5 Mc/s in steps of 1 Mc/s, and from 10 Mc/s to 40 Mc/s in steps of 5 Mc/s; the required frequency is selected by means of a single control which operates all the switches concerned with frequency-selection. A block schematic diagram is shown in Fig. 3.

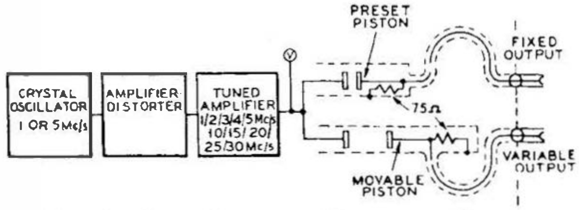

FIG. 3.—BLOCK SCHEMATIC DIAGRAM OF PISTON ATTENUATOR CONTROLLED SIGNAL GENERATOR.

The first stage is a conventional crystal oscillator operating at 1 Mc/s or 5 Mc/s. The 1-Mc/s crystal is used for output frequencies from 1 Mc/s to 5 Mc/s, and the 5-Mc/s crystal for output frequencies from 10 Mc/s to 40 Mc/s.†

The oscillator is followed by an overdriven amplifier which generates harmonics. A two-stage amplifier follows, having anode circuits tuned to the desired output frequency, the appropriate inductors and capacitors being selected by switches.

The second tuned amplifier stage is connected to the input disks of the two piston attenuators. A diode valve-voltmeter circuit is provided to give an indication of the voltage at this point. This facility is intended to assist in checking that the instrument is in working order; it is not intended to be used as a means of obtaining an accurately known output.

Supplies at 250V D.C. and 6·3V A.C. or D.C. are required. The incoming supply leads are filtered to minimise leakage of R.F. energy along these leads.

General Layout.

Fig. 4 shows the signal generator complete with its

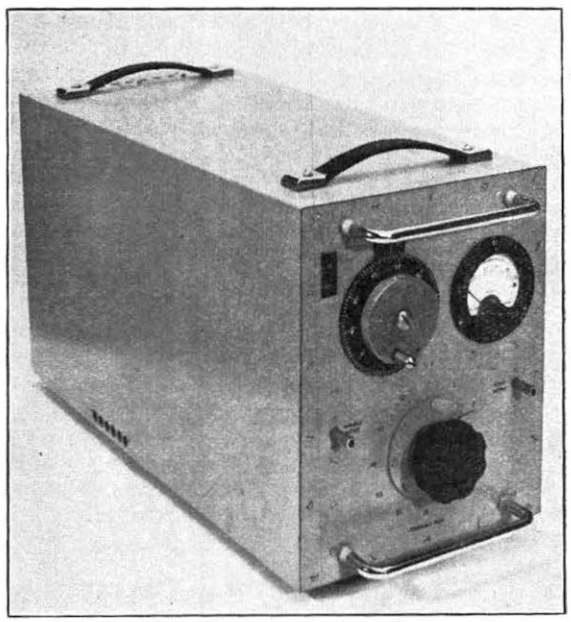

FIG. 4.—THE COMPLETE SIGNAL GENERATOR.

cover, and Fig. 5 shows it with the cover removed. The front panel is of $\frac{1}{8}$ in. brass and carries the controls, the output plugs and the output indicator meter. Attached to the panel is the chassis, which is a rectangular copper box containing the oscillator, amplifier and power filter circuits. On the top of the chassis, and towards the rear of it, is mounted a rectangular screening box, which screens the leads connecting the tuned amplifier to the input disks of the piston attenuators, and houses the diode associated with the output indicator. This screening box supports the preset piston attenuator and the rear end of the

† In addition to frequencies in the range 1-30 Mc/s, which are specifically required for cable testing, frequencies of 35 Mc/s and 40 Mc/s are available for other possible applications.

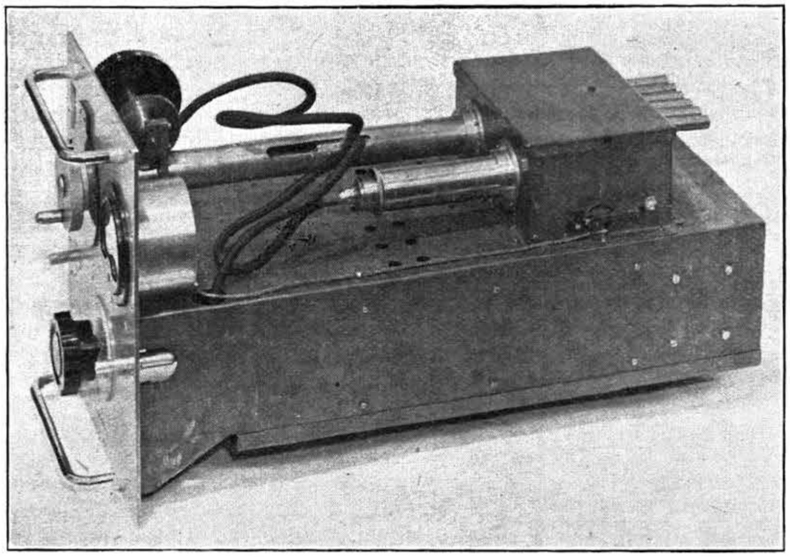

FIG. 5.—THE SIGNAL GENERATOR WITH COVER REMOVED.

main piston attenuator housing ; the front end of the latter is fixed to the front panel.

The assembly so far described is inherently screened. An outer screen is provided by the cover, which is made of copper in the form of a box open at the front end. The open end is reinforced with brass angle to form a mask to which the front panel is screwed.

Metal tubes, $\frac{3}{8}$ in. in diameter and about 2 in. long, are used for ventilation. A set of six tubes, projecting to the rear from the screening box on the top of the chassis, can be seen in Fig. 5; the ends of further tubes, fixed inside the cover, can be seen in Fig. 4. From the point of view of leakage of R.F. energy, the tubes are waveguides operated well below the cut-off frequency, and they have a very large attenuation. A similar device is used to prevent leakage where the operating rod for the frequency selector switches is connected to its control knob ; a coupling rod of insulating material passes through a metal tube fixed to the front panel. The power supply input socket is mounted in a circular housing at the rear of the chassis ; this housing passes through a hole in the cover, and a clamping ring is screwed on after the instrument has been inserted in the cover.

Construction of Attenuators.

Both piston attenuators can be seen in Fig. 5. The more important features of the main piston attenuator will be described with reference to the simplified sectional drawing given in Fig. 6.

The housing (1) is a 12-in. length of brass tube of $\frac{7}{8}$ in. internal diameter ; the part of the tube extending about four inches from the rear end (the right-hand end in Fig. 6) forms the waveguide of the piston attenuator, and the remainder acts as a guide for the piston and a support for the drive mechanism. The input disk (2) is carried by a distrene mounting (3) at the rear end of the housing. The output disk (4) is integral with the piston conductor (5), which is supported in the piston sleeve (6) by distrene pieces (7, 8). The piston conductor and the piston sleeve form a coaxial circuit, which is extended by way of the cable adaptor (9) and a length of flexible coaxial cable to the output plug on the front panel ; a 75-ohm 0·1-watt resistor is connected across the output circuit inside the piston. The cable adaptor (9) travels in a longitudinal guide slot in the housing (1) and serves as a key to prevent rotation of the piston. The guide slot limits the travel of the piston to three inches, corresponding to an attenuation of about 140 decibels. Fixed to the piston sleeve is the steel motion screw (10) which has 24 threads per inch. The front of this screw enters a phosphor-bronze driving nut (11) carried in the driving sleeve (12), which is rigidly connected to the driving knob (13). Thrust bearings (14, 15), tensioned by the spring (16), permit the driving sleeve to rotate with a minimum of friction, but prevent axial movement of the sleeve relative to the attenuator housing. The setting of the attenuator is indicated, in terms of revolutions of the driving sleeve, by means of a dial and a worm-driven counter. The dial (17) is rigidly fixed relative to the driving sleeve, and is engraved to indicate hundredths of a revolution. Complete revolutions are read on the drum (18), which is driven by a worm wheel engaging with a worm on the outside of the driving sleeve.

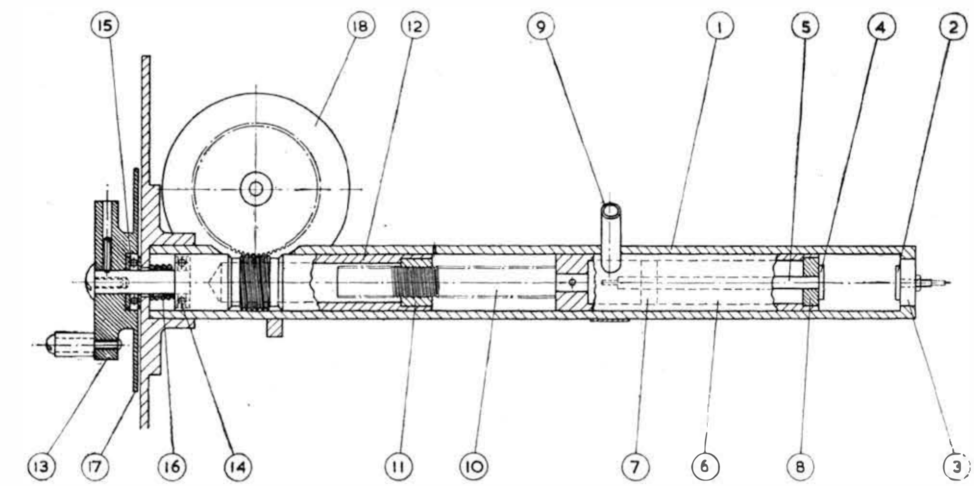

FIG. 6.—SECTIONAL VIEW OF MAIN PISTON ATTENUATOR.

The preset piston attenuator is identical with the main piston attenuator so far as features affecting the attenuation for a given position of the piston are concerned. It is, however, arranged for adjustment over a limited range only, and the piston can be locked in position after adjustment, by the knurled ring which can be seen in Fig. **5**.

ADJUSTMENT AND PERFORMANCE OF THE EQUIPMENT

Minimum Setting of Main Piston Attenuator.

Fig. **7** is a typical graph showing approximate

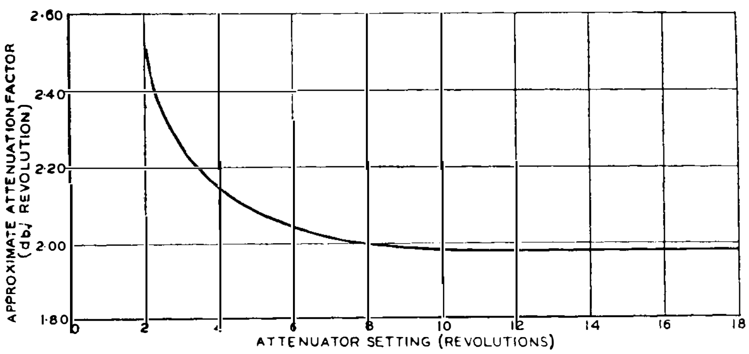

FIG. 7.—VARIATION OF ATTENUATION FACTOR WITH SETTING OF MAIN ATTENUATOR.

attenuation factor (db. per revolution of the driving spindle) plotted against setting for the main piston attenuator. The attenuation factor is substantially constant at settings greater than 10·00; that setting is, therefore, taken as the minimum to be normally used, and is described as the reference setting. The determination of the precise value of the attenuation factor is discussed later.

Alignment.

In the initial alignment of each instrument, the main piston attenuator is set at a reading of 10·00 and the preset piston attenuator is adjusted so that the output at the "Fixed Output" plug is equal to that at the "Variable Output" plug. This adjustment can be made at any convenient frequency, and the two outputs are then equal at all frequencies.

At each frequency, the preset tuning of the anode circuits of the two tuned amplifier stages is adjusted to give maximum reading on the output indicator. This adjustment is made in the initial alignment, but requires an occasional check subsequently.

Backlash in the Piston Attenuator.

Backlash in the main piston attenuator, which would cause the output at any given setting to depend upon the direction of approach to the setting, can be made negligible if special care is taken in the screw-cutting and fitting of the motion screw and driving nut. If special care is not taken, backlash may not be negligible, but no error in measurements will result if the final adjustment of the attenuator is always made in the same direction.

Output.

The output at the "Fixed Output" plug, or the output at the "Variable Output" plug at the reference setting of the main attenuator, increases with frequency over the range used for cable testing, 1-30 Mc/s. The range of output is from about −53 db. to −24 db. relative to 1 milliwatt into 75 ohms. Although a variation of output with frequency is unusual in a source of test signal, it is not inconvenient in this instance, since the method of measuring loss does not require a knowledge of the actual output. The increase of output with frequency is in fact useful, since the loss to be measured in cable testing increases with frequency.

The output may contain a component at any harmonic of the crystal frequency. As the signal generator is intended to be used with a highly selective receiving unit, the unwanted components are unlikely to cause any difficulty; most of them are 40 db. or more below the wanted output.

Maximum Loss Measurable.

The maximum loss that can be measured depends, not only on the magnitude of the reference output from the signal generator, but also on the sensitivity and signal/noise ratio of the receiving unit, which determine the lowest input at which sufficiently small changes of input can be detected. A typical receiving unit comprises a radio receiver of the "communications" type, slightly modified to give an indication of the input level on a meter, and having a 10-db. 75-ohm pad at the input to provide an input impedance close to 75 ohms. Using this receiving unit, the maximum loss that can be measured, if a change of input to the receiving unit of 0·025 db. is to be detectable, varies from about 68 decibels at 1 Mc/s to about 88 decibels at 30 Mc/s.

Screening.

The effectiveness of the screening of the signal generator was checked by exploration with a small search coil connected to the input of a sensitive radio receiver tuned to the signal generator output frequency. Slight leakage was found near the output indicator meter, but elsewhere no leakage could be detected. An exceedingly small amount of leakage between the signal generator and the receiving unit can, however, cause a significant error in the measurement of large losses; leakage equivalent to an input to the receiver 57 db. below the wanted input may, according to the phase shift in the circuit under test and the phase of the leakage relative to the signal, cause an error up to 0·025 db. It is, therefore, desirable for the receiving unit to have screening and power supply filtering arrangements similar to those of the signal generator, particularly if the two instruments are to be connected to the same power supplies.

Value of Attenuation Factor.

Simple production methods enable the bore of the main piston attenuator to be made reasonably uniform, but do not readily give a pre-determined diameter. It is, therefore, desirable to determine the attenuation factor for each instrument. This can be done by calculation, based on measurement of the diameter, and also by reference to other methods of measuring loss. The consistency between the results of different methods indicates that the attenuation coefficient can be determined to an accuracy of 2 parts in 1,000.

Accuracy of Measurement of Loss.

In addition to the error due to inaccurate knowledge of the attenuation factor, some error will be incurred in the actual process of measurement. This is not likely to exceed 0·1 db., and the magnitude of the total error in a measurement is, therefore, not likely to exceed 2 parts in 1,000 of the loss in decibels measured, plus 0·1 db.

Application.

Signal generators of the type described have been used throughout the acceptance testing of the London-Birmingham television cable for the measurement of the attenuation of the 0·975-in. coaxial pairs; they have given reliable service and have been found convenient and easy to operate.

Book Reviews

"Progressive Mathematics." P. Clyne, A.C.G.I., A.M.I.E.E. Chapman & Hall. 270 pp. 121 ill. 15s.

This book is a welcome addition to the literature on mathematics particularly intended for engineering students. It collects together, as far as is known for the first time, a number of modern methods of approach which have been introduced by the more progressive teachers during the last twenty years or so—methods which appeal particularly to the student of engineering and which teach him how to understand and use his mathematics for the solution of engineering problems.

Although it is agreed that graphical illustrations and short, snappy proofs are useful adjuncts in presenting a subject for the first time, it cannot be agreed—as the writer of the foreword and the author both suggest—that such proofs can entirely replace the longer and more involved but invariably sounder proofs based on the more powerful methods of mathematical analysis.

The professional engineer—who, of course, does not pursue mathematics for its own sake, but wants to use it as a tool—needs substantially more than the relatively superficial knowledge of the subject which this book provides—but for those who do not aspire to full professional status, it is possible that the book may suffice in itself; certainly, the student is much more likely to grasp the more rigid analytical method if he has been helped to understand all that is involved in the problem by the use of graphical illustrations when the subject is first presented.

In view of the author's excellent graphical treatment of algebraic, trigonometrical and hyperbolic functions and their differentiation, it is somewhat disappointing that he has omitted to use the same approach to differential equations. The graphical approach to differential equations gets rid, at the outset, of a whole host of the usual difficulties of students who approach this subject by the analytic method of treatment—difficulties, which, if not removed early, continue to obstruct the student's progress well beyond the beginner stage. This omission is all the more surprising since the author appears to have been studying mathematics at the Imperial College at the time when Levy was doing so much to encourage the graphical approach to the study of differential equations.

This method of approach could easily have been introduced in Chapter 10, para. 92. Fig. 40 is itself an illustration of the graphical representation of a differential equation, and this fact only needs to be pointed out in passing, referring back to it in Chapters 15 and 18, and developing it a little further. It is most noticeable, in fact, that Chapter 18, entitled "More Differential Equations," does not contain a single diagram.

The author may wish to adopt this suggestion or a modification of it in a later edition. It would certainly add substantially to the value of the book.

In conclusion, the book can be thoroughly recommended to engineering students, particularly to adult students who are commencing a study of more advanced mathematics. But for those who need more than a superficial knowledge of mathematics, the treatment will need to be consolidated by the parallel reading of a text book dealing with the subject on more rigid analytical lines.

F. C. M.

"Accumulator Charging." W. S. Ibbetson. Sir Isaac Pitman & Sons, Ltd. 190 pp. 41 ill. 10s.

The first edition of this book was published in 1928 and in this, the 10th edition, the author has been able to accomplish a complete revision, including some rearrangement of the subject-matter. Elementary D.C. theory is dealt with in the first two chapters, followed by chapters on the elements of accumulators, the effect of charge and discharge and capacity under various conditions, leading to detailed consideration of the construction and characteristics of modern accumulators in Chapter VI. The remainder of the book is devoted to battery charging and the maintenance of batteries, including repairs and workshop facilities necessary. The rather sketchy treatment of rectifiers for charging is explained by the author, "Unlike most of the D.C. charging units the construction of A.C. appliances is beyond the range of the ordinary electrician and they are best bought to suit the consumer's specification direct from the manufacturers." Even so, the almost universal use of A.C. warrants fuller treatment.

A useful chapter on Alkaline Cells is included and appendices give the syllabus for City & Guilds Motor Vehicle Electricians' Course, with selected questions from recent examinations and a suggested syllabus for Head Colliery Lamp-men responsible for maintenance of miners' battery lamps.

A book not over-burdened with theory for the practical electrician dealing with secondary batteries of the smaller type, it contains much useful information which should help towards a better understanding of the often neglected accumulator.

W. T. G.

A Simple Phase Measuring Circuit

R. A. SEYMOUR†

U.D.C. 621.317.772

The author describes a circuit designed for comparative phase angle measurements between two sinusoidal signals of the same frequency, and gives a theoretical analysis of its operation. The circuit can be used for measurements on feedback amplifiers over the range 50 c/s to 200 kc/s and has an accuracy of ±1° between 0° and 60°. Angles from 60° to 90° can be measured directly but with rapidly diminishing accuracy, and for this range the use of an auxiliary phase-shift network is recommended.

Introduction.

THE circuit to be described is used in conjunction with an oscillator and selective measuring set to make comparative phase measurements between two sinusoidal signals of the same frequency, such data being required, for example, in feed-back amplifier investigations. The general principle of operation is to measure the magnitude of one signal, subtract from it the component in-phase with the other signal, and then to measure the magnitude of the remainder. The ratio between the two magnitudes gives a measure of the phase angle between the two signals.

Circuit Description.

The circuit employed is given in Fig. 1 for a system having two high impedance inputs, input 1 being normally used for the reference voltage, and input 2 for the voltage whose phase relation to the reference voltage is required. The potentiometer, R3, in the cathode of V1 permits variation of the magnitude of the reference voltage fed into the addition circuit V2 and V3. Switch K1 enables the voltage from input 2 to be given an alternative 0° or 180° phase-shift to ensure that the in-phase components of the two signals will cancel in the addition circuit.

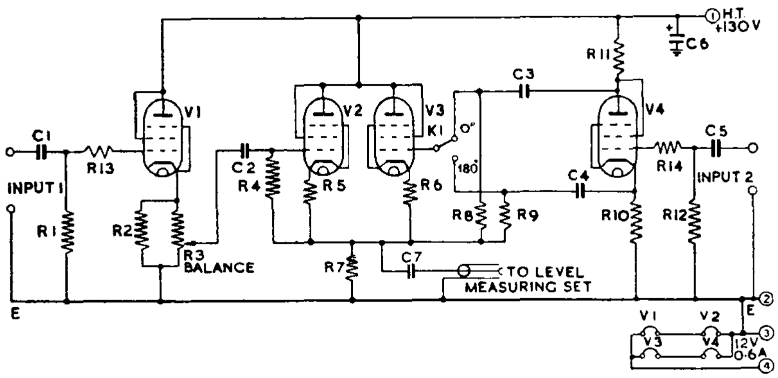

FIG. 1.—THE PHASE MEASURING CIRCUIT.

Analysis of the Addition Circuit.

As a first step in analysing the phase measurement process, consider the addition circuit shown in Fig. 2 (*a*). This consists of two cathode-coupled valves, V2 and V3; e_1 and e_2 are the applied signals whose sum is required, and e_3 the output to be measured. In the equivalent circuit shown in Fig. 2 (*b*) it is assumed that the cathode impedance of each valve can be represented as a fixed resistance, which is added to the load resistance R. Then:—

$$R_1 i_1 + R_3 i_2 - e_1 = 0 \quad \ldots\ldots (1)$$

$$-R_2 i_1 + (R_2 + R_3) i_2 - e_2 = 0 \quad \ldots\ldots (2)$$

From (1) and (2), $i_2 = \dfrac{R_2 e_1 + R_1 e_2}{R_3 (R_1 + R_2) + R_1 R_2}$

$$\text{and, } e_3 = R_3 i_2 = \frac{R_2 e_1 + R_1 e_2}{R_1 + R_2 + R_1 R_2 / R_3} \quad \ldots\ldots (3)$$

If R_3 is large compared with $R_1 R_2$,

$$\text{then, } e_3 = \frac{R_2 e_1 + R_1 e_2}{R_1 + R_2}$$

Stability of Cathode Resistance with Level.

The validity of the foregoing paragraph depends on the equivalent cathode resistance being constant with the level of the applied signal. This is partly accomplished by means of the added series resistance R but, in addition, the choice of valve type is important.

A method of arriving at the order of change of cathode resistance with level is as follows. A general expression for the current i generated in a valve used in Class A is:—

$$i = a + be + ce^2 + de^3 +$$

where e is the input voltage.

Let $e = E \sin \omega t$.

$$\text{Then, } i = a + bE \sin \omega t + c E^2 \sin^2 \omega t + dE^3 \sin^3 \omega t +$$

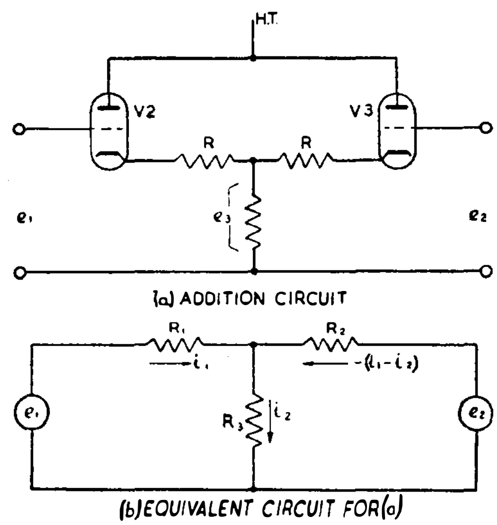

FIG. 2.—THE ADDITION CIRCUIT AND ITS EQUIVALENT NETWORK.

†*Executive Engineer, Research Station.*

$$= (a+cE^2/2+..) + (bE+\tfrac{3}{4}dE^3+..)\sin\omega t$$
$$-(cE^2/2+..)\cos 2\omega t - (dE^3/4+..)\sin 3\omega t$$

If a selective amplifier is used at the output then only the fundamental term $(bE+\frac{3}{4}dE^3+..)$ need be considered, and it can be seen that, as a first approximation, the percentage change of cathode resistance will not exceed three times the change in percentage of third harmonic with change of input voltage. In addition, V2 and V3 are used in triode form to ensure that the third harmonic product is kept to a minimum.

Operation of Circuit.

The phase bridge will need to have a selective amplifier and level measuring set, or voltmeter connected to its output circuit, this measuring equipment being free from interference by unwanted signals over a 40 db. range of levels. The dependence of the accuracy of measurement of phase angle on the accuracy of level measurement is shown later.

To operate the set, consider the reference signal connected to input 1, and the test signal, whose relative phase is required, connected to input 2. Potentiometer R3 is initially at zero (i.e. no signal into V2) and the output meter set to its maximum reading. Potentiometer R3 is then operated to send a signal into V2, and if the reading on the output meter tends to increase, the switch K1 is used to reverse the phase of the test signal applied to V3. Potentiometer R3 is further adjusted until a minimum reading on the output meter is achieved. The ratio between the initial and final output readings is then used, as follows, to evaluate the phase angle.

Calculation of Phase Angle.

Let the input voltage to V2 $= e_1$ and the input voltage to V3 $= -e_2(\cos\theta + j\sin\theta)$. Initially, $e_1 = 0$, i.e., potentiometer R3 at zero.

Then from equation (3) the output voltage, e_3, will be,

$$e_3 = e_{31} = \frac{R_1}{R_1+R_2+R_1R_2/R_3}\cdot|e_2|$$

Now give e_1 a value by increasing potentiometer R3.

$$\text{Then,} e_3 = e_{32} = \frac{R_2e_1 - R_1e_2(\cos\theta + j\sin\theta)}{R_1+R_2+R_1R_2/R_3}$$
$$= \frac{R_2e_1 - R_1e_2\cos\theta}{R_1+R_2+R_1R_2/R_3} - j\frac{R_1e_2\sin\theta}{R_1+R_2+R_1R_2/R_3}$$

When a minimum balance is obtained by adjustment of potentiometer R3, then,

$$R_2e_1 = R_1e_2\cos\theta$$

$$\text{Hence, } e_{32} = \frac{R_1}{R_1+R_2+R_1R_2/R_3}\cdot|e_2\sin\theta|$$

$$\text{and, } e_{31}/e_{32} = \operatorname{cosec}\theta$$

$$\therefore \theta = \operatorname{cosec}^{-1} e_{31}/e_{32}$$

also, $\theta = \log\operatorname{cosec}^{-1} N/20$, where N is the difference between the initial and final readings expressed in decibels.

$$\text{Let, } e_{31}/e_{32} = m$$

$$\text{Then, } \theta = \operatorname{cosec}^{-1} m$$

$$\text{and, } \frac{d\theta}{dm} = -\frac{1}{m\sqrt{m^2-1}}$$

From this latter expression it can be observed that the greatest accuracy of voltage ratio measurement is required when the phase angle is approaching 90°.

With regard to the effect of harmonic production on the accuracy of measurement of the voltage ratio, it should be noted that when the error in the ratio is likely to be greatest, namely, around zero phase shift (i.e. when the change of voltage on the addition valves during balancing is greatest) the error caused in the measured phase angle is least. The opposite state of affairs occurs when the angle is around 90°, since the change of voltage on the valves is then at a minimum. The production of third harmonic in the addition circuit described does not exceed 1 per cent. at the maximum input level.

Performance.

In practice the circuit illustrated in Fig. **1** will maintain an accuracy of phase angle measurement within 1° from 0°-60°, over the frequency range 50 c/s-200 kc/s provided that the voltage ratio can be measured with an accuracy of 1 per cent. Angles from 60°-90° can also be measured directly but with a rapidly diminishing accuracy, e.g. a 1% inaccuracy of voltage ratio measurement, when the angle is in the region of 90°, will result in an error of 8°. An accurate measurement of angles in this range can, however, be obtained if one or other of the signals is given a known phase-shift by means of an auxiliary network, so that the resultant phase angle to be measured falls within the 0°-60° range. The input capacitances are of the order of 20 pF, and the maximum input level should not exceed 2 volts R.M.S.

The foregoing frequency limits are imposed on account of the physical properties of the components used in the particular model described. Provided that care is taken with the choice of components and the layout, there is no theoretical reason why this circuit should not be used over a considerably greater frequency range.

An advantage of the present method of measurement over that used in an H.F. phase meter recently described,[1] is that only two readings of the output meter are required against three, to evaluate a phase angle.

Note.—Since the design of this equipment an article[2] has been published describing a phase measurement circuit employing an addition circuit of similar principle but differing in detail. No theoretical analysis of the performance of the addition circuit is given.

[1] Duerdoth, W. T. "A Phase-meter for the Frequency Band 100 kc/s-20 Mc/s. *P.O.E.E.J.*, Vol. 42, p. 43.

[2] F. A. Benson and A. ●. Carter. "A New Method of Measuring Phase Angle." *Journal of Scientific Instruments*, Vol. 26, No. 8, p. 285.

The Calculation of Phase Constant from Small Differences of Open and Closed Impedance

P. R. BRAY, M.Sc.(Eng.), A.M.I.E.E.†

U.D.C. 621.392.4

A method is given for calculating the phase constant of a line where the differences between open and closed impedance bridge readings are small. Under certain conditions, the significance of these small differences may be lost by the direct application of standard formulae unless tables to at least seven figures are employed.

Introduction.

THE phase constant, in rads./unit length, on a line of length l may be found from the expression

$$2\beta l = n\pi + \tan^{-1}\frac{2\sqrt{M}\sin\mu}{1-M} \text{ rads. } \ldots\ldots (1)$$

$$\text{where } M = Z_c/Z_f \text{ and } \mu = \frac{\phi_c-\phi_f}{2},$$

$Z_c/\underline{\phi_c}$ and $Z_f/\underline{\phi_f}$ being the sending end impedances with the far end closed and opened, respectively. There is normally little difficulty in applying this equation. Tan^{-1} may be positive or negative, depending on the sign of $(1-M)$ and of μ (should ϕ_c or ϕ_f be negative, it must be prefixed by the appropriate sign). There is a possible ambiguity about the value of the factor n (=0, 1, 2, etc.), which is resolved either by the inspection of the sequence of the results obtained at a number of frequencies or by using the estimated figure in the calculation of one of the primary constants (such as capacitance C) whose order is known.

It will be seen, however, that for frequencies at which the line is becoming electrically long, i.e., where $Z_c \rightarrow Z_f$ and $\phi_c \rightarrow \phi_f$, both $(1-M)$ and $\sin\mu$ become small quantities based on the difference of much larger quantities. Unless tables are used, having significant figures adequate for the sensitivity of the measuring apparatus, the $\tan^{-1}$ term will be determined to a poor degree of approximation.

At audio and higher frequencies, it is found that n usually has a value sufficiently high to make an approximate value of $\tan^{-1}$ tolerable. On the other hand, as the frequency is decreased through the low-audio and sub-audio range, the angle of the characteristic impedance tends to a value of $-45°$ and the angle of the propagation constant to $+45°$, this latter fact signifying that the phase constant in radians per unit length is approximately equal to the attenuation constant in nepers per unit length, i.e., on a 27·3 db. line which is fairly long electrically, $2\beta l \doteq 2\pi$ rads. Since n is small, it becomes correspondingly more important to compute the $\tan^{-1}$ term accurately. A method of doing this by utilising bridge differences directly will be developed, but at the outset it is thought that a brief description should be given of the type of bridge suitable for line impedance measurements at low frequencies.

The Series Artifice Bridge.

Partly from consideration of the design of the input circuit of the bridge detecting apparatus, it is preferable that an equal-ratio bridge should be employed. This being so, it is found that the values of the capacitances required in a simple series or parallel bridge become impracticably high at low frequencies. A method of overcoming this difficulty is to limit the series capacitance of the load by means of an added series capacitor, as in Fig. **1**.

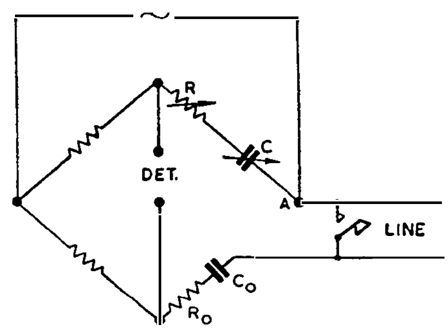

FIG. 1.—SIMPLIFIED CIRCUIT OF SERIES ARTIFICE BRIDGE.

This diagram is schematic only, and does not include screening details or refinements necessary for work on balanced cables. For coaxial cables, or other unbalanced types, such as single-core submarine telegraph cables, the point A is connected to the return or earth circuit. C_0 is the capacitor in series with the line, and R_0 an added series resistor, the value given (R_0) including the effective resistance of the capacitor at any particular frequency.

An initial balance is taken with the line input short-circuited, giving $R = R_0$ and $C = C_0$. The input short-circuiting key is then opened and two balances obtained, R_1, C_1 and R_2, C_2, with the far end of the line respectively short-circuited and open-circuited.

Then the series components R_c, C_c (or R_f, C_f) of the closed (or open) impedances are given by,

$$\left.\begin{aligned} R_c &= R_1 - R_0, & C_c &= \frac{C_0C_1}{C_0-C_1} \\ R_f &= R_2 - R_0, & C_f &= \frac{C_0C_2}{C_0-C_2} \end{aligned}\right\} \ldots\ldots\ldots (2)$$

The bridge differences are thus equal to,

$$\left.\begin{aligned} \delta R &= R_f - R_c = R_2 - R_1 \\ \delta C &= C_f - C_c = \frac{C_0^2(C_2-C_1)}{(C_0-C_1)(C_0-C_2)} \end{aligned}\right\} \ldots\ldots\ldots (3)$$

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When δC is small, it should be calculated directly from the difference terms as indicated and not from C_e and C_f obtained separately.

The angles of the impedances are given by

$$-\phi_e = \cot^{-1}\omega C_e R_e, \quad -\phi_f = \cot^{-1}\omega C_f R_f$$

where $\omega = 2\pi \times$ frequency (in cycles per second), and the moduli by

$$Z_e = R_e \sec \phi_e, \qquad Z_f = R_f \sec \phi_f \quad \ldots\ldots(4)$$

ϕ_e and ϕ_f will normally be negative, since the reactance of a capacitor is negative. A positive angle would be indicated by a negative value for the capacitance derived from equation (2).

The characteristic impedance of the line is

$$Z_0 = \sqrt{Z_e Z_f} \text{ with an angle } \phi_0 = (\phi_e + \phi_f)/2 \ldots (5)$$

Formula for Phase Constant using Bridge Differences.

Let $2\beta l = n\pi + \theta$, where $\theta = \tan^{-1} \dfrac{2\sqrt{M}\sin\mu}{1-M}$

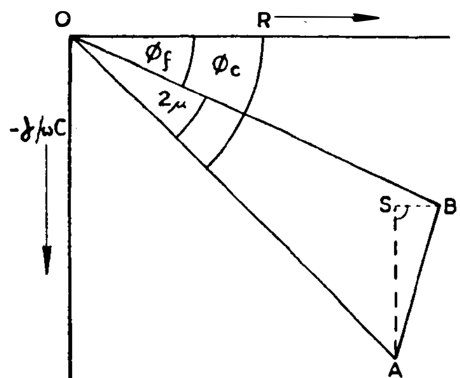


Fig. 2.—Vectorial Representation of Open and Closed Impedances.

and in Fig. 2 let OA and OB illustrate the closed and open impedance vectors :—

In the triangle OAB

$$AB^2 = OA^2 + OB^2 - 2.OA.OB \cos 2\mu$$
$$= OA^2 + OB^2 - 2.OA.OB + 4.OA.OB \sin^2\mu$$
$$\therefore\ 4\,(OA/OB)\sin^2\mu = \frac{AB^2 - (OA-OB)^2}{OB^2}$$

$$\text{But } \theta = \tan^{-1}\frac{2\sqrt{M}\sin\mu}{1-M}$$
$$= \tan^{-1}\frac{2\sqrt{OA/OB}\sin\mu}{1-OA/OB}$$

$$\text{Then, } \tan^2\theta = \frac{4(OA/OB)\sin^2\mu}{(1-OA/OB)^2} = \frac{AB^2-(OA-OB)^2}{(1-OA/OB)^2.OB^2}$$
$$= \frac{AB^2-(OA-OB)^2}{(OB-OA)^2} = \frac{AB^2}{(OB-OA)^2} - 1$$

$$\therefore\ \sec^2\theta = \frac{AB^2}{(OB-OA)^2}$$

$$\text{or } \cos\theta = \pm\frac{OB-OA}{AB}$$

$$= \pm\frac{\text{Difference of moduli of } Z_e \text{ and } Z_f}{\text{Modulus of vector difference of } Z_e \text{ and } Z_f} \ldots\ldots(6)$$

$$AB^2 = AS^2 + BS^2 = (1/\omega C_e - 1/\omega C_f)^2 + (R_f - R_e)^2$$
$$= \left(\frac{C_f - C_e}{\omega C_e C_f}\right)^2 + \delta R^2$$

Writing $R_e R_f = R_g^2$, $C_e C_f = C_g^2$, where suffix g signifies geometric mean,

$$AB = \sqrt{\frac{\delta C^2}{\omega^2 C_g^4} + \delta R^2} = \frac{\sqrt{\delta C^2 + \omega^2.\delta R^2.C_g^4}}{\omega C_g^2} \ldots(7)$$

For values of μ of 3° or less, an error of less than 0·5 per cent. is involved in writing

$$\sin\mu \simeq \tfrac{1}{2}\sin 2\mu \simeq \tfrac{1}{2}\tan 2\mu$$

$$\tfrac{1}{2}\tan 2\mu = \tfrac{1}{2}\tan(\phi_e - \phi_f)$$
$$= \tfrac{1}{2}\cdot\frac{\tan\phi_e - \tan\phi_f}{1 + \tan\phi_e\tan\phi_f}$$
$$\simeq \tfrac{1}{2}\cdot\frac{\tan\phi_e - \tan\phi_f}{1+\tan^2\phi_0}$$
$$= \frac{\cos^2\phi_0}{2}\left[-\frac{1}{\omega R_e C_e} + \frac{1}{\omega R_f C_f}\right]$$
$$= \frac{\cos^2\phi_0}{2\omega C_g^2 R_g^2}\left[-R_f C_f + R_e C_e\right]$$
$$= \frac{\cos^2\phi_0}{2\omega C_g^2 R_g^2}\left[-(R_e+\delta R)(C_e+\delta C) + R_e C_e\right]$$

$$\text{Hence } \sin\mu \simeq \frac{\cos^2\phi_0}{2\omega C_g^2 R_g^2}\left[-\delta C.R_f - \delta R.C_e\right]\ldots(8)$$

$$\text{From equation (1), } \tan\theta = \frac{2\sqrt{M}\sin\mu}{1-M}$$
$$= \frac{2\sqrt{Z_e/Z_f}\sin\mu}{1-Z_e/Z_f}$$
$$\therefore\ Z_f - Z_e = 2Z_0\sin\mu\cot\theta$$
$$\simeq -2Z_0\cot\theta\frac{\cos^2\phi_0}{2\omega C_g^2 R_g^2}\left[\delta R.C_e + \delta C.R_f\right]\ldots\ldots(9)$$

Substituting for $Z_f - Z_e$ (=OB−OA) and for AB (equation (7)), equation (6) becomes

$$\cos\theta = \pm\left[\frac{2Z_0\,\omega C_g^2\cot\theta}{\sqrt{\delta C^2 + \omega^2.\delta R^2.C_g^4}}\cdot\frac{\cos^2\phi_0}{2\omega C_g^2 R_g^2}\right]\times\left[\delta R.C_e + \delta C.R_f\right]$$

$$\therefore\ \sin\theta = \pm\frac{Z_0\cos^2\phi_0}{R_g^2\sqrt{\delta C^2+\omega^2.\delta R^2.C_g^4}}\left[\delta R.C_e + \delta C.R_f\right]$$

For small differences between Z_e and Z_f, $R_g^2\sec^2\phi_0 = Z_0^2$

$$\text{Hence } \sin\theta = \pm\frac{1}{Z_0}\cdot\frac{(\delta R.C_e + \delta C.R_f)}{\sqrt{\delta C^2 + \omega^2.\delta R^2.C_g^4}}$$

$$\text{and } 2\beta l = n\pi \pm \sin^{-1}\frac{1}{Z_0}\cdot\frac{(\delta R.C_e + \delta C.R_f)}{\sqrt{\delta C^2+\omega^2.\delta R^2.C_g^4}}\text{ rads (10)}$$

The appropriate signs of δR and δC as given by equations (3) must be employed in this formula.

Compared with equation (1) there is an extra degree of ambiguity due to the sign of the sine term. For a series of measurements at different frequencies, the quadrant in which θ lies usually becomes self-evident. In other cases, the sign of the tangent in equation (1) is often clear down to fairly small differences of Z_e and Z_f, even though the approximate formula is necessary to give the numerical value of θ. If the attenuation is also calculated, the derivation of one of the primary constants, whose order is known, will also indicate the correct quadrant for θ.

The Implementation of the New Radio Frequency Allocation Table

U.D.C. 654.1 : 621.3.029.5

Introduction.

THE International Administrative Radio Conference (Atlantic City 1947)[1] recognised that the changes made by the Conference to the bands of radio frequencies allocated for use by the various types of radio services would involve the preparation of a new and accurate list of individual stations using the various frequencies. This factual frequency list was regarded as an indispensable requirement to enable Administrations to select frequencies for new circuits and to replace those that were not in accordance with the new table, with a minimum risk of causing or suffering interference, as well as to enable the newly created International Frequency Registration Board to fulfil completely the task for which it was set up. A resolution was therefore adopted by the Conference defining the methods to be followed to prepare such a new frequency list as a prerequisite to the implementation of the new frequency allocation table.

Since the new frequency allocation table contained certain bands of frequencies set aside for the exclusive use of certain types of radio services, such as broadcasting, aeronautical mobile, and maritime mobile, and since frequencies lying between 150 and 2850 kc/s and above 27·5 Mc/s are of regional rather than global significance, the resolution visualised that the work of preparing the new frequency list would be divided amongst a number of specialised Conferences. Such specialised Conferences have been and are being held ; amongst these were an aeronautical mobile conference, held in two parts in 1948 and 1949 in Geneva, a high-frequency broadcasting Conference held in Mexico City in 1948/49[2] and at present continuing in Rapallo, and Regional Conferences which were held during 1949 in respect of Regions 1 and 3 in Geneva, and for Region 2 in Washington. The geographical division of the world into the three regions for the purposes of frequency allocation is shown in Fig. 1.

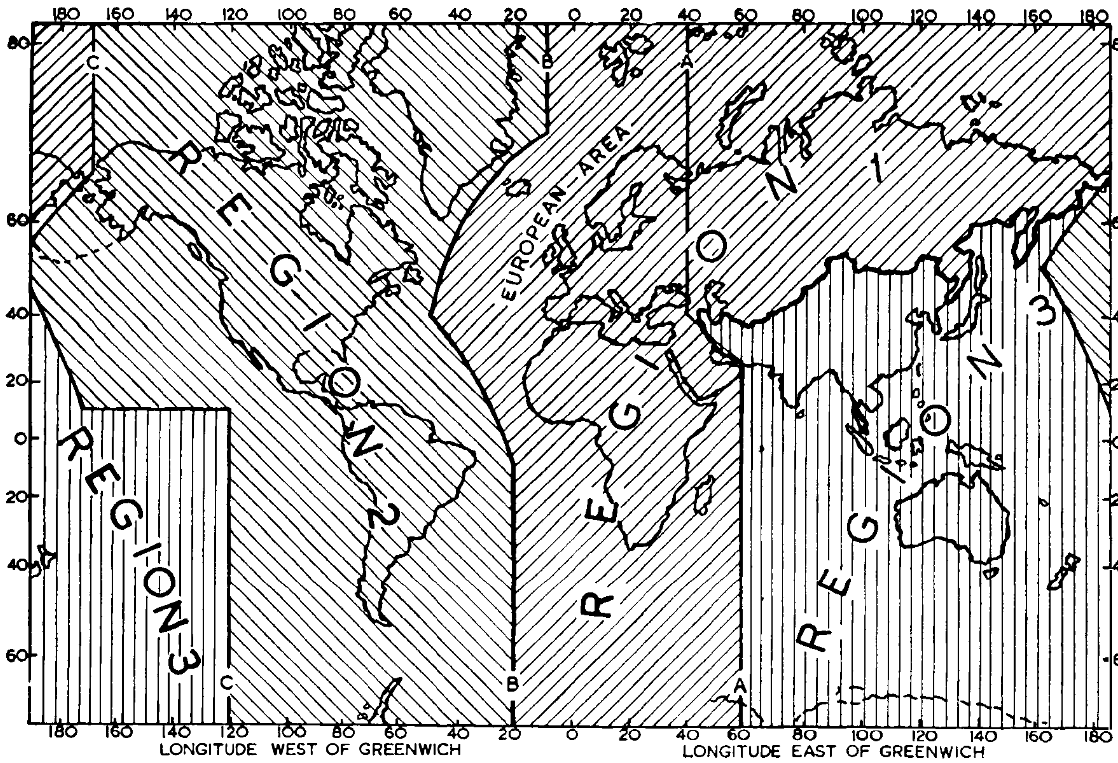


FIG. 1.—GEOGRAPHICAL DIVISION OF THE WORLD FOR FREQUENCY ALLOCATIONS.

These specialised Aeronautical and Broadcasting Conferences, however, covered only a proportion of the high-frequency spectrum and were not concerned with the fixed services which, together with tropical broadcasting and land mobile services, occupy the remaining, and greater, part of the spectrum. The fixed services form the backbone of world communication facilities both internationally, and nationally in the cases of geographically large countries. In order

[1] *P.O.E.E.J.*, Vol. 40, p. 175.

[2] *P.O.E.E.J.*, Vol. 42, p. 166.

to prepare the draft of a new frequency assignment list for these fixed services a special technical Board, known as the Provisional Frequency Board, was established and given clear but restrictive terms of reference by the Conference, and this Board functioned continuously from January 1948 until February 1950.

The Provisional Frequency Board, Geneva, 1948-1950.

The constitution of the Board, as laid down by the Atlantic City Conference, was to be the eleven members of the International Frequency Registration Board assisted by one technically expert representative of each Administration wishing to take part in the work, these latter experts being assisted by as many advisers as desired. Thus it will be seen that the Board was essentially technical, being, in fact, a preparatory technical committee set up to draft a new frequency list on a technical basis for the consideration of an Administrative Conference. This was often forgotten at plenary assemblies of the Board where national members tended to consider themselves as delegates and strayed from the technical into the political field. During the long life of the full Board there were generally present some fifty members and advisers possessing varying degrees of skill in the problem under discussion. As directed by the Atlantic City Conference, the Board convened in January 1948 and will formally dissolve at some date still in the future when a new frequency list has been accepted by a Special Administrative Radio Conference.

In the past, whenever a new radio circuit was about to be established it has generally been the practice for the design engineer to select the number and position in the spectrum of the frequencies considered necessary for the maintenance of the circuit and then to examine the current list of frequencies published by the International Telecommunications Union (I.T.U.) secretariat and select what appeared to be clear spaces in the spectrum of sufficient width to accommodate the intelligence to be carried by the circuit. As a safeguard, wherever possible, the receiving terminal of the circuit was requested to monitor the spaces selected during the appropriate times when the frequencies were likely to be used to confirm that they were in fact clear of interference. After such confirmation the frequencies would be brought into use and this fact communicated to the I.T.U. secretariat for inclusion in the subsequent publications of the frequency list. It was also the theory, but not the practice, that when an Administration ceased to use a frequency it should be deleted from the list, but since this was hardly ever done, the latest lists published contained a good deal of redundant information which seriously limited their usefulness to the operating engineers. The principal consideration influencing the reluctance of an Administration to cancel notifications in the list was undoubtedly that of losing its claim to the use of such frequencies, this claim being tacitly admitted by virtue of the publication of the use and further supported by the date published of such use against the frequency entry. Although these dates of use have no legal force, they have come to be considered as conferring some degree of priority to the use of frequencies in the case of disputes.

From the foregoing it will be clear that it was a matter of almost personal discretion how many individual frequencies were employed on any particular circuit and their disposition throughout the spectrum, and it was thought by the Atlantic City Conference that if some technical rules could be established that could be universally applied to all circuits, from which the minimum number of frequencies and the minimum band width of the emissions could be determined, it should be possible to effect a very great saving in the use of spectrum space and, at the same time, produce a new frequency list based upon sound technical principles. This, then, was the task given to the Board and it was hoped that the work could be completed within twelve months.

In the discussions at Atlantic City the United Kingdom had expected the Board to approach its task in a practical rather than an academic manner and to base its work on good engineering practice. It was, of course, recognised that many of the problems to be solved were far more appropriate to the C.C.I.R. if the best possible solutions were to be found, but the time available would not permit this course to be followed although very often the Board spent a good deal of time endeavouring to reach perfection with imperfect data.

Some idea of the magnitude of the work can be gained from the fact that about 15,000 radio circuits of all types were filed for engineering by the Board and the mere editorial work of checking, correcting and issuing lists of all these requirements occupied some six months. In the meantime, various working groups were set up to consider the various technical principles to be used, such as tolerable signal-to-interference ratios, minimum band widths required for different types of emission, and the degree of fading to be allowed for, whilst others were employed in drawing up propagation charts for various types of circuit. All this preliminary work was not completed until early in 1949 after which, of course, the principles had to be applied to the 15,000 circuits, and the frequency list drawn up. Since, on an average, a circuit requires some two or three different frequencies, the list would have to contain some 40,000 individual frequency assignments each, ideally, operating without interference.

Although the Atlantic City Conference had anticipated that the whole task of the Board could be completed by the end of 1948 the Administrative Council of the I.T.U., being aware of the delays experienced by the Board, extended its life up to May 1949 in the hope that sufficient time would be available for the completion of the technical rules and their application to all the circuits.

An examination of the current I.T.U. frequency list will disclose the fact that almost every frequency is shared by many individual stations although, on theoretical considerations, such sharing would be impossible without some of the stations experiencing intolerable interference. It must, therefore, be presumed that the sharing has been developed on a practical rather than theoretical basis, with its imperfect assumptions, and is possible either on account of the intermittent nature of the traffic on some circuits, or the provision of special means to reduce the interference to tolerable levels, such as directive aerials or even, maybe, very slight changes of frequencies. Whatever means have been adopted there is no doubt that this existing world frequency-sharing pattern is both practical and economical. The frequency complement rules adopted by the Board, whilst being theoretically sound, within the limits of their assumptions, had the effect of entirely destroying this highly developed practical sharing pattern and must be regarded as one of the principal causes of the failure of the Board. For example, a circuit to-day might be operating quite satisfactorily with frequencies of the order of 6, 12 and 18 Mc/s, and on the 12 Mc/s frequency there might be six other stations sharing the frequency; under the new complement rules the circuit might have been given a complement of 4, 9, 15 and 21 Mc/s and it would be quite fortuitous if the six stations sharing a frequency with this circuit found themselves allocated either a 9 or 15 Mc/s frequency that would permit the same sharing pattern to be maintained.

There was also another major difficulty impeding the work, which was the complete lack of co-operation of the U.S.S.R. and certain other countries sympathetic with its political views. It had been hoped all along that these unco-operative countries would, in the end, give their valuable assistance to bring the work to a successful conclusion, but this hope was not fulfilled. When this situation became abundantly clear without the slightest doubt, the United Kingdom felt that there was no chance of a practical list being produced that could be implemented with any confidence because, if one of the greatest users of radio frequencies would not agree to conform with any new plan for the use of radio frequencies, there would exist the gravest danger of severe interference being caused to world communications. Had the U.S.S.R. co-operated, there might have been some slight chance of an acceptable list being drawn up, although it must be admitted that the great number of " requirements " filed with the Board, coupled with the generous frequency complements permitted by the technical principles adopted by the Board, tended to make this chance remote.

The United Kingdom therefore proposed formally early in 1949 that the Board should adjourn indefinitely after May of that year, since, in view of the obvious difficulties facing it, there seemed to be no chance of it completing its work, and that alternative solutions should be sought. This course, however, did not commend itself to the Board, which continued to work on and reported the situation at the next meeting of the Administrative Council which was held in August 1949. Having been told that the Board hoped to be able to complete its work within a matter of some six months, a view with which the United Kingdom member and some other members of the Council did not concur, by a majority the Council prolonged the life of the Board, by voting funds for its maintenance, until the end of February 1950.

The United Kingdom accepted this majority decision and continued to support the work of the Board until it adjourned at the end of February 1950. The results of its work were due to be examined by an Extraordinary Radio Administrative Conference to be convened at The Hague in September 1950 for this purpose.

The results of the work cannot be said to be very promising so far as their acceptance and implementation are concerned. Draft frequency assignment plans were drawn up for the maritime mobile telegraph and telephone bands at 4, 6, 8, 12, 16 and 22 Mc/s which, although not completely acceptable in their draft form, are believed to be capable of being made into a practical and acceptable form. So far as the vital fixed services are concerned, frequency assignment plans were drawn up for some frequency bands, although such plans were made only by arbitrary reductions in the number of frequencies allocated to Administrations, and arbitrary assignments made to meet the estimated requirements of the U.S.S.R. and the other unco-operative countries. In the other frequency bands the number of requirements for frequencies so greatly exceeded the number available that no attempt was made to draft an assignment plan

Throughout the life of the Board the Engineering Department maintained at least one officer, and for long periods as many as three officers, in Geneva and it is a matter of regret that the efforts of the Board have resulted in so little that is useful to the solution of this complex problem.

The Region 1 Conference, Geneva, 1949.

This Conference was required to assign frequencies in the bands 255 to 415 kc/s, 1605 to 2850 kc/s, 3155 to 3400 kc/s and 3500 to 3900 kc/s, bearing in mind the results of the Copenhagen Broadcasting and Maritime Radio Conferences (1948) in the band 255 to 415 kc/s.

Of the forty-five countries in the Region, thirty-six took part in the Conference, although a number of these took no effective part and gave proxies to other delegations. The Post Office members of the delegation held the leadership of the United Kingdom, United Kingdom Colonies and Southern Rhodesian delegation and were assisted by officers from the Services, Ministry of Civil Aviation, Ministry of Transport and Cable & Wireless, Ltd.

The Conference commenced its work by discussing at great length various questions such as the admission of observers and the languages to be used, many of which had a political flavour. After the first few meetings of the Plenary Assembly only French and English were used, maximum use being made of the simultaneous translation system, although in working groups consecutive translation was the rule.

The Conference divided its work among six committees, of which the chairmanship of the important Committee 6, dealing with assignments between 1605 and 3900 kc/s, fell to the United Kingdom. The other assignment committee (No. 5) had as its major problem the assignment of frequencies for maritime and aeronautical radio beacons which permitted the application of fairly rigid technical principles, but owing to the volume of requirements for fixed and mobile services in the Committee 6 bands, such an approach was never available in the same way in that committee.

As the work of the Conference progressed the sharp split between the U.S.S.R. and its sympathiser countries on the one hand and the other countries of the Region extended to the technical plane and resulted in the so-called Eastern bloc preparing its own minority assignment plan which naturally was unacceptable to the Conference.

When all requirements had been submitted, they amounted to nearly 4,000, the bulk of which fell in the bands above 1605 kc/s, and in spite of the efforts of the working groups of Committee 6 it was impossible to satisfy all countries. The amount of dissatisfaction was noticeable when it came to the point of signing the Final Acts, at which stage every country prepared to enter reservations on the Plan. However, it became possible to dispense with the majority of these by adopting a formula whereby countries signed the Final Acts subject to their retaining the right "... to submit, if it should be found necessary, certain amended or additional requirements at the time of the Special Administrative Conference."[3]

The Final Acts were signed on the 17th September, 1949, after four months' work, of which the real task of writing the frequency assignment list was carried out mainly in the final six weeks.

It will be noted that the frequency bands dealt with exclude the bands 150-255 kc/s and 415-1605 kc/s which for the European area of Region 1 had been dealt with at the Copenhagen Conference in 1948. In order to rectify this omission a separate African Committee was set up to make the necessary assignments and successfully completed its task during a few days in September 1949 but with the same reservation on signature as in the Region 1 Final Acts.

[3] Now the Extraordinary Administrative Conference charged with drawing up the complete new International Frequency List.

The Region 3 Conference, Geneva, 1949.

This Conference which opened on the 18th May, 1949, concurrently with the Region 1 Conference, was required to assign frequencies in the frequency bands below 3900 kc/s, excluding 14-150 kc/s, 2850-3159 kc/s and 3400-3500 kc/s. Of the sixteen countries members of the International Telecommunications Union in the Region, fourteen took part in the Conference and the leadership of the United Kingdom Colonial delegation was held by a member of the Post Office.

The Region 3 Conference had an advantage over the Region 1 Conference in that a Preparatory Committee had met in 1948 and had prepared the ground for the Conference proper. Thus the preparatory stages of designating committees and chairmen and vice-chairmen were very quickly completed.

However, the volume of requirements in the Region proved to be some three times that of Region 1. Bearing in mind that the frequency bands considered included the medium and low frequency broadcasting bands, the problem of satisfying all requirements became even more acute than in Region 1. In particular, broadcasting requirements in the bands 2300-2498 kc/s and 3200-3400 kc/s which were of great importance to many of the countries of the Region proved to be an extremely difficult problem and held up the work of the Conference for a week or so.

As a result of these difficulties, coupled with various other subjects of a political nature which arose during the Conference, a Final Plan was not evolved until late October 1949 and signatures under the same formula as in Region 1 were not appended to the Final Acts until the 4th November, 1949.

A. H. M.

Commission Mixte Internationale (C.M.I.), Paris, 1950

U.D.C. 061.3 : 621.316.9 : 620.193.92

THE Sixth Plenary Assembly of the Commission Mixte Internationale was held at the Headquarters Building of the Administration Française des Postes, Télégraphes, et Téléphones in Paris, from 19th to 26th June, 1950. Two officers of the Post Office Engineering Department attended the Assembly as representatives of the C.C.I.F. and the British Post Office. Other organisations represented at the Assembly were :—

The Conférence Internationale des Grands Réseaux Electriques (C.I.G.R.E.),
Union Internationale des Chemins de fer (U.I.C.),
Union Internationale des Producteurs et Distributeurs d'énergie électrique (U.N.I.P.E.D.E.),
Union Internationale de l'Industrie du Gaz (U.I.G.),

together with associated members including representatives of the Institution of Electrical Engineers, the Electrical Research Association and manufacturers of electrical apparatus in various European countries.

The C.M.I. provides an opportunity for the discussion of common problems affecting telecommunications, generation and distribution of electric power, electric transport and the distribution of gas and water. The C.M.I. has two sections, as below, which deal with the two main problems :—

First Section.—The protection of telecommunication circuits from difficulties and dangers arising from electric power and traction systems,

Second Section.—Protection of underground plant from corrosion.

There are two distinct aspects of the first problem,

(*a*) noise interference in telecommunication circuits arising from electric power and traction systems, and
(*b*) dangers due to contact between power and telecommunication systems, or due to induction at fundamental frequency.

The main item of interest under (*a*) was the revised psophometer weighting curve which had been approved at the C.C.I.F. XVth Plenary Assembly in Paris, 1949. As a result of the discussion, it was decided to recommend that the table of "weights" from which the weighting curve is derived should be extended to include figures for every 50 cycles from 50 to 3,000, and every 100 cycles from 3,000-5,000 cycles per second. It was further recommended that the admissible tolerances on these figures should be :—

50- 300 c/s	± 2 db.
300- 800 c/s	± 1 db.
800 c/s	0 db.
800-3,000 c/s	± 1 db.
3,000-3,500 c/s	± 2 db.
3,500-5,000 c/s	± 3 db.

The question of the weighting curve and tolerances received further consideration at the meeting of the C.C.I.F. in Geneva in October, 1950.

Other matters discussed under (*a*) were the generation and flow of harmonics in power systems arising from the use of ionic convertors, e.g. mercury arc rectifiers ; the effect of electric railway systems on telecommunication lines ; the use of carrier currents on H.V. transmission lines ; and the permissible limit of induced noise in telephone circuits.

The main topic of interest to Great Britain under item (*b*) was the presentation of a full report on and the showing of the film record of some tests carried out in July, 1948, at Waresley Park in Huntingdonshire, when a live 33-kV (19 kV to earth) power conductor was dropped on to a telephone route of open wires and a small aerial cable. The film was made by the Post Office Research Station, is in colour and runs for about 10 minutes. The fall of the "dropped" power conductor was photographed in each of three tests by two cameras, one running at 500 frames per second and the other at 64 frames per second, so that when the film is shown at normal speed (16 frames per second) the actual dropping of the power conductor can be observed at about one-thirtieth and one-quarter actual speed. The most spectacular part of the film is the third test, in which the fault current was about 900 amperes and the duration of the fault (controlled at the power station) was 2·98 seconds. All the telephone wires were brought down (for the third test the aerial cable had been removed) with much arcing between the power conductor and the telephone wires, and between the telephone wires themselves.

The report presented to the Assembly contains details (not shown in the film) of the damage caused to specially erected exchange and subscribers' apparatus and lead-in cables. The cables were burst and burnt-out in each test. The lightning protectors and fuses fitted to the telephone lines suffered heavy discharges and damage, one protector unit setting fire to the wall of the wooden hut on which it was mounted. The discharge on the protectors and lead-in cables prevented appreciable damage to the telephones and switchboards which were connected to the telephone wires, but a voltage device, fitted to one of the telephones to simulate a man in the act of dialling, was found to have recorded over 1,000V. This voltage would most probably have given a fatal shock under the circumstances of the test.

The tests provided much valuable information, although in the last one the equipment measuring the voltage to earth of the telephone wires flashed over and caught fire, spoiling the last part of the record. The maximum voltage recorded was about 5,000V between the telephone wires and earth, the rest of the power voltage being dissipated in the line and the large neutral earthing resistance at the power station. The results of the tests indicate that when the existing regulations concerning the guarding and protection of telephone lines from power lines were framed they were not unreasonable. There may be a case, however, for reconsideration of the position if quick-acting circuit breakers could be assured in every circumstance.

Other matters discussed under (*b*) were induction at fundamental frequency between power and telephone lines, and the existence together of telecommunication lines and H.V. D.C. power systems. In connection with this latter item an interesting report was presented by a Swedish representative on the projected scheme for the laying of a H.V. D.C. submarine power cable between the Swedish mainland and the Island of Gotland. Fuller details of this scheme were presented subsequently at the meeting of C.I.G.R.E. held in Paris in July, 1950.

In connection with the problem of corrosion dealt with by the Second Section of the C.M.I., prior to the main Assembly in Paris, an interesting demonstration had been arranged in Brussels and Antwerp of the various methods of protecting underground pipes and cables against electrolytic corrosion caused by stray currents. The measures demonstrated included direct and polarised drainage at tramway and electric railway sub-stations, forced electric drainage using an external source of E.M.F. at points on the tramway system remote from the sub-station, and cathodic protection in areas remote from a D.C. traction system using "sacrificial" anodes or reactive anodes (magnesium billets).

The problem of corrosion, which affects equally the telecommunications, water and gas authorities, and to a smaller extent the power authorities, was discussed in all its aspects, including the statistical recording of information concerning corrosion faults; the production, flow and prevention of stray currents; the protection of cables or pipes by wrappings or armourings; the protection of cables or pipes by the use of electric or cathodic protection; the particular problem of the existence of trolley vehicle systems and their effect on stray current corrosion; the problem of corrosion arising from the use of H.V. D.C. power systems; and the study of the physico-chemical aspect of corrosion. In connection with the last item, a lecture was given by Professor Pourbaix, of the University of Brussels, in which he gave particulars of some fundamental research which he had carried out on the problem of the negative potential necessary to immunise from corrosion such metals as iron, lead and copper. The potential required was specified precisely by means of diagrams giving equilibrium potential plotted against pH value for these three metals, and showing the circumstances under which the various reactions are thermo-dynamically possible.

A full report on the Proceedings of the Sixth Plenary Assembly of the C.M.I. is to be printed and published in due course.

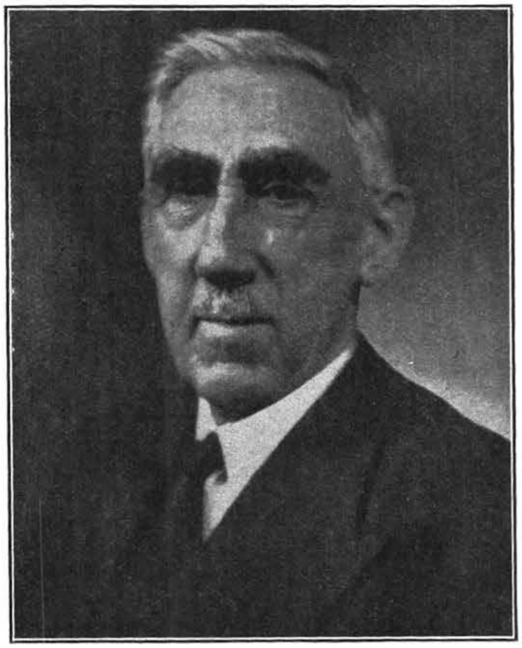
E. C. S.

Obituary

SIR FRANK GILL, K.C.M.G., O.B.E., Hon.M.I.E.E.

Frank Gill, born in 1866 in the Isle of Man, was educated at private schools and joined the United Telephone Co. in London in 1882. The Company owned many of the early master patents in this country, and Gill was in the telephone business almost from the start. His technical education seems to have followed later, chiefly by evening classes at Finsbury Technical College under Professor Ayrton, although he also studied later under such pioneers in the radio field as Lodge and Fleming. He knew Alexander Graham Bell and Oliver Heaviside.

Two years after entering the telephone service, Gill went to Ireland with the Telephone Company of Ireland. Appointed chief electrician for the Liverpool district of the National Telephone Co. in 1890, he subsequently became district manager at Blackburn, provincial manager for Ireland in Dublin, and, in 1902, Engineer-in-Chief of the Company. He held this position during an eventful period in the history of the telephone in Great Britain until the Company was taken over by the Post Office on 1st January, 1912, adding its engineering staff of about 7,000 to the 9,000 already in the Post Office Engineering Department.



For the next few years, Gill did consulting work, chiefly in South America and Europe, although during the latter part of World War I he served as Controller in the Central Stores Department of the Ministry of Munitions. In 1919, however, he became European Chief Engineer of the International Western Electric Co. (later the International Standard Electric Corporation). During the years that followed, he was responsible for the reconstruction of the Spanish telephone system and for the building of an up-to-date system in China for the Shanghai Telephone Co. At the time of his death, he was Chairman of Standard Telephones & Cables, Ltd., the International Marine Radio Co., Ltd., Standard Telecommunication Laboratories, Ltd., and Creed & Co., Ltd.; he was also a Vice-President of the International Standard Electric Corporation. Despite his great commercial and technical responsibilities, he retained a great interest in the younger generation of engineers to whom he was always accessible.

In 1922, Gill was elected President of the Institution of Electrical Engineers. In his inaugural address, he suggested a body to do for long-distance telephony in Europe all that no one nation could do alone. His suggestion led to the formation, two years later, of the Comité Consultatif International Téléphonique (C.C.I.F.), which has not only promoted international telephony but, during the last quarter of a century, has done much to co-ordinate technical development in Europe It is fitting that he should have died, in harness, while attending a meeting of the C.C.I.F. in Geneva.

Elected as Honorary Member of the Institution of Electrical Engineers in 1938, he was also a Member of the Institution of Civil Engineers, a Fellow of the American Institute of Electrical Engineers, Honorary Member of the Institute of Royal Engineers, and a member of the Royal Institution, the Société des Ingenieurs Civil de France and the Société Française des Electriciens.

He was made K.C.M.G. in 1941 for his services to international telephony and was awarded honours by the Spanish and Chinese Governments for his assistance to these countries as a telephone engineer. His interests, however, extended beyond the limits of telecommunication and found expression in a variety of activities prompted by his faith in the doctrines of Christianity. The practical idealism of the man was revealed in the closing sentences of his Presidential address to the I.E.E.—"If only we will use it (international telephony), we shall be making a definite step towards reducing international jealousies and fears, and increasing the goodwill without which there cannot be peace on earth."

The crowded congregation at the Memorial Services in the King's Chapel, of the Savoy in London, and the service in the English Church at Geneva, attended by the C.C.I.F. as a body, were tributes, not only to one of the outstanding telephone engineers of the first half of the century but also to the personal esteem in which he was held.

W. G. R.

Notes and Comments

Recent Awards

The Board of Editors has learnt with great pleasure of the honours recently conferred upon the following members of the Engineering Department :—

London Telecomms. Region ..	Burch, L. J. ..	Technician, Class I ..	Sergeant, Royal Signals	Mentioned in Despatches
London Telecomms. Region ..	Garrad, R. C...	Technical Officer ..	Sergeant, Royal Signals	British Empire Medal and Mentioned in Despatches

Mr. R. J. Hines, B.Sc., M.I.E.E.

Mr. Hines was born in 1902 and many will remember his father, Capt. J. G. Hines, Staff Engineer of the Lines Branch at the time of his retirement in 1937.

Receiving his training at Royal School and King's College, London, Mr. Hines commenced his career with Messrs. Siemens Bros., and there gained experience in the design of automatic telephone circuits.

Entering the London Engineering District as a U.S.W., he was shortly successful in the competitive examination for acting Inspector. With this appointment, he became one of those known as the "forty thieves," many of whom now occupy senior posts in the Department.

After two years on cable-testing, and being successful in the open competition for Assistant Engineer (old style), he was appointed to the automatic training school at King Edward Building.

Self-confessed "Jack of All Trades" rather than a specialist, and always more interested in the

managerial aspects as against the narrower technical field, Mr. Hines secured early transfer to Colchester and thence, on promotion, to Sectional Engineer at Bournemouth.

Less than four years later, promotion to Regional Engineer brought the commencement of a period of nearly 14 years in the North-Eastern Region

In 1942 he accepted a commission in the Royal Signals. Having planned many emergency schemes in this country, he was admirably fitted to tackle the problem of replanning communications on the Continent, first as a Civil Affairs Officer in Belgium and Holland, and later as a Lt.-Col. in the American-occupied part of Bremen, where he says that the letters C.C.G. were more aptly interpreted as "complete chaos in Germany."

Returning to Leeds in 1945, he again took charge of the Internal group in the Regional Office, well content again to take up the threads of life in a city he appeared to find so congenial.

He now goes "north of the border" as Chief Regional Engineer of the Scottish Region.

W. F. S.

Heaviside Centenary Volume

Many readers will be interested to know that a "Heaviside Centenary Volume" has recently been published containing the authoritative papers read, and the tributes paid by eminent scientists, on the occasion of the Centenary Celebrations as described in our last issue.

Copies of this publication can be obtained on application to The Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C.2, the price being 4s. to members of the I.E.E. and 10s. to non-members.

Welcome to New Readers

Special steps have been taken recently to bring to the notice of junior engineering staff the advantages to be obtained by reading the Journal, and the initial response has proved most encouraging.

This opportunity is taken, therefore, to extend a warm welcome to the new subscribers, numbering more than 1,000, and to ensure them of our intentions to continue to include in each issue of the Journal as wide a range of articles as possible so as to cater for all interests.

Elsewhere in this issue will be found reports from Local Centres of the Institution's Junior Section—a regular feature designed to publicise this important part of the Institution's activities. It is hoped that junior readers not yet taking advantage of the valuable facilities available from membership of the Junior Section will study this section of the Journal and be encouraged to join in the local activities.

Sir Archibald Gill's I.E.E. Presidential Address

As most of our readers are now aware, Sir Archibald J. Gill, B.Sc.(Eng.), M.I.E.E., F.I.R.E., Engineer-in-Chief of the Post Office, has been elected as President of the Institution of Electrical Engineers for the session 1950-51. This latest distinction, the highest honour in the electrical engineering profession, has been noted with pleasure by the members of his Department and by his many friends and associates in the sphere of telecommunications.

For his Inaugural Address, delivered before a crowded Institution on 5th October, 1950, the new President took as his subject the more recent developments in telecommunications in this country, and in particular those concerning the telephone service.

Dealing first with local-line cables, representing about 40 per cent. of the total capital cost of the telephone service, he referred to the close study at home and abroad of methods by which cheaper construction costs could be obtained. Thus, in this country during recent years, a system of distribution, using street cabinets and pillars, had been introduced, giving cross-connection facilities which obviated the necessity for frequent opening and rearrangements at cable joints. Other economies had arisen from the introduction of shared service in which two subscribers share a single exchange line with individual calling facilities and, in many instances, individual metering. Quoting the reasons why it was preferable that shared service should be non-private, Sir Archibald intimated that the system appeared to be quite popular with the 230,000 subscribers now connected in this manner.

Turning next to the subject of switching, some account was given regarding the present extent of the conversion from manual to automatic working, the stations now served by automatic exchanges representing 70 per cent. of the total as against only 25 per cent. in 1929. In recent years, the conversion policy had been steadily applied to small caretaker-operated rural exchanges, many of which were housed in private premises ; in emergencies, such as the removal of a caretaker at short notice, service could be maintained, pending conversion, by the use of the mobile automatic exchanges now available.

Referring to recent visits by experts from this country to all parts of the world to examine progress in telephone development, Sir Archibald emphasised that nothing had been seen to suggest that the step-by-step system was obsolete or even obsolescent. In paying tribute to the late Sir Thomas Purves for the wisdom of his decision 25 years earlier to standardise on the Strowger system, he said that the system continued to fulfil every demand made upon it since this type of equipment could be simply applied to the largest and smallest of exchanges. He mentioned, however, the possibility that something entirely novel might appear in the future, as, for example, an electronic system ; in this connection, the Post Office had already designed and tested a two-digit electronic director, examples of which would shortly be on field trial. Subject to the production of long-life valves—and it was pointed out that this possibility no longer appeared remote—a fully electronic system with its high operating speeds and elimination of moving contacts opened up great possibilities.

The address continued with a survey of recent signalling developments and, in particular, their bearing on the present objective of a mechanised inland trunk network. Sir Archibald explained that when this network was completed a controlling operator at any trunk centre would be able to complete a call to any subscriber on an automatic exchange without the assistance of a second operator. The resultant extension of tandem dialling would fundamentally change the requirements of manual switchboards in that the need for an outgoing manual multiple would be removed ; under these conditions the cord-type board would be replaced by a cordless board with key-controlled connecting circuits, and much improved working conditions would result for operators. An indication was also given that the mechanisation of trunk switching, with its immediate objective of a saving in operators, had been engineered so as not to prejudice unduly the possible long-term project of a scheme of subscriber-to-subscriber dialling with national numbering.

Because the most rapid advances in recent years have been concerned with transmission, this subject was dealt with at some length, and, after stressing the fundamental importance of the negative-feedback amplifier in carrier working, Sir Archibald detailed the main features of the various carrier and coaxial systems now in use in this country. He pointed out that a disadvantage of the coaxial system was that circuits could not readily be taken off at intermediate points on the cable, but against this the cost per channel was less than for multi-pair carrier working and, in addition, the coaxial system could be used for the transmission of television signals. As a result, most new long-distance trunk cables laid in recent years had been of the coaxial type. Special mention was made of the new London-Birmingham coaxial cable, of composite construction, which includes two 0·975-in. tubes for a television circuit between London and Birmingham alternative to the V.H.F. chain now in operation.

A matter of particular interest, which was enlarged upon, concerned the provision of television circuits for outside broadcasts. Although special cables had been laid in the London area to serve selected points, circuits also had to be provided, often at short notice, to locations at some distance from the nearest point of access to the special network. On such occasions the circuit was completed by the use of ordinary pairs in the local telephone distribution cables which normally carried only audio frequencies. Such circuits had to be connected through adjustable equaliser and amplifier equipment, and were lined-up by transmitting pulses of 20 microsec. length, the received pulse shape being examined on an oscillograph at the distant end and adjustments made as necessary.

Details of the progress on submarine cables were of special interest in that many of the audience had recently visited the exhibition at the Science Museum organised by the Post Office to celebrate the centenary of the laying of the first submarine cable across the Straits of Dover. The most notable advances had occurred in the introduction of carrier working as for land cables, the striking increase in circuit capacity being evidenced by the latest Anglo-Belgian coaxial cable (using polythene insulant) in which capacity for 216 circuits is available. It was revealed that, during the period under review, considerable progress had been made in the design and construction of the submerged amplifier, a device which made possible great economies in circuit provision. On the two cables now provided with these amplifiers, very satisfactory results were being obtained.

To conclude his review, Sir Archibald dealt briefly with the overseas and internal radio services, a subject with which he has been intimately concerned for many years and on which he is a leading authority of international repute. He referred to the continued expansion of the overseas services which had been effected in spite of serious equipment shortages and accommodation difficulties, explaining that much of the progress had been made possible by the policy of converting from double-sideband to single-sideband multi-channel working. To cater for the continued growth in overseas traffic, the engineering terminal (recently transferred to Hendon) was equipped for a total of 48 overseas circuits.

The most recent development in the internal radio service is the current provision of radio chains as part of the country-wide system for the distribution of television programmes. Sir Archibald explained that the existing London-Birmingham chain would be followed by a second chain between Manchester and Edinburgh, and that with two different types of coaxial cable for television working (i.e., the London-Birmingham cable and that projected for Birmingham-Manchester) the performance of the alternative systems would provide valuable data for the future.

To illustrate that section of the address relating to television circuits and equipment, two most interesting demonstrations were staged. The first was the equalisation, by the pulse method previously mentioned, of an ordinary two-wire telephone circuit from Gerrard exchange to the Institution building.

This demonstration was a preliminary to a second demonstration—the transmission of a television programme from the Alexandra Palace studio of the B.B.C., firstly, direct to the Institution building and, secondly, from Alexandra Palace to Birmingham and back to the Institution building over the new large diameter coaxial cable. It was possible to observe that the picture had suffered no distinguishable degradation in its transmission over the second path of over 250 miles.

Finally, the two pictures were superposed to demonstrate the time of transmission which amounted to about 1/700 sec. (1·4 mS) and resulted in the two pictures being displaced 14 lines. The corresponding velocity of transmission was about 170,000 miles per sec.

The belief was expressed that in this demonstration the longest line transmission of television over cable in Europe had been effected, and the longest transmission in the world, over a cable, considering the bandwidth employed and picture quality achieved.

It had not been possible during the address to cover the whole of the developments in public telecommunications services in this country, but the hope was expressed that matters omitted or curtailed, such as the important advances in telegraphy, would be brought to the notice of the Institution in future papers.

Readers will appreciate that this very brief summary gives only the barest outline of the Presidential Address, but arrangements have been made for its publication in the I.E.E. Journal and an opportunity will thus be available to read in greater detail of the striking advances in this country's telecommunications during the past few years.

Institution of Post Office Electrical Engineers

ANNUAL AWARDS FOR JUNIOR SECTION PAPERS —SESSION 1949-50

The Judging Committee has selected the following from the papers submitted by the Local Centre Committees, and awards of £3 3s. 0d. and Institution Certificates have been made accordingly.

Author	*Junior Centre*	*Title of Paper*
K. T. Stephens	Southampton	"Radio Interference"
W. N. Pallier	York	"The Telegraph Auto. Switching System"
G. E. C. Cochrane	London	"Precision Testing"

Normally five awards are made, but in view of the comparatively small number of papers submitted on this occasion, the Council decided to limit the awards to three.

The Council is indebted to Messrs. A. C. Warren, M. C. Cooper and F. B. Wilcher for kindly undertaking the adjudication of the papers forwarded for consideration.

J. Reading,
Secretary.

London Centre

The attendances at meetings of the London Centre for the first half of the current Session have compared favourably with previous years, and there is no doubt that interest will be sustained by future papers to be presented this Session as follows :—

Ordinary Meetings

6th February.—"Some Aspects of Electronic Circuit Design," S. W. Broadhurst and A. W. M. Coombes, Ph.D.

6th March.—"The Provision and Maintenance of Long-Distance Circuits, London Trunk Transmission Control." E. H. Jeynes, A.M.I.E.E., and J. E. Isherwood.

8th May.—"Trunk Mechanisation." J. H. Broadhurst, A.M.I.E.E., and A. J. Thompson.

Informal Meetings

24th January.—"ENG Service." C. Feather (N.E. Region).

21st February.—"The Art of Public Speaking." A. K. Robinson, A.M.I.E.E.

21st March.—"The 2,000-type Selector and its Problems." J. O. Thompson, B.Sc., A.M.I.E.E., and F. Haythornethwaite.

18th April.—"Training for Management." D. G. Dafforn, B.Sc., A.M.I.E.E. (C.T.S.).

The Committee would be glad to receive offers of papers from prospective authors for next Session or, alternatively, suggested subjects for papers.

It was the pre-war practice to include in printed papers a record of the relevant discussion and it would assist towards a resumption of this practice if contributors to a discussion would furnish the Local Secretary with a written record of their remarks. W. H. F.

Recent Additions to the Library

1936 *Machines that Think* (*or Giant Brains*). E. C. Berkeley (Amer. 1949).
Describes several large-scale mechanical computers and sets these "Mechanical Brains" in perspective by comparison with the human brain and various languages.

570A *Scientific Management.* F. W. Taylor (Amer. 1949).
Collects in one volume "Shop Management," "Principles of Scientific Management," and "Taylor's Testimony before the Special House of Representatives Committee."

1937 *Magnetism.* D. Shoenberg (Brit. 1949).
Explains as simply as possible what magnetism really is, and how it is used in many ways which affect everyday lives.

1938 *Applied Mechanics.* A. Morley (Brit. 1943).
Covers the ground of the third and final year of a three-year, part-time course of instruction leading to an Ordinary National Certificate in Mechanical Engineering.

1939 *Radio Communication at U.H.F.* J. Thomson (Brit. 1950).
Aims at providing an account of modern developments in telecommunications employing radio waves of lengths ranging from a few metres to a few millimetres.

1940 *The Electrolytic Capacitor.* A. M. Georgiev (Amer. 1945).
Describes the construction, manufacture, function and testing of dry and wet electrolytic capacitors, explains the operating characteristics of the various types, and indicates both their useful applications and their limitations.

1941 *Glued Laminated Timber Structures.* R. T. Walters (Brit. 1950).
A Timber Development Association's Constructional Research Bulletin.

1942 *Timber Pests.* Timber Development Association (Brit. 1945).
Shows how to avoid decay by the proper use of timber.

1943 *Timber Preservation.* Timber Development Association (Brit. 1949).
Gives concise information on the types of preservatives available and their methods of application.

1944 *The Making of Scientific Management.* L. Urwick and E. F. L. Brech, Vol. I—Thirteen Pioneers (Brit. 1949).
Describes the parts played by the pioneers of the scientific approach to management.

1945 *Vol. II—Management in British Industry* (Brit. 1946).
An interpretation of the part played by management in British economic history.

1946 *Electric Circuits and Fields.* H. Pender and S. R. Warren (Amer. 1943).
Describes the more important effects commonly described as electric and magnetic phenomena ; the fundamental principles in accordance with which these phenomena are related ; and their application to some of the simpler problems that arise in connection with the generation, transmission and utilisation of electric energy.

1947 *Super-Regenerative Receivers.* J. R. Whitehead (Brit. 1950).
Introduces the whole subject of super-regenerative receivers in the light of advances made in wartime radar.

1948 *Transformers.* E. E. Wild (Brit. 1948).
Covers briefly the theory, design and operation of transformers.

1949 *Sound Reproduction.* G. A. Briggs (Brit. 1950).
Gives in non-technical terms, a general outline of the technique of sound reproduction under domestic conditions.

1950 *Cold-Cathode Fluorescent Lighting.* H. A. Miller (Brit. 1949).
Describes the principles, manufacture, operation and installation of cold-cathode fluorescent lighting.

1951 *Electronics in the Factory.* H. F. Trewman (Brit. 1949).
Provides a fairly wide survey of the fields in which electronics have been successfully applied in aid of industry to improve the quality and quantity of its output.

1952 *The Theory and Design of Inductance Coils.* V. G. Welsby (Brit. 1950).†

1953 *Progressive Mathematics.* P. Clyne (Brit. 1950).*

1954 *The Theory of Machines.* T. Bevan (Brit. 1943).
Designed mainly for students preparing for a University degree in engineering, or for membership of one of the Engineering Institutions ; but many sections will appeal to the draughtsman and designer.

1955 *An Introduction to the Gas Turbine.* D. G. Shepherd (Brit. 1949).
This book aims at filling a gap between the largely descriptive matter for the general reader and the technical reports and papers for the specialist.

1956 *Inventions, Patents and Monopoly.* P. Meinhardt (Brit. 1950).
Presents a concise description of British Patent Law and Practice under the 1949 Act.

460 *Theory of Structures.* A. Morley (Brit. 1948).
In this fifth edition new diagrams have been made, and several sections of the book have been rewritten.

W. D. Florence, *Librarian.*

* Reviewed on p. 197 of this issue.
† Reviewed on p. 218 of this issue.

Regional Notes

South Western Region

COMMUNICATIONS FOR THE TRADE AND TARIFF CONFERENCE, TORQUAY, 1950

In late 1949 it became apparent that advance planning was imperative if adequate telecommunications were to be provided in time for the opening of the Conference in September of the following year. A list of hotels to be taken over was obtained, therefore, and an estimate of the telephones prepared, based roughly on the number of rooms per hotel and bearing in mind other facilities, such as main conference rooms, committee rooms and so on. A large measure of flexibility was introduced by the provision of three cross-connection cabinets and the use of the M.D.F. at the Conference P.B.X. located in the Princes Hotel. The cabinets were sited also to cater for future local line requirements.

The line plant proposals necessitated additional underground duct and manholes, comprising 3,060 yards of duct, 8 manholes and 54 jointing chambers, provision being completed in August 1950, by contract and direct P.O. labour.

Following completion of the main tracks and leads to the hotels, 4·3 miles of cable, of sizes from 30 to 1,000 pair, was pulled in and jointed by the Area staff, assisted by loans of jointers from the Bournemouth and Southampton Telephone Managers' Areas.

At the outset, it was visualised that, in view of the size of the Conference, some 42 countries being represented, a central Conference P.B.X. should be constructed. Consequently, at the hotel chosen for the Secretariat, a P.M.B.X. 1A of 12 positions was installed to give an ultimate extension multiple of 500 and a 100 exchange line multiple, a special feature of the extension multiple being an ancillary lamp jack provided for a proportion of the extension multiple. These ancillary lamp jacks were left unlamped, but in the event of a variation in traffic loading per position being required the lamps could be removed from the home positions and placed in the ancillary-lamped positions. The work involved on the Conference P.B.X. required the running of 2,000 yards of switchboard cable and the termination of 36,000 wires.

At the Torquay auto exchange, an idea of the additional engineering work can be gathered from the following :—

(*a*) Provision of 60 additional circuits in the O.G.J. multiple of the auto-manual board.

(*b*) Fitting of a P.B.X. final selector rack, equipped with 20 final selectors, 11 and over, cabled and tested for the 20 outgoing lines to the Conference P.B.X., together with the fitting of additional group selectors and re-grading of two groups to cater for increase in traffic.

(*c*) Provision of 30 O.G. junction dial relay sets and 34 impulse suppression equipments for the provision of V.F. dialling circuits to London ; the changing of all the dials on the manual board.

In readiness for the increased traffic to London, the London trunk circuits were augmented from 14 O.G., 10 B.W., and 12 I.C., generator signalling circuits to 34 O.G. V.F. dialling, 10 B.W., and 32 I.C. generator signalling circuits. The conversion to V.F. dialling was something entirely new to the Area staff, and some brief mention of the arrangements made with the concurrence and assistance of the Engineer-in-Chief's Office will not be out of place.

A non-standard signalling system was employed, using a separate V.F. telegraph channel for the dialling path, the V.F. signals being rectified at the distant end, and thus able to operate selectors in the London trunk network. To provide these facilities, a mobile V.F. unit was located adjacent to the repeater station at Shiphay Collaton, thus giving access to the carrier network used for the V.F. systems. Three 12-channel V.F. systems were housed in the mobile unit, and the separate V.F. signalling channels were cabled via special conversion units to the phantom circuit of the 4-wire speech path between Shiphay Collaton and Torquay.

Besides housing the 12-channel V.F. equipments, the mobile unit also contained amplifiers for the 4-wire line circuits, together with the necessary power plant. The main power supply for the V.F. equipment was arranged by running an external lead from the repeater station, cabled via a change-over switch, so that in the event of a mains failure a standby 6-kW petrol engine set could be switched in as required.

To meet telegraph requirements an 8-channel V.F. equipment, consisting of two 4-channel bays of out-station equipment, was installed at Torquay repeater station to provide additional circuits to London for the duration of the Conference and three additional teleprinter positions were provided in the Torquay H.P.O. telegraph instrument room.

Thanks to the assistance given by the hotel proprietors it was found possible to block-wire the hotels while the summer holiday guests were still in residence and in all, 24 hotels were block-wired prior to the taking over by the various delegations and some 1,250 telephones fitted.

That the installation work was completed to time was a credit to all concerned, and praise from the delegates and tributes over the wireless and in the Press have amply justified the remark that the work had been well done.

J. E. M.

ILFRACOMBE CONVERSION—MAGNETO TO C.B.10

At Ilfracombe one more of the steadily diminishing number of magneto exchanges in the country was taken out of service. A transfer from magneto to C.B. may leave something to be desired when the automatisation of the country is the ultimate goal, but in this case the H.P.O. which housed the old magneto exchange did not have suitable accommodation for an automatic exchange and the possibility of the early provision of a new building seemed unlikely. A C.B. exchange could be provided at the H.P.O., however, after some necessary floor strengthening and structural alterations had been carried out, and it was decided to go ahead and provide a C.B.10 exchange with 1,200 subscribers' calling equipments and a multiple of similar size spread over six A sections, with one B board and the usual T. and P.U. section.

A feature of interest was the method used to supplant the existing M.D.F. Development requirements called for 26 verticals under the new conditions ; 12 only could be provided at the outset as the old main frame had to remain *in situ* and occupied most of the space needed for the complete new frame. The 12 new verticals were erected, two 800 pair cables brought from the basement to the main frame (which is situated on the second floor) and working pairs were diverted to these new verticals so freeing the line side of the old frame whilst leaving the multiple side of the old frame connected to the switchboard. Connection between the two frames was carried out by means of switchboard cable (plastic type mainly). The old frame was then shifted bodily out of the way and the new frame extended to its 26 verticals. Another 800 pair cable, plus the usual junction cables, were next provided and terminated over the length of the frame. This re-distribution of all working pairs was carried out with remarkably little interference to subscribers, and tribute is due to the manner in which the staff performed this by no means straightforward operation. The two main frames being close together obviated the need for changeover strips and a lot of rather tedious terminating was thus avoided.

Most of the 80 wire switchboard cable used was of the plastic type. This type of cable tends to "flow" and needs close and careful stitching on flat runs. On vertical runs there was difficulty in keeping it in position, but after two or three re-ties it has "anchored" in its intended position.

With reasonable care terminations on plastic cable are no more difficult than with the textile type and the insulation showed no tendency to run back.

To an "old magneto man" there is something forlorn about the recovered magneto sections standing lonely and deserted alongside the smart and efficient C.B. successor, now a centre of activity. R. E. K.

North Eastern Region

WHITLEY BAY AUTOMATIC EXCHANGE

A further step towards the complete automatisation of the Newcastle-on-Tyne Telephone Area was achieved on 11th October, 1950, when Whitley Bay N.D. automatic exchange was brought into service. The new equipment replaces a C.B.10 system installed in 1925 in the Whitley Bay Post Office, and also a relief exchange accommodated in the new automatic exchange building, Norham Road, and brought into service in 1947. The new building was commenced in 1939, but the incidence of hostilities suspended operations and it was not until 1947 that completion was sufficiently far advanced to commence the installation of the automatic equipment.

The automatic exchange, which was installed by the G.E.C., is a remote N.D. type, parented on Newcastle. Equipment for 6,000 subscribers has been provided, witn facilities for direct access to Newcastle and associated common-charge satellite exchanges. Tandem dialling facilities are also provided for U.A.X.s with direct routes to Whitley Bay.

The transfer involved 3,663 subscribers and 176 junctions, and is the largest undertaken in the Newcastle Telephone Area since the conversion of Newcastle multi-office area in 1931. Although two manual exchanges in separate buildings were being displaced simultaneously, the almost faultless conversion which was accomplished reflects great credit on the staffs of all divisions, who showed great enthusiasm to achieve this objective.

A formal opening ceremony took place on Friday, 13th October, and included among the guests were Miss Irene Ward, M.P. for the constituency, the chairman of the Whitley Bay U.D.C., and several local dignitaries. Mr. W. F. Smith, Chief Regional Engineer, was also present on behalf of the Regional Director, N.E.R.

After a tour of the new exchange, the guests, together with a number of the local staff, were entertained to tea arranged by the Postmaster, Whitley Bay. T. P. P.

INTRODUCTION OF MULTI-METERING FACILITIES AT LEEDS EXCHANGE

In October, 1946, authority was given for the Region to proceed with the installation of multi-metering equipment at Leeds main exchange to enable automatic metering of calls of one to four unit fees when dialled by subscribers to exchanges in the 15-mile circle. A saving of 11 toll positions at 1948 was then envisaged, but the saving at present is estimated to be between 15 and 20 positions, due to the automatic completion of from 7,000 to 9,000 calls daily. The scheme has also considerably enlarged the extent of the tandem dialling facilities between exchanges in the 15-mile circle. It has not been extended to cover subscribers on satellite exchanges due, mainly, to the age of the equipment, but as the Leeds automatic area is to be converted to director working it will be possible to give the director exchange subscribers dialling access to the 15-mile circle as conversion proceeds.

The equipment has been manufactured and installed by the Automatic Telephone & Electric Co., Ltd., and, for the multi-metering portion, 538 relay sets and 958 selectors with associated banks and racks were supplied.

The scheme is the first of its kind, using level multi-metering on a large scale, and it was introduced on the 29th October, 1950, when over 10,000 subscribers at the main exchange were given direct dialling access to 46 exchanges (manual or automatic).

The codes have been arranged on the second and third selector levels trunked from level 8, and the multi-metering relay sets with regenerators have been placed between the second and third selectors.

The change-over was complicated by the fact that a tandem dialling scheme for U.A.X.s and operators was already in existence on level 8 giving dialling access to 21 exchanges. To enable these exchanges to be re-arranged in fee order on various levels, and to enable the metering strappings to be re-arranged to agree at the U.A.X.s, level 8 of the U.A.X. group was intercepted five weeks before the transfer and diverted to the auto-manual board. All calls via this level were completed and ticketed by the operators who were provided with additional circuits to first selectors to give them access to revised codes on the levels concerned. In the case of the dialling-in exchanges, it was sufficient to withdraw access to level 8 for one week-end during which time the calls were routed (by instruction) via level "0," in order that the existing codes could be re-arranged at the main exchange.

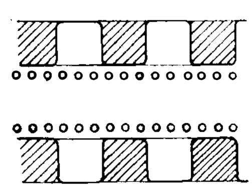
The subscribers on the main exchange were issued with directories in which a separate dialling list had been inserted, giving the code for each of the exchanges to which dialling is allowed. If a satellite subscriber dials one of the codes above unit fee, he receives "number unobtainable" tone.

The whole transfer was successfully completed as a result of the excellent co-operation between the Contractors and the Department. F. E. P.

UNUSUAL TELEVISION INTERFERENCE IN LEEDS AREA

An unusual type of television interference was recently investigated in the Leeds area and a brief account may be of interest.

The interference, which occurred only during hours of darkness, consisted of four lines horizontally across the screen, with pattern as illustrated. Although the four lines were stationary the dots under and over the lines travelled rapidly from left to right.



PATTERN FORMED ON TELEVISION SCREEN BY INTERFERENCE FROM FAULTY ELECTRIC LAMP.

Listening on the official locator (W.T.12) with the complainant's aerial in circuit revealed no interference whatever on either the sound or vision channels. On detuning from 61·75 Mc/s to 60·50 Mc/s, a very faint hum was heard but, using the normal vertical antenna on the locator, no interference could be heard on any frequency. Touring the district in the van proved fruitless. On foot, however, the hum on 60·50 Mc/s was again picked up at a considerable distance from the complainant's premises, but it had to be proved that the hum heard and the lines seen were due to the same cause. The hum was found to be due to a defective filament in an ordinary 60-watt bulb, but the lines still persisted when the lamp was replaced.

Further investigations proved a hum peaking at a transformer station. The Yorkshire Electricity Board was called in, and momentarily flashed each section; the section with the fault was thus found, reducing the line of investigation to about 200 houses. The line of the television beam suggested the source to be in line with Sutton Coldfield, but owing to misleading intensities of interference received, due to mains-borne and direct radiation, difficulty was found in being sure of the source which finally proved to be at a point some 50 yards behind the aerial. Another lamp? Yes!

The interference arose from a badly soldered contact between the filament and the bayonet cap. Replacing this gave entire satisfaction to the complainant and, considering the distance from Sutton Coldfield, the picture received was excellent.

J. V. D.

Midland Region

FIRE AT NARBOROUGH U.A.X. 7

A fire occurred at Narborough U.A.X. 7 at midnight on 7th August, 1950. A nearby resident observed smoke coming from the building and immediately attempted to call the Leicester Fire Brigade from a kiosk. This, however, was unusable. The resident then went to the local railway station and gave the alarm over the British Railways network. The Brigade arrived at 1·58 a.m. (8th August) and had the fire under control shortly afterwards. There is little doubt that the prompt action and initiative of the local resident saved the exchange from complete destruction.

An examination of the exchange was immediately carried out. It was found that one B-unit had been completely destroyed, adjacent units scorched, and switches in the remaining units "gummed up" by the heat and smoke. Damage to the building was confined to the ceiling and roof timbers. On completion of the survey of the damage, it was decided that there was a reasonable prospect of restoring service on the existing equipment by dispensing with secondary working. As a precaution, however, it was considered advisable to obtain a mobile U.A.X. and install it ready for service if necessary. This work was completed within 24 hours. Meanwhile, service had been given to thirteen priority subscribers working on a trunk subscribers' basis to Leicester exchange. Concurrently, staff was employed cleaning and renovating switches ready for service and rewiring to cut out secondary working. During the morning of 9th August, service was restored to all emergency subscribers via the normal exchange equipment. The remaining subscribers were given service as equipment became ready for service, and full service was restored by 9 a.m. on 10th August. It is fitting to record the prompt attention and valuable assistance on the part of Headquarters, Regional and Area staff, whose untiring efforts resulted in the speedy restoration of service to some 300 subscribers.

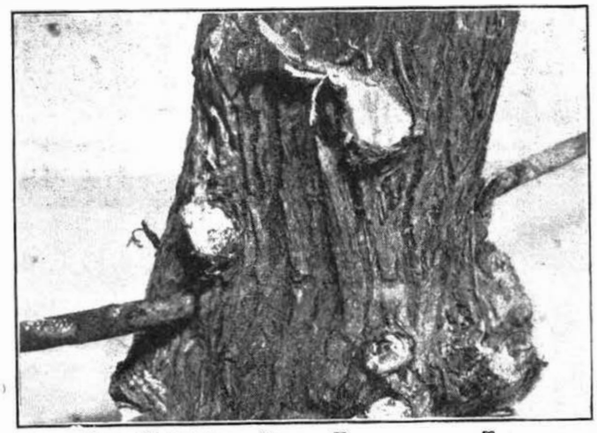
E. S. L.

Home Counties Region

CABLE EMBEDDED IN TREE

The associated photograph shows the trunk of an elderberry tree that has grown around a portion of cable P.C.T.D. 15/10 protected.

This cable formed part of about 300 yards of buried cable serving a D.P. in Westgate-on-Sea, Kent. The route



15-PR. PROTECTED CABLE EMBEDDED IN TREE.

passed through gardens and allotments, and one portion was along a hedge. In the past five years or so, several faults developed due to the operations of gardeners, and recently faults developed close to the elderberry tree. It was then seen that the cable was completely embedded in the tree and, although no faults had developed due to this cause, the opportunity was taken to re-route the cable and recover the buried section by the hedge.

R. S. V. P.

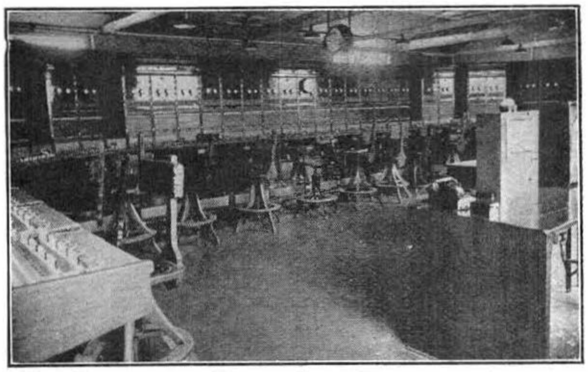
THE ROYAL SHOW, OXFORD, 1950

In 1950 the Royal Society of England's annual show revisited its birthplace, but, whereas the first of the Society's shows was held in 1839 on a site occupying seven acres, the recent show occupied 170 acres and had to be accommodated on the Oxford airport, eight miles from the City centre.

The demands for telephone service at these shows had increased in recent years, and a new peak was anticipated and, in fact, realised this year. It was decided that, despite the local arrears of telephone provision, the international importance of the show justified the work involved in meeting all the exhibitors' telephone requirements. These were estimated to be approximately 280 exchange lines and a high calling rate was anticipated. This forecast was nearly achieved, as 232 D.E.L.s for exhibitors were provided with 14 other lines and 32 kiosks. P.B.X.s were provided for the show authorities and the caterer.

No adjacent exchange was found to have a sufficient margin of spare plant to handle the temporary load, and the Oxford exchange was already fully loaded. It was decided, therefore, to open an independent C.B. No. 10 exchange on the showground and to give the exchange temporary Group Centre status so that the considerable trunk and junction traffic could be expeditiously handled. A 22-position board with six monitorial positions was built in a wooden sectional building provided by the show authorities. This board was equipped with a 400-line subscribers' multiple and an 80-line outgoing junction multiple.

A general view of the switchroom is shown in the photograph.



THE SWITCHROOM, ROYAL SHOW EXCHANGE, OXFORD.

A considerable number of trunks and junctions were required, and an advance portion of an Oxford-Charlbury C.J. cable was intercepted and led into the showground to provide 104 circuits to the Oxford repeater station, from which 4-wire circuits were provided to London, Birmingham, Bristol, etc. An M.U. cable was also intercepted to provide circuits to Woodstock and Banbury.

The problem of providing a reliable, efficient, inexpensive and yet unobstructive distribution on the showground was a difficult one, in view of the need to economise in manpower, avoid wastage of cable and yet give a service which would meet all contingencies. Rock was found at an average depth of one foot below the surface, but it was decided that the main distribution cables should be laid at shallow depth in the cover available. The majority of the three miles of cable provided was moledrained, but the more important sections of the main 500-pair cable were protected by steel pipe laid in trenches excavated by an Aveling Barford trench excavator. It was possible to utilise a joint trench with the electricity supply on one section of the route, but, in general, considerable care had to be taken to avoid interference with other services. Underground feeds to a number of the stands were necessary, and the newly introduced one-pair polythene cable was used for this purpose. Distribution to the majority of exhibitors was provided by drop-wiring from 36-ft. poles situated in a 1-ft. gangway between the rows of (back-to-back) stands. These pole routes were used jointly with the electrical authorities and the work of poling materially reduced. A number of steel poles were used for subsidiary distribution. It is a tribute to the care with which the construction was carried out that very few faults were experienced either on the external or internal plant during the show, despite appalling weather conditions. It was necessary, however, in one instance to erect a jointer's tent hurriedly over one section of the main cable route which became exposed due to abnormal traffic removing the top soil.

The "Royal Show" exchange opened on 26th June, 1950, and from the following call figures it will be seen that the apparent lavish provision of telephone plant was justified :—

	8 a.m.-8 p.m.	*Busy Hour*
Monday, 3rd July ..	22329	2322
Tuesday, 4th July ..	37527	4090
Wednesday, 5th July ..	39009	4265
Thursday, 6th July ..	36884	4494
Friday, 7th July ..	31872	4121
Saturday, 8th July ..	4649	1047

At the conclusion of the show, all plant was recovered and the showground returned to its normal condition. The exchange building and equipment were forwarded to Cambridge for the 1951 show, the underground cable and poles recovered, and the 32 kiosks transported bodily to their permanent sites in the Oxford countryside.

H. F. G.

RECOVERY OF LONDON-BRIGHTON NO. 3 AERIAL CABLE

The London-Brighton No. 3 cable erected by Post Office staff in 1931/32 was one of the first experimental long-distance aerial cables to provide 4-wire repeatered circuits when the introduction of "Trunk Demand" service was inaugurated. The cable was manufactured by Messrs. Johnson & Phillips and the Pirelli Cable Companies, who provided the London-Crawley and Crawley-Brighton sections, respectively, and consisted of 37 quads, the core of paper insulated 10 lb. conductors being laid in star-quad formation. This cable provided 37 4-wire repeatered telephone trunk circuits between London and Brighton, which had up to this time, been working on 70 lb. multiple twin cable without amplification.

Specially constructed loading coils having a D.C. resistance of 4·1 ohms and an inductance of 120 millihenries were installed at predetermined points and were fitted on poles at intervals of approximately 2,000 yards.

The cable was suspended on 7/14 steel strand wire throughout its entire length, except on spans exceeding the normal distance when "long span" construction was adopted. This arrangement consisted 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. An important feature in providing this auxiliary strand (7/12) was that the provision of additional poles to strengthen the route was avoided and also it reduced possible damage to the cable, caused by the swaying action of strong winds.

Although of an experimental nature, the cable has given good service in providing long-distance circuits over a considerable period of time, but with the provision of further underground trunk cables on this route, it was decided that the recovery of the Crawley-Brighton section should be effected and all working circuits transferred to other cables. This work was put in hand and recovery work was able to commence in March of last year. The work was allotted to several gangs placed at suitable intervals along the route, each gang being provided with motor transport, whilst one 30-cwt. stores-carrying vehicle was used to collect the recovered cable and place it in safe custody each night, a recently vacated small U.A.X. building on the route being used for this purpose. As the cable was taken down it was cut into lengths of 15 yards and coiled up to facilitate handling, each coil weighing approximately ½ cwt. At no time did a large amount accrue in local storage.

With nearly 18 miles of aerial cable to be recovered, representing some 54 tons of scrap, transportation to the Supplies Department was no small part of the operation, but with the co-operation of that Department's motor transport section and assistance by Area transport the arrangements were carried out in a smooth and efficient manner.

The recovery of this route will be greatly appreciated by those who desire to preserve rural beauty and the fine views seen from this famous road will be greatly enhanced.

E. H. B.

North Western Region

DOUGLAS (I.O.M.)—SKYREBURN CABLE

To improve the standard of service between the mainland and Isle of Man, a new submarine cable has been laid, the landing point on the Island being at Port Groudle, about four miles from Douglas.

Work on the island included the construction of a repeater station at Douglas, construction of a cable hut at Groudle, installation of about four miles of balanced pair cable between these places by Area staff and also the installation by Area staff of about 360 yards of submarine-type cable from the cable hut to a jointing point on the beach to link up with the submarine cable. All this work, including trenching and ductwork for the cables, was put in hand mid-1949 and completed early in 1950 in readiness for the laying of the submarine cable.

The laying of the submarine section of the cable was undertaken by H.M.T.S. *Iris*, and the ship arrived off Port Groudle on 22nd June, 1950, to proceed with the operations. A shore party, on landing, set up communication with the ship via a "walkie-talkie" and the ship's jointer opened up the land section of the submarine cable. This, on test, was found to be low insulation in the order of 25 megohms.

THE SHORE PARTY EQUIPPED WITH "WALKIE-TALKIE" SET.

The cable was, therefore, recapped and CO_2 left in under pressure for 12 hours. At the end of the period, pressure was maintained and an infinity reading obtained on retest. During the operation of applying gas, it was found that the gas did not pass through from one end of the cable to the other, due to a "stopper" incorporated in the cable at 200 metre intervals to prevent water running along the cable in the event of a fracture to the sheath. Gas was, therefore, applied at both ends.

"Sealing ends" of a special design, which at the hut end forms part of the termination and at the beach end half the submarine cable joint, were fitted to the cable. The insulation was satisfactory at the conclusion of these operations, but fell to approximately 300 megohms on the fitting of the lead cap at the beach end.

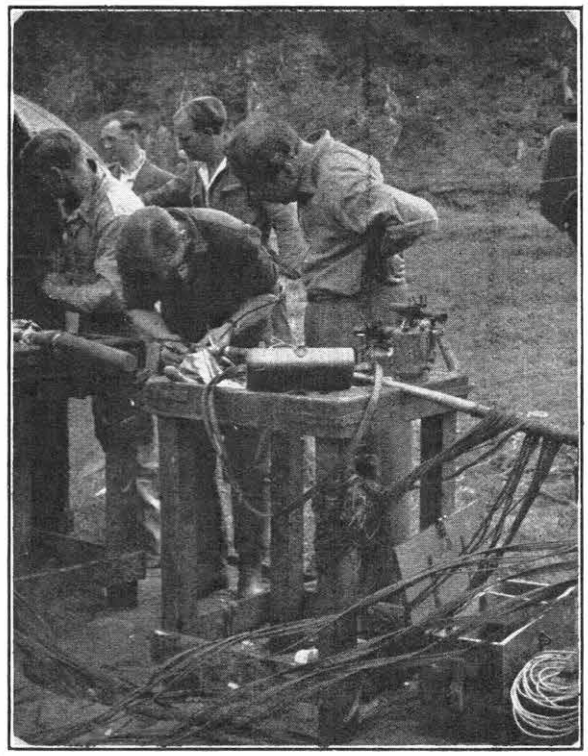
Several discussions took place and tests were then made to ascertain the reason for apparent instability of the cable. As a result, it appeared that, due to the large air space in the cable, damp air was too readily absorbed during the operation of fitting the air-tight sealing ends. These sealing ends were taking up to four hours to complete and with the temperature changes during this time it was considered feasible that the air would flow in and out of the air space in the cable, equalising with outside pressure. On cooling of the air within the cable, any moisture condenses on the Styroflex, causing a drop in insulation.

The beach end of the cable was eventually cut off and the cable reglanded at both ends. After the application of CO_2 gas for a period, the insulation was raised to over 1,000 megohms, to the satisfaction of the I Branch representative.

It was decided to land the sea end of the cable on 26th June, 1950, but weather conditions were unsuitable and the cable was eventually landed the following day. Satisfactory tests were made from the shore through the full length of cable in the ship's tanks, but the sea section of cable broke down, due to damage while the ship was swinging. A second shore end was landed which proved to be satisfactory.

The actual landing of the cable at Port Groudle was uneventful. A raft was built with two lifeboats from the ship, and sufficient cable to reach the agreed jointing point on the beach coiled on the platform. This raft was then towed from the ship, the personnel in the raft paying out the cable as shore was approached.

Completion of the laying of the sea section was delayed by unsatisfactory weather conditions, but was finally effected on 2nd July, 1950.



PREPARING FOR FINAL JOINTING OF LAND-SEA SECTIONS.

The 49·46 nauts of submarine cable is of the coaxial type, the centre conductor consisting of a steel wire approximately 0·184 in. diameter covered by a shell of copper to an overall diameter of 0·24 in. A laminated helix of Styroflex tap 0·135 in. wide is spiralled on to the centre conductor, and eight copper tapes forming the tube are bedded on to the Styroflex spiral. Two steel tapes are lapped over the outer conductor in opposite lay and covered with blue Styroflex ribbon over which is a lead sheath. The lead sheath is covered with tarred jute and armouring wire, giving an overall diameter of approximately 1·875 in. B. W.

Junior Section Notes

Bishop's Stortford Centre

The membership suffered a disappointment in early September because a hoped-for trip to the De-Havilland Aircraft Factory did not materialise, due to pressure of work on the aircraft manufacturers. However, on 12th September an interesting film show was given by the Central Office of Information. The presentation included a film showing the various stages in the manufacture of both low- and high-tension cables.

On 18th October the first paper to be read since the inception of the Bishop's Stortford Centre was very ably given by Mr. R. Warboys. "Astronomy" was the subject of the paper, and the members present found it extremely interesting. This was followed on 8th November with a visit to the Observatory at Cambridge, where a very instructive and interesting evening was spent.

At the time of writing, the future programme included a paper on "Faraday Building Communications," by an E.-in-C.'s officer, to be followed later by a visit to Faraday Building, and a paper on "Internal Combustion Engines," by Mr. R. A. Collins.

Although in its infancy, interest in the Centre appears to be growing, but we would like to see still more join us. So come on in, those of you who have not yet done so. There is something of interest to everyone. J. S. R.

Darlington Centre

It is encouraging to any committee making programme arrangements to receive requests for the number of meetings to be increased. This is the happy position of the Darlington Centre, and the forthcoming programme is now as follows :—

16th January.—"Where the Money Goes," Mr. K. Millard.

20th February.—"Steel." Mr. W. French, A.M.I.M.E., C.E., F.I.W.M.

13th March.—"Two-Way Quiz." Darlington *v.* Middlesbrough.

10th April.—"Radar-Up-To-Date." Capt. R. R. Johnson, R.A.

15th May.—Annual General Meeting.

The Centre's activities commenced on 21st September, 1950, with a visit to the Darlington Power Station, which proved most interesting and educative. The talk by Mr. T. E. Daniels, of the North-Eastern Electricity Board, was exceptionally interesting.

The opening meeting of the session attracted a good number of our members, and the talk, "Audioddities," by Mr. H. C. Naylor, A.M.I.E.E., was thoroughly enjoyed. A lively discussion followed. Mr. Naylor has given several talks to the Centre in the past and his services are always appreciated.

The second meeting, "The Telephone Service in Hong Kong," by Mr. W. J. Geall, had to follow quickly after the previous meeting owing to Mr. Geall having to return to Hong Kong. The occasion was unique, because the speaker, formerly a member of the Darlington Post Office Engineering Staff, had returned after 25 years as District Manager of the Hong Kong Tele. Co.

A Darlington Junior Centre Member, Mr. G. Dale, journeyed to the York Centre and gave a talk, "U.A.X.s Simplified," on 12th October, 1950. This new departure in Regional Centre activities, proposed at the Area Conference, and implemented by Mr. A. C. Holmes, Regional Liaison Officer, is welcomed. G. N. H.

Tunbridge Wells Centre

The seventh winter Session commenced on 5th October, 1950, and the following officers were elected :—

Chairman : A. E. Chapman ; *Treasurer :* G. E. Kingswood ; *Secretary :* E. L. English ; *Committee :* Messrs. W. J. Edwards, A. G. Shoebridge, G. Harrison, J. Whyte, J. English, A. C. G. Hasted.

The programme for the 1950-51 Session will be continued as follows :—

January.—"Shared Service." E. L. English.

February.—"Fundamentals of Television." W. E. Thompson.

March.—"Some Further Aspects of Trunk Telecommunications in India." G. M. Blair.

April.—Film Show, followed by A.G.M.

Bradford Centre

The 1950-51 Session opened on 17th October with a visit to John Players, Ltd., Nottingham, when 31 members spent the afternoon touring the tobacco factory and left with a complimentary box of 25 "Players Please," The centre is indebted to the firm for a very interesting and instructive two hours.

A Quiz, Bradford *v.* Scarborough, took place on 3rd November over amplified land lines. The programme for the rest of the Session is given below :—

January.—"Ship-to-Shore Radio." Mr. E. Bauer.

February.—Hobbies Night. Exhibition Talk. Films. "O"-gauge Model Railway : ¾-in. scale Steam Locos.

March.—"Transport in the Department." Mr. G. Lean.

April.—"Intercommunication Systems." Mr. J. Gleeson.

May.—Details later.

May.—Annual General Meeting.

Although a fairly full and comprehensive programme has been arranged, suggestions for its improvement will be welcomed from all members. A. E.

Glasgow and Scotland West Centre

Since the revival of the Centre it is pleasing to be able to record a continuation of enthusiasm by members, of whom there are 60, with every indication of a further increase.

The Committee has arranged a comprehensive programme, and the opening meeting took place on Friday, 29th September, when a very interesting evening was spent in the form of a Film Show and discussion. On Thursday, 19th October, 1950, members visited the works of Messrs. Scottish Cables, Renfrew, and on Friday, 17th November, 1950, Mr. J. Haddon, A.T.O., gave a lecture, illustrated with slides, his subject being "Some Aspects of Main Cable Maintenance."

The remainder of the programme is as follows :—

January	19th	"General Transmission"
February	16th	Visit to B.B.C.
March	16th	"Quiz"
April	20th	A.G.M.

May I draw members' attention to the excellent facilities offered by the Central Library of the Institution. For further information contact the Secretary, R. T. Shanks, PAI 2744.

The attendance at visits and lectures could be improved upon, and a special invitation is extended to youths-in-training. R. T. S.

(*Continued on page* 221)

Book Reviews

"The Theory and Design of Inductance Coils." V. G. Welsby, Ph.D., A.M.I.E.E. Macdonald & Co. (Publishers), Ltd. 180 pp. 61 ill. 18s.

Dr. Welsby uses an admirable mixture of theory and experiment to derive working formulæ for the design of many types of coil and the prediction of their resistances at high frequencies. The only serious criticism of this book is that this approach limits its scope more than the author may have realised; some of his statements that certain types of loss are unimportant, while true for the coils used in telecommunications systems, are not always true for the specialised coils needed for laboratory equipment (for which accurately-known performance may be even more important than for the bread-and-butter types). Similarly, his treatment for air-cored coils differs from that of Butterworth; the fundamental difference seems to be the author's assumption that, for good performance, the winding space will need to be nearly filled, while Butterworth assumed that the windings should be widely spaced. Both authors are right—they are thinking of different kinds of coil, for different purposes; unfortunately, neither of them gives a hint that the other kind of coil exists.

The debunking of Litz wire is welcome, and very simple—why did nobody think of it before?

The various chapters of the book are well proportioned, except that 17 pages on the technique of measurement are far too few. The reviewer disagrees with some of the author's recommendations on bridges, perhaps because they are not explained in enough detail.

The bibliography is useful as far as it goes; but it omits, for example, Butterworth's discussions of toroidal coils and of the resistance of closely-spaced turns, Howe's discussion of the principles of screening, and Rosa's papers on the inductance of spaced turns. Detailed references from the text to the bibliography would be helpful; at present, one must guess from the titles of the articles which of them is relevant to a particular problem. The contents pages and index are good. The diagrams are fair, but some of them are cramped and some do not show what the text says they do.

Generally, this book is excellent for the design of everyday coils for line communication work. For unusual coils it may help or it may not. It never avoids a difficult question if the answer is going to be needed in practice, yet everything in it is intelligible to the non-specialist.

A. C. L.

"Electrical Transmission of Power and Signals." Edward W. Kimbark. John Wiley & Sons, Inc., and Chapman & Hall, Ltd. 461 pp. 211 ill. 48s.

This is a general textbook covering basic theory appropriate to the transmission of power, telephony and ultra-high-frequency signals. As far as is known it is the first book to deal with the subject in this general way, and for the student who wishes to obtain a comprehensive knowledge of line transmission, it can be recommended without reserve. A knowledge of circuits with lumped parameters is assumed, but the book deals with distributed parameters from first principles. Rationalised m.k.s. units are used throughout.

Early chapters are devoted to the primary coefficients of two-conductor lines (coaxial and parallel wires), multi-conductor lines, stranded and miscellaneous conductors (dealt with from the conception of geometric mean distance) and ground-return lines. In using the formulæ given, the student will need to remember that R, L, G and C refer here to total quantities and not per unit of length. Elastance—the reciprocal of capacitance, in megadarafs per metre—will be an unfamiliar unit to most readers.

Steady-state transmission along uniform lines and the equivalent lumped networks are dealt with in a manner familiar to communication engineers, while transient phenomena are covered in a very practical manner in relation to switching surges, lightning and the transmission of D.C. pulses. Circle diagrams and other graphical methods of determining the performance of lines terminated in any impedance are derived, and the particular requirements of the power engineer follow.

The remaining six chapters apply mainly to the field of communication and first deal with impedance matching, image characteristics and signal distortion in a comprehensive manner; coil loading, superimposed circuits, crosstalk and line transpositions are also adequately covered. Coaxial cables are dealt with in the section on radio-frequency lines where such artifices as short-circuiting pistons and the many applications of quarter-wave-length stubs are conveniently included. There is a chapter on electric wave filters, but this confines itself to networks terminated in their image impedances, and makes only passing reference to dissipation. Skin effect is dealt with in some detail, first in flat plates and then in circular wires, the latter involving an introduction to the modified Bessel functions.

The final chapter discusses guided waves, the Poynting vector and the application of Maxwell's equations to wave propagation in rectangular and circular guides. Two appendices give useful and comprehensive data on practical conductors and transmission lines.

Each chapter contains an adequate list of references and many numerical problems for the exercise of the student.

R. J. H.

"Maintenance Manual of Electronic Control." Edited by Robert E. Miller. McGraw-Hill Pub. Co., Ltd., London, 1949. 304 pp. 200 ill. 39s.

This book has been written primarily for the electronic technician and its pages are full of detailed material and sound practical advice on installation as well as maintenance. The work was first published as a series of articles in an engineering magazine; each subject is dealt with by a specialist in a most authoritative and thorough manner.

The main subjects covered (following elementary circuit arrangements common to most electronic controls, general matters of installation and maintenance and testing equipment) are Timing Devices, Photo-Cells, Motor Control, Resistance-welding and Temperature Control, with a final chapter on Sealed Ignitron Rectifiers.

There is no doubt that novel results can be obtained in suitable circumstances from electronic control but progress in application is at present being hindered, for example, by lack of trained technicians and by fear of plant engineers arising from the apparently delicate nature of electronic equipment. That this fear is unfounded will be recognised by communication engineers who will not be discouraged by the length and complexity of the many "Trouble-Shooting Tables" (as they are called) given in this book. However, there is no doubt that to enable the best performance from electronic devices to be realised, even in ideal applications, the installation and maintenance staff must be specially trained. This book, therefore, to some extent fulfils a need, but it is seldom that any one maintenance man, or group, is required to cover the full scope of the work. Further, there are many diverse applications which perforce have been left undescribed, such as electronic plate-cutting machinery (using original drawings as templates) and component inspection, testing, etc., except in general terms.

J. P.

Staff Changes

Promotions

Name	Region	Date
Reg. Engr. to C.R.E.		
Hines, R. J.	N.E. Reg. to Scot.	1.11.50
Sen. Exec. Engr. to Reg. Engr.		
Summers, F.	E.-in-C.O. to Mid. Reg.	14.9.50
Area Engr. to Asst. Staff Engr.		
MacWhirter, R.	Scot. to E.-in-C.O.	1.11.50
Exec. Engr. to Sen. Exec. Engr.		
Urben, T. F. A.	E.-in-C.O.	30.10.50
Welsby, V. G.	E.-in-C.O.	8.11.50
Raby, R. E.	L.T. Reg.	18.8.50
Stonebanks, A. M.	E.-in-C.O. to L.T. Reg.	1.9.50
Mason, H. J. S.	E.-in-C.O.	1.10.50
Barratt, L. W.	S.W. Reg. to H.C. Reg.	4.10.50
Dixon, J.	N.W. Reg. to Scot.	1.11.50
Lafosse, L. P.	E.-in-C.O.	26.9.50
Marchant, P. A.	E.-in-C.O.	26.9.50
Exec. Engr. to Sen. Sc. Offr.		
Bassett, H. G.	E.-in-C.O.	16.10.50
Sc. Offr. to Sen. Sc. Offr.		
North, J. C.	E.-in-C.O.	9.11.50
Asst. Engr. to Exec. Engr.		
Polhill, C. T.	H.C. Reg. to E.-in-C.O.	2.9.50
Cox, E. B.	E.-in-C.O.	3.9.50
Wilson, A. A.	Scot.	7.9.50
Greenall, J.	N.W. Reg. to E.-in-C.O.	9.9.50
Came, C. H.	S.W. Reg.	3.8.50
Whitting, W. G.	S.W. Reg.	4.10.50
Burgess, C. L.	S.W. Reg.	3.8.50
Rolls, A.	Mid. Reg. to S.W.Reg.	19.8.50
Phillips, H. A.	S.W. Reg.	26.8.50
Asst. Engr. to Exec. Engr.—continued.		
Reynolds, W. H.	E.-in-C.O.	22.9.50
Mainwaring, G.	Mid. Reg.	23.10.50
Seymour, P. W.	E.-in-C.O.	9.10.50
Kelly, P. T. F.	E.-in-C.O.	23.10.50
Rata, S.	L.T. Reg. to E.-in-C.O.	16.10.50
Collins, J. H.	E.-in-C.O.	25.9.50
Lowe, W. T.	E.-in-C.O.	16.10.50
Groves, K.	E.-in-C.O.	7.10.50
Judd, D. L.	E.-in-C.O.	16.10.50
Yeo, B. F.	E.-in-C.O.	25.9.50
Simpson, W. G.	E.-in-C.O.	25.9.50
Stoate, K. W.	E.-in-C.O.	25.9.50
Naulls, R. W.	E.-in-C.O.	10.10.50
Hawley, A. E.	E.-in-C.O.	16.10.50
Hawkins, A. P.	E.-in-C.O.	2.10.50
Williams, J. B. F.	E.-in-C.O.	9.10.50
McPherson, J. W.	E.-in-C.O.	19.9.50
Walker, R. R.	E.-in-C.O.	20.9.50
Thompson, C. D.	E.-in-C.O.	20.9.50
Shearme, J. N.	E.-in-C.O.	19.9.50
Jeynes, E.	E.-in-C.O.	19.9.50
Boggis, R. J.	E.-in-C.O.	25.9.50
McLusky, R. F.	E.-in-C.O.	25.9.50
Fudge, E. W.	E.-in-C.O.	2.10.50
Windell, S. R.	E.-in-C.O.	2.10.50
Stephenson, M.	L.T. Reg. to E.-in-C.O.	23.10.50
Spencer, H. J. C.	H.C. Reg. to E.-in-C.O.	13.11.50
Rawlinson, W. A.	E.-in-C.O.	13.11.50
Harding, D. J.	E.-in-C.O.	20.11.50
Tech. Offr. to Exec. Engr.		
Hare, A. G.	E.-in-C.O.	9.10.50
McGrath, H. T.	E.-in-C.O.	25.9.50
Tech. Offr. to Asst. Engr.		
Kitchen, F. T. W.	E.-in-C.O.	9.9.50
Evans, J. H. G.	E.-in-C.O.	12.10.50

Transfers

Name	Region	Date
Asst. Staff Engr.		
Couch, P. R.	E.-in-C.O. to N.E. Reg.	1.11.50
Sen. Exec. Engr.		
Chorley, J. W. A.	E.-in-C.O. to Civil Service Comm.	25.10.49
Exec. Engr.		
Padgham, F. V.	E.-in-C.O. to H.C. Reg.	1.10.50
Hudson, G. K.	E.-in-C.O. to N.Ire. Reg.	1.10.50
Thompson, J. E.	Mid. Reg. to N.E. Reg.	1.11.50
Asst. Engr.		
Edwards, A. J.	E.-in-C.O. seconded to Anglo - Iranian Oil Company	2.10.50
Mallett, T. H.	E.-in-C.O. to Min. of Civil Aviation	9.10.50
Eason, D. J.	E.-in-C.O. to W.B.C. Reg.	16.10.50
Maxted, V. O.	W.B.C. Reg. to E.-in-C.O.	23.10.50
Farres, T. S.	L.T. Reg. to E.-in-C.O.	6.11.50

Retirements

Name	Region	Date
Exec. Engr.		
Smith, J. A.	Scot.	30.11.50
Asst. Engr.		
Masters, F. R.	L.T. Reg.	1.9.50
Dean, W. J.	Mid. Reg.	10.9.50
Gregory, E. G. S.	L.T. Reg.	10.11.50
Saville, E. W.	N.E. Reg.	18.11.50
Inspector.		
Basgallop, H.	L.T. Reg.	31.10.50
Inspector—continued.		
Cooke, W. E.	E.-in-C.O.	9.11.50
Hindes, R. W.	L.T. Reg.	10.11.50
Aaron, R. H.	Mid. Reg.	23.11.50
Senior Draughtsman.		
Stewart, R. J.	Scot.	27.11.50
Leading Draughtsman.		
Wood, S. P.	L.T. Reg.	5.10.50
Lawrie, R.	Scot.	30.10.50

Resignations

Name	Region	Date	Name	Region	Date
Exec. Engr.			*Asst. Engr.*		
Tough, J. D. ..	.. S.W. Reg.	23.10.50	Geercke, S. M. G.	.. E.-in-C.O.	31.8.50
Scott, B. ..	.. E.-in-C.O.	6.9.50	Edgar, F. L. ..	.. E.-in-C.O.	10.10.50
			Thomas, A. ..	.. E.-in-C.O.	31.10.50
			Turner, W. ..	.. Mid. Reg.	30.11.50
			Liddell, A. ..	.. Scot.	23.11.50

Deaths

Name	Region	Date	Name	Region	Date
Asst. Engr.			*Inspector.*		
Fitzgerald, S. G. M.	.. L.T. Reg.	30.7.50	Bardsley, A. ..	.. N.W. Reg.	25.9.50
Jardine, S. ..	.. Scot.	3.10.50	Weaight, A. T. ..	.. H.C. Reg.	15.11.50
			Leading Draughtsman.		
			Rooks, E. W. ..	.. H.C. Reg.	6.11.50

CLERICAL GRADES

Promotions

Name	Region	Date	Name	Region	Date
Sen. Exec. Offr. to Staff Controller.			*E.O. to H.E.O.*		
Daly, G. ..	.. E.-in-C.O.	2.11.50	Root, J. M. (Miss)	.. E.-in-C.O.	1.10.50
H.E.O. to Sen. Exec. Offr.			*C.O. to E.O.*		
Southgate, A. G.	.. E.-in-C.O.	1.10.50	Milner, G. ..	.. E.-in-C.O.	5.8.50
			Hicks, G. ..	.. E.-in-C.O.	13.9.50
			Smart, C. H. ..	.. E.-in-C.O.	1.10.50

Transfers

Name	Region	Date	Name	Region	Date
H.E.O.			*E.O.*		
Quartermaine, H.	.. E.-in-C.O. to Ministry of National Insurance	7.11.50	Bevans, H. G. ..	.. E.-in-C.O. to Ministry of Labour	20.11.50

Retirements

Name	Region	Date	Name	Region	Date
Staff Controller.			*H.C.O.*		
Dunster, H. L. ..	.. E.-in-C.O. (Ill-health)	1.10.50	Hamilton, D. ..	.. E.-in-C.O.	12.9.50
S.E.O.					
Baker, A. J. ..	.. E.-in-C.O.	30.9.50			

JUNIOR SECTION NOTES

(*Continued from page* 217)

Lincoln Centre

On Wednesday, 27th September, a limited number of members, together with invited representatives of the Senior Section, paid a most interesting visit to the telephone works of Messrs. Ericssons at Beeston, Notts.

On arrival the members were split up into four parties, and then conducted via different routes round a very representative number of departments of the works. The operations seen varied from the manufacture of the smallest screws and mountings, etc., to the assembly of complete suites of switchboards and bays of automatic equipment.

One process which attracted much attention was the R.F. heating of material used in the manufacture of moulded telephone cases. After a most enjoyable tour which ended with a tea in the canteen, the only regrets were that it was unavoidable that the time available for each department was so short. D. C.

Middlesbrough Centre

The 1950-51 Session opened with a large attendance at a Film Display and Social Evening on 26th October. The Telephone Manager attended along with 41 members, 9 Senior members and 20 visitors. Thanks again to Mr. J. S. Gill, our Liaison Officer, for organising the social entertainment. It was agreed that an enjoyable evening had been spent by all.

At the time of writing these notes, we have a membership of 63; it is hoped that this figure will be increased as the Session develops. The officers for the 1950-51 Session are :—

Chairman : D. Paterson; *Vice-Chairman :* C. Allison; *Secretary :* J. Brown; *Vice-Secretary :* R. R. Johnson; *Treasurer :* K. Lynas; *Local Committee :* Messrs. G. A. Buckle, W. Burke, J. Mansfield, P. B. Sawyer, H. D. Sloan, and E. E. Sparkes.

As usual an excellent programme was planned, and the remaining items are as follows :—

25th January.—"Television." B. V. Northall (Darlington Centre).

22nd February.—"Electrical Engineering in Iron and Steel Works." R. Dingwall, M.I.E.E.

13th March.—Two-Way Quiz: Darlington *v.* Middlesbrough.

10th May.—Annual General Meeting.

The Telephone Manager has generously offered £1 1s. as a prize for the best lecture given at Darlington or Middlesbrough Centre during the present Session.

J. B.

Southampton Centre

The Committee of the Centre has arranged a varied programme for the remainder of the 1950-51 Session to include the following :—

9th January.—A Quiz with Portsmouth Centre, using land-lines between the Centres.

13th February.—"Problems in Wartime Communications." H. Knee.

13th March.—"Telegraph Auto. Switching." R. Katon.

10th April.—Annual General Meeting, and "Five-Minute Papers out of the Hat."

In addition to the programme of papers, during the early months of 1951, arrangements are in hand for visits to the Terminal Building, Southampton Docks; B.B.C. Transmitter, Bartley; and Pirelli-General Cable Works, Eastleigh.

The Centre will also arrange further visits during the coming months if a sufficient number of members so desire. N. H. R. Y.

The Board of Editors is not responsible for the statements made or the opinions expressed in any of the articles in this Journal, unless such statement is made specifically by the Board.

Communications

All communications should be addressed to the Managing Editor, *P.O.E.E. Journal*, Engineer-in-Chief's Office, Alder House, Aldersgate Street, London, E.C.1. Telephone: HEAdquarters 1234. Remittances should be made payable to "*The P.O.E.E. Journal*" and should be crossed "& Co."

Binding Cases

Cases for binding are available, and may be obtained from the Local Agents for 2s. Subscribers can have their copies of volumes bound, at a cost of 7s. 6d., by sending the complete set of parts to the Local Agents or to the *P.O.E.E. Journal*, Engineer-in-Chief's Office, Alder House, Aldersgate Street, London, E.C.1. Orders for binding for Vols. 1-19 should indicate whether the original binding case with black lettering, or the later pattern with gold, is required. Cases with gold lettering are the only type stocked from Vol. 20 onwards.

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The price of the Journal, which is published quarterly, is 1s. 6d. (1s. 9d. post free) per copy, or 7s. per annum post free. Back numbers can be supplied, subject to availability of stocks, at 1s. 6d. each (1s. 9d. post free). Orders for back numbers may be sent to the Local Agents or to the Publishers.

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Post Office Electrical Engineers' Journal

Volume 43, April 1950—January 1951

INDEX


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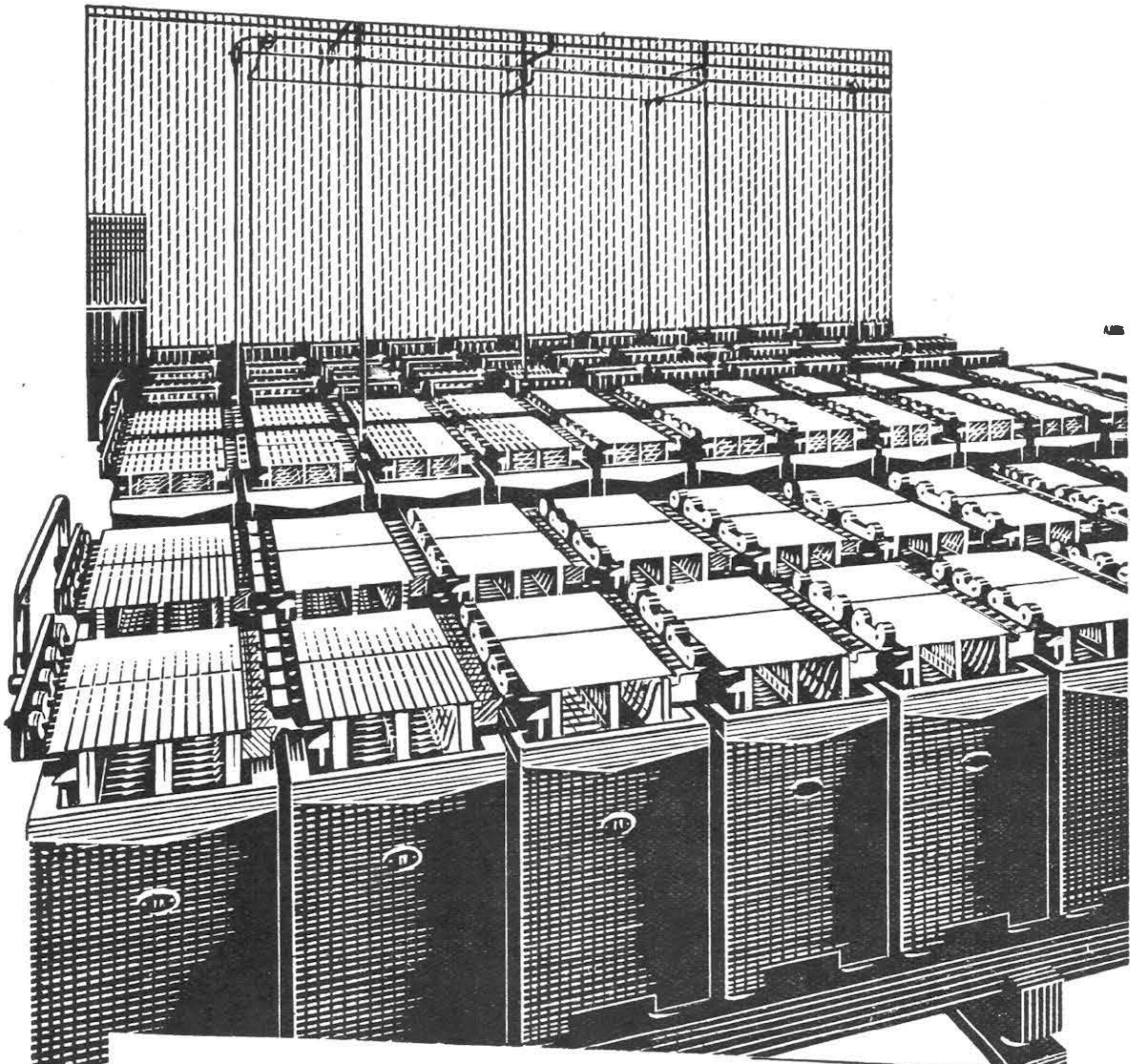
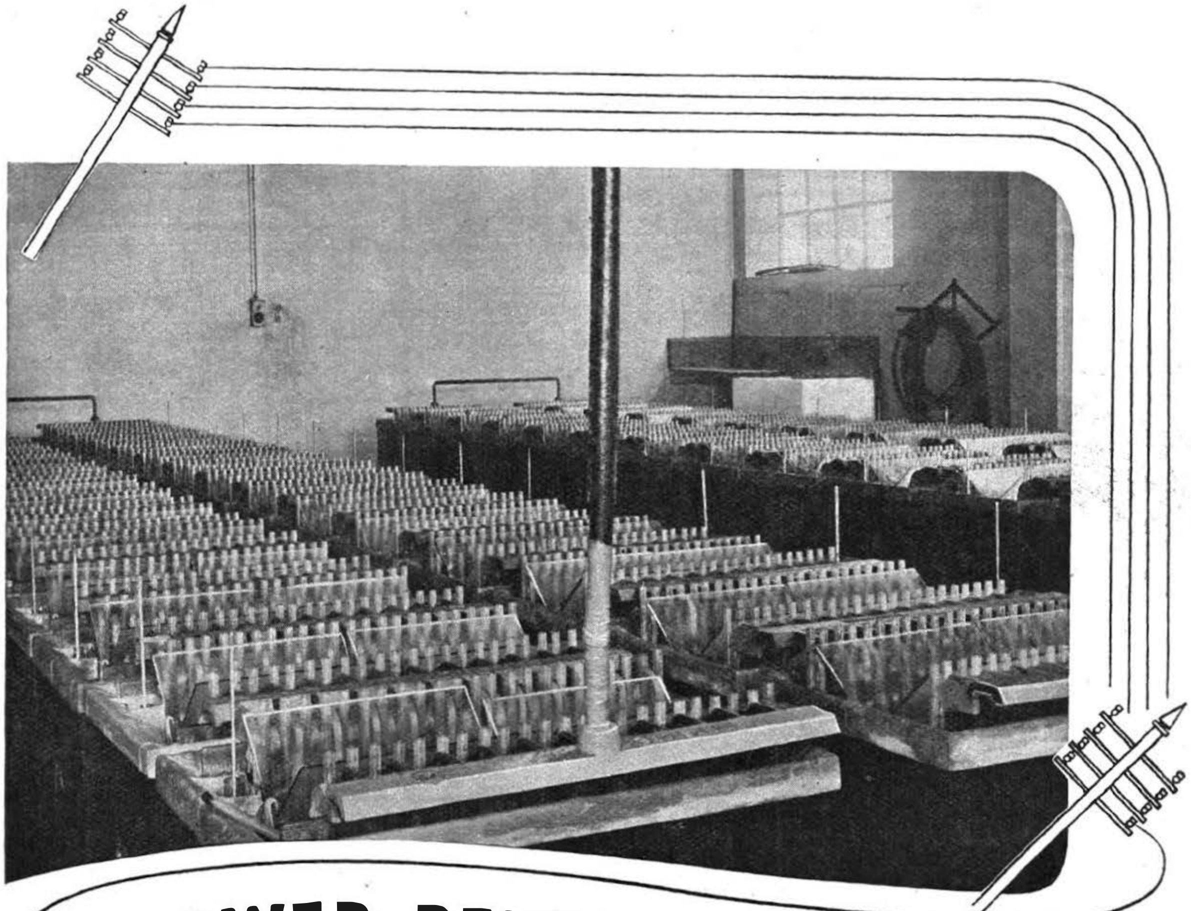
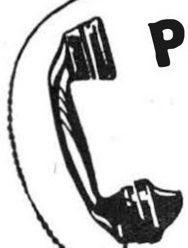
Works: BEESTON, NOTTS.





POWER BEHIND THE LINES



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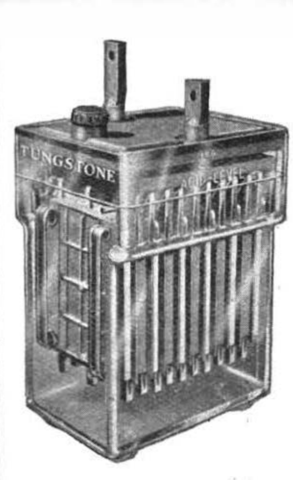

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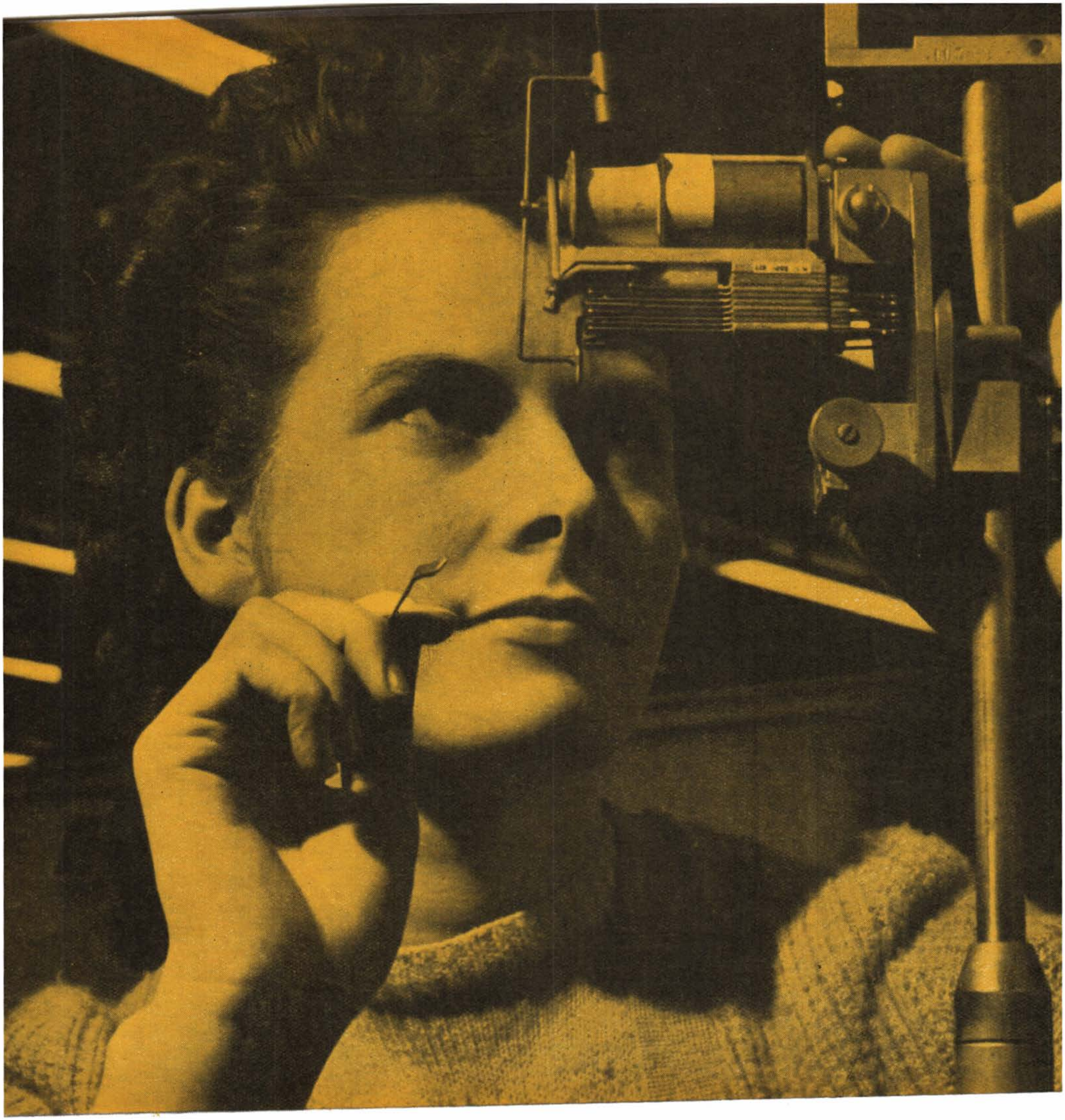

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AI263-A2·I04

All relay springs are fitted with twin contacts to ensure faultless connection. This operator is adjusting contacts for correct alignment using an instrument specially designed for the purpose. All the operations involved in the assembly and testing of these mechanisms require a high degree of aptitude and skill.

From First Principles to Finished Product

In 1835 the first relay was invented by Joseph Henry as a natural product of his earlier researches into the principles of electromagnetism. This invention is, without doubt, one of the most important which has contributed to the development of the science of Telecommunications and there are today few communication systems which do not depend, either wholly or in part, on the operation of relays.

Constant research into the metallurgical, magnetic and electrical properties of relays is carried on in Strowger laboratories. The production departments manufacture scores of thousands of relays a week, this entire output being absorbed in the assembly of the Company's major products.

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P.O. Engineers rely on Bridge-Megger Testers

64% of all the faults on the 34,000 miles of main underground cables in the U.K. are located by Megger Testers.

Megger Testers play an important part in maintaining the efficiency of the Post Office communications system.

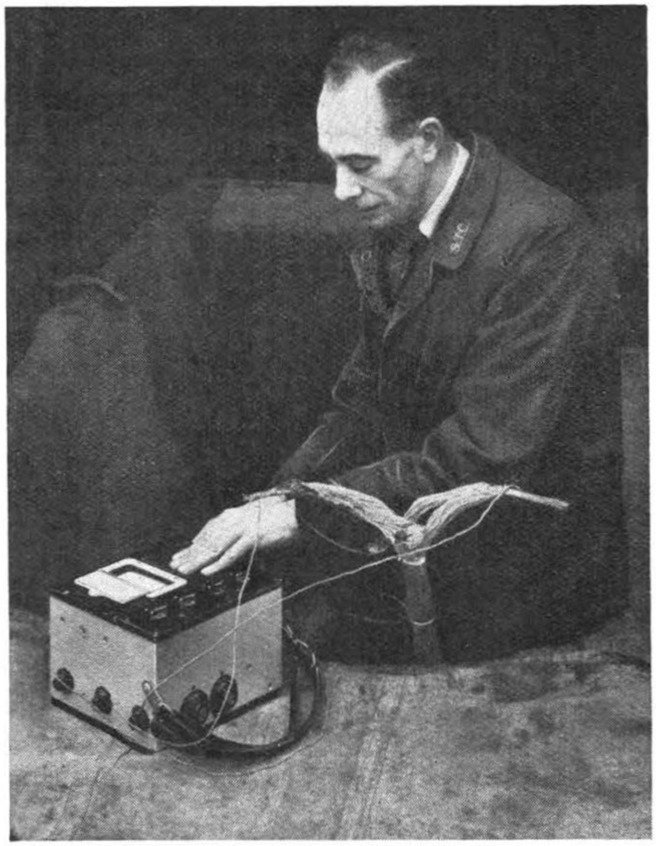
The 500 V. Bridge-Megger Tester is used by cable maintenance engineers for measuring the loop resistance and insulation resistance of underground cable pairs and for locating contact and dielectric faults of underground cable pairs. Dielectric faults with values ranging from full earths to several megohms, are successfully located depending upon the ratio of the " good " to " bad " wires. Varley, Murray, Simon and Poleck tests are carried out with the instrument.

Bridge-Megger Testers are widely used for routine maintenance tests, such as checking the insulation resistance of condensers or the value of suspected resistors.

Bridge-Megger Testers prove equally valuable to the Post Office down under. Instruments equipped with Varley fault localisation facilities are used extensively by the Australian Postmaster-General's Department for the location of faults on underground cables. They report that " it is outstanding when used to perform this function ".

The Bridge-Megger Testing Set is dual-purpose. In addition to being an insulation tester, it is capable of measuring to a high degree of accuracy a wide range of conductor resistances and is very suitable for fault location by the Varley Loop Method where the resistance of the loop is not less than one ohm.

Full details of its operation are contained in Publication No. X 212.



A Bridge-Megger Tester, Series 2, in use by the Post Office Engineering Department. The engineer is shown testing the insulation of 300 pair $6\frac{1}{2}$ lb. P.C.U.T. cable at a pavement box.

Increased need to check Earth Systems regularly

The growing tendency of water companies to use asbestos-cement type water mains, resulting in several cases of electric shock recently in the Manchester and Rochdale areas, stresses the increased need for regular checking of electrical earthing systems.

The Megger Earth Tester enables the resistance to earth of an earth plate or structure to be measured directly in as simple a manner as possible. The Megger Earth Tester complies with the Testing requirements laid down in the I.E.E. Regulations, and is invaluable not only for the initial test of soil resistivity, but also to ensure by periodical tests that the low value of the soil resistivity is maintained.

Send for Publications Nos. X 051/20, 22 and 25.

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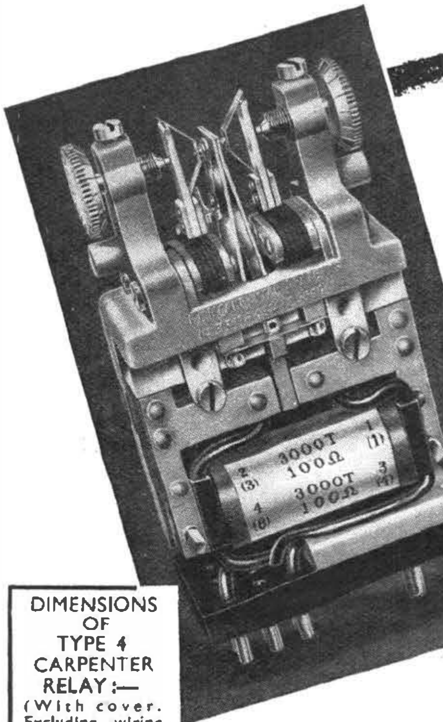
TYPE 4



DIMENSIONS OF TYPE 4 CARPENTER RELAY:— (With cover. Excluding wiring tags) 3.5 ins. high x 2.2 ins. wide x 1 in. deep. Weight 13 ozs

THIS is a medium speed, sensitive polarized relay designed primarily as a telephone impulsing relay (D.C. dialling up to 100 miles and V.F dialling on trunk circuits). It has also been successfully adopted for use in Telex systems, but can be used satisfactorily up to speeds of 100 c/s without contact chatter or serious bias disturbances.

Its sensitivity is such that when the gap is adjusted to .004 in. nominal, the relay will just operate at 50 cycles with 3.5 ampere-turns R.M.S. (corresponding to approximately 2 mVA) or on 4.5 D.C. ampere-turns at low speeds. In service, however, the relay is normally operated at currents substantially larger than the minimum operating current quoted.

Contact chatter is absent if the contact gap does not exceed .005 in. The contact gap is adjustable by means of fine pitch screws with knurled heads marked with .001 in. divisions. Contacts on the armature tongue are insulated from it and thereby from the frame.

The relay has a magnetic screening cover with transparent removable top to facilitate contact adjustment.

Dimensionally the relay is interchangeable with the type " 3000 " relay and can be supplied to fit directly to the drilling normally provided for the " 3000 " relay.

Termination can either be made by means of a 12 in. plug base as illustrated, or with soldering tags in place of the pins.

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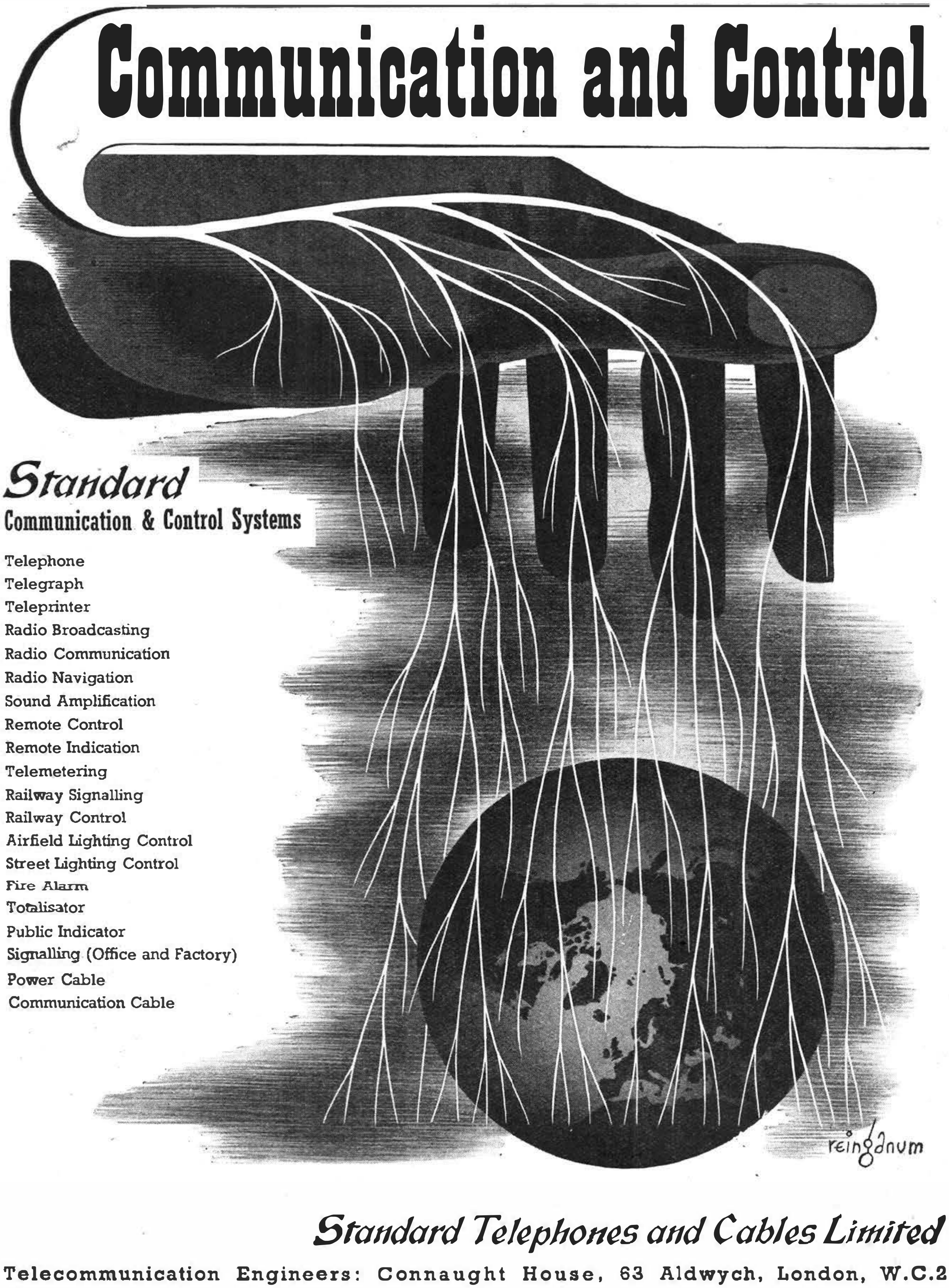
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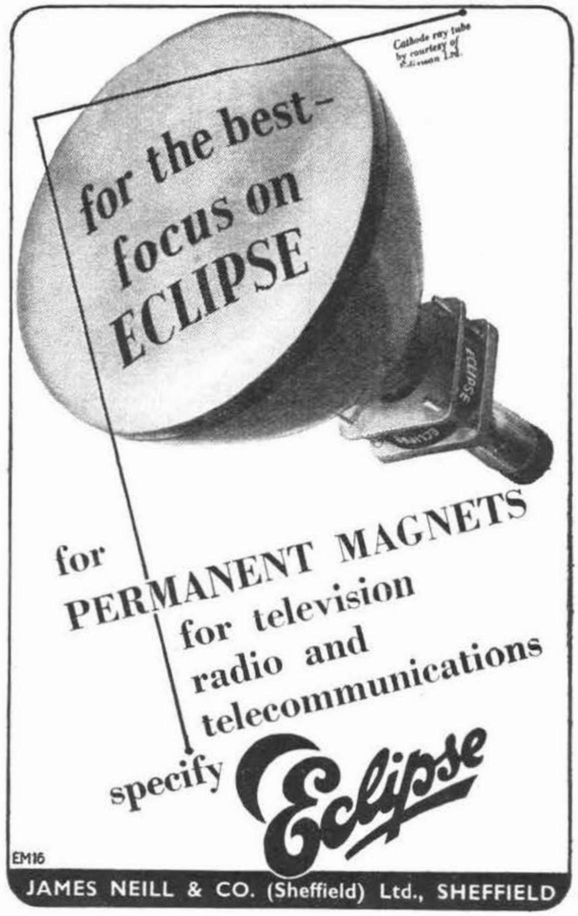

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