RA Roe
Cromwell Rd

# THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

Vol. 50 JANUARY 1958 Part 4

## CONTENTS



Price 2/6 net

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

# THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

Vol. 50 January 1958 Part 4

## Telecommunications in Nigeria

SIR GORDON RADLEY, K.C.B., C.B.E., Ph.D.(Eng.), M.I.E.E.†

THE Postmaster General and I paid a short but most interesting visit to Nigeria in September, 1957. We were there only nine days and I can hardly claim to know the country thoroughly. We did, however, manage to visit Lagos, West, East and North Nigeria, and the Cameroons as well. We inspected existing equipment and establishments, discussed future plans and visited engineering training schools.

Thanks to the very generous hospitality of the Nigerian Ministry of Communications and Aviation, we were able to meet a large proportion of the British staff and their wives on social occasions. We heard their grumbles—human beings never cease to grumble—but came to the conclusion that, taken all round, they were very happy. We also saw inside a number of their homes.

I came away with the impression of a country that had realized that an efficient telecommunication system was essential to its progressive development; moreover, that Nigeria was determined to build such a system as quickly as possible. I came away also convinced that the country offers unique opportunities for a young engineer who wishes to obtain wide experience with modern radio, line and telephone switching equipment. In Nigeria he can do all this, provided he is not afraid of standing on his own feet and shouldering rather more responsibility than he might have to do as a member of a much larger team at home.

Nigeria is a Federation with three Territories, Northern, Eastern and Western, each with its own Governor and Legislature. The Federation also includes the British Cameroons. The Federal Government deals with matters, and controls Departments, which are of national application. The Department of Posts and Telegraphs is such a Federal Department.

Taken together, Nigeria and the Cameroons cover 373,000 square miles. They form the largest British Dependency, four times the size of the United Kingdom, with a population of 33 million people. This makes the combined territories the most densely populated country in the whole of Africa. The population exceeds that of Canada, South Africa and New Zealand put together. But in this vast area, and for all these people, there are only 25,000 telephones.

The background to the present position is the recognition, by the authorities, in 1953, that posts and telecommunications in Nigeria were in a serious state of disorganization. Much of the equipment was then out of date, buildings were sub-standard in many cases, overhead lines suffering from lack of maintenance, and the discontented public were pressing for more and more development. In 1954 a report on the situation was prepared by Mr. H. O. Ellis and Major W. J. Aedy. Following the report, plans for the reorganization and development were set out in a Government White Paper. Mr. Ellis, who had had a distinguished career as an engineer in the British Post Office and subsequently served as Assistant Controller General in the Control Commission for Germany (P. & T.) and later as Postmaster General in Nyasaland, was appointed Director—the equivalent in Nigeria of the Director General in St. Martin's-le-Grand.

The Department of Posts and Telegraphs was reorganized on British Post Office lines, adapted to the requirements of Nigeria and remodelled, where necessary, to take account of the relatively very much smaller size of the Department. A regional organization was adopted. This was based on the three Territories, Lagos (which, like Washington, D.C., is in no Territory) and the Cameroons. The Territorial Controller's functions are similar to those of Regional Directors in the British Post Office.

*By courtesy of Nigeria Trade Journal and the Federal Information Services*

LAGOS AUTOMATIC EXCHANGE, EQUIPPED WITH PRE-2,000-TYPE SWITCHES. NEW EXCHANGES ARE BEING EQUIPPED WITH S.E.50 SWITCHES.

The Federal Government prepared a 5-year economic development program covering the years 1955–60. Within this program £13 million was allocated for the development of the postal and telecommunication services—a large

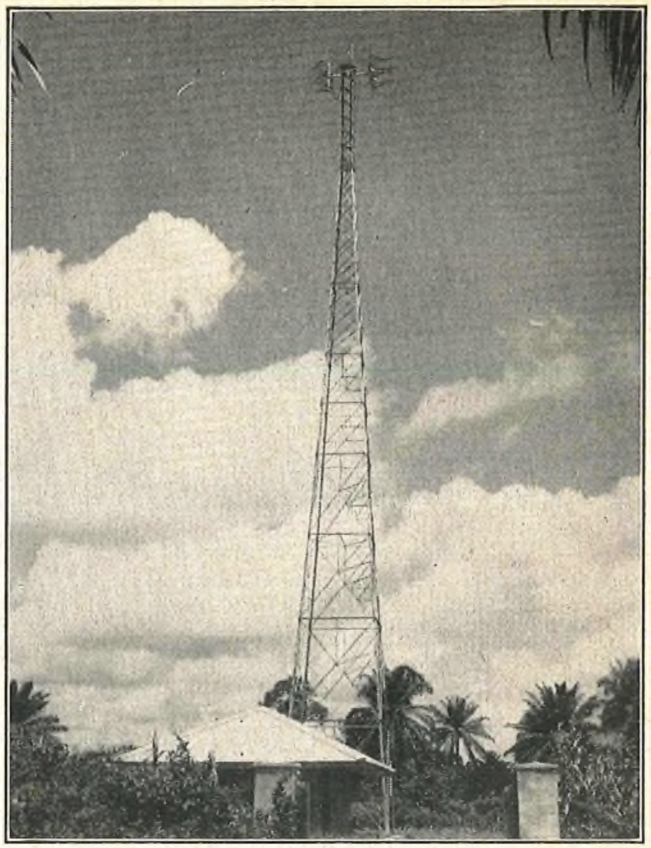
† Director General of the British Post Office.



A

sum for Nigeria. Dr. the Hon. K. O. Mbadiwe, who was then Minister of Communications and Aviation, took a great personal interest in the plans that were made. He visited the United Kingdom and sought the help of Dr. Charles Hill, who was then Postmaster General. He invited British manufacturers to assist in making available a steady flow of equipment for the telecommunication services. Bulk-supply agreements between the Federal Government and certain United Kingdom manufacturers were signed in the spring of 1956. They covered the provision of transmission equipment, telephone exchange and subscribers' apparatus, cable and wire. In all this the British Post Office acted in a technical advisory capacity. We helped in drawing up the agreements; we acted in an advisory capacity on equipment as orders came forward. Finally the Post Office sent a senior engineer to Nigeria in the summer of 1956 to assist the Director in assessing the problems involved in moulding into the development plan facilities for subscriber trunk dialling.

In some towns in Nigeria the telephone exchanges are very old and the equipment is in the "museum piece" category. New demand in some places is two or three times the number of working lines. But to meet the new demand and to replace the outdated apparatus modern automatic exchanges are being built. Lagos, for example, which we first visited, is now served by a main automatic exchange with three satellites providing, at the moment, for 7,000 subscribers on a non-director basis. The development plans envisage 11 main non-director automatic exchanges in other towns in Nigeria, and some 30 rural exchanges which will be served by Rurax equipment. They also include subscriber trunk dialling between Lagos and Ibadan, 76 miles. Funds do not permit the installation of automatic equipment in all the exchanges which are being built,



*By courtesy of Nigeria Trade Journal and the Federal Information Services*

A Typical V.H.F. Repeater Station in the Bush.

12-Channel Carrier Equipment at Kaduna.

but, in addition to the automatic exchanges, existing manual exchanges are being extended and new ones provided.

At present, telephones are concentrated in a few comparatively large towns which are business and administrative centres. These are separated by long distances. Consequently, development of the trunk system is of primary importance. Before modernization started all the long-distance circuits were provided on open wires. Carrier equipment has been added to these open-wire routes to increase their capacity, and on some of the routes transistorized rural carrier systems will be installed. There is no doubt about the up-to-dateness of some of the equipment that is going in in Nigeria. There are, in fact, already between 25,000 and 30,000 circuit miles provided by modern carrier equipment. In addition to this, Nigeria will shortly complete a v.h.f. radio-relay system linking up the main centres. The intention is to add u.h.f. links.

The British Cameroons, running along the eastern side of Southern Nigeria, is a rugged mountainous country. It is the centre of the banana industry and a rapidly developing tea-growing region, but has, so far, been without any proper telephone service. Here the engineers have had to cope with the problem of finding a site for a v.h.f. station to provide a radio link making connexion with the Nigerian trunk network. The solution lay in a site 8,000 ft up the side of the Cameroon Mountain, and the Department is at present building a 13-mile road snaking up the mountainside to reach it. The power equipment will be located at the base of the mountain, a feed being taken up alongside the road. The v.h.f. station will be linked with the station at Buea, the administrative centre, by means of carrier cables.

Many unusual problems present themselves. One is the provision of telephone services to the huge area formed by the delta of the Niger, which is interspersed with numerous water channels and mangrove swamps. In this area there are many small communities, often with their local schools and hospital dispensaries, which require telephone service. The only practical means of providing it is by radio telephone, using transmitters and receivers capable of operation for long periods on small 12V batteries, and many such units are to be installed.

The telegraph system presents a special problem because of the great distances between offices, which make it far too expensive to contemplate telex working at this stage in the development of the country. Instead, a punched-tape relay system is to be installed which will be unique in the Commonwealth so far as public traffic is concerned, although of course it is a system that has been well tried in aeronautical circles. With the new equipment a great increase in the rate of transmission of telegrams will be achieved. Large business houses will be provided with tape terminals which will enable them to operate directly into the public system for both the transmission and reception of messages.

Nigeria is, in fact, building a modern telecommunication system using advanced equipment. In this land of technical adventure there is no time for the gradual gathering of experience. For many years the country must rely for technical assistance and staff on the United Kingdom, and in the United Kingdom Nigeria looks first to the Post Office. Dr. Mbadiwe made this clear two years ago and the new Federal Minister of Communications and Aviation, Chief Akintola, has repeated Dr. Mbadiwe's request for help. We have already done something. There are, in Nigeria, at the moment, a number of engineers of various ranks from the Post Office. Some are serving on approved employment terms, some on temporary transfer pending appointment to the Colonial Service, and some have been transferred to the Colonial Service. But Nigeria requires many more. Nigeria requires engineers whose training has given them a grasp of contemporary technical possibilities, to which they have added a measure of engineering experience. They must be intellectually capable of a broad outlook. They will find abundant good will in Nigeria and abundant opportunity for exercising their talents.

The new Minister of Communications and Aviation fully realizes the necessity of making the terms of employment and conditions of service attractive to engineers who come to his country from the United Kingdom, whatever the period of their expected stay. I have promised, on behalf of the Engineer-in-Chief, that Post Office engineers who respond to invitations to go to Nigeria will not be forgotten as regards their promotion in the Home Service. We will take into full account the valuable experience that engineers can gain in Nigeria, sometimes more rapidly than they could at home.

Living conditions throughout Nigeria vary considerably. In the large towns there are shopping facilities although, of course, these are not as elaborate as those which are found at home. Elsewhere, conditions are more primitive, and reliance has to be placed on the native market. Houses are provided for the expatriate staff, and although there is a shortage of these at the moment I believe that energetic steps are being taken to put this right. The houses which we saw belonging to the most senior officers were indeed very pleasing, and it is, I think, fair to say that it is the intention of the Federal Government that good homes should be available for all those staff coming out from the United Kingdom. And, finally, Nigeria has long been thought of as most unhealthy, but that is now far from true. Certainly the many members of the Post Office serving in Nigeria, whom I met, looked extremely well.

*By courtesy of Nigeria Trade Journal and the Federal Information Services*

RADIO AND TELEPRINTER OPERATORS AT IKEJA AIRPORT ON POINT-TO-POINT SERVICES FOR THE DEPARTMENT OF CIVIL AVIATION, WHICH ARE RUN BY THE P. & T.

## Postscript by the Postmaster General

The Director General has asked me to add a few lines to the story he has written about our trip to Nigeria. I do so gladly.

He and I came away with a shared impression. He has tried to convey it to you. It is that of a country which has made far-reaching plans for the rapid growth of its telecommunication services—and for its roads, railways and other facilities that are essential to a progressive and developing country. Amazing progress has already been made towards carrying out these plans for more telephones and an efficient long-distance service. We saw this for ourselves. But there is very much more still to be done. And both now, and for many years to come, Nigeria will have to rely on British engineers for this if she is going to do what she wants to do. Chief Akintola, the Minister of Communications and Aviation, appreciates this. He told me so.

The Director General tells me that the work to be done offers great opportunities for technical adventure. All that I can say is that it is technical adventure in a very friendly country. Anyone who decides to help Mr. Ellis and his staff for a period will find it so.

Ernest Marples.

# Nigeria's Posts and Telecommunications Developments

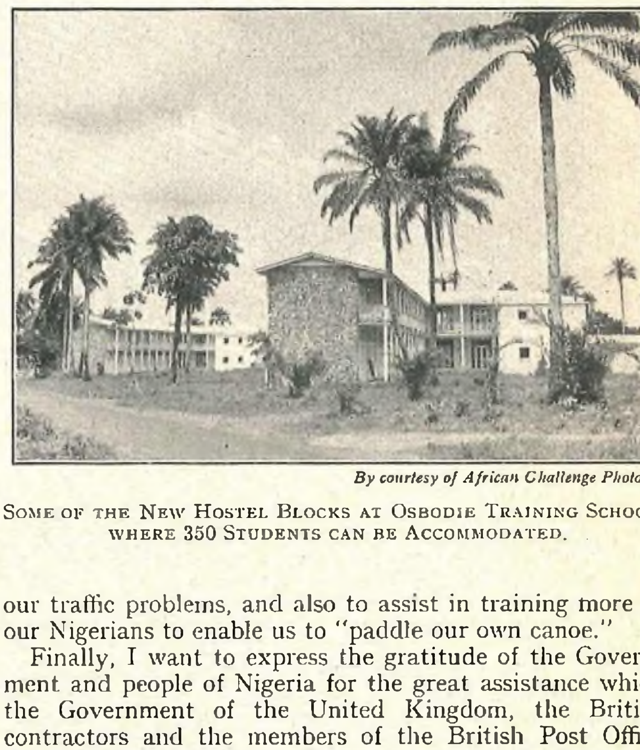
The Honourable Chief
S. AKINTOLA†

The Honourable Chief S. Akintola, Minister of Communications and Aviation, Federal Government of Nigeria.

THE visit of Mr. Marples, the Postmaster General, and Sir Gordon Radley, the Director General of the British Post Office, which took place recently, was a great pleasure to me and to the members of my Ministry and my Department in Nigeria. Not only was it a great pleasure but it marked for us in Nigeria, the recognition by such eminent people of the great effort which is being put into the modernization of the postal and telecommunication system of the country. Much has appeared in British newspapers of recent months about Nigeria, but I think it is true to say that comparatively little is known in the United Kingdom about the country and even less about its communications system. As you would expect, I make no claims to be able to discuss the telecommunication problems of Nigeria from any technical aspect. From my point of view, and that of the general public, it is urgently necessary to provide all our services as widespread and as rapidly as possible.

Nigeria stretches some 700 miles inland from the Gulf of Guinea and, roughly rectangular in shape, it is nearly 600 miles from its East to West boundaries. Within this large Territory the climate varies from the hot humidity of the South to the dry and sandy North; while in the East the Territory is bounded by the massive Cameroons' mountain ranges and hills. The country is well served by roads, including several thousand miles of tarmacadam main roads. It has long since ceased to be a country of sickness and ill-health. The introduction of the painless yellow fever innoculation and the use of well-tried malaria prophylactics keep Europeans in very good health throughout the whole Territory and the frequent incidence of leave in the United Kingdom serves to provide very adequately for the change and rest which contributes to their well-being. Meanwhile, the health of the Nigerian population is being vastly improved by modern methods of hygiene and of health control. As a consequence of this, the country is well fitted for the vast commercial, industrial and agricultural development which is taking place so rapidly in it, and its exports of cocoa, palm and ground nut oil, skins, timber and tin, find a ready market in keeping the economy of the country buoyant. Hundreds of thousands of young Nigerians now enjoy free education which equips them to take part in the commercial development of the Territory.

All these factors add up to a great demand for an improved telecommunication and postal service. My Ministry, my Department and I are doing our best to help ourselves by training Nigerians to undertake an increasing amount of the technical, clerical and administrative work which is involved in this great expansion. On the engineering side, we are receiving a great deal of help in the loan of staff from the British contractors who are supplying the equipment necessary to expand our telecommunication facilities. Already we have no fewer than 37 men from the British Post Office engaged on engineering and traffic work, and they are an efficient body of men who work closely and happily with their Nigerian colleagues. But we still require more people from the British Post Office to enable us to complete the installation of our modern automatic, telegraph and transmission systems; to keep our large fleet of postal and engineering vehicles on the roads; to look after our underground cable schemes and our overhead lines; to deal with our traffic problems, and also to assist in training more of our Nigerians to enable us to "paddle our own canoe."



*By courtesy of African Challenge Photo*

Some of the New Hostel Blocks at Osbodie Training School, where 350 Students can be Accommodated.

Finally, I want to express the gratitude of the Government and people of Nigeria for the great assistance which the Government of the United Kingdom, the British contractors and the members of the British Post Office have so willingly given in the past. I look forward to our continuing friendship and to further help. Those who respond to our requests for officers to come out and help us in the many intricate and modern developments of our telecommunications program will be welcomed; they will have a unique opportunity of undertaking work of exceptional interest and responsibility and they will have the unusual privilege of taking a very real and personal part in the development of a young and rapidly developing country.

† Minister of Communications and Aviation, Federal Government of Nigeria.

# Flameproof Telephones and the Development of a Table Model

J. L. BELK, Associate I.E.E., and E. WOODWARD†

U.D.C. 621.395.721.1:614.83

**This article outlines the methods of ensuring that telephones used in situations where dangerous gases and vapours are present do not cause explosions, and refers to the arrangements for certification of the degree of safety provided by specific items of telephone apparatus. The article then refers briefly to existing Post Office flameproof telephones and continues with descriptions of two versions of a newly developed table model flameproof telephone.**

## Introduction

ALTHOUGH the telephone works at such low power that its safety in everyday use is never in question, there are circumstances in which great care must be taken to ensure that a spark at a contact or at an accidental disconnexion cannot cause an explosion if dangerous gases or vapours should be present.

Oil refineries and chemical plants are perhaps the two main places which spring to mind when considering where explosive gases might occur, and with the increasing consumption of both oil products and synthetic materials, and the consequent increase in the number and size of the industrial plants concerned, the safety of life and plant from the dangers of explosion is worthy of all the care and attention that is given to the design and manufacture, and the installation and maintenance of special equipment.

Telephone apparatus for use in mines, which is not fitted by the Post Office, is outside the scope of this article. The design, installation and maintenance of all telephone and signalling apparatus for use in mines is governed by the Mines and Quarries Act 1954, and the specific requirements are given in Statutory Rules and Orders No. 797 and No. 1407: 1938.

## Methods of Providing Safety

Although alternative methods are occasionally used in heavier forms of electrical engineering, in telephone engineering the two principal methods of providing safety utilize either a circuit that is safe because it cannot cause a dangerous spark (intrinsic safety), or a mechanical construction that will withstand an internal explosion and will not transmit flame outwards to an external explosive atmosphere (flameproof construction).

These two methods, which are described in more detail in the following sections, are the subject of practical tests which are imposed on actual items of equipment by the Safety in Mines Research Establishment at Sheffield and Buxton. On the results of these tests, a Flameproof Certificate is issued by the Ministry of Power, or a Certificate of Intrinsic Safety is issued by H.M. Chief Inspector of Factories, Ministry of Labour and National Service, or the Ministry of Power, depending on whether the equipment is for use in industry or coal mines. The equipment is type tested, i.e. the item that is tested is regarded as fully representative of the manufacturer's normal production and the certificate covers this normal production. Any subsequent change to the drawing mentioned on the certificate requires further certification.

There are cases, however, where it is not practical to use either of these two methods, and in such cases safety can be ensured as far as possible by the method and standard of construction. The Factory Inspectorate of the Ministry of Labour and National Service again issue a certificate after consultation with the Safety in Mines Research Establishment. An example of this type of certification is described later when dealing with the development of the flameproof table telephone (1,000-ohm version).

It has not yet been practicable to make a telephone handset and cord flameproof according to the requirements of B.S.229 "Flameproof Enclosure of Electrical Apparatus," and hence, although telephones are commonly described as flameproof, usually only certain parts have been certified as such. Consequently it should be realized that in these instances the term "flameproof" is not strictly correct as a description of the complete telephone, but it is used as a convenient indication of the type of installation for which the telephone is intended.

## Intrinsic Safety

Protection by the method of intrinsic safety is achieved by using a safe source of supply, either primary cells whose open circuit voltage does not exceed 24V, or a special transformer of 15V r.m.s., or in the case of a magneto telephone, by using an approved generator. All these sources of supply have limited short-circuit currents, the limitation usually being obtained by using series resistors or in the case of the generator by the inherently high impedance of the windings in conjunction with a non-inductive shunt resistor. Furthermore, the supply must not be earthed. Together with the limiting of the source of supply, it is usual to fit protective devices in the form of non-inductive resistors or metal rectifiers across the inductive components of the circuit to by-pass the inductive energy that would normally appear as a spark at switching points during the operation of the circuit. By these means any sparks, which might appear at switching points or at any point of fault, are of such low intensity that they are incapable of igniting the gas or vapour which might be present. Intrinsic safety is the statutory method used for signalling and for telephones in coal mines (Mines and Quarries Act 1954). The main reason for this is the need for the telephone system to keep pace with the moving coal face without undue attention to the standard of cabling.

## Flameproof Apparatus

With protection in the form of flameproof apparatus no steps are taken to prevent the sparking that would normally occur during operation of the circuit or which might occur under fault conditions. The protection is obtained by enclosing the components in a robust metal enclosure, defined in B.S.229 : 1957 as:—

"A flameproof enclosure for electrical apparatus is one that will withstand, without injury, any explosion of the prescribed flammable* gas that may occur within it under practical conditions of operation within the rating of the apparatus (and recognized overloads, if any, associated therewith), and will prevent the transmission of flame such as will ignite the prescribed flammable gas which may be present in the surrounding atmosphere."

The design of such an enclosure is based on the following data. All joints in a flameproof enclosure must be either flanged joints, spigoted joints or screwed joints without the

† Mr. Belk is an Executive Engineer in the Subscribers' Apparatus and Miscellaneous Services Branch, E.-in-C.'s Office, and Mr. Woodward is with Ericsson Telephones, Ltd.

* The term "flammable," now used by the British Standards Institution, is synonymous with the more common term "inflammable."

intervention of any loose or perishable packing. The width of these joints and the maximum permissible gap are related to the groups of gases and vapours listed in B.S.229. The flange width in general should be at least 1 in. with a maximum permissible gap of 0·016 in., although where the gap can be more accurately controlled, widths of ½ in. are now acceptable. The maximum gap related to the ½-in. flange is 0·006 in. for the gases encountered in the petroleum and chemical industries.

The tests to ensure that the maximum permissible gap is not exceeded are made by checking that each part of the mating surfaces of the flanges does not vary from a true plane by more than half the stated figure, i.e. for telephone equipment covered by this article, the maximum variation is not greater than 0·003 in.

Where an operating rod or spindle passes through the wall of a flameproof enclosure, it must be of metal and the hole through which it passes must be such that the effective length of the flame-path is not less than 1 in., fitting as closely as operating conditions permit. In no case must the diametral clearances of the flame-path exceed 0·016 in. and 0·008 in. for gases in Groups II and III respectively.

For the purposes of flameproof certification, gases are divided into four groups as follows.

Group I covers requirements for coal mines.

Group II covers, in general, the petroleum, chemical and paint industries. Prior to 1957, this group was divided into five sub-groups *a*, *b*, *c*, *d* and *e* according to the types of gases met in particular classes of industry.

Group III, divided into two sub-groups, covers (*a*) the more sensitive vapours of the petroleum industry and (*b*) coal gas and coke oven gas.

Group IV. The gases (including hydrogen and acetylene) in this group demand a maximum permissible gap which is too small to be practicable to justify certification on the basis of type tests. It is possible to produce apparatus which will withstand a hydrogen test but it is doubtful whether the same standards of construction could reasonably be expected in commercial production. Approval for individual apparatus for use with gases in this group is usually given in the form of a Test Report issued by the Ministry of Power.

When apparatus is certified, the certificate quotes the groups of gases for which the apparatus is considered suitable. The apparatus should not be used in gases of other groups even though the test conditions appear to be the same. If the apparatus were suitable for use in other gases, quite naturally the manufacturer would ensure adequate certification to increase his sales.

The onus for prescribing the groups of gases which might be encountered in any telephone installation rests with the subscriber. Care should then be taken that any apparatus which is used is certified for those groups.

### Existing Flameproof Apparatus

Because of the rigid mechanical requirements, flameproof apparatus has always tended to be strictly functional, and in general the lack of aesthetic appearance has not been questioned.

Fig. 1 shows the Post Office Telephone No. 149, which has been available for use on automatic and C.B. systems for many years. A similar instrument, the Telephone No. 153, has also been available for magneto working. These telephones will continue to be available for installations where the newly developed table telephone cannot be used. They are wall-mounted instruments and are weatherproof.

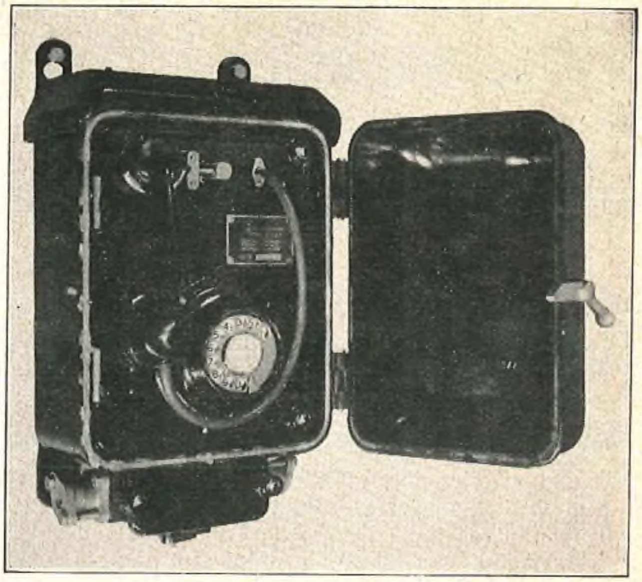


Fig. 1.—Telephone No. 149.

Certificates of flameproof construction which they carry (Groups II and III for the Telephone No. 149 and Groups I and II for the Telephone No. 153) relate only to the enclosure of the more dangerous elements of the circuit such as the dial and the switch-hook contacts.

### Development of a Flameproof Table Telephone (600-ohm Version)

The remarkable developments by the oil industry in the production, refining and distribution techniques of petroleum products have created an increased demand for telephone equipment. It is now commonplace to have remote control rooms in which are housed metering and recording equipment together with the control desks. Telephones are essential features in these control rooms and, apart from their flameproof properties, it was considered desirable that they should be similar to the conventional table telephones if the appearance and function of the control rooms were to be maintained. Consequently the development of a table model was put in hand, and it was soon apparent that the design would have to be based on the following lines:—

(*a*) The bell should be housed in a separate enclosure due to the difficulty of finding a suitable arrangement for the bell gongs. The gongs could not be mounted on the outside of the telephone case if appearance were to be preserved, and they could not be mounted inside, for there they would not be heard.

(*b*) The line connexion to the instrument should be via a flexible cable to permit the telephone to be moved to suit the convenience of the user.

These two considerations led to the design of a unit in which is housed the bell and also the terminal block for the connexion of the rigid permanent line.

The bell coils are mounted inside the case and their cores are carried through the case to actuate the bell-hammers. The bell and terminal unit, which is shown in Fig. 2, can be fitted in a convenient place near the telephone, and connected to it by a tough rubber-sheathed cable, which is a permitted cable in areas when only an occasional hazard may exist. Being a separate unit, the bell and terminal unit can also be mounted as an extension bell if desired.

A range of glands has been developed to enable conduit or any of the accepted forms of permanent cabling for hazardous areas to be connected easily and safely to the bell and terminal unit.

The case of the telephone instrument, shown in Fig. 2 and 3, is constructed throughout in aluminium alloy LM6,

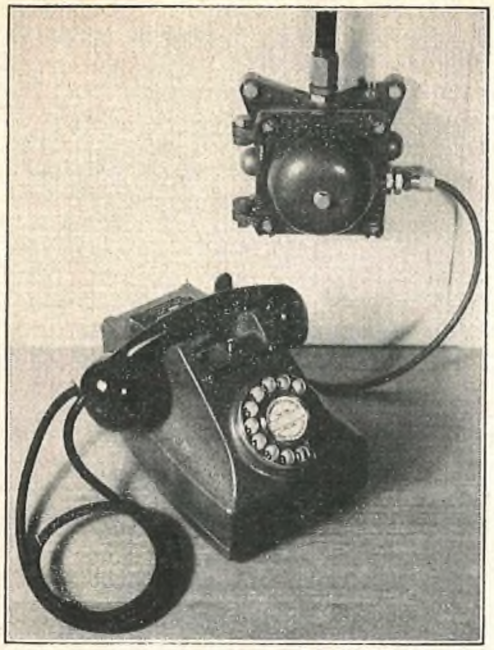


Fig. 2.—Flameproof Table Telephone and Bell.

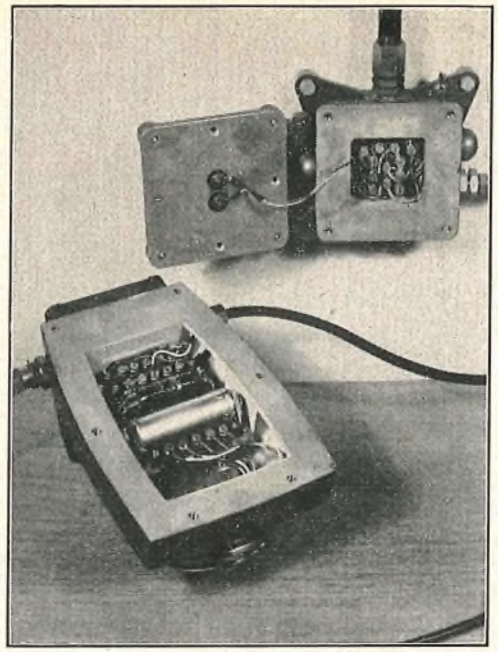


Fig. 3.—Flameproof Table Telephone and Bell with Covers Removed.

the use of which not only permits a great saving in weight, but, more important, because of its low magnesium content, precludes the possibility of frictional sparking which might occur with other materials if the instrument were accidentally dropped.

The case consists of two compartments: (*a*) the main enclosure in which are housed the circuit components and (*b*) the terminal chamber. This segregation is normal practice with all flameproof electrical apparatus to ensure that the main enclosure is not disturbed when connexion or disconnexion of the line wires is required.

The cover of the main compartment serves as the base of the instrument and is fitted with four rubber feet. It is secured to the body by six triangular-headed screws, which are recessed to discourage unauthorized access. A warning notice is embossed on both covers to the effect that the circuit must be isolated elsewhere before either cover is removed.

The dial is of the latest "trigger" type, and the mechanism can be detached from the instrument case by removing three screws located round the rim of the dial case. Owing to the extra friction due to the flame-path along the operating spindle, it is necessary to return the finger plate back to normal independently of the dial mechanism, so enabling the dial mechanism to operate unhindered. In this method of operation the finger plate flies back under the action of its own spring and is locked in the rest position until the dial mechanism has returned to rest. Otherwise the dial would be very prone to mis-operation. Provision is also incorporated in the dial to lock the mechanism for C.B. working.

The remaining elements of the circuit within the case are mounted on a chassis that can easily be removed for attention.

It was evident during the development of the table instrument that it would be difficult and impractical to make the handset and cord of flameproof construction. Hence it was decided to try to make the transmission circuit intrinsically safe by limiting the maximum short-circuit current at the microphone to be less than the minimum igniting current as ascertained from test conditions. Tests using pentane as the representative vapour were conducted by the testing staff of the Safety in Mines Research Establishment and were made with the standard 600-ohm circuit telephone connected to standard Strowger circuits. It was found that under loop conditions ignition could be obtained with zero line and with both a.c. ringing current and d.c. transmitter feed current causing a spark in the microphone circuit with the microphone short circuited. Such a condition could arise with a sticking F relay in the final selector at the exchange and, simultaneously, an instrument fault. The chances of such a condition are extremely remote, but when safety is concerned such are the conditions of test. It was found possible to reduce the intensity of the spark to a safe level under these conditions by inserting a 160-ohm resistor in the circuit as shown in Fig. **4**. Although this resistor reduced transmission by about 2 db in each direction and reduced the line signalling limits by 160 ohms, the losses were regarded as unavoidable in the interests of safety.

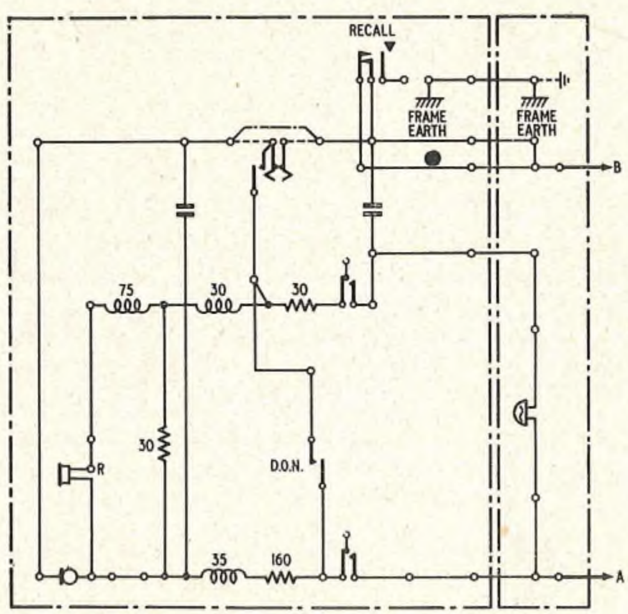



Fig. **4**.—Circuit of the 600-ohm Flameproof Table Telephone.

## Development of the Flameproof Table Telephone (1,000-ohm Version)

With the advent of the 1,000-ohm loop telephone circuit it was decided that any new flameproof telephone should take advantage of this latest development if it were to have a useful life without modification.

Further, while the tests on the 600-ohm version had proved the handset circuit to be safe under the conditions of test, no proof was available that the circuit would still be intrinsically safe if the instrument were to be connected to any of the many earlier and different systems used by the Post Office. A very involved testing program would have been necessary to check the safety of the circuit in practical tests in conjunction with all these circuits and circuit elements and, moreover, possible earth fault conditions were an additional point of doubt. The new table telephone (600-ohm version) was, however, an improvement on the existing instruments.

Because of all these points it was decided to utilize the 1,000-ohm loop circuit (Fig. **5**), and in consultation with the Safety in Mines Research Establishment a different approach was made to the problem of the safety of the handset and cord.

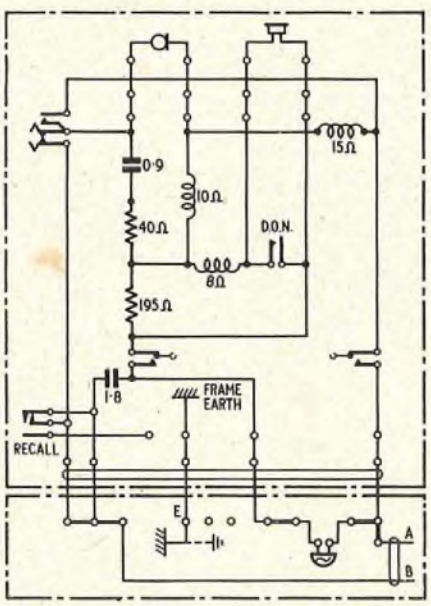



Fig. **5**.—Circuit of the 1,000-ohm Flameproof Table Telephone.

As mentioned earlier, an accepted method of providing an adequate degree of safety under practical working conditions is by ensuring a suitable design and standard of construction.

The scheme adopted in this instance was:—

(*a*) To fill the free space where pockets of gas or vapour could possibly collect in the Handset No. 1,[1] which is used in conjunction with the 1,000-ohm circuit. This was done by fitting a moulded rubber insert at the back of the transmitter, and fitting rubber plugs into the ends of the hollow handle to seal the space around the wires. No filling was required for the receiver end of the handset because the presence of the lead weight was considered sufficient.

(*b*) To secure the receiver and mouthpiece caps to prevent unauthorized entry. The caps on the Handset No. 1 are both of the screw-on type and it was decided that the use of Allen screws to secure the cups would give adequate safeguard against indiscriminate removal.

(*c*) To provide some form of metallic braid to a robust tough-rubber sheathed flexible handset cord which should be firmly secured at each end. The type of cord which met the approval of the testing authority is "Stranded 55/·004 in., 4-core, V.I.R. 0·02-in. radial, neoprene sheathed 0·04 in. nominal, braided with 0·006-in. tinned copper wire and covered overall with nylon cordonet."

This telephone with the 1,000-ohm circuit has now received its certificates as follows, the bell and terminal unit and telephone case remaining as for the 600-ohm version.

| | |
|---|---|
| Complete Telephone .. | Factory Inspectorate Certificate No. 202 |
| Telephone Case .. .. | Flameproof Certificate No. F.L.P. 3651 |
| Bell and Terminal Unit.. | Flameproof Certificate No. F.L.P. 3652 |

These certificates were based on B.S. 229 : 1946 and cover groups II(*a*) and II(*b*).

## Installation and Maintenance

With all the care and attention taken in the design and certification of these special telephones, it is obvious that they should be installed carefully and maintained in good condition. The precaution of disconnecting a circuit at a point outside the area of risk or at a certified switching point should always be taken before opening flameproof apparatus in an area of risk. When covers are replaced, the flanges should always be wiped clean to ensure that the joint gap is not widened by any trapped dirt or foreign objects. Any repairs or replacements must be in conformity with the drawings specified on the safety certificates, and, because of this, only minor replacements are permitted in the field. The ultimate success of the standard of safety provided by the apparatus depends on the standards of installation and maintenance.

## Conclusion

The foregoing is but an outline of the certification of telephones for use in locations where there might be an occasional danger from explosive gases or vapours. Present-day knowledge of the behaviour of explosive mixtures is the result of years of research and the statistical evaluation of very many practical tests, and its application to telephones is only part of the work of the Safety in Mines Research Establishment, where all types of industrial equipment are dealt with.

In addition to gases and vapours, there are many dusts which ignite easily and explode with considerable force. These dusts, many of which are of such common materials as cocoa, flour and sawdust, demand precautions which are, if anything, more exacting than the flameproof construction that has been described. In addition to the flameproof construction, it is necessary to make the equipment completely dustproof. The use of flameproof equipment for protection in dusty atmospheres is not therefore justified and the publication of a British Standard on this subject is awaited with interest.


## Acknowledgments

The authors wish to express their appreciation of the co-operation that they received in the testing and certifying of the new telephones from the Safety in Mines Research Establishment and the Inspectorate of Factories. They also wish to record that the request for a flameproof table telephone came from the Oil Companies Materials Committee.


[1] Spencer, H. J. C., and Wilson, F. A. The New, 700-Type Telephone. *P.O.E.E.J.*, Vol. 49, p. 69, July 1956.

# Recent Developments in the Use of Polythene Cables for Subscribers' Lines

E. J. WADDON,
Graduate I.E.E.†

U.D.C. 621.315.2:621.315.616.96:678.742.2

**This article reviews developments in the use of polythene cable for subscribers' lines, describes some new jointing techniques and discusses the maintenance and economic implications.**

## Introduction

SINCE the large-scale introduction by the Post Office of polythene insulated and sheathed cables in local distribution networks, the use of this type of cable has increased rapidly, and over 225,000 loop miles of polythene cable have now been installed, representing a capital value of approximately £9,000,000. While a certain amount of this has been erected as aerial cable and some drawn into ducts, most of it has been directly buried in the ground, chiefly by hand-trenching, although quite a large amount has been laid by mole-drainer. Methods of installing and jointing polythene cables have been described in an earlier article in the Journal[1]; the purpose of this article is to review developments that have taken place during the last few years.

## Engineering and Economic Considerations of Polythene Cable

Earlier supplies of polythene cable had a screen of aluminium foil tape under the sheath. The screening thus provided was of doubtful value, and has now been omitted except for cables used for special purposes, such as B.B.C. outside broadcasts. Furthermore, a survey has shown that very few of the telephone cables in the United Kingdom require a screen. This does not include cables in close proximity to main railway systems scheduled for electrification,* where it is probable that even the screening provided by a lead sheath of normal thickness will be insufficient.

The metal foil screening tapes have been replaced by paper tapes, which prevent the polythene sheath sticking to the core during manufacture and facilitate subsequent removal of the sheath where required during jointing operations.

Advancements in extrusion techniques have made possible a reduced thickness of 12 mils of polythene insulation over each conductor, resulting in a cable of smaller overall diameter and a certain saving in polythene. Coupled with the fall in price of polythene, this has led to the cost of polythene cable in the sizes that are available (up to 50 pairs) becoming less than that of the equivalent-sized lead-sheathed paper-core cables protected with hessian tape; and the smaller sizes of polythene cable (up to 15 pairs) are also cheaper than the equivalent plain lead cable. The reduction in overall diameter of all sizes of polythene cable due to the omission of the aluminium tape screening and the use of thinner insulation has resulted in a cable of approximately the same diameter as, or in many cases less than, the equivalent lead-sheathed paper-core cable protected with hessian tape. By virtue of the waxy texture of polythene, cables having a sheath of this material are well known for the ease with which they can be drawn into duct, and it is possible to achieve far tighter "draw-overs" than would be possible using lead cable protected with hessian tape; in addition, polythene cable is less objectionable to handle.

† Assistant Engineer, External Plant and Protection Branch, E.-in-C.'s Office.

* British Railways have announced their intention of electrifying main lines in several parts of the country; power will be supplied at 25 kV, 50 c/s by means of an overhead catenary.

[1] Donovan, J. G., and Lanfear, J. S. A New Method of Underground Distribution. *P.O.E.E.J.*, Vol. 46, p. 183, Jan. 1954.

## Water Barriers

After a certain amount of polythene cable had been installed, cases were brought to light where the sheath of directly-buried polythene cable had been punctured by mechanical means, allowing the ingress of water, but no damage had occurred to the conductors or their insulation. Since the polythene insulation was impervious to water, no electrical fault resulted until the water reached a jointing point and came into contact with the wire joints. The rate of flow of water along the cable can be very rapid and has been observed to be at least 7 yd/hour under average conditions.

Some form of water barrier was necessary, and for all new work a rubber sleeve with a flexible tapered skirt (Fig. 1)

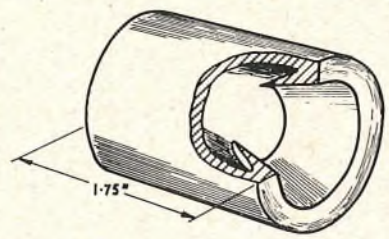



Fig. 1.—"Sleeve, Water-Barrier" Part Sectional View.

was fitted over the butt of each cable at jointing points, and filled with compound. A completed joint, in which the water-barrier sleeves can be seen, is shown in Fig. 2. The

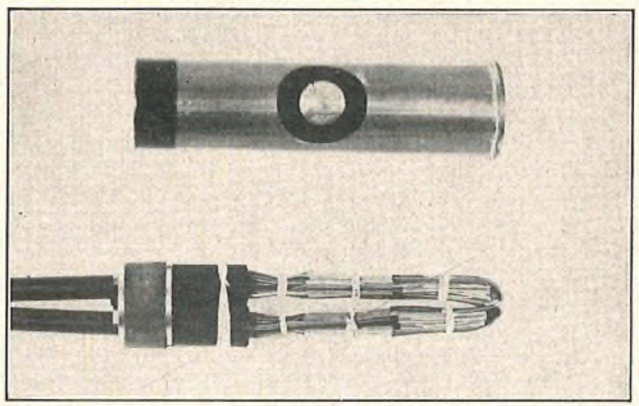


Fig. 2.—Expanding Plug Joint, Showing Water-Barrier Sleeves

choice of a suitable compound presented a difficult problem, certain proprietory brands which were originally tried proved inconsistent; however, a specially developed compound based on a micro-crystalline wax isolated as a by-product in petroleum distillation, and having a low viscosity when molten, is now used with success. It was found essential to the success of the completed seal that the temperature of the compound, when poured, should exceed the crystal melting point (235°F) of the polythene insulation over the conductors. Although a "cold-setting" resin of the epoxide or polyester type would at first sight appear a more attractive sealing medium, such materials suffer from several disadvantages, namely, high cost, limited shelf life of the constituent chemicals and unsuitability for use in the field where it would be difficult to ensure the correct proportion of resin to hardener. An additional factor which should be borne in mind is the strong possibility of dermatitis being caused on men who would be in regular contact with the material. (In the U.S.A., where such materials are widely used for various purposes, it has been stated that "epoxy resins and amine hardeners are the greatest single source of contact dermatitis in industry."[2])

A properly constructed water barrier will effectively withstand an appreciable head of water, and many lengths of cable which are in service are working satisfactorily despite the fact that between jointing points the cable is completely flooded. Although the mutual electrostatic capacitance between pairs of a cable is increased by flooding, the resulting increase in attenuation is not noticeable in practice over short lengths of cable.

### Jointing

The versatile expanding plug is used on all joints on larger polythene cables, but if it is required to join together lengths of cable of small size (seven pairs and less), the wire twist joints are first tip-soldered, then insulated by paper sleeves, and the whole joint encased in a "water-barrier coupling," which is afterwards filled with compound. A coupling is shown in Fig. **3**; it comprises two identical

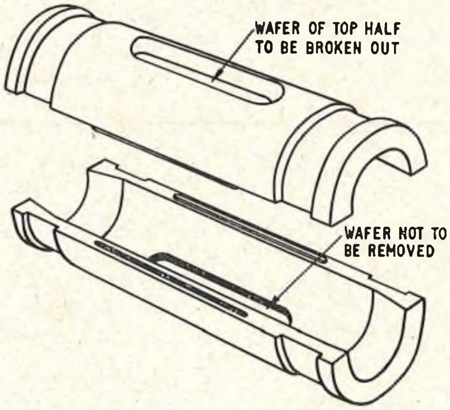



Fig. **3**.—Water-Barrier Coupling.

mouldings of phenol formaldehyde, which, when fitted together, form a cylindrical body; good alignment being obtained by means of fins and slots. In each half of the coupling a hole, normally blanked by a thin wafer of material, is provided to permit filling of the coupling with sealing compound, the wafer being "knocked-out" of the uppermost hole when the coupling is in position. Lappings of adhesive rubber tape round the cable sheath at each side of the joint provide a resilient bedding for the coupling, which is held together by wire bindings.

Until now, it has been the practice to leave a loop of cable buried at each point where it is expected that a spur joint may be required at a later date: the method of converting a buried loop into a spur joint using an expanding plug has already been described.[1]

A tee-coupling (Fig. **4**), similar in principle to the water-barrier coupling has been designed to enable a one- or two-pair spur to be taken from a cable at any point, thus dispensing with the need for providing buried loops. Some of the advantages of such a method of providing spur pairs are:—

(*a*) It is not necessary to forecast the probable location of future spur joints at the time of installation of the cable.

(*b*) There are savings in the cost of jointing materials and time.

(*c*) There is a saving of cable, since buried loops are not required.

[2] Chemistry & Industry, No 19, p. 578, 11th May, 1957.

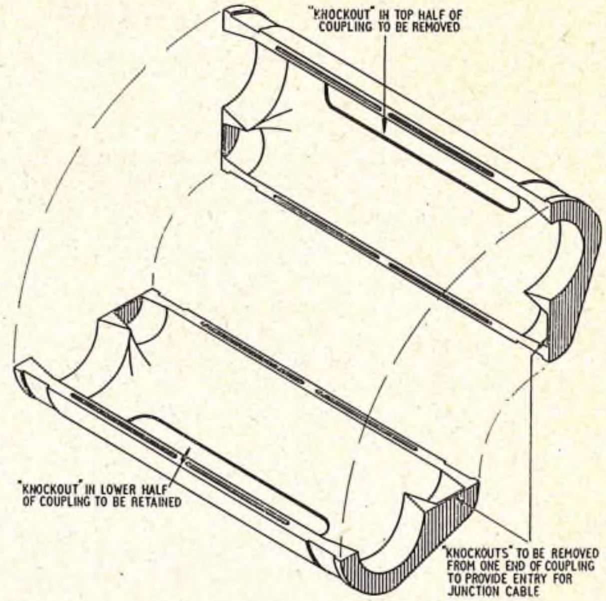



Fig. **4**.—Tee-Coupling.

Four sizes of tee-couplings permit the method to be used on any size of polythene cable available.

Sleeves made of plastic instead of lead are being introduced for use in conjunction with expanding plugs. The sleeves, which are available in both single-ended and double-ended types, are injection-moulded in polythene and are reinforced at each open end with a brass insert.

The advantages of such an item over the lead sleeve are:—

(*a*) It is cheaper than a lead sleeve of equivalent size.

(*b*) It requires no preparation in the field, unlike the lead sleeve, which has to be dressed perfectly circular, have all extrusion scores removed, and requires the fitting of a brass reinforcing collar and usually a lead end-cap.

(*c*) It is light; a lead sleeve of equivalent size is 15 times as heavy.

(*d*) It is not subject to corrosion.

Furthermore, by reinforcing the open end of the sleeve with a brass insert instead of with a brass collar fitted externally, de-zincification and subsequent failure of the brass is avoided.

Normal methods of pressure-testing joints involve the puncturing of the lead sleeve to enable air to be introduced; the hole being repaired afterwards by soldering. Since it is not possible to use this technique on a joint having a plastic sleeve, a hollow pressure-testing bolt (Fig. **5**) has been developed,

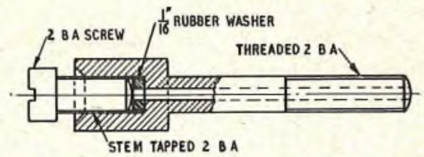



Fig. **5**.—Hollow Pressure-Testing Bolt.

which is substituted for one of the bolts of the expanding plug. The head of the bolt has an internal thread, into which can be screwed a special adapter to enable pressure testing to be carried out as shown in Fig. **6**, using a standard footpump.

After completion of the pressure tests, the adapter is removed, and replaced by a screw which seats on a rubber washer, to seal the bolt head (Fig. **5**).

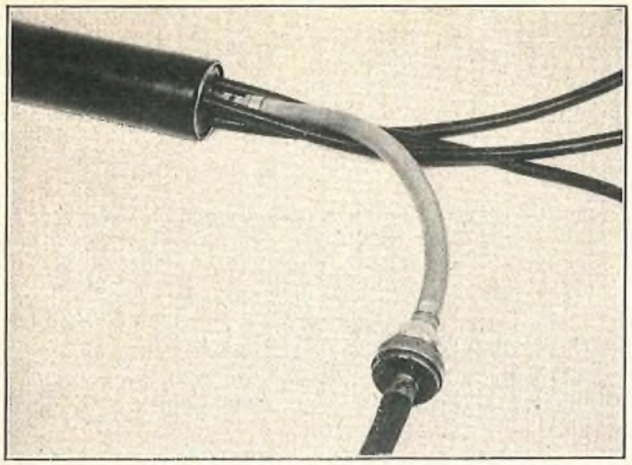


FIG. 6.—PRESSURE-TESTING A JOINT HAVING A PLASTIC SLEEVE.

## MAINTENANCE CONSIDERATIONS

Although polythene cables are immune from most of the types of fault that affect lead-sheathed paper-core cables, they are, because they are normally buried directly in the ground at shallow depths with no mechanical protection, vulnerable to certain types of fault rarely met with in conventional cables laid in duct. The most prevalent cause of fault is mechanical damage to the cable resulting from digging operations carried out for other services, or by subscribers (where direct underground leads-in exist). If damage to the sheath only is caused, and water enters the cable, there will be no electrical fault unless the water enters a joint; an occurrence that is normally prevented by the water-barrier sleeves. Since it is impracticable to fit this type of water barrier in existing joints made before such devices were considered necessary, isolation of these joints is effected by means of water-barrier couplings, which are introduced additionally into the sheaths of all cables entering the joint whenever a suitable opportunity occurs. A section of the cable sheath is removed near the joint, and the core thus exposed is "ballooned" out; the coupling is then fitted and filled with compound.

Polythene cables that have been installed by mole-drainer have proved to be particularly prone to damage by moles and all kinds of rodents. Most of the older types of mole-drainer form a circular hole in the earth, much larger than is necessary to accommodate the cable, and it is apparent that this excess space has been used as a runway by the smaller animals, which have gnawed the cable at various points along its length. Fig. 7 shows a typical case of such damage. No known additive which will make the polythene unpalatable can survive the high temperature of extrusion. An improved form of mole-drainer now available cuts a rectangular hole about 4 in. wide by a little over ½ in. high, which collapses more readily than a circular hole and thus ensures that the polythene cable is in contact with the earth all round its periphery.

FIG. 7.—TYPICAL CASE OF DAMAGE BY VERMIN.

If localized damage to the conductors has occurred a repair can be effected *in situ* by means of a water-barrier coupling, broken conductors being jointed by soldering into a jointing ferrule and insulated by paper sleeves, as shown in Fig. 8; the procedure is similar to that for constructing a compound-filled joint.

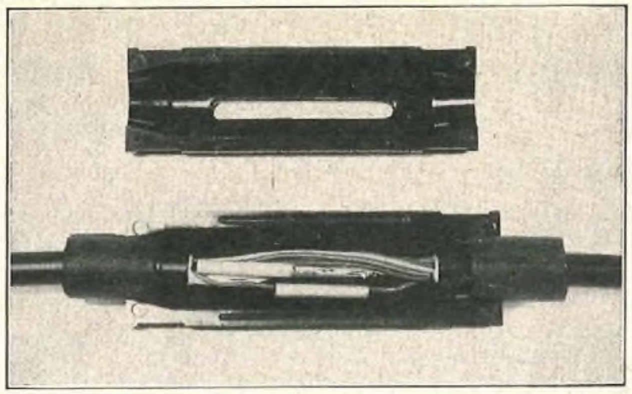


FIG. 8.—METHOD OF REPAIR OF DAMAGED PAIRS.

It is probable that some more extensive protection than is now generally used for buried polythene cable would considerably reduce the number of faults that occur; but a survey (which is still in progress) has indicated, so far, that the maintenance charges for polythene cable are only a fraction of the equivalent charges for lead-sheathed paper-core cable. Thus, in general, the cost of an effective form of overall protection against mechanical damage would far exceed any resultant saving in maintenance costs during the normal life of the cable. It is interesting to note that only a small proportion of faults which have so far occurred have been directly due to failure at jointing points, and of these, an almost negligible number have been due to the use of expanding plug joints, in spite of the large number of this type of joint that are in service. There is no doubt that, if properly constructed, this is a most effective method of jointing large-size polythene cables, where access may be required at some later date.

## FUTURE DEVELOPMENTS

As manufacturing techniques improve with the advance of plastics technology, it may be expected that smaller-dimensioned and even cheaper plastic cables will be produced. Since, however, the mutual electrostatic capacitance value for a cable increases as the thickness of insulation decreases, it is possible that the final size of plastic-insulated cable may be determined by the maximum attentuation that can be tolerated, rather than by manufacturing considerations.

## CONCLUSIONS

The introduction of cheaper plastic cables will tend more and more to replace, in the subscribers' distribution network, the conventional paper-core lead-sheathed cables with their inherent liability of corrosion.

Uneasiness should not be felt over the occurrence in polythene cables of a number of faults of a type rarely encountered in conventional lead-sheathed cable laid in duct, since the average cost of repair for a fault is far less in polythene cable than in lead-sheathed paper-core cable.

The development of plastic sleeves and compound-filled couplings has led to a considerable reduction in cost of jointing materials. The introduction of a tee-coupling where spur joints are required will obviate the need for leaving buried loops of cable at the time of installation.

## ACKNOWLEDGMENTS

The author wishes to record his appreciation of the part played in the developments described in this article by colleagues in the External Plant and Protection Branch, E.-in-C.'s Office, particularly Mr. R. H. Harris and Mr. H. R. Wardall. Thanks are also due to Mr. E. D. Latimer, of that branch, for his help in the preparation of the article.

# The Acoustical Impedance of Some Normal Ears, the 3-c.c. Artificial Ear and Three Earphones

J. Y. MORTON, A.M.C.T., A.M.I.E.E.†

U.D.C. 534.64

**Comparison of the measured acoustical impedance of a number of real ears with the impedance of a 3-c.c. artificial ear shows good agreement. The measured acoustical source impedance of three earphones is given and two advantages of a low source impedance are discussed.**

## Introduction

To the acoustical engineer the study of acoustical impedance is as important as the study of electrical impedance is to the electrical engineer. The acoustical impedance is the ratio of sound pressure to volume displacement, or volume current as it is sometimes called. The unit is the acoustical ohm. An acoustical system has an acoustical resistance of 1 ohm if a sound pressure of 1 dyne/cm$^2$ produces a volume current of 1 cm$^3$/sec. It will be appreciated, therefore, that there is a marked similarity between acoustical and electrical systems, in fact it is possible to represent acoustical systems by electrical circuits, an artifice that is often used to solve acoustical problems. The equivalents of electrical capacitance and inductance are acoustical compliance and mass, respectively; the compliance usually takes the form of a cavity and the mass the form of a restriction such as a narrow tube. Unfortunately, acoustical impedance cannot be measured so easily as electrical impedance. The design and construction of an acoustical impedance measuring set[1] for the acoustics laboratory at Dollis Hill has, however, considerably simplified the acoustical problem in so far as certain measurements of interest to the telephone engineer are concerned. These measurements are of impedances associated with ears and earphones.

## Real and Artificial Ears

The artificial ears[2] used by the Post Office for testing earphones in the laboratory and the factory consist of a cavity of approximately 3 cm$^3$ with two 15-ft resistance tubes of internal diameter $\frac{3}{16}$ in. leading from it (Fig. **1** (*a*)).

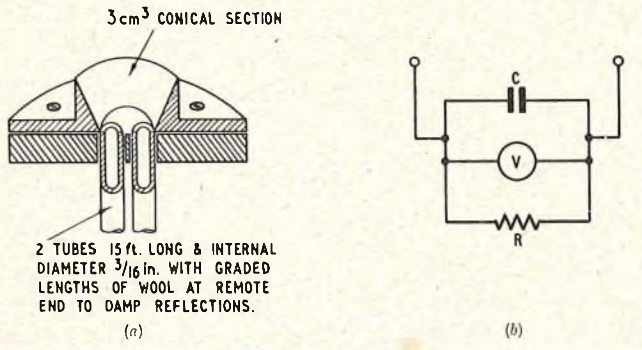



Fig. 1.—Artificial Ear.

One tube of twice the cross-sectional area of a $\frac{3}{16}$-in. tube would suffice for telephone earphones but the equipment, with minor modifications, is also used for testing insert hearing aid earphones pending the design of a more suitable artificial ear for this type of earphone. The modifications reduce the cavity to 1·5 cm$^3$ and blank off one of the tubes. A probe microphone, which is not shown in Fig. **1**, is used to measure the sound pressure in the ear. The impedance of the probe microphone is very much greater than that of the artificial ear of which it forms a part. Fig. **1** (*b*) shows the electrical analogue, the 3 cm$^3$ cavity is represented by C, and the resistance of the two tubes in parallel by R. The analogue of the probe microphone, which is a pressure-measuring device, is the voltmeter V.

The artificial ear was designed from ear impedance measurements made at the Research Station in 1928,[3] hence it was an interesting exercise to check the impedance of the artificial ear with a number of human ears, using modern equipment. An earcap of a Receiver, Inset, No. 2P was cut away at the back to facilitate its connexion to the measuring set, so that the measuring plane corresponded to the plane of the bottom of the well in the earcap, Fig. **2**.

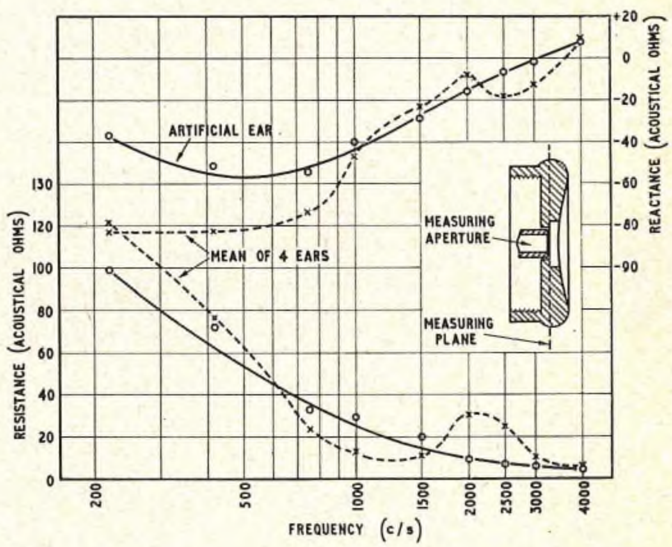



Fig. 2.—Acoustical Impedance of Real and Artificial Ears.

The diameter of the measuring aperture was 0·25 in. The subject held the assembly against his ear using a telephone handle, as in telephone practice, and the mass of the assembly was counterbalanced by a cord, pulley and weight system.

Fig. **2** shows the mean impedance of four subjects' ears and the impedance of the artificial ear seen through the earcap. The artificial ear gives good representation of the impedance presented by subjects to the earcap, including representation of the leak between the earcap and the ear which causes the flattening of the reactance curve at low frequencies. The measurements of the artificial ear at low frequencies do not lie on a smooth curve because of the variation in acoustical resistance of the resistance tubes. Measurements on similar tubes have shown variations of the order of $\pm 5$ per cent, which are caused by reflections in the tubes.

Work on the impedance presented by normal ears to insert hearing aid earphones has shown that most ear-canal impedances change from a negative to a positive reactance between 2,000 and 4,000 c/s[4]; the measurements were made approximately 1 cm down the ear-canal. Hence, it is assumed that the resonance at 2,000 c/s in the real ear curve,

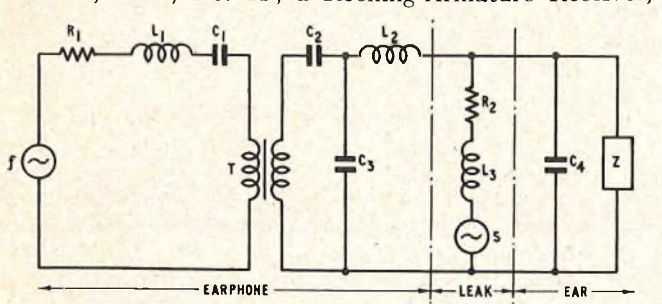
† The author is a Senior Executive Engineer, Post Office Research Station.

Fig. 2, is caused by a parallel resonance between the cavity under the earcap and the acoustical mass of the ear-canal. It will be appreciated that in individual cases the "Q" of the resonance is greater than would appear from the mean curve. The positive reactance at 4,000 c/s is caused by the acoustical mass of the well of the earcap.

## Earphones

The condition for maximum transference of power from source to load in the acoustical case is exactly the same as in the electrical case. If the acoustical source impedance is equal to the conjugate of the load impedance, maximum power will be transferred to the load. Considering the earphone as the acoustical sound source, Fig. 3, and the ear and leak between the earcap and ear as the load, it will be appreciated that only over small frequency bands can there be a conjugate impedance match between the earphone and the load. If the leak impedance is very high, both the source and load have a negative reactance over the lower part of their useful frequency range for telephone work and the earphone tends to have a flat response curve. If, however, as is often the case, the leak has a small impedance, a resonance occurs with the leak acoustical mass and the diaphragm compliance playing dominant roles. This resonance is usually at some frequency between 500 and 1,000 c/s. It will be appreciated, therefore, that any variations in the leak will cause variations in the loudness experienced by the earphone user. This effect is reduced if the earphone has a low source impedance, for it will behave as a source of constant sound pressure. Another advantage of a low-source-impedance earphone is that it causes a large pressure drop in the leak impedance of unwanted room noise entering by the leak, which reduces this unwanted sound pressure in the ear. Hence, there are two conflicting requirements, one of source impedance modulus equal to load modulus, to give maximum power transference; and one of low source impedance to reduce signal variability and unwanted room noise caused by leaks. Fortunately modern telephone earphones are so sensitive that impedance matching is only of secondary importance.

Fig. 4 shows the measured acoustical impedance of a Receiver, Inset, No. 2P, a Rocking-Armature Receiver,[5]




$C_1$ = Compliance of diaphragm.
$C_2$ = Acoustical compliance of volume behind diaphragm.
$C_3$ = ,, ,, ,, ,, in front of diaphragm.
$C_4$ = ,, ,, ,, ,, between earcap and entrance to ear-canal.
f = Force between diaphragm and pole pieces.
$L_1$ = Effective mass of diaphragm.
$L_2$ = Acoustical mass of holes in earcap.
$L_3$ = ,, ,, ,, leak between earcap and ear.
$R_1$ = Mechanical resistance of diaphragm.
$R_2$ = Acoustical resistance of leak between earcap and ear.
S = Unwanted noise source (room noise).
T = Mechano-acoustical transformer.
Z = Acoustical impedance of ear from entrance of ear-canal.

Fig. 3.—Simplified Analagous Electrical Circuit of Earphone and Ear.

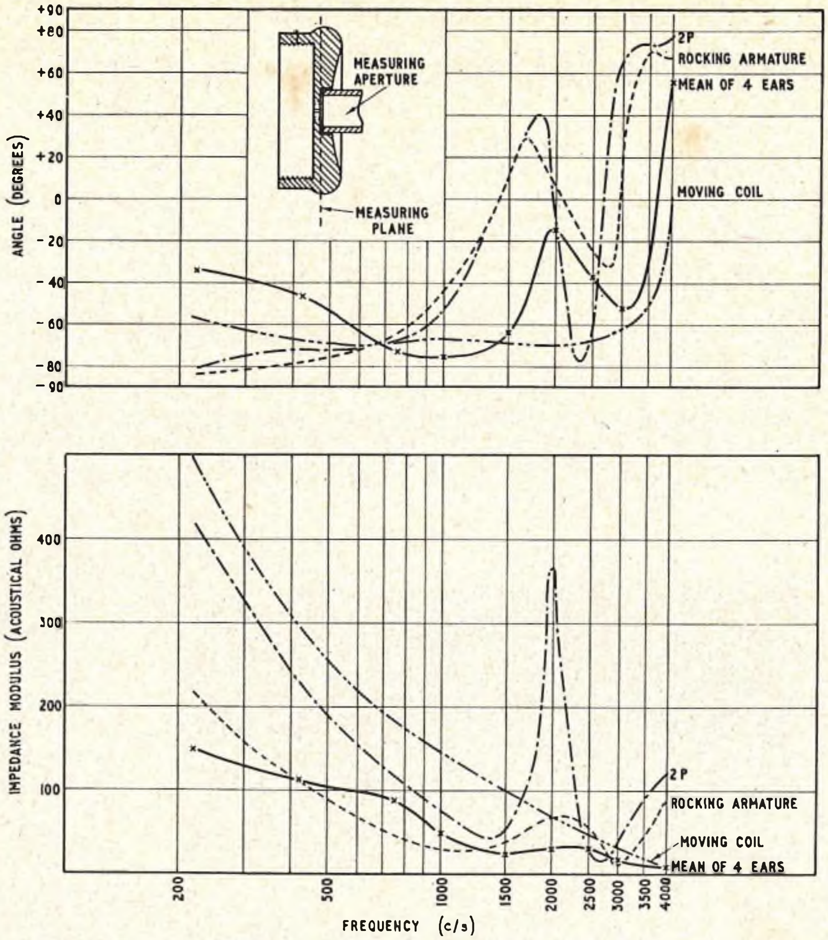



Fig. 4.—Earphone Impedances.

a moving-coil headgear earphone and the mean impedance of four normal ears. The telephone earphones were measured from the plane of the bottom of the well in their earcaps and the moving coil earphone was measured through seven holes in its grille, the remaining 30 holes were blanked off because they lay outside the aperture of the measuring set. The silk covering the grille was removed so that a good acoustical connexion could be made at the measuring set. A 0·5-in. diameter aperture was used when measuring earphones. Because the leak impedance, Fig. 3, is less than the ear impedance at low frequencies it will be seen that the Rocking-Armature Earphone impedance, Fig. 4, is lower than the ear impedance below 1,200 c/s, which is the frequency range most troublesome so far as room noise is concerned, and also that most influenced by the variability of the leak. Hence, this earphone tends to reduce room noise and changes in signal level due to leak variability, compared with the other two types of earphone. The Rocking-Armature Earphone is to be used by the Post Office in the Telephone No. 700[6] and will be known as a Receiver, Inset, No. 4T.


*References.*

[1] Ayers, E. W., Aspinall, E., and Morton, J. Y. An Impedance Measuring Set for Electrical, Acoustical and Mechanical Impedances. *Acustica*, Vol. 6, p. 11, 1956.

[2] British Standard 2042 : 1953. An Artificial Ear for the Calibration of Earphones of the External Type.

[3] West, W. Measurements of the Acoustical Impedances of Human Ears. *P.O.E.E.J.*, Vol. 21, p. 293, Jan., 1929.

[4] Morton, J. Y., and Jones, R. A. The Acoustical Impedance Presented by some Human Ears to Hearing-aid Earphones of the Insert Type. *Acustica*, Vol. 6, p. 339, 1956.

[5] Roberton, J. S. P. The Rocking-Armature Receiver. *P.O.E.E.J.*, Vol. 49, p. 40, April, 1956.

[6] Spencer, H. J. C., and Wilson, F. A. The New, 700-Type Telephone. *P.O.E.E.J.*, Vol. 49, p. 69, July, 1956.

# A 340-yard Overhead Span for a Subscriber's Line to Thorn Island, South Wales

H. W. S. HAYMAN, A.M.I.E.E., and G. CHALLENGER†

U.D.C. 621.315.17:621.395.73

**The provision of telephone service for a hotel on an island in Milford Haven presented unusual problems. This article describes how the difficulties were overcome by using a 340-yd overhead span of 4/14 steel conductors.**

### Introduction

About a century ago a number of forts were built to protect the entrance to the harbour at Milford Haven, at the south-western extremity of Wales. Among the forts that have now been adapted to new purposes is one on Thorn Island (Fig. 1) that has been opened as a hotel. Thorn Island commands the mouth of the Haven and lies about a furlong from the mainland. It rises some 50 ft above the sea and is separated from the cliffs of the mainland by deep water at all tides. The provision of telephone service for the hotel therefore presented unusual problems.

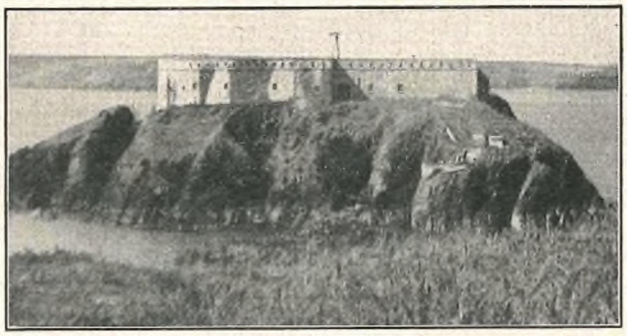


Fig. 1.—View of Thorn Island from Mainland.

Admiralty charts indicated the existence of a submarine cable to the island but, although a survey did disclose the remnants of old cables on the mainland, nothing of any practical help in providing a telephone line was found. Replacement of the cable was considered but this would have been too costly as the landings on both sides were found to be very difficult, and the tidal race rapid. The use of a radio link was feasible but would also have been expensive. It was, therefore, decided to explore the possibility of a long span of overhead conductors.

A span of about 350 yd was required, and the heights of the ends had to be such as to allow an adequate clearance over the sea, so that the wires should not constitute a navigational hazard. Consent to the project was obtained from the Commissioners for Crown Lands, via the Ministry of Transport and Civil Aviation, subject to the proviso that the wires should be at least 50 ft above "Mean High Water Springs" (m.h.w.s.). This is the average of spring high tides.

### Planning and Construction of the Overhead Span

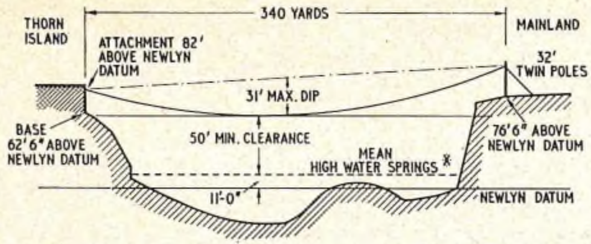
A plan and levels of the salient features of the ground and water below the span were the first requirements. As the fort was a military establishment when the last issue of the Ordnance Survey maps was prepared, in 1908, only the outlines of the island and the mainland were shown, and no levels in the vicinity were recorded. The current Admiralty chart gave both soundings and heights of prominences above m.h.w.s., but this information was not sufficiently precise to work from. The Director General of Ordnance Survey was consulted, and the existence of a bench mark on a farm some distance inland was disclosed. The height of the bench mark above Newlyn datum was quoted and was related to m.h.w.s. by information supplied by the Hydrographical Department of the Admiralty; the m.h.w.s. level at the Haven is 11 ft above the Newlyn datum. Using a Cowley instrument, a level survey established the height of a chosen point on the mainland cliff, by reference to the bench mark. This was found to be 76 ft above Newlyn datum, or 65 ft above m.h.w.s. Sighting on the island proved the parapet of the fort to be a few feet higher. Accuracy could not be obtained at that stage.

Thorn Island was visited to decide the most convenient means of terminating the overhead wires, and attention turned upon the embrasures in the battlements above the elevated gun walk running around the inside of the walls. These narrow loopholes in the massive stone walls were well situated, and at a height that could be exceeded only by lengthening the span by several yards and erecting poles more than 40 ft long. The conveying of poles to the island, and worse still, the handling of them into position were operations to be avoided, if possible.

Calculations were then made to determine the type of conductor required. The length of the span was assessed from the maps as 356 yd. The elevation of the mainland end, when raised on a 32-ft pole, was 91 ft above m.h.w.s., and that of the island attachment was 71 ft, giving a mean elevation of 81 ft, so that a sag of some 31 ft under summer conditions could be allowed. This was not a precise figure, and allowing for contraction due to changes of temperature, an equivalent flat span of 356 yd with 20-ft sag at 20°F was used for calculating stresses in the wire. It was shown that no copper conductor could meet the requirement with an adequate safety margin, and it was, therefore, proposed that 7/14 steel wire should be used for each conductor. The behaviour of this wire under storm conditions, and in summer temperatures was studied. It was shown that it would have a safety factor in excess of 2 in a wind of 100 m.p.h., that its tension at 20°F would need to be 870 lb and that an increase of 5 ft 3 in. in sag could be expected at 100°F.

While the terminations for the wires were being designed, 4/14 steel wire became available. This had the merit of lightness and therefore of requiring a lower tension; a tension of 500 lb at 20°F, giving a static safety factor of 6, was sufficient. When checked for storm conditions with the dip and span as originally assumed, it was found that the safety factor was rather less than thought desirable. A more precise survey was therefore made, using a "dumpy" level. Pole sites were chosen and pegged, the level of the terminations of the wires on the mainland and the island were determined accurately and the span length was computed by triangulation. This showed that the span was 340 yd, materially less than had been assumed. The profile shown in Fig. 2 was obtained. When recalculated on the flat span of 340 yd and 20-ft dip, a safety factor of 2 was obtained for a transverse wind of 95 m.p.h. at 20°F. This is a condition well in excess of the 80 m.p.h. used by the Post Office and Electricity Board for designing lines.

† The authors are, respectively, Executive Engineer and Leading Draughtsman, Swansea Telephone Area, Wales and Border Counties.




*Exceptional tides up to 3 ft higher.

Fig. 2.—Span Profile.

While winds in excess of 95 m.p.h. are not unknown in west Wales, they would probably occur under mild weather conditions, and furthermore, the chance of such gales being normal to this line, which runs from east to west, is not very great. It was decided that 4/14 conductors would be satisfactory.

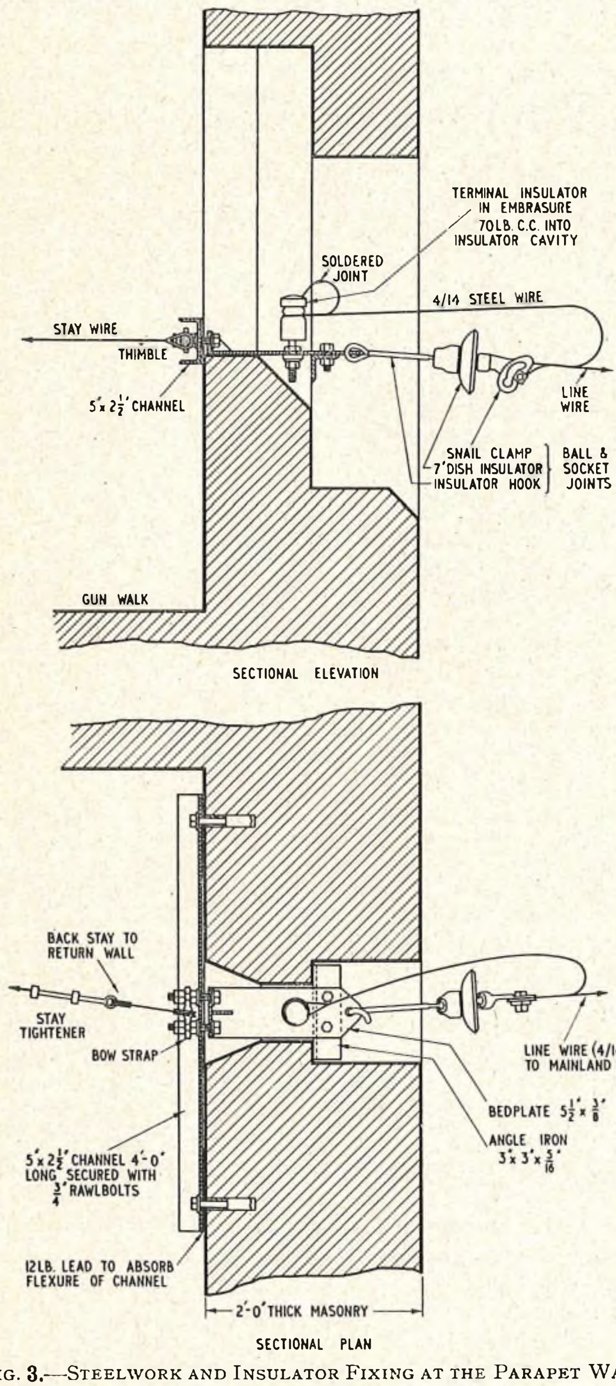



Fig. 3.—Steelwork and Insulator Fixing at the Parapet Wall on the Fort.

Having decided to use the embrasures to secure the wires to the fort, it followed that the wires would also be disposed horizontally on the support on the mainland. While some authorities claim that the danger of chance contact of wires through "galloping" vibration is diminished by a horizontal formation of the wires, there is little guidance as to the minimum separating distance for such a span as this. A separation of 13 ft 6 in. was obtained on the fort, and a spacing of 8 ft was planned on the mainland. Termination of the steel wire called for fittings different from normal Post Office practice, and the local Electricity Board were helpful in providing information on, and samples of, the fittings used in power line construction. Tension suspenders incorporating a ball-and-socket joint, with 7-in. dish insulators were chosen. At the fort the insulator hooks were secured to bed plates in the embrasures, which were bolted to channels behind the wall, and the whole fixture was stayed back to the adjacent walls, as shown in Fig. 3. To obtain the spacing on the mainland, twin poles were used, the assembly being as shown in Fig. 4.

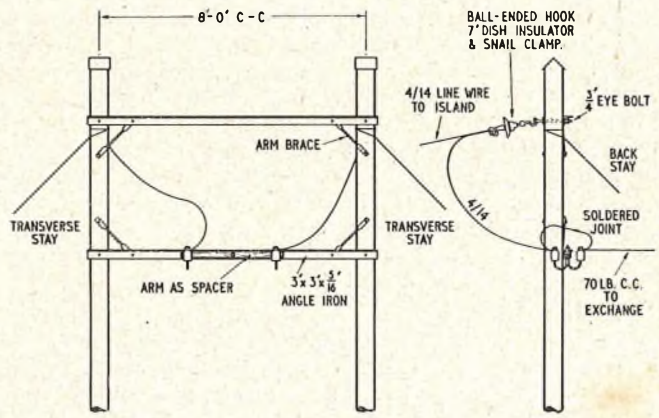



Fig. 4.—32-ft medium Twin Pole Assembly on Mainland.

The work of providing the line to the hotel on Thorn Island from the U.A.X. No. 12 at Angle, some 4 miles away, was carried out early in 1957. A disused line was overhauled, and extended to the headland overlooking the Haven. The twin poles were erected and stayed, holes having been blasted out of the red sandstone of the cliff. The ironwork for the fort was manufactured and galvanized, assembled and fitted in place. The wires were hauled across and made off. Tension was applied by means of a chain puller from the twin poles and a dynamometer was used to watch tension, as in normal aerial cable practice. The tension was set by checking the dip. A range in dip of 5 ft between 20° and 100°F had been calculated and the dip corresponding to the ambient temperature was known. A dumpy level was set up at an appropriate lower ground level, and the wires were adjusted so that the lowest point of each was at this level. The ping-pong method was used to check the tension. The time of travel of a transverse wave to the far end and back was 5·4 sec, from which the mean tension was calculated as 310 lb. This agrees well with the values obtained theoretically from the profile.

A gas discharge tube is used to protect the line; it is housed in a box on the inside of the parapet wall.

## Conclusion

There has not yet been an opportunity of studying the behaviour of this span under gale conditions, but in a wind of about force 5 it was observed that there was no independent motion of the conductors. The two were displaced laterally by the wind, and due to the inertia of the span, were very steady. The future performance of this unusual span will be watched with interest.

# Radio Interference

Edited and Introduced by D. A. THORN, B.Sc.(Eng.), A.M.I.E.E.†

## Part 1.—Introduction

U.D.C. 621.396.82 : 621.397.82

**Radio interference is something that is equally familiar to telecommunications engineers and to the general public. In these days when a broadcast receiver is found in almost every home the existence and possible reduction of interference is a subject of general interest, while many members of the Post Office staff and their colleagues in the radio industry are concerned with the technical and administrative aspects of this problem. This article introduces a series of six articles that will present a general survey of the subject with particular emphasis on those aspects that particularly concern the telecommunications engineer. Parts 2 to 6 will be articles dealing, respectively, with the Post Office radio interference services, suppression of radio interference, measurement of radio interference, incidental radiation devices and the control of radio interference.**

RADIO interference in its broadest sense embraces anything which mars or hinders the enjoyment or satisfactory reception of a wanted program. Clearly, acoustic interference caused by a vexed or thoughtless neighbour comes within this range, but this is not normally accepted as being radio interference, and attention is confined to unwanted energy picked up at radio frequency by the listener's receiver, producing noise in the output. Such energy may arise from natural sources or may be man-made, being generated by various items of electrical equipment in common use. It is the noise produced by the latter sources which is normally understood by the term radio interference and which constitutes the basis of this series of articles. The most common items that produce interference are those incorporating commutator-type motors, contact devices such as thermostats, radio-frequency oscillators used for industrial, scientific or medical purposes and even radio receivers themselves.

All radio services are susceptible to radio interference to some degree, but the major interest from both the national and international point of view is centred on its effect on the reception of the domestic broadcasting and television programs. In this country, the medium and long-wave sound broadcasting services, and the Band I* television channels have, until recently, been those principally concerned, but with the development of the use of Band II* for frequency-modulated sound broadcast transmissions, and Band III* for additional television channels, the radio-frequency range of interest from the interference aspect has been widened appreciably. It must not be thought from the foregoing comments that the vast network of commercial radio communications services in operation are either immune to the effects of radio interference or are ignored. The fact is that these services can be so planned and organized, and their receiving stations so sited, as to reduce interference troubles to a minimum. This point has not been overlooked in dealing with domestic broadcasting interference, and it has always been regarded as an essential requirement that the complainant should adopt all reasonable measures to ensure that the receiving set and the aerial installation are so designed and adjusted as to get the best possible signal from the wanted program and to reduce as far as possible the picking up of interference.

From the technical point of view, the problem of dealing with radio interference in an effective and economical way presents many difficulties and inevitably involves matters of policy and practical politics which can only be resolved by resort to compromise. In the ideal state, and starting afresh, it could be ensured that all electrical equipment was so designed that however it was used it would not produce radio interference, or if this could not be achieved its use would be banned. In practice there exists a wide range of electrical appliances, many of which started their useful life before the present broadcasting services had been developed. Under these circumstances it is necessary, if the desired objective is ultimately to be achieved, to encourage and publicize means by which interference from existing electrical equipment may be reduced (by the fitting of suppressors, the use of screening, or other means) and to encourage the production of new equipment that shall be as free from interference as technical knowledge and economic considerations will permit. Ideally, radio interference should be eliminated entirely, but as this is not practicable, the aim is to reduce the background noise to such a level that over as large an area of the country as possible the domestic broadcast programs can be received satisfactorily. To this end, careful planning and co-ordination is necessary between the various interests concerned. In the United Kingdom the Postmaster-General is administratively responsible for the control of radio interference, particularly as far as any legal regulations are concerned. The Post Office operates a country-wide radio interference service which not only deals with specific cases of interference, but is also available for giving advice and guidance on the various technical problems that arise. For this purpose an organization has been built up consisting of technical staff attached to the various Telephone Areas, backed by specialized laboratory facilities in the Engineering Department. Apart from the Post Office, the broadcasting organizations and the various branches of the radio and electrical industry take an active part in studying the problem of radio interference and co-operate in putting into effect such measures for its control as may be decided as desirable and practicable. This obviously involves a considerable measure of compromise and it is gratifying to record that a spirit of willing give and take has generally been shown in this work. The co-ordination of these interests has primarily been undertaken through the appropriate committees of The Institution of Electrical Engineers and the British Standards Institution.

Up to the time of the passing of the Wireless Telegraph Act of 1949, the control of radio interference in the United Kingdom depended solely on the voluntary action of the parties concerned. Under this Act, however, the Postmaster General is empowered, after due consultation with an advisory committee set up for the purpose, to make regulations governing the manufacture and/or use of specific items of electrical equipment which may cause radio interference, laying down the limits which must be met when the level of the interference is measured in a stated manner and with measuring equipment whose essential characteristics are specified. It is important to note that under the terms of the Act and any consequential Regulations it is not, with certain exceptions, an offence to cause interference with radio reception. The action to which legal penalties may apply is the failure to comply, within a stated time, with a properly issued notice to reduce the interference so as not to exceed the level given in the appropriate Regulation. Up to the present time Regulations have been issued covering a number of electrical

† Assistant Staff Engineer, Radio Experimental and Development Branch, E.-in-C.'s Office.

* Band I = 41 to 68 Mc/s. Band II = 87·5 to 100 Mc/s. Band III = 174 to 216 Mc/s.

appliances whose use has been shown by experience to give rise to the most frequent complaints of interference.

The problem of radio interference is obviously one that concerns any country which has an established broadcasting system. Over the past 20 years international conferences and exchanges of views and experiences have taken place between countries interested in this work, the international body concerned in co-ordinating this task being the International Special Committee on Radio Interference, generally known by the initials of its title in French, C.I.S.P.R., which operates under the aegis of the International Electrotechnical Commission. The C.I.S.P.R. aims at the eventual establishment of internationally agreed methods of measuring radio interference and hopes to achieve some agreement on the desirable limits to be achieved. Consideration is also given to the safety aspect of any methods of suppression that may be adopted. All these measures should facilitate international trade by providing a yardstick by which the suitability, as far as radio interference is concerned, of any item of electrical equipment for import or export may be assessed.

Other articles in this series on radio interference will explain in detail the various items outlined in this Introduction and have been planned so as to present a comprehensive picture of the whole subject with particular emphasis on the technical aspects that affect telecommunications engineers in general and Post Office engineering staff in particular.

---

# Radio Interference

G. A. C. R. BRITTON, A.M.I.E.E.†

## Part 2.—The Post Office Radio Interference Service

U.D.C. 621.396.82: 621.397.82

**This article describes briefly the organization—past and present—for dealing with radio interference complaints. Costs of the service, methods of tracing interference, and apparatus used for the purpose are also mentioned. Finally, mention is made of the main types of apparatus that give rise to interference.**

### History up to 1946

In the middle 1920s the radio functions of the Engineering Sections* throughout the country consisted primarily of licence "combs" and investigations of complaints of "oscillation" by broadcast receivers. The work consisted of publicity about the need to have a licence and cajolery to persuade users of broadcast receivers to refrain from pushing reaction to the extent of self-oscillation and so interfering with reception by their neighbours: complaints of "electrical" interference were rare. The first significant change in the work followed the introduction of the B.B.C.'s plan for a country-wide coverage with a choice of two programs. This plan was based on the use of pairs of co-sited medium-frequency high-power transmitters, thus calling for a high standard of adjacent-channel selectivity far beyond the capabilities of the simple receiver with reacting detector. As the super-heterodyne receiver came into general use, oscillator interference disappeared. On the other hand, the rapid growth in popularity of both sound broadcasting and the use of electricity in homes and factories resulted in a growth of radio interference caused by electrical appliances and machinery.

The Post Office accepted a liability to investigate complaints of such interference; to locate the apparatus causing the interference, find the type of suppressor required to remove the interference, and appeal to the public spirit of the owner of the offending apparatus, asking him either to pay for the suppressor demonstrated or to have a similar one installed by an electrical dealer. It was recognized that few staff of supervisory rank in the Sections had knowledge and experience of this class of work; in general, therefore, only disciplinary control and routine guidance of the field investigation staff were vested in the Sectional Engineer, more specialized technical control and guidance being left to the Superintending Engineer and the Engineer-in-Chief; the latter was also responsible for planning, the training of staff, and the provision of the specialized motor transport, interference-tracing radio receivers and suppression components required. Another facet of the work of the Engineer-in-Chief was collaboration in the national and international studies directed to the technique of measuring interference quantitatively and assessing permissible limits of interference which, while giving a good standard of protection to broadcast reception, would not be unduly onerous on the manufacturers and users of the electrical apparatus that gave rise to interference.

By 1939 the annual totals of complaints received and investigated had grown to about 48,000 for sound broadcasting and 100 for television broadcasting, and the field staff had grown to nearly 250 men. After the outbreak of war the service to the general public was drastically curtailed, the objective being limited to giving tolerable reception of the "Home" program only. Many of the staff were thus released and diverted to other work. The skeleton organization that remained was fully occupied, work being carried out for the fighting services, other government departments etc., concerned with the prosecution of the war, as can be seen from Table 1, as well as for the general public.

TABLE 1

*Radio Interference Complaints by Government Departments, etc., handled during the war*

| | No. of complaints |
|---|---|
| Air Ministry | 348 |
| War Office | 274 |
| Admiralty | 65 |
| Post Office | 34 |
| B.B.C. | 29 |
| U.S. Forces | 25 |
| Home Office | 9 |
| British Railways | 7 |
| Foreign Office | 3 |
| Ministry of Information | 3 |
| B.O.A.C. | 2 |
| Foreign Embassies | 2 |
| Ministry of Economic Warfare | 1 |
| Canadian Army | 1 |
| Regional Commissioner's Office | 1 |
| Total | 804 |

† Senior Executive Engineer, Radio Planning and Provision Branch, E.-in-C.'s Office.

* Now absorbed into Telephone Areas.

### Post-War History

After the war, the Post Office resumed its practice of investigating complaints of interference with the Home and Light programs and complaints by the public resumed their pre-war proportion. When the Third program was introduced and the television service revived, these services were also protected in localities in which they afforded a tolerable strength of signals. The very rapid growth in television viewing in the past few years led to an equivalent growth in the number of complaints. Fig. **1**

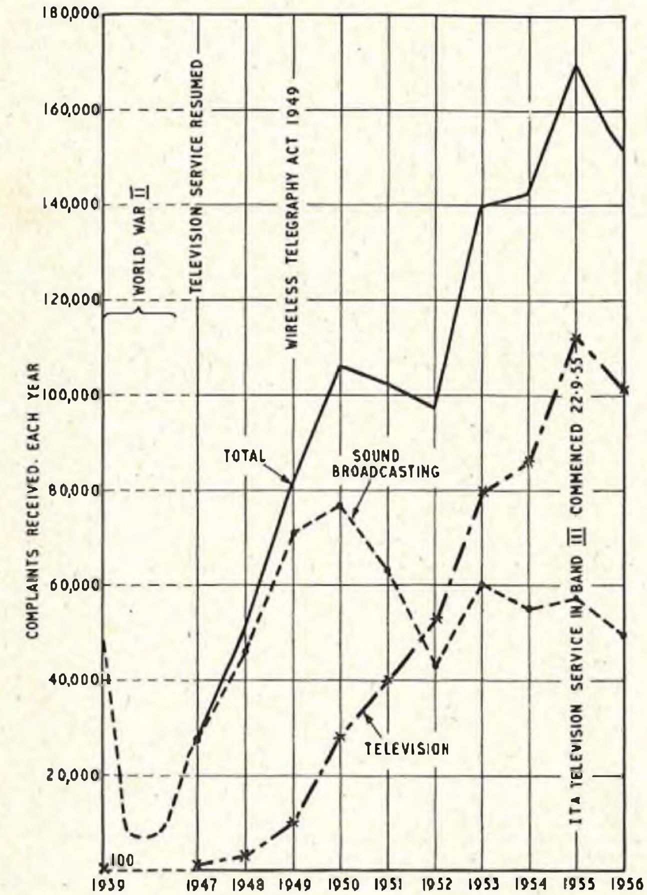



Fig. 1.—Annual Totals of Complaints Received, 1939–1956.

shows the tendency in recent years. It is interesting to see that television now accounts for more than half of the complaints received. The rapid increase in complaints of interference with television reception accompanied the expansion of the B.B.C. service. Table 2 shows the

TABLE 2

*Cost of the Radio Interference Service*

| Year | Total cost (£) | Total cost per £1 of licence revenue collected (pence) | Total cost per case | |
|---|---|---|---|---|
| | | | Sound (£) | Television (£) |
| 1949/50 | 341,674 | 6·56 | 3·81 | 5·06 |
| 1950/51 | 395,720 | 7·27 | 3·72 | 3·96 |
| 1951/52 | 427,415 | 7·33 | 4·18 | 3·69 |
| 1952/53 | 458,543 | 7·39 | 4·41 | 4·13 |
| 1953/54 | 489,298 | 7·14 | 3·48 | 3·42 |
| 1954/55 | 555,475 | 5·94 | 4·16 | 3·69 |
| 1955/56 | 563,220 | 5·76 | 3·56 | 3·22 |

varying cost of the service during recent years, the cost per case and the cost in terms of the licence revenue.

The growth of work called for an increase in staff, and the Radio Interference Service now employs about 500 men with 400 motor vehicles. In some Telephone Areas employing a number of radio staff, the experiment has been tried of grouping them in a "control" system analogous to Fault Control, but though in some Areas this system appears to work satisfactorily and is favoured by the Telephone Managers concerned, it cannot be said that the system has shown sufficient advantages to merit country-wide adoption.

From the point of view of size and cost of the Radio Interference Service and the thoroughness with which its work can be done, it is indeed fortunate that the B.B.C.'s network of transmitting stations now covers the bulk of the population of the U.K., so that the past rate of growth in numbers of complaints can hardly be maintained. Indeed, present indications are that since the introduction of the Independent Television Authority (I.T.A.) service in Band III—a band which is less susceptible to interference than Band I—the complaints are now declining. The reduction in the number of complaints of interference with sound broadcasting clearly reflects the declining public interest in this medium. The decline is probably attributable to a diversion of interest to television reception, plus the present unsatisfactory reception conditions in the medium-frequency band—heterodyne whistles caused by eastern European transmitters, and the widespread interference caused by television receivers.

### Field Investigation Work

Radio interference investigation officers are provided with vans, and their testing apparatus includes in particular, Receivers, Radio, Nos. 11 and 12 (see Fig. **2**). These are portable battery-operated sets covering the low and medium frequencies used for sound broadcasting and the higher frequencies used for television broadcasting in Band I (41–68 Mc/s) and sound broadcasting in Band II. A further receiver, Receiver, Radio, No. 24A, covering Band III, which is used for commercial television broadcasting, is about to be issued. The receivers have aerials built-in or directly attached to them, so that they can be carried in the hand. They can thus be used to trace an interference to its source by a combination of direction-finding and "homing" by the intensity-of-signals method. This is the strictly engineering method, but for a variety of

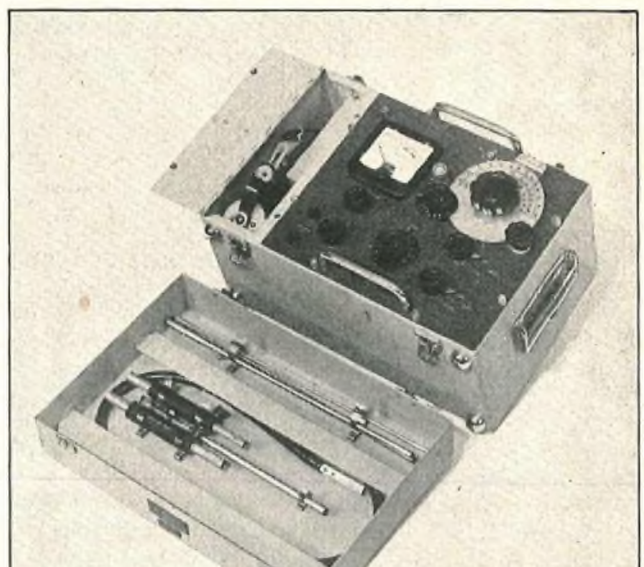


Fig. 2.—Receiver, Radio, No. 12 (30 to 100 Mc/s).

reasons it is not necessarily employed in the majority of cases. For example, the characteristics of an interference, as heard or seen at a complainant's premises, or the times of occurrence of the interference, may give so positive a clue as to the nature of the source and hence its location, that the painstaking tracing can be omitted, one or two enquiries at likely premises disclosing the source. Several examples of this deductive method of identifying types of apparatus which cause interference are shown in Table 3.

TABLE 3

*Duration and Times of Occurrence of some Kinds of Interference*

| Characteristics of Interference | Likely Source |
|---|---|
| Only experienced after dark | Lighting system (of streets or buildings) or neon signs |
| Intermittently by day and night | Refrigerator |
| Interference with sound broadcasting only experienced during television program times | Neighbouring television receiver (probably time-base radiation) |
| Intermittent long drawn-out buzzes or clicks, heard at bed-time in cold weather | Bedwarmers incorporating thermostats |
| Short but very frequent periods of buzzing, each beginning and ending with a "click" | Electric sewing-machine in neighbour's house |
| Continuous but chiefly in hot weather | Fans |
| "Herringbone" patterning on television screen | Diathermy apparatus in hospital or clinic |
| Random spots on television screen | Ignition systems of passing motor vehicles |
| Bands of spots on television screen and buzzing on sound occurring for long periods under some weather conditions in locations near overhead high-voltage power lines | Discharges across insulators or faulty bonding of metalwork of the power line |

The technical standard of a receiving installation has a considerable bearing on its susceptibility to interference, and during the initial visit of the Investigation Officer (I.O.) to a complainant, it is his duty to examine the installation and point out any features which should be improved before the Post Office investigates further. In some cases faults in receivers may be noticed. In others—far too many—it may be found that a very inferior aerial is in use; such an aerial is an inefficient collector of the wanted radio signals, and if indoors, where it is necessarily closely coupled to the electrical wiring of the building, it is unduly susceptible to electrical interference, the nett result being a low signal/interference ratio. It is clearly unreasonable to expect the owner of a machine to spend money on a suppressor if interference is experienced solely because the listener or viewer has not gone to the expense of having a satisfactory aerial installed in the first place. In such a case, if the I.O. is satisfied that a good aerial will substantially reduce or eliminate the interference and that facilities exist for erecting such an aerial, he will give advice and intimate that the Post Office cannot pursue the case further until an adequate aerial has been erected. If in doubt, the I.O. will demonstrate the result obtained with a temporary aerial.

Assuming that the receiving installation is in order, the I.O. will locate the source of the interference and, with the owner's consent, ascertain by trial the type of suppressor required. The owner is then asked to choose between paying for the Post Office suppressor and having a suppressor fitted by an electrical dealer. Although the Postmaster General now has certain legislative powers in relation to radio interference—to be dealt with in a later article in this series—it is the intention that, as far as possible, the work should continue in a voluntary co-operative manner. There is a growing tendency for manufacturers of interfering apparatus, particularly domestic electrical appliances, either to fit suppressors during manufacture, or else to have standard suppressors, specially designed for specific appliances, available for fitting when the need arises. A number, as yet relatively small, of radio and electrical dealers are now taking an interest in fitting suppressors to their customers' appliances. Where such facilities exist and are of known efficiency, it is possible for the I.O. to restrict his work to locating the source of the interference, and leave the suppression of it to the trade.

### Causes of Interference

The only comprehensive information available on the nature of the apparatus that gives rise to radio interference in the U.K. is the annual summaries of complaints received and investigated in Telephone Areas, which are prepared by the E.-in-C.'s Office. The figures for the 12 months ended 17th January, 1957, are the latest available, and the following comments refer to those data.

Table 4 gives those cases investigated in which reasonable complaint was considered to have been made, while Table 5 refers to cases in which the complainant was unco-operative, the receiving installation was defective or the wanted signal was too weak to protect.

TABLE 4

*Incidence of Interference from Specified Sources*

| | | Number of complaints attributable to each source | | | |
|---|---|---|---|---|---|
| | | L.W. and M.W. | Band I | Band II | Band III |
| 1 | Sewing machines | 1,208 | 9,374 | 3 | 55 |
| 2 | Hairdryers | 526 | 5,298 | 5 | 38 |
| 3 | Portable electric tools | 1,613 | 3,761 | — | 24 |
| 4 | Vacuum cleaners | 1,842 | 6,489 | 2 | 32 |
| 5 | All other motors, generators, convertors, etc. | 3,063 | 8,469 | 8 | 52 |
| 6 | Bedwarmers | 350 | 1,124 | — | 8 |
| 7 | Smoothing irons | 260 | 232 | — | — |
| 8 | All other "contact" devices | 2,151 | 4,354 | 2 | 64 |
| 9 | Gaseous discharge lamps (excluding neon signs) | 2,027 | 506 | — | 3 |
| 10 | Neon signs | 441 | 1,817 | 5 | 24 |
| 11 | Filament type lamps | 90 | 2,334 | 12 | 7 |
| 12 | Power Lines, overhead, all voltages | 484 | 4,327 | 3 | 18 |
| 13 | Industrial and medical r.f. apparatus | 88 | 1,636 | 1 | 54 |
| 14 | Radio transmitters, amateur stations only | 137 | 473 | 1 | 13 |
| 15 | Radiation from television receiver time-base circuits | 5,553 | 433 | — | 92 |
| 16 | Radiation from local oscillators of Band I television receivers | — | 1,735 | 3 | 83 |
| 17 | Radiation from local oscillators of Band II v.h.f. receivers | — | 32* | — | 4 |
| 18 | Radiation from Band III convertors | — | 2,463 | 1 | 71 |
| 19 | Vibratory devices (bells, buzzers, etc.) | 141 | 504 | — | 7 |
| 20 | Faulty electrical wiring of premises | 1,664 | 576 | — | 5 |
| 21 | Identified sources other than those specified above | 2,391 | 6,043 | 27 | 223 |
| 22 | Unidentified sources | 10,594 | 24,704 | 32 | 461 |

* Fourth harmonic (approx. 43 Mc/s) radiation from i.f. stage.

TABLE 5

*Complaints arising from Unsatisfactory Conditions at the Receiving Site*

| | | | | | |
|---|---|---|---|---|---|
| 1 | Inefficient aerial installations .. .. | 9,899 | 4,113 | 36 | 265 |
| 2 | Faulty receivers .. .. .. .. | 4,376 | 8,231 | 28 | 522 |
| 3 | Maladjustment of receivers .. .. | 244 | 989 | 3 | 57 |
| 4 | "Ghosts" and "Flutter" .. .. .. | — | 214 | — | 30 |
| 5 | Other conditions affecting reception* .. | 5,367 | 12,259 | 21 | 309 |

* Item 5 covers, among others, such miscellaneous conditions as:—
(*a*) interference arising from spurious responses in the receiver;
(*b*) poor signal/noise ratio because of the distance from the transmitter, or because of local screening;
(*c*) failure on the part of the complainant to reply to requests for information (lapsed complaints).

When considering Table 4 it should be borne in mind that:—

(*a*) The number of viewers or listeners whose reception is affected by interference is usually much greater than the number of complaints received.

(*b*) More than one source of a given kind may be concerned in some complaints, and more than one complaint may sometimes be made about a common source.

(*c*) Complaints about ignition interference are seldom made on a scale commensurate with the known extent of the interference.

The total number of complaints in the two tables may exceed the number of investigations completed during the period under review; this is because two or more sources of different kinds may be involved in a single complaint. Against unidentified sources (item 22) are all those complaints in which the interference ceased before or during an investigation, or in which the interference was of too infrequent occurrence to justify continued investigation to the exclusion of more deserving complaints. In certain circumstances suppressors are fitted at the premises of the complainants.

It is a regrettable fact that television receivers are, themselves, a prominent cause of interference. In the period under review time-base radiation was responsible for not less than 5,553 complaints by listeners to long-wave and medium-wave broadcasts, while radiation from the fre-

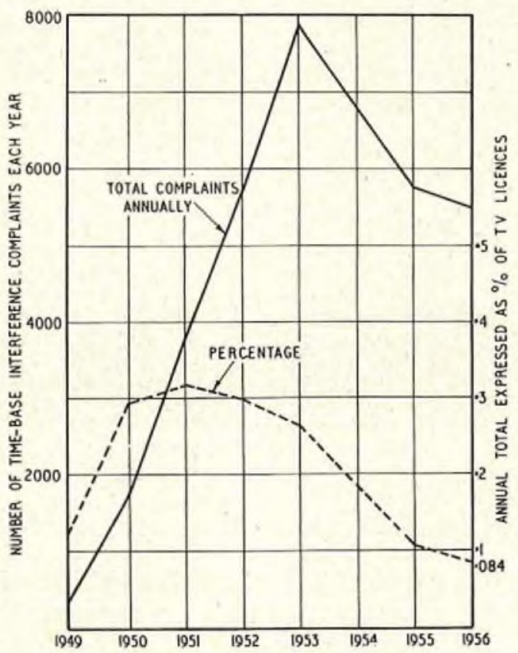



FIG. 3.—TIME-BASE INTERFERENCE WITH SOUND BROADCASTING.

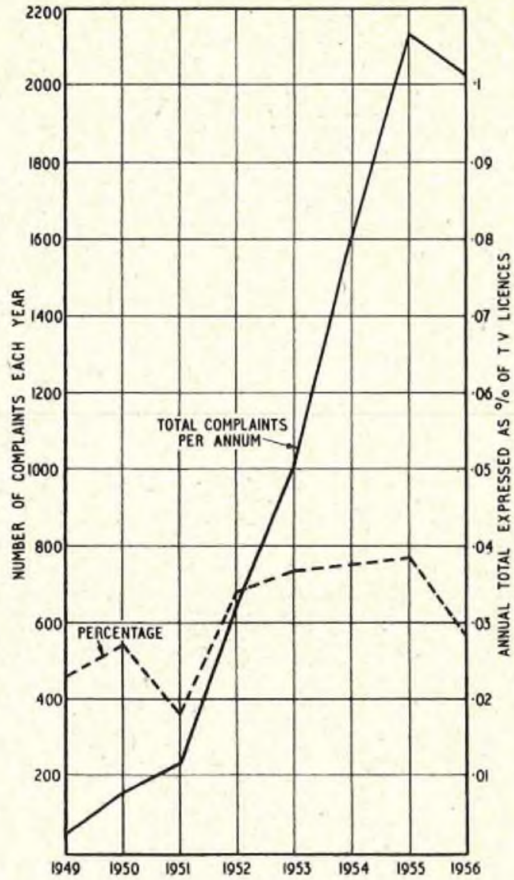



FIG. 4.—INTERFERENCE WITH TELEVISION CAUSED BY RADIATION FROM FREQUENCY-CHANGING OSCILLATORS OF OTHER TELEVISION RECEIVERS.

quency-changing oscillators of television sets was responsible for 1,821 complaints, and a relatively new source, Band III convertors (item 18), was responsible for 2,535 complaints. Fig. 3 and 4 show the trend of complaints received in recent years about the first two sources of interference by television. Clearly, complaints of time-base radiation have been arrested, this having resulted partly from the declining public interest in sound broadcasting and partly from the action of the British Radio Equipment Manufacturers' Association which has evolved methods of test and limits of radiation to which it has urged all of its members to conform. Similar action in relation to radiation from frequency-changing oscillators also appears to be producing beneficial results.

Another prominent cause of interference with both sound radio and television reception is the sewing machine. However, models now being sold by the largest manufacturer incorporate suppressors, which are also available as separate components for fitting to old machines.

Taking the figures as a whole and grouping them into large blocks according to the mechanism by which interference is generated, it can be seen that the main causes of interference are commutator motors, contact devices (including thermostats), television receivers, overhead power lines, gaseous discharge lighting and industrial scientific and medical r.f. apparatus. Existing and/or possible future methods of controlling interference from such large classes of apparatus by legislation will be discussed in a later article in this series.

(*to be continued*)

# An Experimental Announcing Machine for Information Services

A. J. FORTY
and R. J. JURY†

U.D.C. 621.395.91

**Announcing machines have been used by the Post Office for some years for providing announcement services. These machines fall into two categories: those that provide speech signals which are never varied or which are changed in a predetermined cyclic order; and those that give a repeated announcement which can be changed at intervals. The requirements of both categories of machine are discussed and a development project is described which has led to the design of a reliable machine, based on magnetic recording, for producing announcements that can be changed when necessary by unskilled staff.**

## Introduction

ANNOUNCING machines have for some years been used by the Post Office for providing announcement services which, for economic reasons and because of the sheer monotony of repetition, cannot be given by operators. The earliest example of this application known to the authors was the Robot Operator (or more familiarly the "potted operator") installed at Folkestone on 29th April, 1935,[1] for an experiment in replacing busy tone with the spoken word "engaged."

Broadly speaking, the various announcing machines which have since been put into service fall into two categories. The Speaking Clocks,[2,3] the Mechanical Delay Announcer[4] and the Congestion and Delay Announcer[5] provide speech signals which are never varied, or which are changed in a predetermined cyclic manner. This type of machine is required to have a long life, to need little maintenance and (especially when the announcements are heard by the public) to be absolutely reliable in operation. For these reasons the design of this kind of machine has been robust and the recording medium employed has been the glass disc record.[6]

The second class of machine is also required to give a repeated announcement, but one that can be changed in content at intervals which may be measured in hours or weeks. This type of equipment includes the Changed Number Announcer,[7] the announcing apparatus for the Master Standard Frequency (M.S.F.) transmissions from Rugby Radio Station,[8] and, more recently, the announcers for the Weather Forecast Service.[9]

If the message given by a machine is to be changed at intervals, the use of pre-recorded glass discs for carrying the information would necessitate a complex and bulky construction unless the choice of available phrases was unduly restricted. For this type of application magnetic recording, which permits instant erasure and replacement of a message, has no competitor.

For some applications in this field, long life and sturdy construction are again desirable; for others, involving greater numbers of machines, the opposing requirements of cheap construction and low maintenance charges are a matter for economic study. In all cases where a service for the public is involved, however, the need for reliability is unquestioned. This article describes a development project which has led to the design of a machine based on magnetic recording, as reliable as the Speaking Clock in its own field, for producing announcements that can be changed at will by unskilled staff.

## Choice of Recording Medium

Ordinary magnetic recorders employing a coated plastic tape are unsuitable for repeated playback of a message over a long period of time. Magnetic tape has a limited life: it curls as it ages (resulting in poor contact with the replay head and loss of speech quality) and it breaks after repeated flexure. The vicinity of the joint in a continuous loop is particularly liable to fatigue failure. Furthermore, the magnetic coating is intrinsically abrasive, resulting in wear of the playback head and sometimes in a build-up of "corns" of abraded material. Breakage problems can be avoided by using coated drums, but with heads in contact difficulty arises from microphonic noise unless the drum surface is resilient. A drum operated with heads out of contact is the ideal solution to the wear problem, but this technique requires precision engineering and so is expensive; there is also difficulty in obtaining an adequate frequency response with surface speeds that are low enough to give the required message length on a drum of practical size.

In 1952 a new form of magnetic recording medium was announced.[10] It consisted of a synthetic rubber base impregnated with magnetic oxide and also with a paraffin wax which, it was claimed, would gradually migrate to the surface and act as a lubricant, thus reducing head wear. The material was available in continuous bands in a restricted range of sizes, with thicknesses of $\frac{1}{16}$ in. and $\frac{1}{8}$ in.

Some samples of this material were obtained and tested, and it was found to give excellent results provided that certain modifications to the normal technique were made.

For continuous running it is necessary to lubricate the surface of the medium with a silicone oil, which is conveniently applied by a spring-loaded felt pad. Without this lubrication the surface quickly becomes dry and head squeal results; with it the head operation is very smooth, and wear, both of head and medium, is reduced to negligible proportions. (It is of interest that silicone lubrication of cinema film has recently been introduced and has proved very successful in reducing wear.[11]) The thickness of the medium ($\frac{1}{8}$ in. compared with less than 0·001 in. for conventional tape) gives rise to undesirable effects unless certain precautions are taken, mainly because the lower-frequency signals penetrate to a greater depth than those of higher frequency. Thus, if a normal frequency value (of 50 kc/s or more) is adopted for the bias and erase oscillator it is found that low audio frequencies are recorded without bias at the deeper levels of the medium and so give distorted signals when replayed. Furthermore, the erase field does not penetrate to the full depth, with the result that heavily-recorded signals from over-modulation or switching surges are not fully erased, and the signal-to-noise ratio gradually deteriorates. It has been found, however, that by reducing the frequency of the bias and erase oscillator to a lower value adequate quality and erasure are obtained. For the present application the problem is eased by the fact that the required audio bandwidth only extends to 4,000 c/s, and a bias frequency of 21 kc/s has been found to give excellent results.

In common with other rubbers, natural and synthetic, the material is adversely affected by strong sunlight and excessive strain (both of which ultimately lead to crazing of the surface) and by mineral oil (which causes swelling). By suitable design, however, the action of the first two causes can be avoided, while by the use of a silicone oil for lubrication both of the band and of the machine bearings the last factor does not arise.

†Mr. Forty, Assistant Staff Engineer, Subscribers' Apparatus and Miscellaneous Services Branch, E.-in-C.'s Office, was formerly a Senior Executive Engineer, Post Office Research Station. Mr. Jury is a Senior Draughtsman, Post Office Research Station.

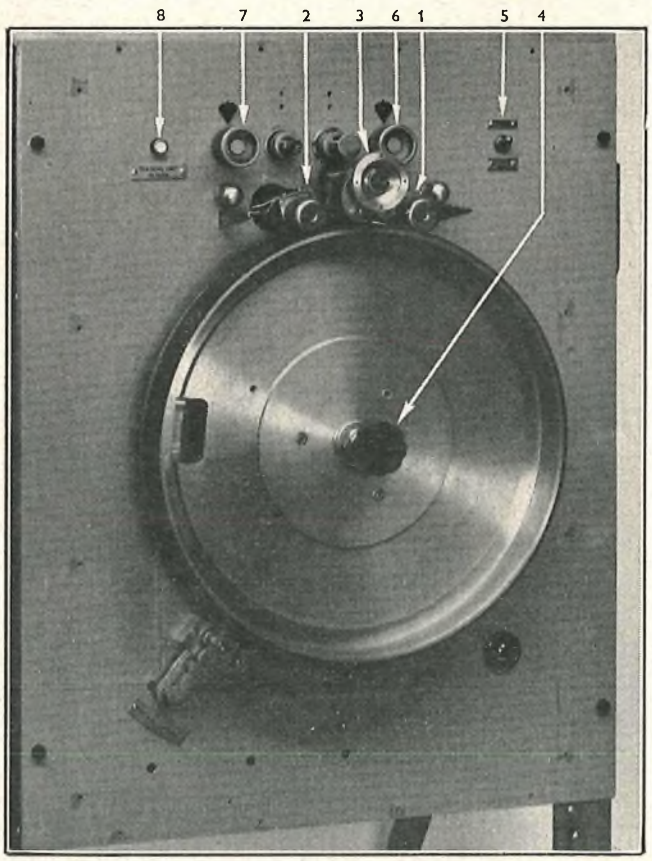
The favourable characteristics of the medium may be summarized as follows:

1. Long life of the material and of the magnetic heads. (Tests after 1,000 hours of running have shown no detectable wear of either.)
2. Frequency response equivalent to that of tape.
3. Noise level, although greater than that of tape, is adequate.
4. Resilient: consequently no microphony of heads.
5. Available in continuous bands of convenient size.

Unfortunately, the oxide-loaded neoprene is not manufactured in this country and supplies have to be imported. Since, however, the quantity required per machine is small and will not need replacement this was not considered to be a serious objection to its use, and it was adopted as the recording medium for the series of experimental machines which will now be described.

### Early Machine

Fig. **1** is a photograph of a machine that was constructed to explore the technique. The recording medium was carried on a drum $13\frac{1}{2}$ in. in diameter, rotating about a horizontal axis. A record/replay head (1) and an erase head (2) could be lowered singly on to the drum by means of the knob (3). The complete head assembly could be moved horizontally across the face of the drum so that the heads traced a helical path on the surface. This action was controlled by a leadscrew and pawl and ratchet gear which could be thrown out of engagement by means of the knob (4), thus permitting single circular tracks to be recorded. At a later stage in the development, the switch (5) was added to control this operation electrically. The limits of travel of the heads (and thus the length of the helical path) were set by means of knobs (6) and (7), which fixed the position of microswitches operating the carriage return mechanism. A trip button (8) enabled carriage return to be made instantly if required.




1. Record/Replay head.
2. Erase head.
3. Head lowering control.
4. Clutch control.
5. Circular track/helix switch.
6. Front stop control.
7. Back stop control.
8. Carriage return button.

Fig. 1.—Early Machine.

To operate this machine the recording amplifier was first switched to the RECORD condition, and the erase head was lowered manually on to the drum. The machine was started and left running until the carriage return circuit was operated, by which time any previous message had been erased. The front and back stops were then moved, if necessary, by means of knobs (6) and (7) in order to accommodate the new length of announcement. Next the erase head was lifted, the record head lowered, and the carriage return button (8) pressed. The new message was then spoken into the recording microphone. Finally, the amplifier was switched to the replay condition and the limit stops adjusted to restrict the head travel to the required length of message. When this had been done the message would be repeated by the machine indefinitely with the least possible delay between repeats.

Several useful lessons were learned from the experience gained with this machine:—

1. Since the position of the start of the helical recorded track is fixed on the drum and the end of the track can occur at any radial position depending on the length of the message, the maximum delay which can occur between successive repetitions of the announcement is equal to the period of revolution of the drum. In order to reduce call-holding times, it is desirable to make this delay as small as is economically possible: a figure of 4 sec was chosen as the target. This means that the drum must rotate at 15 r.p.m., and if the surface speed is restricted to about 4 in./sec (which gives an adequate frequency response for telephone applications) then the drum diameter is fixed at about 5 in.

2. The use of springs for carriage return was unsatisfactory. Eventually this problem was solved by using nylon threads carried over pulleys and attached to weights. If the drum axis were vertical, however (which would be feasible with the proposed smaller drum), the force of gravity could be used directly and simply for carriage return.

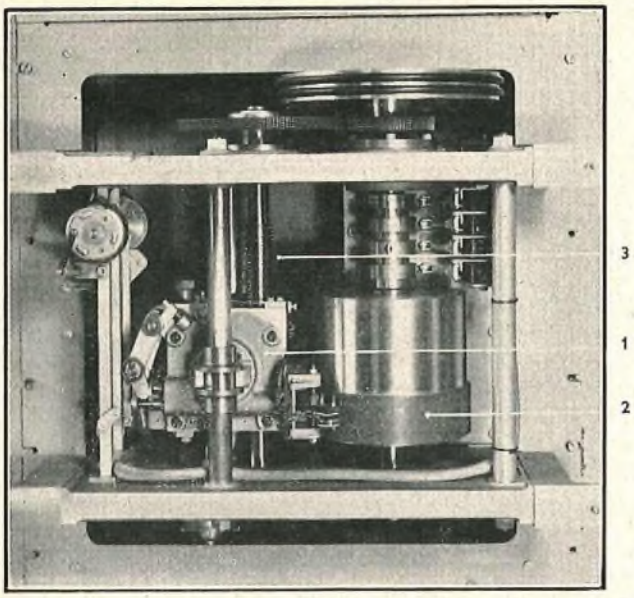
3. Although the limit switch controls made an accurate selection of the wanted message possible it was desirable to make this feature automatic. Similarly automatic switching of the record/replay condition was also required and preferably both of these functions should be under the control of operating staff. These modifications would involve the introduction of a memory device, relay circuits and remote control.

4. Automatic erasure during recording should be applied as in conventional tape recorders.

5. The drive of the early machine was provided by a mains-driven motor followed by a gearbox and friction coupling to the inside of the drum. The use of the gearbox necessitated the introduction of mechanical smoothing to reduce the speech flutter to a reasonable figure. This difficulty could be avoided by employing a two-stage friction drive reduction which would not only give a better performance but also be cheaper to make.

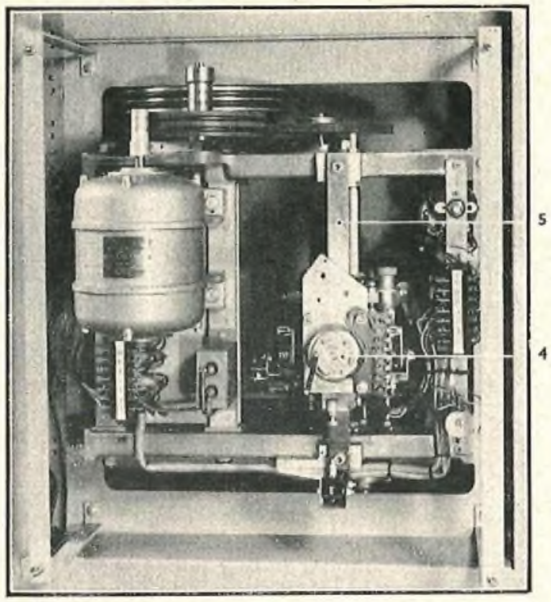
### Machine with Mechanical Memory

As the next stage in the development the machine shown in Fig. **2** and **3** was built. Commercial equipment was adapted to provide the associated power unit and amplifiers and the whole assembly occupied a space of 51 in. on a 19-in. rack. A detailed description of this machine will not be given since it was quickly superseded by a simpler and more economical model providing the same facilities.




1. Head carriage.
2. Drum.
3. Leadscrew.

Fig. 2.—Machine with Mechanical Memory. Front View.




4. Memory carriage.
5. Guide bar.

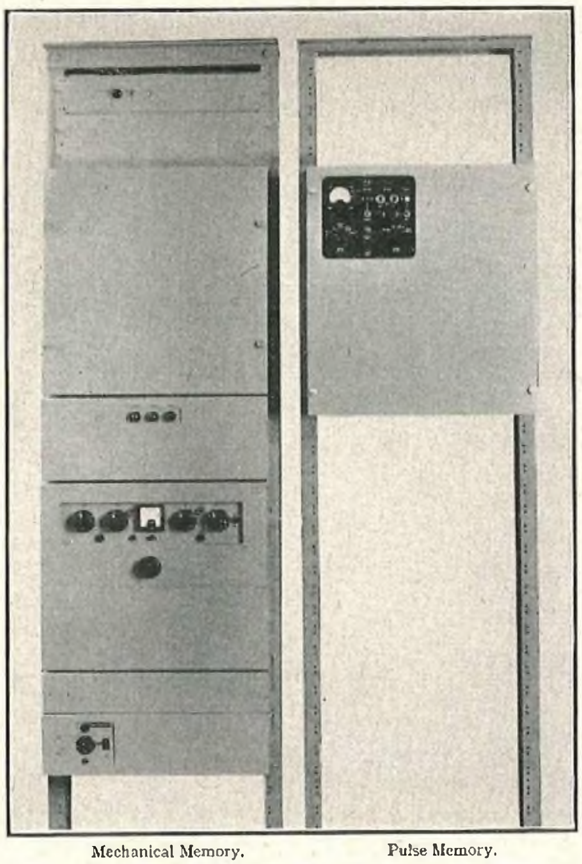
Fig. 3.—Machine with Mechanical Memory. Rear View.

Briefly, referring to Fig. 2 and 3, the recording and erase heads were attached to a carriage (1) which was moved vertically across the face of the drum (2), under control of the leadscrew (3). During recording, this carriage also lifted a second (memory) carriage (4), sliding on a square bar (5). At the end of the recording operation the head carriage was returned to the base, but the memory carriage was locked to the bar, thus determining the extent of travel of the heads for subsequent replaying.

This machine was fully automatic in operation, but the mechanical precision required in the construction of the head and memory carriages made the manufacture expensive. It was then realized that a considerable simplification and cheapening of the design could be achieved by causing the drum to travel axially as it rotated and by fixing the head assembly to the body of the machine. The head carriage, its guides and the leadscrew drive assembly could then be dispensed with, for the leadscrew could be carried on the main drum shaft. The number of main bearing surfaces would thus be reduced to two. A further simplification would be obtained by replacing the complex mechanical memory by one in the form of a pulse recorded on the drum at the termination of each recording.

## Machine with Pulse Memory

The modifications described above, together with a reconsideration of manufacturing techniques, have led to a design which is much more economical and compact than its predecessors; it can be built almost entirely from stock material with very few components requiring fine tolerances. Fig. 4 shows, for comparison, the mechanical- and pulse-memory machines side by side. The two equipments provide identical facilities. Tests of the pulse-memory machine have shown that its operation is very reliable. There has not yet been time for an extended life test, but examination of a machine after 1,000 hours of running has shown no measurable wear of the heads, of the medium, or of any other working part. The remainder of this article is concerned with a description of the performance of this model.



Mechanical Memory. Pulse Memory.

Fig. 4.—Comparison of Machines.

### *Facilities.*

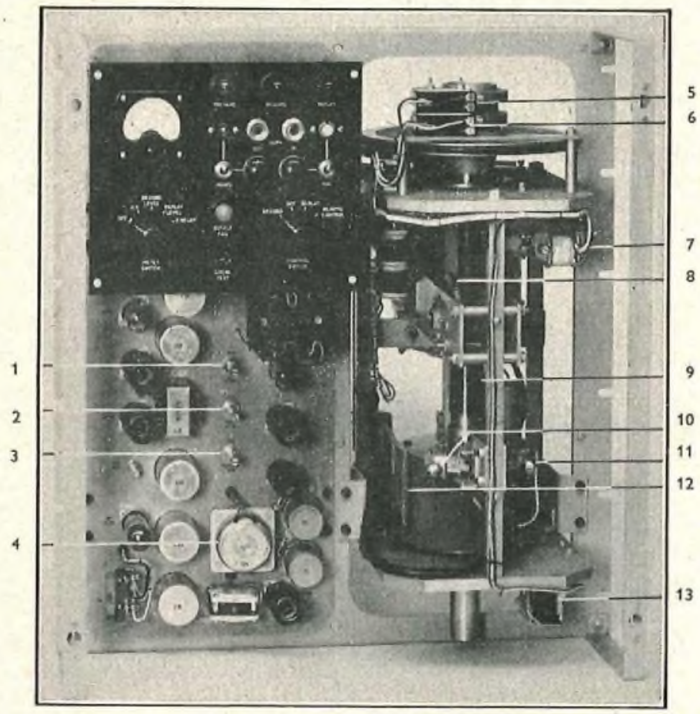
The machine is designed for mounting on a 19-in. rack, and the mechanical unit together with its associated electrical equipment is carried on a No. 12 panel (21 in. high). Remote control is provided by means of a single switch on a small desk (Fig. 5), which may be distant from the main apparatus. A telephone-type handset is used with the desk for making the recordings and for monitoring the result; the operation is fully automatic, and the recording and replaying of announcements can be carried out by staff with no technical knowledge.

A message of any duration from 4 sec to 3 min can be recorded by turning the control switch on the desk to

FIG. 5.—REMOTE-CONTROL DESK.

RECORD and speaking into the microphone. A yellow PREPARE lamp gives a warning to the operator to prepare to speak. After a short pause this lamp goes out and the red RECORD lamp lights, whereupon the operator speaks the message into the microphone of the handset. When recording is complete the control switch is restored to OFF and the machine stops.

To check the recording the control switch is turned to REPLAY. The green REPLAY lamp lights, and the recorded message is heard in the receiver of the handset. If an error is apparent the machine is switched to OFF and then again to RECORD, when a fresh recording can be made immediately and the existing message automatically erased.




1. Alarm level control.
2. Drum return control.
3. Output level control.
4. Solenoid switch RPL.
5. Microswitch J.
6. Microswitch K.
7. Electromagnet CRS.
8. Ratchet wheel.
9. Leadscrew.
10. Erase head.
11. Record/replay head.
12. Oiling pad.
13. Microswitch BS.

FIG. 6.—PULSE MEMORY MACHINE. FRONT VIEW.

When the operator is satisfied that the wording is correct, the control switch is left in the REPLAY condition and the machine is put into service. The message will then be played back continuously (irrespective of its length) with no delay between repeats except for rounding up to the nearest 4 sec (e.g. a message of duration 1 min 10 sec will be repeated at 1 min 12 sec intervals).

The machine can be stopped and restarted retaining the recorded message, which is lost only when the control switch is again turned to RECORD.

Automatic gain control is provided in the microphone circuit and so no volume indicator is required for the operator. The gain of the replay amplifier may be preset to give the required output level to line; this will be maintained within specified limits for a range of talker levels. Consequently no adjustment is normally required by maintenance staff after a fresh recording has been made. An alarm valve gives warning of output failure. This warning may be set to operate at any required level below the normal working level.

For maintenance purposes the control may be transferred to a switch on the machine itself. The indicator lamps on the control desk are duplicated on the machine to show which stage of recording or replay is in progress.

*Principle of Operation.*

Fig. 6 and 7 show the front and rear views of the machine with the covers removed.

The recording medium is mounted on a cylindrical drum of 5 in. diameter, which turns about a vertical axis. The drum is driven at a speed of one revolution in 4 sec by a mains-driven synchronous motor via a two-stage friction reduction train. The driving torque is applied to the drum shaft by means of a key which operates in a slot in the final driving wheel; consequently the shaft may move vertically while it is rotating. The shaft carries a leadscrew which engages with a toothed gear coupled to a ratchet

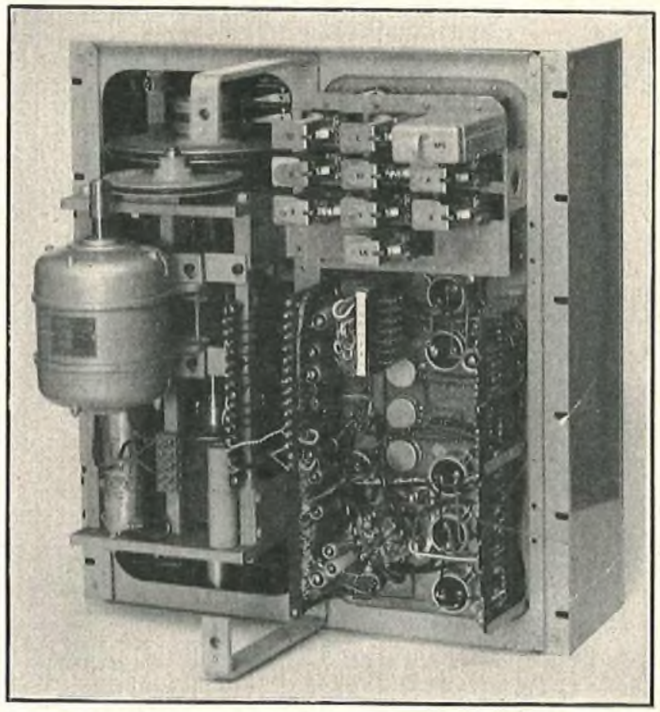


FIG. 7.—PULSE MEMORY MACHINE. REAR VIEW.

wheel which can be locked by means of a pawl. When this wheel is locked the drum will rise by one pitch of the leadscrew ($\frac{1}{16}$ in.) for every revolution that it makes. Magnetic heads mounted on the machine base thus trace out a helical path on the drum surface as the drum rises. This is the condition which applies when a message is being recorded, the leading head erasing any previous message and the trailing head recording the new information. When the machine is switched from the RECORD condition, a short pulse of 50 c/s is automatically recorded on the drum, and the pawl mechanism is then operated. The wheel engaging the leadscrew is now free to revolve, and the drum assembly falls to the base of the machine under gravity, the last part of the travel being cushioned by an air dashpot. When the machine is switched to REPLAY, the pawl is operated at the correct moment, the leadscrew wheel is locked, and the drum commences to rise as it revolves. The trailing head now replays the message until the end is reached. It then encounters the recorded pulse and this causes the operation of the pawl-release mechanism. The drum then returns to the base and the cycle starts once again, repeating indefinitely until the machine is switched to OFF.

If a long recording is made to supersede a short one, the whole of the early recording, including the terminating pulse, is erased in the process. If a short recording is made subsequently then only that part of the space of the long recording which is required is erased, but the new terminating pulse prevents the unwanted remainder of the long recording from being replayed.

The pulse memory has proved to be simple and trouble-free. It has the merit that it retains its precision of operation provided that the normal electronic equipment is in working order, and, unlike its mechanical counterpart, it has no moving parts which may wear and give rise to erratic operation.

A more detailed description of the operation of the control circuits is given in the Appendix.

*Electronic Unit.*

The circuits used for replay amplification and for erase and bias supplies are of a conventional design. For recording, the same amplifier is used as for replay, with the substitution of a variable-$\mu$ valve to give compression control. The rectified voltage derived from the output stage and used for the a.v.c. during recording is also used during replay to control the output level alarm circuit.

A double triode controls the carriage return mechanism in the following novel manner. At the end of a recording when the control switch is restored to OFF, the first triode has a 50-c/s pulse injected into its cathode circuit. This is amplified, rectified and used to bias off the second triode thus causing the release of a relay (X) which, in turn, trips the carriage return mechanism. Meanwhile a similar 50-c/s signal has been fed to the record head and recorded on the drum. At the end of a subsequent replay the pulse is read from the drum, amplified by the first triode and fed to the second to cause carriage return in the same way as before. The time constant of the charging circuit of the grid of the second triode is increased for the recording operation to ensure that an adequate length of pulse is recorded for replay tripping.

The replay amplifier will deliver 3W into a 4-ohm load. This value of terminating resistance has been chosen to provide a low impedance source of signals across which a number of subscribers' lines can be connected without change of level and without the possibility of cross-talk. The amplifier can thus be used for local distribution if desired. For large installations with centralized power amplifiers it may be desirable to fit an alternative output transformer to the machine to avoid loss due to resistance in the leads of the machine–amplifier connexion.

*Maintenance Facilities.*

A LOCAL TEST jack is provided in the machine panel for maintenance staff to make recordings and to listen to the output as required. The control switch on this panel enables RECORDING, REPLAY and OFF conditions to be set up, and when turned to any one of these positions it overrides the remote control. When the machine control switch is turned to the REMOTE CONTROL position, the remote desk is brought into operation, an indicator lamp on the desk is lit to show that it is now in charge, and the microphone circuit of the LOCAL TEST jack is muted. It is thus no longer possible for the maintenance man to record on the machine, though he is still able to monitor messages recorded from the remote position.

A meter provided for maintenance purposes can be switched to indicate any of the following:—

HT supply voltage
Recording level
Replay output level
Current through relay X.

Measurement of the last-named quantity is useful for ensuring correct carriage return. It is not essential, however, to use the meter in order to set up the machine: the facility has been provided mainly as an aid for fault finding. The meter and switch can be omitted if this is thought to be desirable on the score of economy.

An alarm circuit is included for indication of fall of output level below a predetermined value which can be selected by means of a potentiometer under the cover (see (1) of Fig. **6**). An OUTPUT FAIL lamp is mounted on the machine panel and the alarm circuit can also be connected via tags to give a remote warning.

The switching has been arranged so that:—

(i) Both local and remote alarms are suppressed during recording (whether under local or remote control) and also when the machine is switched off.
(ii) Both local and remote alarms are operative when the machine is switched to play-back under remote control.
(iii) The local alarm only is operative when the machine is switched to play-back under local control.

When several machines are available for use at one centre (see below) special provision will be necessary at the switching desk to connect the relevant alarms and to provide "receiving attention" conditions.

COPY IN and COPY OUT jacks are provided on each machine panel. Thus by means of a single patching cord the message recorded on any one machine may be transferred to a second which can then serve as a standby. The copy facility can be extended to a central supervisor's position if necessary. No adjustment of gain is necessary when copying.

A potentiometer for setting the replay level is located under the cover of the machine on the electronic equipment panel (see (3) of Fig. **6**). Normally, this will be set once and for all when the machine is installed. The automatic gain control in the recording circuit then ensures that the required output on replay is maintained. A 30-db variation of input signal is reduced by the a.g.c. to 6 db change at the output. (The level variation to be encountered in different voices is more likely to be of the order of $\pm 6$ db. This will give a variation of $\pm 1\frac{1}{2}$ db in the output level.)

The only mechanical maintenance required is attention to infrequent oiling routines. A felt pad in contact with the drum maintains constant lubrication of the surface of the recording medium. This pad should be kept moist with a silicone oil; it is important that a silicone and not a mineral oil should be used since the latter would have an adverse effect on the neoprene base. For this reason, and since other oil requirements are very small, it is recommended that the silicone oil be used for all lubrication of the machine.

*The Use of Multiple Units.*

The machine has been designed so that it can be adapted for use either singly or in numbers for providing information services. The mechanical unit and the electronic sub-panel have identical mountings and can be interchanged on the main panel. Consequently, it is possible to mount two mechanical units side by side if desired, with their electronic equipment mounted similarly on a panel beneath. In this way the maximum flexibility in the layout of banks of machines has been the aim.

For a single machine the electronic and mechanical units are mounted as shown in Fig. 7. Interconnexion of the two is by means of soldered links between two adjacent tag strips so that either unit can be replaced if faulty with the minimum of delay.

When only one machine is provided at a centre the remote control desk will normally be wired permanently to the machine. For larger installations the remote control leads and the output and alarm leads would be wired to a single control position where any one of the machines could be selected for recording or for replay into an output channel. Only one remote control box would be required: this would be connected to the selected machine by the supervisor when a fresh recording was to be made. The situation of the remote control would naturally be chosen with due regard to the acoustic conditions required for satisfactory recording (i.e. absence of background noise and of undue reverberation). A normal telephone handset incorporating a linear microphone has been adopted for recording and monitoring since it gives a close speaking distance and so reduces the influence of room noise and reverberation.

## Conclusion

The last of the machines that have been described represents the present stage of the development project. It may have a successor, but at present it is difficult to see how it could be further simplified without sacrifice of reliability or versatility.

The design is thought to be capable of giving a long and satisfactory service, and this, it is hoped, will be demonstrated by three machines given a Regional field trial carrying weather forecast announcements.

## Acknowledgment

The authors are indebted to their colleagues at the Post Office Research Station who with them formed the team engaged on this work.

*References.*

[1] Williams, H., and Hibberd, W. A. The Replacement of Busy Tone by Verbal Announcement. *P.O.E.E.J.*, Vol. 28, p. 208, Oct. 1935.

[2] Speight, E. A., and Gill, O. W. The Speaking Clock, Part II. *P.O.E.E.J.*, Vol. 29, p. 263, Jan. 1937.

[3] Forty, A. J., and Milne, F. A. The British Post Office Speaking Clock Mark II: Part I.—Design and Performance. *P.O.E.E.J.*, Vol. 48, p. 154, Oct. 1955.

[4] Corkett, H., and Lynch, A. C. Trunk Delay Announcing. *P.O.E.E.J.*, Vol. 35, p. 73, Oct. 1942.

[5] Manning, D. J., and Mitchell, F. J. H. The Congestion and Delay Announcer. *P.O.E.E.J.*, Vol. 47, p. 127, Oct. 1954.

[6] Forty, A. J. A Photographic Technique of Sound Recording on Glass Discs. *P.O.E.E.J.*, Vol. 47, p. 19, April 1954.

[7] The Changed Number Announcer. *P.O.E.E.J.*, Vol. 47, p. 179, Oct. 1954.

[8] Law, H. B. Standard Frequency Transmission Equipment at Rugby Radio Station. *Proc.I.E.E.*, Vol. 102, Part B, No. 2, March 1955.

[9] Manning, D. J. The Introduction of a Telephone Weather Service in London. *P.O.E.E.J.*, Vol. 49, p. 47, April 1956.

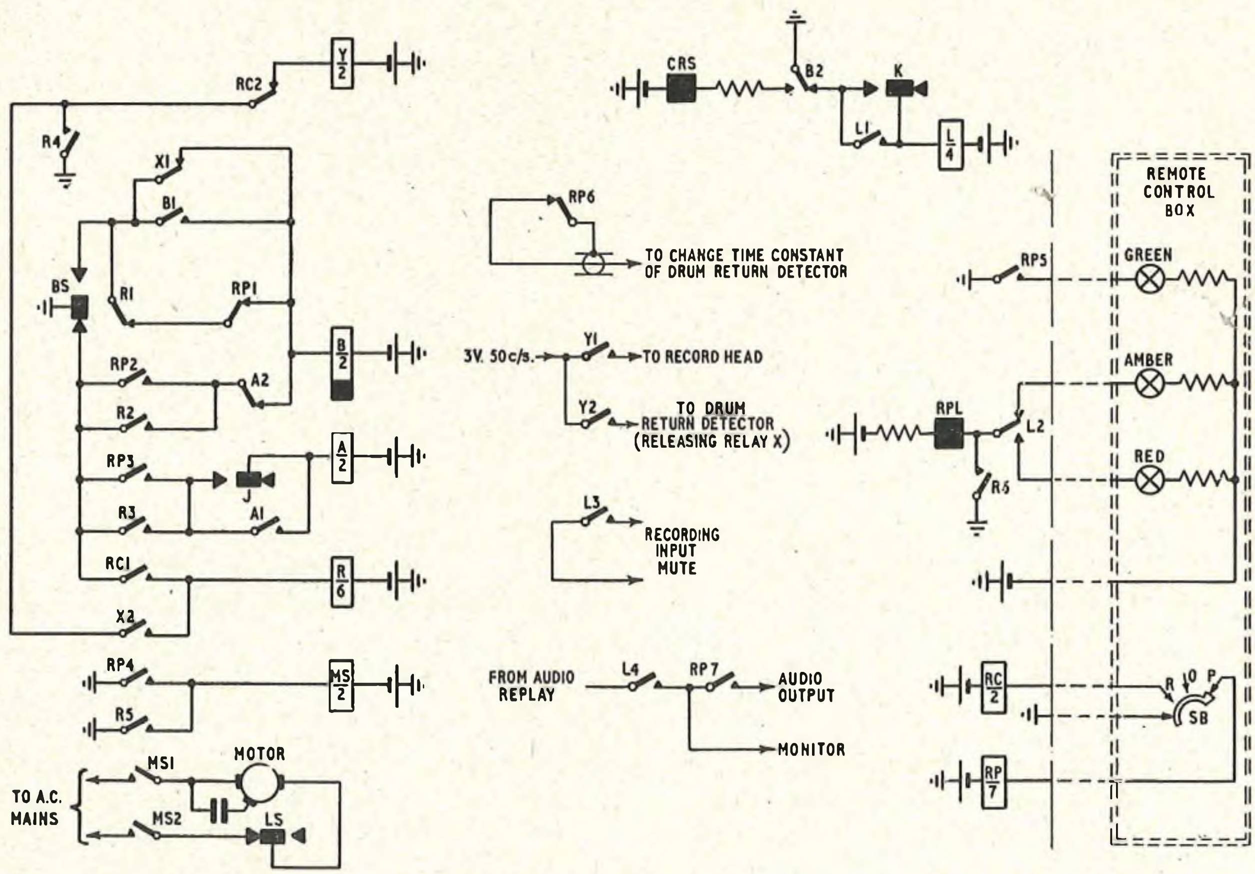
[10] Menard, J. Z. A New Recording Medium for Transcribed Message Services. *B.S.T.J.*, Vol. 31, p. 530, May 1952.

[11] Brueggemann, H. Lubrication of Release Prints with Silicone. *J.S.M.P.T.E.*, Vol. 66, No. 3, p. 106, March 1957.

## APPENDIX

### Control Circuit Details

A simplified diagram of the Control Circuit is given in Fig. 8. For the sake of clarity, the monitoring, copying and microphone switching circuits have been omitted.




RP Relay for remote control of playback.
RC Relay for remote control of recording.
RPL Solenoid switch for changing amplifier connexions for record/playback.
CRS Electromagnet controlling drum return.
BS Microswitch operated by drum return.
J, K Microswitches operated by cams on the drum shaft.
LS Microswitch for preventing over-run of the drum.

Fig. 8.—Basic Control Circuit.

The operating of the machine by means of the remote control switch (SB) is described. The same conditions can be applied by the machine control switch (SA) which is not shown in Fig. 8.

In the following description of the operation of the control circuit, relay contacts that have no function at the stage under consideration are not referred to in the sequence of operation.

*Static Condition.*

With all supplies connected and the machine switched to REMOTE CONTROL, relay X (not shown in Fig. 8) is operated. With the desk remote control switch OFF the drum rests at the base of the machine (having stopped in a random angular position), the motor is switched off, and the magnetic heads have been lowered. R6 is normal, so that RPL rests in the REPLAY condition.

*Replay Sequence.*

*Control switch SB operated to* REPLAY.—RP operates. RP1 breaks the "drum return" circuit. RP2 energizes B via A2 and BS in the "down" position. RP3 prepares an operate circuit for A. RP4 energizes MS which starts the motor via MS1 and MS2. RP5 lights the REPLAY lamp (green). RP6 alters the time constant of the detector circuit. RP7 prepares the audio output circuit.

B2 energizes CRS which lifts the heads and pawl and so holds the drum at the base of the machine.

On the first subsequent operation of J, A operates and holds via A1. A2 releases B. B2 releases CRS.

The heads are lowered and the drum starts to climb. When the drum leaves the backstop, BS changes over to the "up" position and breaks the hold circuit of A, which releases.

Shortly after J has closed, K operates and energizes L via B2. L holds via L1. L4 completes the audio output circuit.

The recorded announcement now goes out to line. At the end of the message the 50-c/s recorded tone is detected and X releases. X1 operates B via BS in the "up" position. B1 holds B operated until BS restores (B is slow-to-release to cover the transit time of BS). B2 energizes CRS and releases L.

The heads are lifted and the drum returns to the base. L4 breaks the audio output before the drum returns.

When the drum reaches the base, BS changes over and breaks the locking circuit of B, but B holds via A2 and RP2. When J next operates the sequence is repeated.

Replay of the message thus continues indefinitely.

*Control Switch restored to* OFF.—This can happen at any point of the replay cycle. RP releases and RP1 operates B via BS and R1. B2 operates CRS.

The heads are lifted, the drum returns to the base, and BS changes over.

RP2 has released, so B now releases. B2 releases CRS.

The heads are lowered, and the pawl engages.

RP3 isolates the A relay circuit from the earth given by BS. Consequently A will not operate and lock even if the motor over-runs sufficiently to operate J after the drum has returned to the base.

RP4 releases MS and the motor stops. RP5 extinguishes the REPLAY lamp. RP6 restores the detector time-constant to the RECORD condition. RP7 breaks the audio output.

*Record Sequence.*

*Control switch SB operated to* RECORD.—RC is energized. RC1 extends earth from BS (in the "down" position) to operate R. RC2 disconnects Y.

R1 breaks the "drum return" circuit. R2 operates B via BS and A2. R3 prepares an operate circuit for A. R5 energizes MS and starts the motor. R6 switches RPL to the RECORD condition and lights the PREPARE lamp (amber) via L2.

B2 energizes CRS which disengages the pawl mechanism and lifts the heads.

J makes during the first subsequent revolution of the drum shaft and operates A which holds via A1. A2 releases B which in turn causes the release of CRS.

The drum commences to climb as in playback.

After BS has changed over R holds via R4 and X2.

Shortly after the operation of J, K makes and operates L via B2. L holds via L1. L2 lights the RECORD lamp (red) and extinguishes the PREPARE lamp. L3 removes the mute from the recording input. L4 is ineffective since RP7 is open.

The delay between the operation of the J and the K contacts is required to ensure that the beginning of the message will subsequently be erased (since the erase head is mounted 90° in advance of the record/replay head). Since both replay and record are muted during this interval no unwanted signal will be heard at the commencement of each message. The delay also gives the operator warning (via the PREPARE lamp) of the commencement of recording.

Recording proceeds.

*Control switch restored to* OFF.—RC releases. RC1 releases A, which has held via A1, R3, RC1, X2 and R4. R holds via R4 and X2. RC2 operates Y via R4.

Y1 switches a 50-c/s tone to the record head. Y2 switches a 50-c/s tone to the detector circuit.

After a predetermined delay time (increased for the record condition) X releases. X1 operates B via BS. X2 releases R.

B locks via B1 until the drum has reached the base. B2 operates CRS and releases L. CRS causes the drum to return to the base.

R5 releases MS and the motor stops. R6 releases and RPL changes to the REPLAY condition. R6 in releasing extinguishes the RECORD lamp.

The increase of the time constant of the detector circuit ensures that an adequate length of release pulse is recorded to control subsequent replay.

# The Development of Electronic Exchanges in the United Kingdom

U.D.C. 621.395.722:621.318.57:621.395.34

THE telecommunications industry has, for many years, exploited electronics in transmission equipment, as is evidenced by the solid achievements in line repeaters, carrier and coaxial systems, radio telephone systems and recently in the introduction of the first transatlantic telephone cable. The possibility that electronics could be similarly exploited in the development of new automatic telephone switching systems was not overlooked, but until after the Second World War the available equipment and techniques for switching applications were unable to measure up to the stringent requirements of service in public automatic telephone exchanges. Within the last 10 years, however, the rapid developments in electronic techniques, particularly in electronic computers, have thrown up new devices and methods of application capable of exploitation in the design of switching equipment of adequate performance and reliability.

Following a period of research by the Post Office Research Branch and, independently, by the manufacturers of telephone exchange equipment in this country it became apparent by 1950 that electronic telephone switching equipment was feasible and that an all-electronic exchange was at least a possibility. Manufacture of an experimental exchange was, of course, still a matter for the future but field trials of various devices and techniques were considered to be practicable and, in 1952, the first all-electronic register-translator was placed in public service at Richmond exchange in the London Telecommunications Region. This was quickly followed by an improved miniaturized version, which was also placed on trial at Richmond. Both trials proved technically successful and a design was prepared for a new register-translator based on the same type of components and intended for use in the Bristol Telephone Area in the South West Region, on the introduction there of subscriber trunk dialling. This new equipment is already in production on a limited scale.

Since 1952 new techniques have become available leading to the trial, in 1957 at Lee Green exchange, also in the London Telecommunications Region, of a register-translator based on the properties of the magnetic drum of a type similar to those now widely used in the memory systems of electronic computers. Concurrently with the trials of the various register-translators research into switching techniques continued with much interchange of ideas between the Post Office and the various telephone exchange equipment manufacturers independently. During this period the outcome of the research effort was the design of a number of experimental semi-electronic and all-electronic exchange systems of which some are now in daily use as P.A.B.Xs. Taken together they demonstrated conclusively that an all-electronic public exchange was no longer an interesting possibility but something which could be achieved in a relatively short time given the effort necessary.

By 1953 the Post Office had begun to study, in some detail, the problem of producing a full-scale public exchange and it soon became apparent that the problem was one of great complexity, not so much in the details of the techniques to be used but in the variety of the facilities required and the possible interactions between these facilities. A public exchange, unlike a simple internal telephone system, a computor or a radar set, must cope with a large variety of input conditions in order to provide the wide range of facilities demanded by the users. Moreover, during the normal course of a day's operation abnormal input conditions may arise, due perhaps to an incorrect use of a telephone or switchboard by a caller. Although such abnormal conditions may be rare in incidence they may react so profoundly on the operation of the exchange control equipment that special and expensive measures must be taken to ensure that the normal operation of the exchange can be resumed without affecting subsequent calls. Again, a public exchange equipment must operate continuously. Shut-down for maintenance is out of the question and this applies equally to power supply arrangements. It follows that not only must the components and circuits of an exchange system be very reliable in themselves but means must be provided to ensure that when faults do occur the working of the exchange will not be affected except perhaps for a temporary reduction in traffic efficiency occurring while the fault is located and rendered harmless. This requirement implies a certain amount of redundancy in the system, which not only adds to the cost of the exchange but also introduces circuit complications which themselves may introduce new problems. Maintenance too must be taken into account and means provided to assist the maintenance staff to locate faulty items of equipment rapidly and effectively. By and large the present electro-mechanical exchanges meet these requirements and the fundamental reason for investigating the possibilities of electronic techniques is to secure a greater efficiency at a lower cost.

It is to be remembered that the primary objective of the research that has gone on since 1947 was, and still is, the construction of an all-electronic exchange suitable for public service. With the task understood it became evident by 1954 that if the objective was to be achieved within a reasonable period a very considerable effort would be needed—an effort unlikely to be achieved by any single qualified group then available. Moreover the effort required would need to embrace not only research on electronic techniques but component design and production, circuit design, system planning, factory manufacture, the development of new types of power supply, ventilation of equipment racks, maintenance techniques and the application of automatic accounting equipment.

After much consideration it became clear to the Post Office that the only effective way of achieving the objective in the United Kingdom would be to enlist the co-operation, in a joint research project, of those telephone exchange equipment manufacturers who possessed the essential combination of experience in telephone switching and in electronics. In this way the Joint Electronic Research Committee came into being in 1956. Co-operation in the development of automatic exchange equipment in the interests of standardization had long been, and still is, a feature of the relationship between the Post Office and the manufacturers in the United Kingdom but until that time research had always been organized on an individual basis. With the introduction of the joint committee the situation changed to the extent that co-operation on the electronic exchange project now covers research rather than engineering development (although, of course, engineering effort is essential if the project is to succeed) and the principal objective is no longer standardization for production but the design of an experimental all-electronic exchange capable of carrying public traffic. The experimental exchange, when complete, will serve to define the design and manufacturing problems more precisely than has hitherto been possible and will enable solutions to be tried in practice. More particularly the operation of the exchange will provide information essential to the development of future exchanges and will enable studies to be made of maintenance practices. Last, but by no means least, it will be possible to determine the economics of the all-electronic exchange precisely enough to show in what directions future effort should be directed to secure an acceptable basis for the introduction of electronic techniques into the present automatic system.

Already co-operation in research has accelerated progress to a remarkable extent and this aspect of the joint project can be said to have been fully justified. As might be expected co-operation on the scale needed to achieve the desired results has called for an organization which has many ramifications.

As things stand at present the task of producing an all-electronic exchange has reached the point where the various techniques to be employed have been determined and logical design is virtually complete. The problems to be solved have been divided among the co-operating parties and as solutions are produced the parties become responsible for detailed circuit design and, in most cases, manufacture.

The agreed program aims at providing a 2,000-line all-electronic director-type exchange ready for service early in 1960. The exchange will be known as Highgate Wood, located in the area of that name in the London Telecommunications Region. The fact that the timetable has been maintained to a remarkable extent despite the emergence of several unexpected problems can be attributed to the excellent way in which all parties have entered into the spirit of the project.

To conclude, it is perhaps desirable to sound a word of warning that the opening of Highgate Wood in 1960 will not of itself necessarily herald the immediate introduction of electronic exchanges generally into the system. The Highgate Wood exchange is essentially experimental and as such is not likely to prove to be an economic unit. The ultimate production of an economic unit offers problems which are quite as complex as those already encountered, although different in nature, and some time will almost certainly elapse before the introduction of a standard system can be contemplated bearing in mind that technical excellence is not enough alone—there must also be economic advantages since the duty of the Administration must always be to secure the best possible service at the lowest possible cost. The production of Highgate Wood exchange is, however, a necessary first step toward the appreciation of the problems to be solved and to permit considered solutions of the problems to be devised and proved.

# A Pulse Corrector for Telephone Exchange Equipment

R. W. GIBSON, A.M.I.E.E., and C. J. MAURER†

U.D.C. 621.372.55:621.395.636

**A new pulse corrector has been developed for use in the British Post Office telephone network to overcome the effects of distortion of dial pulses in links preceding a pulse-repetition point. The corrector gives a controlled-break-output pulse of 57 ± 4 ms and responds to input pulses of less than 5 ms duration. It is relatively simple and inexpensive and requires little mounting space. This article first discusses briefly the principles of various types of pulsing aid and then describes the new corrector for Post Office use and gives details of its performance.**

## Introduction

In a telephone system employing direct dialling principles the selector equipment at each exchange involved in the setting up of a connexion is required to respond to the digits dialled by the calling operator or subscriber. If the system design is such that the dialled pulses are repeated directly at all switching points through which the call is routed, the pulse distortion is cumulative, that introduced by one link being, to a first approximation, additive to that introduced by other links. In consequence it is necessary with systems employing these principles to limit the number of links that may be connected in tandem to ensure that the characteristics of the pulses received at the terminal exchange are such that the selector equipment responds correctly.

The limitations resulting from the direct repetition of pulses may be overcome by introducing some form of equipment at pulse-repetition points which will respond to received pulses that have suffered distortion and retransmit these pulses with "standard" characteristics. Equipment that performs this function is known as a "pulsing aid." The use of such an aid at pulse-repetition points gives two immediate advantages. First, the pulse distortion is no longer cumulative and, other factors permitting, any number of links may be connected in tandem. Secondly, assuming that the sensitivity of the pulsing aid is at least as good as that of selector equipment, the whole of the distortion margin available between a pulsing source and the selector equipment may be taken up by each link. This, depending on the method of signalling employed, may permit the use of longer circuits and/or the relaxation of the pulse-distortion performance requirements of signalling systems.

## Pulsing Aids

Pulsing aids are of two general types,

(*a*) pulse regenerators, with which the received pulses are completely regenerated and are retransmitted at standard speed and ratio, and

(*b*) pulse correctors, with which the transmitted pulses are of correct pulse ratio or pulse duration, but the speed is unchanged.

*Pulse Regenerators.*

If it is required that the speed and ratio of the transmitted pulses are to be completely independent of the characteristics of the received pulses, it is necessary to store and retransmit each pulse train. This sequence of operation—receipt, storage and transmission—with a controlled inter-train pause period between successive trains of transmitted pulses, is common to most types of pulse regenerator and is inherent in the mechanical pulse regenerator[1] employed in the Post Office network. The storage feature and controlled inter-train pause introduce a delay in the time taken to set up a call. This delay is greatest when the subscriber or operator dials quickly, and it increases as the number of pulse regenerators included in a connexion increases.

*Pulse Correctors.*

(*a*) *Pulse-ratio-correction type.*—If the speed of the pulses transmitted by the source of a dialled call is accurately controlled, then the received pulses may be corrected and transmitted at standard ratio without changing the speed. In practice the speed of pulses transmitted from dials and similar sources is not controlled to close limits, and if it is desired to correct the ratio without alteration of the pulse speed, it is first necessary to examine the received pulse trains to determine the total period of the individual pulses—break-pulse period plus make-pulse period. Having determined the total pulse period, $T_1$ in Fig. 1, the pulse may then be transmitted with a break/make pulse ratio of 2/1 by making $t_B = (2/3)T_1$ and $t_M = (1/3)T_1$.

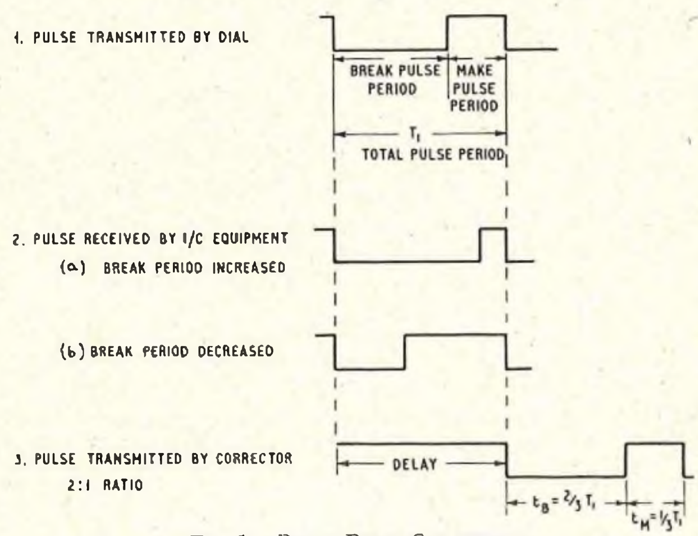



Fig. 1.—Pulse Ratio Correction.

The need to determine the total period of the received pulse results in a slight delay in the transmission of the corrected pulse. In Fig. 1 this delay is shown as equal to the total period of the received pulse, but it may be reduced, depending upon the expected variations in received pulse speed, by commencing the transmission of the corrected pulse before a complete pulse has been received. Because of the need to examine the received pulses before ratio correction can be effected, correctors of this type tend to be relatively complex and costly.

(*b*) *Make- or break-pulse-duration correction.*—An alternative to ratio correction is to transmit pulses with the make- or break-pulse periods corrected to standard values or controlled to certain limits. While such correctors are relatively simple, they suffer the disadvantage that the ratio of the pulses transmitted depends on the pulse speed. This is illustrated by Fig. 2, in which a constant-break-pulse output of 67 ms is assumed. If pulses are received at a speed of 10 p.p.s., then the ratio of the pulses transmitted will be 67 per cent break, 33 per cent make. If, however, the

† The authors are Executive Engineers, Telephone Development and Maintenance Branch, E.-in-C.'s Office.

[1] Edwards, A. G., and Lawrence, J. A. The Mechanical Impulse Regenerator. *P.O.E.E.J.*, Vol. 30, p. 261, January, 1938.

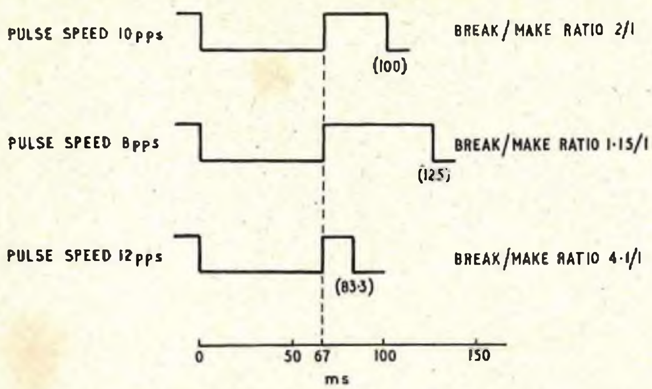



FIG. 2.—ILLUSTRATING EFFECT OF PULSE SPEED ON PULSE RATIO WITH A CONSTANT BREAK PULSE OF 67 MS.

received pulse speed is 8 p.p.s., the ratio of the transmitted pulses will be 53·5 per cent break, 46·5 per cent make, and at 12 p.p.s. the ratio will be 80·5 per cent break, 19·5 per cent make. If the operation of the subsequent selector equipment that is required to respond to the pulses transmitted by the corrector depends on the duration of the received make and break pulses, e.g. selector magnets, this characteristic may not be important. If, on the other hand, the operation of the selector equipment depends wholly or partly on the break/make ratio of the received pulses, e.g. slow-to-release relays, the change of ratio with pulse speed may be a serious embarrassment and restrict the use of such correctors.

## PERFORMANCE LIMITS FOR A CONTROLLED-OUTPUT-PULSE CORRECTOR

The simplicity of a controlled-output-pulse corrector makes it attractive, and consideration has been given to the performance required from a corrector of this type to meet the needs of the Post Office network. An application in mind was a pulsing aid on connexions involving two or more links in tandem under operator-dialling conditions. These conditions arise, for instance, within the present trunk mechanization network, where calls are originated and controlled by operators—normally at a group centre—and the traffic is routed on a non-director basis.[2] The use of a pulsing aid in trunk-circuit incoming equipment is attractive as it may permit some relaxation of the performance required from signalling systems used within the trunk network. In this application the output from the corrector, or equivalent pulsing aid, should permit a connexion to be extended over an unamplified loop-dialling junction of 0–1,500 ohms resistance. This is illustrated by Fig. 3, in which the output of the pulse corrector should be

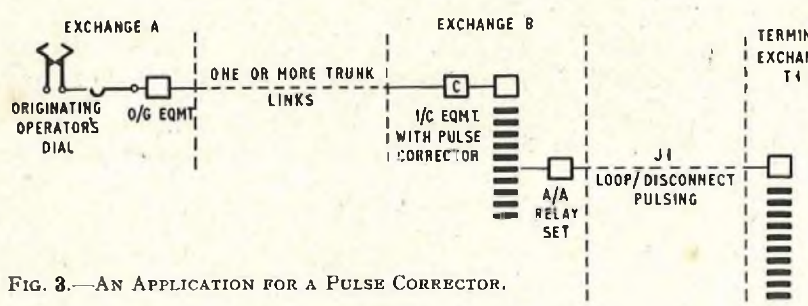



FIG. 3.—AN APPLICATION FOR A PULSE CORRECTOR.

such that, when allowance is made for the distortion introduced by the outgoing loop-dialling relay set at Exchange B and the following junction, J1, the operating requirements of the selector equipment at the terminal exchange, T1, are satisfied. The output must also meet the operating requirements of the selector equipment at exchange B, but normally this will be a less exacting condition.

### *Selector Equipment Performance.*

Typical pulsing elements of 2,000-type and pre-2,000-type selector equipment are shown in Fig. **4**. The operating requirements of such equipment are governed by

(*a*) the operate and release times of the selector magnets, and

(*b*) the pulse-holding performance of relays B and C.

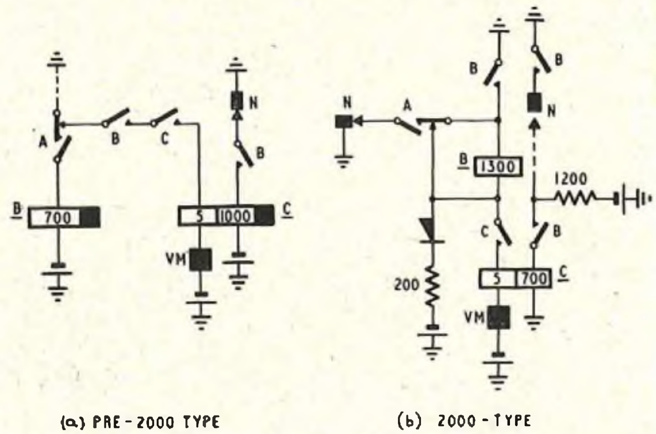



FIG. 4.—TYPICAL SELECTOR PULSING ELEMENTS.

The performance of these items, in terms of the limits of pulse output of the selector A relay for satisfactory operation under adverse conditions of adjustment and exchange voltage, is given by the diagram at Fig. **5**. The interpretation of this diagram may be illustrated by considering the performance of pre-2,000-type selector equipment at a pulsing speed of say 10 p.p.s.—line AF refers. At this pulsing speed relay C requires, for satisfactory operation, that the break-pulse periods repeated by the selector A relay should not be less than 28 ms, point B; for satisfactory operation of the selector magnet the break-pulse period should not be less than 33 ms, point C. Thus at a pulsing speed of 10 p.p.s. the limit is set by the selector-magnet operate requirements. At the other extreme, relay B requires that the break-pulse periods of relay A should not be greater than 79 ms, point D, while the selector-magnet release requirements are satisfied provided that the break-pulse periods are not greater than 92 ms, point E. It follows that for pre-2,000-type selector equipment the limits for the break-pulse periods repeated by the selector A relay at 10 p.p.s. are a minimum of 33 ms, point C, and a maximum of 79 ms, point D.

When account is taken of the performance of both pre-2,000- and 2,000-type selector equipment over a pulsing-speed range of 7–12 p.p.s., the limits for the output of the selector A relay are as indicated by the shaded lines. It will be seen from Fig. **5** that the limits for the pulse output of relay A depend on the pulsing speed. For instance, over a speed range of 7–12 p.p.s. the limiting values for the break-pulse periods are 55 ms minimum, point G, and 66·5 ms maximum, point P, i.e. a range of 55–66·5 ms. For a speed range of 9–12 p.p.s. the limits are 40 ms minimum, point Q, and 66·5 ms maximum, point P.

### *Pulse Distortion Introduced by Outgoing Loop-dialling Relay Set and Following Junction.*

The pulse distortion introduced between the output of

[2] GIBSON, R. W. National Trunk Dialling. *P.O.E.E.J.*, Vol. 43, p. 169, January, 1951.

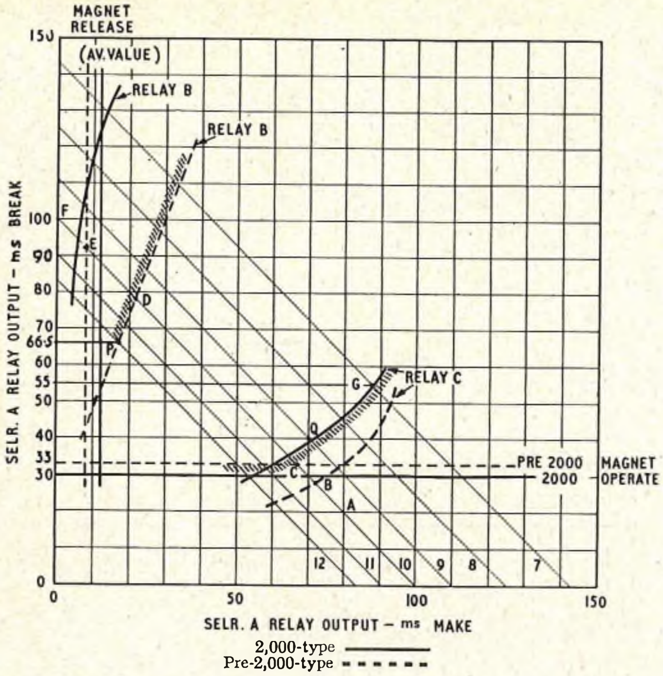



FIG. 5.—SELECTOR PERFORMANCE.

the pulse corrector and the output of relay A of the selector equipment at the terminal exchange will be made up of the distortion introduced by the relay set and the distortion introduced by the following junction. The adverse limits of the overall distortion introduced with an unamplified junction of 0–1,500 ohms resistance, are +13 ms to −5·5 ms. In this sense positive refers to a decrease of the break-pulse period and negative to an increase.

*Corrector Output Limits.*

As stated previously, the immediate application in mind for a pulse corrector was that of a pulsing aid within a network carrying operator-dialled traffic. Although the generally accepted limits for the pulse speed of operators' dials are 9–11 p.p.s., there is in practice a tendency for such dials to run fast, and it was considered that allowance should be made for a speed variation of 9–12 p.p.s. For this speed range the performance requirements of 2,000-type and pre-2,000-type selector equipment dictate a selector A relay break-pulse output of 40 ms minimum, 66·5 ms maximum. Allowing for the distortion introduced by the loop-dialling junction and outgoing relay set, namely 13 ms decrease of the break-pulse period, and 5·5 ms increase, the limits for the break-pulse output of a corrector become

$$40 + 13 = 53 \text{ ms, minimum,}$$
$$66{\cdot}5 - 5{\cdot}5 = 61 \text{ ms, maximum.}$$

Thus the design target set for the performance limits of a controlled-output-pulse corrector was a break-pulse period of 57 ± 4 ms.

*Corrector Response Time.*

For general application the response time of a pulsing aid should be at least as good as that of selector equipment, as otherwise the input requirements of the pulsing aid will limit the pulse distortion that may be introduced by preceding circuits and equipment. Modern selector equipment will respond to pulses within the limits of 12 ms make, 30 ms break.

In certain applications a response time better than that of selector equipment would be an advantage. For example, in the case of v.f. signalling equipment it is often necessary to carry out certain circuit operations on the receipt of the first pulse of a train, and to delay pulse repetition until these operations have been completed. It is also normally required that the received pulses should be repeated with minimum distortion. In such cases the use of a pulsing aid with a short response time would be attractive, as response to the first received pulse could be delayed until other circuit operations have been completed. A pulse corrector which responded to input pulses of the order of 5 ms make or 5 ms break would meet these requirements.

*Overall Performance Requirements for a Pulse Corrector.*

From the foregoing the overall design performance requirements set for the pulse corrector were:—

(*a*) To respond with input make or break pulses of durations down to the order of 5 ms.
(*b*) To give a break-pulse output of 57 ± 4 ms, independently of the duration of the input make or break pulse, over a pulse speed range of at least 9 to 12 p.p.s.

THE CONTROLLED-BREAK-OUTPUT PULSE CORRECTOR

The basic circuit designed to meet the performance requirements quoted above is shown in Fig. **6**. The operate

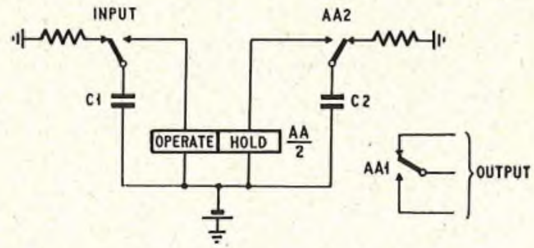



FIG. **6**.—BASIC CORRECTOR CIRCUIT.

coil of relay AA is a low-resistance winding, and the hold coil a high-resistance winding with a large number of turns. The principle of operation is that capacitor C1, previously charged to 50V via the input contact in its normal position, is connected to the operate coil when an input pulse occurs. C1 discharges rapidly and pulse-operates relay AA. Capacitor C2, previously charged to 50V via contact AA2 normal, is connected to the hold coil of relay AA and maintains the relay in the operated condition for a period equal to the time taken for the discharge current of capacitor C2 to decay to such an extent as to permit the relay to release. The minimum pulse to which this corrector element will operate is determined by:—

(*a*) The operate sensitivity of the relay, when energized over the operate coil.
(*b*) The time constant of capacitor C1 and the operate coil.
(*c*) The battery voltage.

The duration of the output pulse will depend upon:—

(*a*) The release sensitivity of the relay, when energized over the hold coil.
(*b*) The time constant of capacitor C2 and the hold coil.
(*c*) The battery voltage.

*Element Using a 2-Contact High-speed Relay.*

The main factor affecting the change of the output pulse is the variation of sensitivity of relay AA over the adjustment range. With this point in mind the first tests of the corrector element were made using a 2-contact high-speed relay. The values of the components are given in Table **1**.

TABLE 1

| | |
|---|---|
| C1 | 2μF |
| C2 | 7μF |
| Operate Coil | 275 ohms, 4,350 turns |
| Hold Coil | 2,850 ohms, 13,000 turns |

The output obtained with C1 and C2 within ±5 per cent of their nominal values was (57 + 9) to (57 − 11) ms, this output being obtained with input pulses of 3 to 97 ms at 10 p.p.s. The 20 ms variation in output was apportioned as:—

14 ms due to relay adjustment.
5 ms due to ±5 per cent change of capacitor C2.
1 ms due to change of battery volts, 46–52V.

Sample-to-sample variations in the relay (particularly variations of the resistance of the coils) would further widen the output limits.

*Element Using a Polarized Type-2B Relay.*

The tests of the 2-contact high-speed relay confirmed that to obtain the required output of 57 ± 4 ms a relay having a closely controlled sensitivity was required. In consequence, tests of a corrector element were made using side-stable polarized relays type-2B.[3] The circuit element is shown in Fig. 7. The non-availability of a production

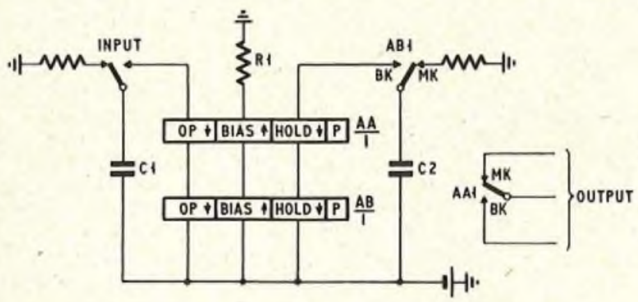



FIG. 7.—POLARIZED RELAY CORRECTOR CIRCUIT.

model 2-contact polarized relay necessitated the use of two single-contact relays, and the appropriate coils of these relays were connected in series. The output relay was designated AA and the control relay AB.

*Differences in the windings of the coils of relays AA and AB.*—The basic sensitivity of polarized relays type-2B is 4·5 ampere-turns. Some variations of sensitivity occur in practice which, with the current design of relay may be as great as ±40 per cent. Hence in the extreme case the moving contact may change from the break position to the make position when the ampere-turns acting in that direction exceed a value of 2·7 ampere-turns, or it may be necessary for the ampere-turns to exceed a value of 6·3 before the contact changes position. To ensure that relay AB maintained control of the duration of the output pulse, the turns of the hold coil of relay AA were made greater than the turns of the hold coil of relay AB. The main reason for ensuring that relay AB maintained control was that if relay AA was permitted to return to the make position before relay AB, the effective ampere-turns in relay AA acting in the make direction would be reduced by the current through the hold coil via contact AB1, and until relay AB released there would be a low contact pressure at the make contact. The other coils of the relays have equal numbers of turns.

*Principle of operation.*—In principle the operation of the corrector element with polarized relays is similar to that of the element with a 2-contact high-speed relay, the normal position of the polarized relays being as shown in Fig. 7. The effective ampere-turns in the normal condition are derived from the bias coil and are equivalent to 12·5 ampere-turns acting in the make direction. Fig. 8 shows the ampere-turns in each coil and the total effective ampere-turns in the relay during the operation of a complete cycle. If an input pulse occurs at time $t_0$, capacitor C1, previously charged, discharges rapidly via the operate coils of relays AA and AB, these coils being connected in the opposite

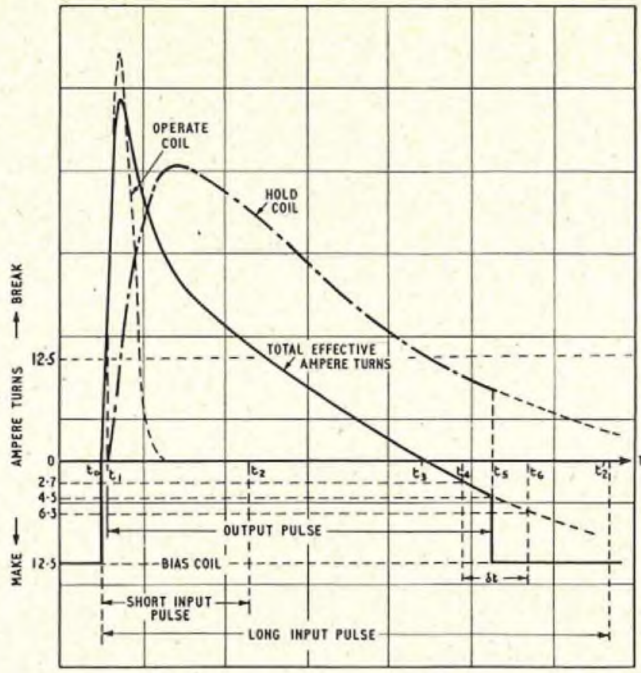



FIG. 8.—VARIATIONS OF AMPERE-TURNS DURING ONE CYCLE.

sense to the bias coils. The contacts of both relays move to the break position and capacitor C2, previously charged, is connected to the hold coils via contact AB1. The discharge current of capacitor C2 starts at time $t_1$ (Fig. 8) and after the initial build-up decays exponentially. At time $t_3$ the ampere-turns in the bias winding acting in the make direction are equal to the ampere-turns in the hold winding acting in the break direction. The effective ampere-turns are therefore zero and the relay remains in the break position due to the force exerted by the permanent magnet of the polarized relay. From time $t_3$ the effective ampere-turns acting in the make direction increase and at time $t_5$ will have reached a value of 4·5 ampere-turns. The armature of a relay in nominal adjustment would at this point move to the make contact and terminate the break output pulse. At the instant that the armature of relay AB moves away from the break contact the effective ampere-turns in the relay change to the bias ampere-turns only and hence the relay moves to the make contact with sufficient energization to ensure adequate contact pressure. The input pulse is shown as finishing at time $t_2$ or $t_2'$. Provided $t_2$ is greater than $t_1$ the output will be independent of the duration of the input pulse.

*Change of output with change of relay sensitivity.*—If relay AB has a sensitivity of 2·7 or 6·3 ampere-turns the armature will move to the make contact at time $t_4$ or $t_6$, respectively. There is therefore a change of output $\delta t$ due to the change of sensitivity of the relay. $\delta t$ may be decreased by changing the slope of the decay curve at the point $t_5$. To do this the size of capacitor C2 may be increased and the effect on the output pulse compensated by increasing the bias current. There is, however, an optimum value of capacitor and of bias current at which the variation in output, $\delta t$, is influenced more by the change of battery voltage and capacitor tolerances than by the change of relay sensitivity.

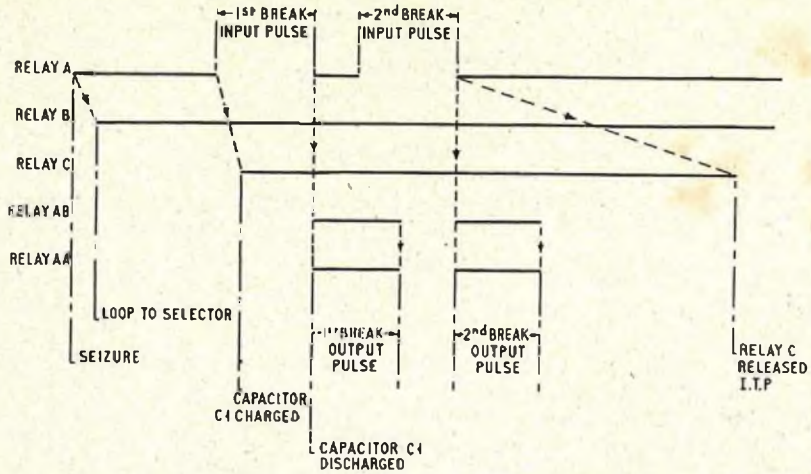
*Change of output due to variations of components.*—The duration of the output pulse may be influenced by:—

1. Variations in the resistance of the hold-coil windings. The windings of type-2B relays are normally specified to have an exact number of turns and a resistance ±20 per cent of nominal, to allow for variations of the gauge of wire with which the coil is wound. The effect on the time constant of the hold circuit of a 20 per cent

[3] TURNER, H. A. and SCOTT, B. A Polarized Relay of Improved Performance. *P.O.E.E.J.*, Vol. 43, p. 85, July, 1950.

resistance variation would result in an appreciable change of the output pulse. To minimize this difficulty the hold-coil winding may be padded-out to a value approaching the upper manufacturing limit.

2. Variations in capacitor C2. Capacitors for common use in telephone apparatus are normally specified to be within 20 per cent of the nominal value. It is possible, however, to select capacitors within $\pm 10$ per cent, $\pm 5$ per cent or $\pm 1$ per cent of nominal, with a corresponding increase in cost. If the capacitor required has a commonly used value, for example, 1 or $2\mu F$, the selection of capacitors having $\pm 5$ per cent tolerance of the nominal value, or even less, is cheaper than the selection of capacitors of non-preferred values. For this reason $2\mu F$ was chosen as the value for capacitors C1 and C2, and the hold-coil windings and bias current values designed to obtain the nominal 57 ms output.




*Note.*—An arrow points to the relay which is energized or de-energized by the operation or release of the relay from which the arrow starts.

FIG. 10.—SEQUENCE OF OPERATION OF RELAYS OF PRACTICAL CIRCUIT.

3. Variations in the bias resistor. The resistance of the bias winding is small in comparison with the bias resistor R1. Provided that the variation of the bias resistor is small, $\pm 1$ per cent, the change of output due to change of resistance in the bias circuit will be small.

*The Practical Circuit.*

Fig. 9 shows a practical circuit for the connexion of the corrector element to an outgoing or incoming relay set.

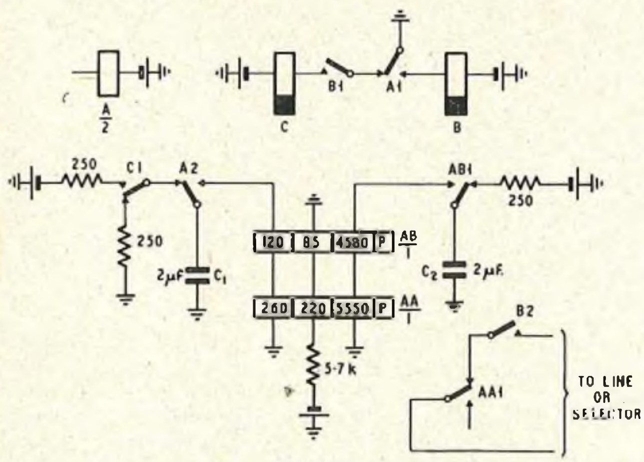



FIG. 9.—PRACTICAL CIRCUIT.

Seizure of the circuit is effected by the operation of relay A. Contact A1 operates relay B. Contact B2 closes the loop to the line or incoming selector. The receipt of the first break pulse releases relay A and contact A1 operates relay C. Contact C1 in the corrector circuit completes a charging circuit for capacitor C1. At the end of the break input pulse relay A re-operates and contact A2 connects capacitor C1 to the operate coils of the corrector relays. Relays AA and AB operate and a pulse of controlled duration is transmitted to line under the control of contact AA1. The receipt of the second and subsequent break pulses will occur during the transmission of the previous pulse. The sequence of operation for the repetition of two pulses is shown in Fig. 10.

*Change of output with variations of components.*—The nominal output of 57 ms was obtained with the relays adjusted to operate at 4·5 ampere-turns, capacitors C1 and C2 of capacitance $2\mu F$, resistor R1 of 5,700 ohms and a battery voltage of 50V. The range of output variation with change in value of components and adjustment of relays is given in Table 2.

TABLE 2

| Change in component | | Variation of Output |
|---|---|---|
| Change of basic sensitivity of relay AB | $\pm 20\%$<br>$\pm 40\%$ | 3·5 ms<br>7·0 ms |
| Change of capacitance C1 | $\pm$ 1%<br>$\pm$ 5% | Negligible<br>0·2 ms |
| Change of capacitance C2 | $\pm$ 1% | 0·8 ms |
| Change of bias resistance | $\pm$ 1% | 0·7 ms |
| Variation of battery voltage | 46–52V | 2·2 ms |
| Relay coil resistance | $\pm$ 5% | 1·5 ms |

The effect on the output of a change of sensitivity of relay AB of $\pm 40$ per cent from the nominal value of 4·5 ampere-turns was $\pm 3·5$ ms, which is greater than the combined effect of all other variables. With a 20 per cent change of relay sensitivity and all other variables simultaneously adverse, the variation of output is $\pm 4·5$ ms which is in fair agreement with the design target, namely $\pm 4$ ms.

The sensitivity of polarized relays type-2B may vary in practice from the basic value of 4·5 ampere-turns due to the effects of ageing, external magnetic fields, ambient temperature variations, etc. In the extreme case, the change of sensitivity of the current design of relay after initial adjustment may be as great as $\pm 40$ per cent. Evidence is available, however, that future products will have an improved performance. In telephone exchange applications where the ambient temperature variations are limited it is unlikely that the change in sensitivity of future products between successive maintenance routines will exceed $\pm 20$ per cent and thus the required performance of $57 \pm 4$ ms should be attained.

*Performance Under Practical Conditions.*

Relay sets incorporating the new pulse-corrector element were connected at Bedford exchange in dialling circuits between Bedford manual board and Rushden non-director exchange. The equipment was brought into service in July, 1956, and periodic checks were made of the corrector pulse output. Over a period of eight months no faults were experienced on the elements and no maintenance attention



c

was given to the polarized relays. The output of the five elements installed did not depart from the initial value by more than 1 ms during the trial period.

### Conclusion

The pulse-corrector element described in this article responds to an input pulse of less than 5 ms and provides a break-output pulse within the limits of 57 $\pm$ 4 ms. Whilst the element has been designed to give a nominal output of 57 ms to meet a specific application in the Post Office network, outputs of other nominal values may be obtained by suitable choice of components.

The use of close-tolerance components has been accepted as a means of obtaining the required output limits in preference to the inclusion of a variable control in the bias circuit. If a variable control were provided, test equipment to measure the duration of the output pulse would be required both for the initial setting-up and for subsequent maintenance.

As it is unnecessary to store each pulse train before retransmission, the element does not require additional relays to control the inter-train pause period. Thus it provides a pulsing aid which is relatively cheap, and requires little mounting space. Where the operating conditions permit the use of a pulse corrector, the element described is an attractive alternative to the present mechanical regenerator.

The initial application of the new element will be as a pulse corrector in the incoming exchange equipment terminating circuits routed over carrier systems providing out-of-speech-band signalling channels. It is expected that the element will also be used in other new designs of exchange signalling relay sets.

At the present time polarized relays with two contact units are not in general production, and in consequence two single-contact relays have been connected in series. It is hoped that a two-contact polarized relay with a suitable sensitivity and stability will be available in the near future, and this will make the element an even more attractive pulsing aid.

### Acknowledgment

The authors wish to acknowledge the assistance given by the members of the Circuit Laboratory, Telephone Development and Maintenance Branch, E.-in-C.'s Office, in the many tests performed during the development of this pulsing aid.

## Book Review

"An Introduction to Junction Transistor Theory." R. D. Middlebrook. John Wiley & Sons, N.Y., Chapman & Hall, Ltd. 296 pp. Illustrated. 68s.

This is the first book that makes a serious attempt to interest the suitably qualified electronic engineer in the physical processes involved in transistor action. In this context "suitably qualified" includes a knowledge of at least the elements of electron motion in an electric field and of the atomic structure of matter (but not including any nuclear properties other than the charge and mass of the nucleus as a whole).

The book is divided into three main parts: Part I deals with semiconductor physics, i.e. the detailed physical mechanisms of conduction in transistor materials; Part II covers semiconductor electronics, i.e. the derivation of the basic electrical properties of the single p-n junction and of the close pair of p-n junctions that form a junction transistor; and Part III is a detailed consideration of one particular equivalent circuit of the transistor from the viewpoint of the circuit designer.

Taking Part III first, it should be remarked that this is not a book in which the transistor circuit engineer can find much guidance in the practical design of his circuits—and practically none at all, for example, in his bias stabilizing circuit arrangements. The book is concerned with the useful rather than the truly parasitic or limiting properties of the transistor—but this statement must be qualified in so far as detailed consideration is given to the fundamental limitations of frequency response by the spread of diffusion times of the minority carriers through the base region of the ordinary junction transistor and by the combined effects of the capacitance of the depletion layer of the collector junction and of the ohmic resistance of the semiconductor material between the active base region and the base electrode. Little or nothing is said about breakdown voltage, whether caused by avalanche effect or punch-through effect; and nothing is said about the very important practical limitation (about which something of theoretical interest can be said) of power dissipation through junction temperature rise and the resultant short-term thermal instability or long-term deterioration.

In Part II no account is given of the physically important effect of surface recombination—which, however, gets some mention in Part III, rather late in view of the large part played by the effect in alloy junction transistors (which comprise by far the largest number of units in production).

Unfortunately for the author of any book in a field that is advancing as rapidly as that of transistors, the inevitable delays of publication result in a number of the more recent advances being absent from the text. Thus the reader of the present book will find no mention of the graded-base structure (or of the diffusion process whereby it is most conveniently realized in practice), and consequently no discussion of the possible (large) improvements of frequency response obtainable by means of the drift field that can be "built-in" the base region thereby. Related to this is the dismissal of the emitter depletion-layer capacitance as unimportant compared with the emitter diffusion capacitance. (This would not be true even in the p-n-i-p structure, which was the conceptual forerunner of the graded-base structure.) Non-linearity of current-gain due to a variety of causes is likewise passed over—together with defects such as the spurious emitter floating potential found in grown junction units and explained in terms of channel effect.

It is perhaps unfair to be critical of the book for its omissions. The author has set himself limited objectives. He has set out to explain to the engineer the basic mechanisms of the p-n junction and the junction transistor—and he has done this well, with many numerical examples throughout the text to give the reader some quantitative idea of the magnitudes involved. Perhaps it could be said that this part of the book (which is contained mainly in Part II) has been accomplished so well that future texts will have no need of more than a reference to Middlebrook for this field. The electronic engineer will have plenty of other problems in reading the physicists' writings on transistors and related topics: Part I will remind him of most of the problems and serve as a guide to the more specialized literature.

The book is well produced, and the diagrams are clear and effective in complementing the text.

F. F. R.

# Teleprinter Private-Wire Automatic Switching

H. WALKER, D. A. JEFFERY, A.M.I.E.E., and D. R. POLLOCK†

U.D.C. 621.394.65:621.394.74

**This article describes the automatic switching system developed for teleprinter private-wire networks in the United Kingdom and the facilities provided, and outlines some of the salient features of the circuits concerned. Details of the Shell Mex and I.C.I. installations and a typical trunking arrangement are also given.**

## Introduction

TELEPRINTER private-wire networks may, broadly speaking, be placed into one of two categories. The first category, known generally as direct switching, includes those systems in which teleprinter stations are directly connected, either by a manual switchboard or by direct dialling through automatic switching equipment. The second category includes tape relay systems, in which messages are transmitted by teleprinter to a central office, where they are automatically recorded on perforated tape. The received signals are then directed to the required outgoing route by manual, semi-automatic or automatic methods for automatic re-transmission to the distant station. The main advantage to be gained from such systems is the high occupied time of the trunk circuits that is achieved by queueing the traffic, and the system is therefore economic where the capital and maintenance costs of the line plant are heavy. In achieving these economies on the trunk network it is inevitable that some delay occurs in the overall transit time of a message, the delay being dependent upon the number of trunk circuits provided on a route and the traffic carried. As is to be expected, this type of system is used when long distances are involved and the cost of the trunk circuits is heavy. Thus it has been extensively used in America and for such services as international civil aviation communications. In the United Kingdom, where distances are relatively short, direct-switching methods are in common use.

Manual switchboard working for teleprinter networks in Great Britain[1] was introduced during the early stages of the second world war and was followed after the war by the development and installation of an automatic switching system for the Post Office inland network.[2] A natural development from the successful operation of this network, particularly as regards speed of connexion and operating savings, was the provision of direct-dialling facilities for private-wire networks, with the necessary additional facilities to meet specific requirements. In general the main facilities provided by the teleprinter automatic switching system are also applicable to private-wire networks.

## Facilities Required for Private-Wire Networks

The main facilities required for an automatic switching network to meet the demands of private-wire renters are as follows:—

*Suspense working.* Because of the relatively small size of most private-wire networks the number of switching centres tends to be small, which leads to small groups of long and expensive station line circuits. A suspense facility is essential, therefore, to economize in station lines and costs. By means of this facility traffic to busy station lines is held in a simple form of queue for a predetermined period to await a free line. In this way a higher circuit efficiency can be achieved for a given grade of service than with traffic offered in the normal way. In practice this facility is incorporated in the final selector.

*Overflow.* In most private-wire networks a few main offices are required to act as controlling centres and to permit this an overflow facility is necessary whereby traffic offered to small offices that are either closed or congested, is automatically routed to the main controlling office.

*Precedence traffic.* A common requirement is for priority treatment for urgent messages under congestion conditions.

*Multi-address traffic.* Most large organizations produce some traffic requiring the transmission of the same message to several addresses and it is desirable that these multi-address messages should be transmitted to each address simultaneously.

*Page teleprinters.* The use of page teleprinters with local record working is universal in private-wire networks.

*Automatic transmitters.* Although not essential, the use of automatic transmitters reduces the holding time of connexions, which improves the loading of the circuits and assists operating efficiency, and also facilitates the transfer of traffic received from the Telex or other systems for re-transmission over the switching network.

*Printing reperforators.* Where automatic transmitters are used printing reperforator machines are normally associated with the overflow positions. Messages are then received from the overflow level on paper tape in a form suitable for re-transmission by an automatic transmitter in a manner which reduces operating time and facilitates operating procedure.

*Message and order-form traffic.* In some cases the incoming traffic to certain offices is divided into two categories, e.g. ordinary messages and order-form messages. It is essential that the order-form messages should be received on machines fitted with the appropriate paper.

*Out of service.* When an office is closed down for any reason, e.g. absence of operating staff, facilities are provided whereby the incoming traffic to the office is automatically routed to the overflow positions at the main controlling office of the switching centre.

Apart from a small amount of development to provide for the disposal of priority traffic the standard switching equipment developed for the teleprinter automatic switching system used for the public inland telegraph service provides the required facilities except for multi-address traffic. To cater for page-type teleprinters the development of a new signalling unit at the renter's premises was also required. To meet the requirement of multi-address traffic it is possible to arrange for a variable number of perforated tapes to be prepared simultaneously for automatic transmission over individual circuits.

## Switching Centre Equipment

Basically the automatic switching equipment[2] is the same as that used in automatic telephone exchanges, i.e. step-by-step equipment, but with different circuit arrangements to cater for double-current dialling and the automatically generated teleprinter service signals which replace the tone signals of automatic telephony. In nearly

† Mr. Walker and Mr. Jeffery are Executive Engineers, and Mr. Pollock an Assistant Engineer, in the Telegraph Branch, E.-in-C.'s Office.

[1] MARTIN, J. A. S., and FREEBODY, J. W. Development of Telegraph Switching in Great Britain. I.P.O.E.E. Printed Paper No. 189. 1944.

[2] WILCOCKSON, H. E., and MITCHELL, C. W. A. The Introduction of Automatic Switching to the Inland Teleprinter Network. I.P.O.E.E. Printed Paper No. 195. 1949.

all cases the switching equipment of the private-wire networks is accommodated alongside the equipment of the public telegraph network, but there is no connexion between these two networks, the switching equipment for each being a separate and distinct unit, except for service signal and power supplies which are common to the centre.

The only additional switching equipment for the private-wire networks is the precedence final selectors, which are provided on the basis of 1 per final selector multiple for the disposal of priority and overflow traffic under congestion conditions. Access to the precedence final selector is confined to the local overflow centre.

The first one or two final selector level contacts of a group of lines are associated with suspense relay sets and are known as waiting contacts. One waiting contact is provided per group of up to four lines and two waiting contacts for larger groups. When all lines of a group are engaged, any subsequent incoming call to the group is connected to the first waiting contact of the group, and the final selector concerned waits on that contact for a period of 30–59 sec for a line of the group to become free and returns the MOM (wait) service signal to the calling subscriber. Should a line of the group become free within the waiting period the final selector is automatically released from the waiting contact and seizes the free line in the normal manner. If, however, all lines are still engaged at the end of the waiting period the final selector is released from the waiting contact and the call is routed automatically, via the overflow level, to the overflow positions at the called switching centre, which then becomes responsible for disposing of the message to the required office.

When the foregoing conditions are encountered by a precedence final selector the period during which the precedence final selector waits to be switched to the first line to become free is unrestricted. Should the first waiting contact be already occupied by a regular final selector, that final selector is automatically released from the waiting contact by the precedence final selector and the waiting contact is occupied by the precedence final selector. The call held at the regular final selector is routed to the overflow level in the normal manner.

### Teleprinter Station Position Equipment

The calling, dialling and clearing facilities offered by the various types of positions are similar to those of the inland network, except that J-Bell alarm facilities are provided together with key control of the local record, and are included in the position signalling unit. Two types of signalling unit, which accommodate the keys, supervisory lamps, and a jack-in type relay set, have been developed, one for association with either a teleprinter or printing reperforator position (Unit, TG, No. 20), and the other for a teleprinter position associated with an automatic transmitter (Unit, TG, No. 23).

*Teleprinter Position.*

This type of position, which caters for keyboard working, comprises a Teleprinter No. 7D and signalling Unit, TG, No. 20 for the calling, dialling, supervisory and alarm facilities. A typical installation is shown in Fig. **1**.

*Printing Reperforator Position.*

This type of position, which is illustrated in Fig. **2**, is normally associated with the overflow level for the receipt of overflow traffic, but it may also be reached by direct dialling. It provides the useful facility of producing a perforated tape from an incoming message, for re-transmission by telex or private wire to a station not served by the automatic network. The equipment is housed in a cabinet that accommodates three printing reperforator positions and the circuitry of the Units, TG, No. 20.

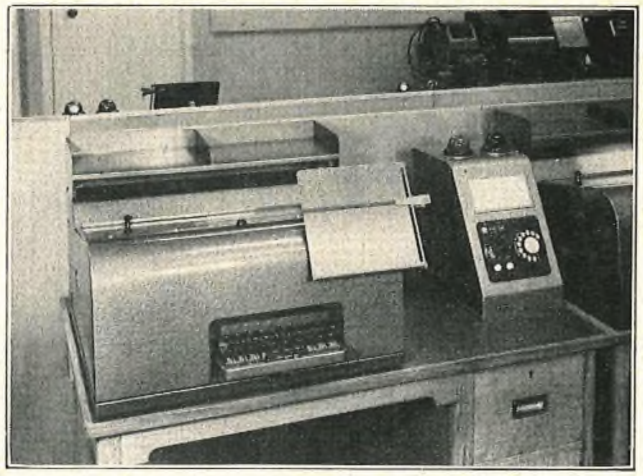


Fig. 1.—Typical Teleprinter No. 7D Position with Signalling Unit, TG, No. 20.

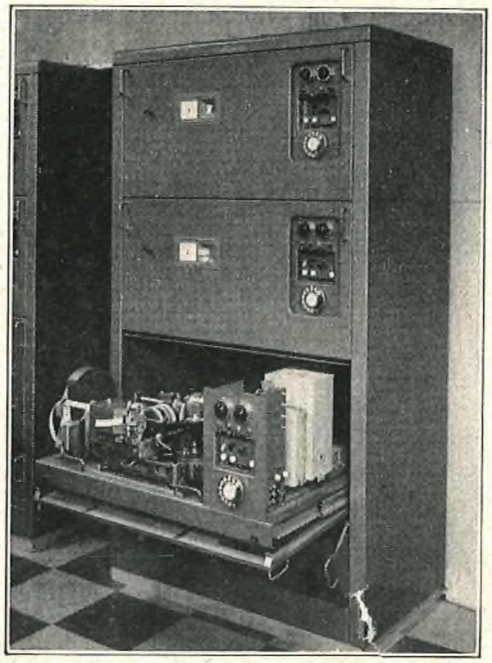


Fig. 2.—Cabinet-mounted Printing Reperforator (Overflow) Equipment.

Received messages are both punched and printed on a paper tape by the printing reperforator. A feature of the received tape is that a punched code signal precedes its printed character by eight character spaces. Use has been made of this feature, in the operating procedure for the processing of the tape before re-transmission, to eliminate the unwanted answer-back code of the printing reperforator position and spurious characters derived from clearing signals.

At the commencement of a transmission the WRU (who are you) code signal, which is received from a calling final selector, is punched on the tape, the character (Maltese Cross), being printed eight spaces or characters behind it. The answer-back code of the printing reperforator position is returned to the calling position but, under the control of the answer-back off-normal contacts, the circuit arrangements are such that the local record of the answer-back transmission is suppressed on the printing reperforator tape and it is replaced by a series of letter shift signals which act as a message separation signal. After the transmission of the message and the receipt of the final WRU, which is sent by the sending station to confirm the continuity of the connexion before finally clearing down, the same operation is repeated. The tape is prepared for re-transmission by tearing at the point where the printed WRU symbol (Maltese Cross) appears at the beginning and end of the message, thereby removing the first WRU punched code signal and any spurious characters from the tape, whilst retaining the final punched WRU code signal. The tape may now be transferred to an automatic transmitter circuit for re-transmission, the final WRU signal being used as a check on the continuity of the connexion.

Audible and flashing visual alarms are given when the supply of tape approaches exhaustion. If this occurs during the reception of a message the operation of the Tape Exhaustion key on the associated signal unit disconnects the audible alarm and replaces the flashing signal by one of a steady glow. On the subsequent clear down of the connexion at the end of the message, the position is automatically placed out of service and can be restored to service only when the supply of tape has been replenished, and the Tape Exhaustion key restored to normal.

To enable a message tape to be ejected from the printing reperforator and also to reset the J-Bell alarm (because the key is not accessible for this purpose) a Tape Run Out and J-Bell reset key, of the push-button type, is fitted. Depression of this key, when the line is normal, connects continuous letter-shift signals to the receive wire of the position signalling unit thus causing tape to be ejected until the key is released. The receipt of an incoming call whilst the key is depressed makes the tape-run-out feature ineffective. The calling lamp lights and the call matures in the normal manner. An audible alarm can be given by transmitting the secondary of letter J from the teleprinter keyboard in the normal way. Should the calling operator transmit this J-Bell alarm signal for any reason, e.g. to call the attention of the printing reperforator operator to an urgent or priority message, the alarm condition—which consists of an audible alarm and a steady visual signal—is set up at both the transmitting and the receiving stations. Receipt of the J-Bell alarm signal may be acknowledged by depression of the reset key, which in this case connects continuous letter-shift signals to both the incoming R wire and outgoing S wire of the connexion thereby causing both the local printing reperforator and distant teleprinter to operate. This clears down the alarms at both stations and indicates to the calling operator that attention is being paid to the incoming message.

*Automatic Transmitter Positions.*

This type of position, which employs a teleprinter and an automatic transmitter associated with a signalling Unit, TG, No. 23, is used extensively throughout the system for the automatic transmission of messages; it is shown in Fig **3**.

An outgoing call is established in the same way as for an ordinary teleprinter position, and after receipt of the answer back code of the called station the automatic transmitter, which has previously been loaded with the message tape, is brought into service by the operation of a key on the signalling unit. This key may be operated in a non-locking or locking position and in either case it causes the automatic transmitter motor to start. When the motor reaches governed speed the opening of the governor contacts allows a relay to operate which lights the AT lamp on the signalling unit and at the same time allows the clutch of the automatic transmitter to engage with the motor drive. The perforated tape now feeds through the automatic transmitter head and a local record of the transmitted message is recorded on the associated teleprinter. If the key is operated in the non-locking position at the commencement of transmission the connexion is automatically cleared down when the perforated tape clears the head of the automatic transmitter at the end of a message. If, however, the key is operated in the locking position the connexion is held and the teleprinter reconnected when the end of the perforated tape clears the head of the automatic transmitter. The automatic transmitter is released and a visual and audible alarm is given. Restoration of the key resets the alarm. Further teleprinter keyboard signals may, if desired, be exchanged with the called station, or the automatic transmitter may be loaded with another perforated message tape for transmission to the station before the connexion is finally cleared down in the normal manner. Normally automatic clearing is used but the alternative method is used when, for example, acknowledgment of receipt of an important message is required.

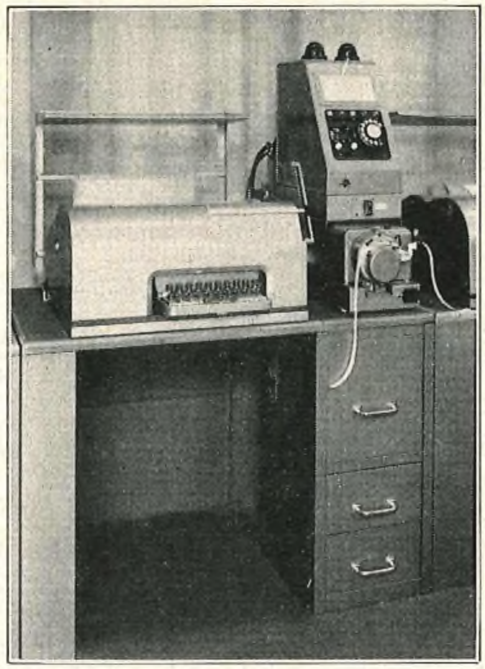


Fig. **3**.—Automatic Transmitter Position with Signalling Unit, TG, No. 23, and Switching Key for Connecting the Automatic Transmitter to another Position.

When a WRU signal is included in the tape message, as at the end of the tape, this signal trips the answer-back unit at both stations. So that the answer-back code of the called station may be received correctly, it is essential that further operation of the automatic transmitter should be suspended and the local record of the answer-back code suppressed. The off-normal contact of the local record teleprinter answer-back unit is therefore arranged to operate a relay within the associated signalling unit, which releases the clutch of the automatic transmitter and at the same time transfers the teleprinter electromagnet from the local record circuit to the incoming R wire, over which the answer-back code of the called station is received. The return of the teleprinter answer-back drum to normal restores the off-normal contacts, which in turn allow the clutch of the automatic transmitter to re-engage and the local record circuit to be restored, for the continuation of the transmission.

Visual and audible alarms are given in the event of any of the following conditions arising:

1. If the called station, or a transient line interruption, clears down the call during the transmission of a message. The position is placed out of service automatically and is restored to normal by the operation of the Reset key.
2. If the tape becomes tight during the transmission of a message. The clutch of the automatic transmitter is released automatically and further sending suspended.

The alarm is cleared down and transmission resumed when the correct tension of the tape is restored.

3. If, for any reason, the called station interrupts the transmission of a message by sending teleprinter keyboard signals. The alarm equipment operates from the received teleprinter signals. The automatic transmission may be stopped by the operation of the Reset key and the interruption acknowledged by teleprinter keyboard signals.

## Miscellaneous Key-switching Facilities at Renters' Premises

To enable the maximum use of equipment to be obtained, and provide flexibility between lines and machines certain miscellaneous key-switching facilities are provided at renters' offices. The keys are mounted as separate units, and, where required, may be accommodated in a suitable position adjacent to the associated equipment.

*Local Record When Working Duplex.*

Under traffic-congestion conditions duplex working between certain offices may be set up, after the establishment of a connexion, by the operation of the Local Record Cut-off key at each office. The normal local record of transmitted signals is therefore not obtained under these circumstances as the teleprinter is occupied in receiving the signals transmitted by the distant office. An additional teleprinter may, however, be provided at each of the offices at which duplex working is permitted and brought into service, by means of a key, to provide a local record of transmitted signals. The additional teleprinter may be associated with either of two positions on which duplex working may be established.

*Access to Precedence Final Selector.*

This facility is provided only at the office at which the overflow positions are situated. Separate terminal equipment may be provided to give direct access to the precedence final selector or, by means of a key, the terminal equipment of an ordinary line may be used for this purpose. The ordinary line is placed out of service during the period of transfer and restored when the key is returned to normal. This latter arrangement is of advantage where the precedence traffic is light and does not justify the provision of separate terminal equipment.

Where separate terminal equipment is fitted a switching key is also provided to enable this equipment to be transferred temporarily to an ordinary line so that access may be gained to the special services, e.g. test position, test messages, etc., to facilitate the maintenance of the equipment.

*Message and Order-Form Machines.*

At certain offices it is necessary to receive incoming traffic either on machines suitable for ordinary messages or on machines fitted with special order paper. The lines serving such offices are divided into two separate final selector groups, one for message traffic and the other for order traffic.

To cater for occasional traffic peaks and to provide some measure of flexibility individual late-choice lines of the two groups may be commoned together and these lines, referred to as dual lines, connected to separate key-switching units at the renter's office. The switching key normally connects the incoming line direct to the message machine, and when operated transfers the line from the message machine to an order machine. The switching key may be operated in a non-locking or locking position, and in each case, a visual indication is given on the switching unit when the transfer of the line has been effected. After the exchange of operating code signals the transfer to an order-form machine may be confirmed by the calling operator transmitting the WRU signal and receiving the distinctive answer back of the order-form machine. Where the key has been operated in the non-locking position the key-switching unit restores to normal on the clear down of a connexion and the line is automatically reconnected to the message machine for further traffic. The operation of the switching key in the locking position maintains service in the event of the message machine becoming faulty.

*Automatic Transmitters.*

An automatic transmitter may be connected to either of two positions by means of an associated switching key. In the normal position this key, which is fitted immediately below the signalling unit in Fig. **3**, connects the automatic transmitter to the position on which it is fitted and when the key is operated the automatic transmitter is connected to the other associated position. This facility is advantageous where an office is served by at least two lines and obviates the tying up of an automatic transmitter with a particular line, which may be engaged on an incoming call or be out of service for any reason.

*Perforating Positions.*

To secure the maximum use of line time, it is preferable to use automatic transmission rather than manual transmission from the teleprinter keyboard. At all busy offices one or more "off line" teleprinters with perforating attachments, or perforators, are often provided and on these machines perforated tapes are cut for messages originating locally for transmission by automatic transmitter.

*Multi-Address Messages.*

The absence of multi-address broadcast facilities on the automatic switching network for the handling of messages with several addresses has, to a certain extent, been overcome by the provision of facilities whereby a number of perforated tapes for transmission over individual circuits may be prepared simultaneously, using "off line" perforating machines. These machines are terminated on individual keys on a unit, with which is associated an automatic transmitter.

The automatic transmitter may be associated with up to 10 machines, by the operation of the appropriate keys, and copies of the perforated tape fed to the automatic transmitter are produced in accordance with the number of keys operated. A local record of the perforated tape is given on each machine.

In practice it has been found that due to the rapidity with which connexions can be established—the time usually required being only that to dial the necessary digits—the absence of broadcast facilities is not important and consecutive transmission from automatic transmitters is found to be adequate even for messages having several addresses. In fact, when sufficient tape has cleared the head of an automatic transmitter, it is common practice to set up a further call to the next addressee on an adjacent position and feed the same tape to the automatic transmitter of this position. By using two positions in this manner multi-address traffic may be cleared very quickly.

## Grade of Service

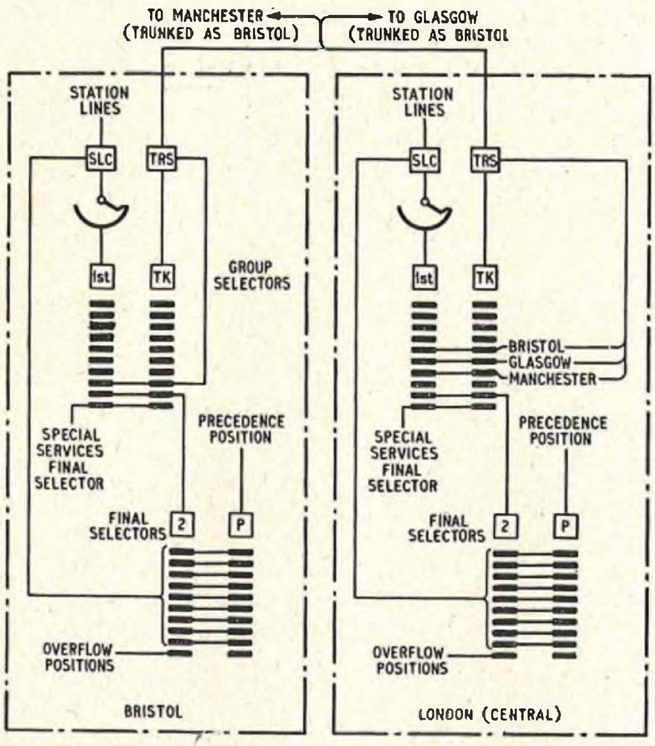
Trunk circuits are provided on a bothway basis between the switching centres to give an agreed grade of service, which is normally 1 in 50.

The number of station lines provided at any office on a private-wire direct-switching network must be determined by balancing the line costs for a given delay time against the equipment and operating costs involved in dealing with the overflow traffic at the controlling office. Most networks have, however, special traffic characteristics, and in view of the wide range in the costs of station lines it is not practicable to lay down a scale of provision that can be generally applied. Each office is therefore treated individually and the grade of service for station lines is not standardized as it is, for example, in the public network.

The overflow positions at each controlling office provide a means whereby any sustained increase in the number of overflow messages received for a particular office may be detected and investigated by the controlling officer.

### Renters' Installations

Two private-wire automatic switching networks, which have recently been provided to replace existing systems employing manual switching, are of particular interest. The first, rented by Shell-Mex & BP, Ltd., was opened for service in October 1956, with 103 station lines connecting 42 offices, refineries and depots to switching centres in London, Manchester, Bristol and Glasgow. Fig. **4** is a trunking diagram of this network. A second network, installed for Imperial Chemical Industries, Ltd., was brought into service in June 1957, with 133 lines serving 58 locations, based on switching centres in London, Birmingham, Manchester and Glasgow. A selected renter's office close to each switching centre is equipped to handle overflow traffic. In addition to teleprinter automatic switching (T.A.S.) circuits both renters have conventional Telex circuits serving offices having relatively small demands on circuit time, and for traffic external to the networks. I.C.I. also operate 18 point-to-point circuits between offices and factories where the nature and volume of traffic justify direct links. Traffic from T.A.S. stations to those not connected to the network is routed direct to the overflow printing reperforator positions in the appropriate centres, for automatic re-transmission from the received tape. Traffic in the other direction from an incoming Telex call or from a point-to-point circuit is also received on tape and re-transmitted over the automatic switching network.



SLC = Station Line Circuit. TRS = Trunk Relay Set. P = Precedence Final Selector.

Fig. **4**.—Trunking Diagram of Shell-Mex Network.

Installations range in size from offices with a single teleprinter position to large main centres such as that at Hexagon House, Blackley, Manchester. This comprises 11 T.A.S. teleprinter positions, six with automatic transmitters, two three-position printing reperforator cabinets, 15 teleprinters for point-to-point circuits and four Telex positions. Fig. **5** shows part of a similar size installation at the Head Office of Shell-Mex and BP, Ltd., at Shell-Mex House, London, in which the layout of the equipment is integrated with the renters' communications system in order to achieve a uniform traffic flow throughout the organization, combined with maximum operating efficiency. Thus a message originating within the building may be sent to the teleprinter room by pneumatic tube or messenger, or may be dictated over a local telephone directly into a speech recorder. In each case a tape is prepared at a perforating teleprinter position working in local, as previously described. The perforated tapes are conveyed to a distribution desk, whence they are allocated to teleprinter and automatic transmitter positions (Fig. **5**) for outward

Fig. 5.—Distribution Desk and Teleprinter Automatic Transmitting Positions. Shell-Mex House.

transmission. Incoming messages are similarly conveyed to a sorting position for distribution by pneumatic tubes or messengers. At both Shell-Mex House and the London headquarters of the Southern Region of I.C.I., Ltd., belt conveyors have been installed to convey messages to distributing and sorting tables.

Position equipment is accommodated on Tables, Teleprinter No. 5A, as shown in Fig. **3**, except where the renter has provided tables or benching. The type of table shown in Fig. **1** and **5**, for example, was supplied by Shell-Mex & BP, Ltd., for several of their larger installations, and was designed in conjunction with the Post Office to allow greater flexibility than conventional benching in instrument rooms. It is constructed of light oak and surfaced with coloured washable plastic. All equipment supplied by the Post Office was hammer finished in grey, which fitted in well with the carefully designed decorative schemes which both renters have adopted for their larger instrument rooms.

CONCLUSION

Facilities for automatically switched teleprinter networks for private subscribers have been developed and the systems installed. In both installations referred to in this article the renters have expressed their entire satisfaction with the networks, which have been successfully operated since their inception. The Shell-Mex network, for example, carried the heavy additional traffic resulting from the Suez crisis, which occurred immediately after the opening date, and, since then, the average delay in clearing messages has fallen to 10 minutes (compared with 60–90 minutes on the previous manually switched network). In addition the renter has been able to reduce operating staff considerably, which it is estimated will show a substantial financial saving.

ACKNOWLEDGMENTS

The authors would like to express their thanks to colleagues in the Telegraph Branch, E.-in-C.'s Office, for their assistance in the preparation of this article, and to Shell-Mex & BP, Ltd., and Imperial Chemical Industries, Ltd., for their co-operation in obtaining the photographs with which this article is illustrated and for permission to reproduce Fig. **4**.

## Book Reviews

"The Principles of Telecommunications Engineering," Vol. I. H. R. Harbottle, O.B.E., B.Sc.(Eng.), D.F.H., M.I.E.E., and B. L. G. Hanman, B.Sc.(Eng.). The English Universities Press Ltd. 373 pp. 196 ill. 17s. 6d.

This book covers the first year syllabus of the City and Guilds of London Institute curriculum in Telecommunications Principles. The authors are the Institution's examiners in the subject of the book and have considerable experience in the training of telecommunication engineering students. They clearly have a thorough understanding of student requirements and reactions, this being very evident in the careful and admirable way the subject is treated. Little prior knowledge is assumed. The subject matter is built up from lucidly explained fundamentals, each step in the detailed treatment being carefully explained. Important points are stressed throughout for the student's particular attention.

Thirteen chapters deal with magnetism, static electricity, current electricity, heat effect of current, magnetic effect of current, electromagnetic induction, chemical effect of current, measuring instruments, potentiometers and Wheatstone bridge, capacitors, sound-microphones and receivers, introduction to electromagnetic radiation, and introduction to electronic theory of matter, respectively. The text of the book adopts the C.G.S. system of units, the opinion of the authors being that this system should be used as a foundation before proceeding to a study of the rationalized M.K.S. units. The M.K.S. units, now being widely adopted, are treated in an appendix. The student is thus able to acquire appreciation of both systems of units without confusion.

Numerous numerical examples are set and solved throughout the book. A notable feature, from the student's point of view, is that each chapter ends with a set of exercises taken very largely from previous examination questions set by the City and Guilds of London Institute. Numerical answers to the exercises are given. Included also in each chapter is a specimen answer to one of the exercises set, study of which enables a student to acquire examination technique, which, as no doubt the authors had in mind, is most important for early-year students.

Any addition to the present range of text-books in this field must be considered on new material, scope and presentation. While obviously in a book of the scope of the present one no new material is included, the book succeeds notably on presentation, as it collects, in one place, all the relevant material for the purpose of the syllabus concerned. The student is not required to make reference to specialized text books.

The authors are to be complimented on producing a book with student requirement foremost in mind. It is strongly recommended for examination students in the subject and as a good investment as a reference book. Lecturers in the subject could usefully base their course work on the book. The diagrams are well drawn, the production excellent, and the price moderate.

*I.P.O.E.E. Library No.* 2463. S. W.

"Voltage Stabilized Supplies." F. A. Benson, M.Eng., Ph.D., A.M.I.E.E., M.I.R.E. Macdonald & Co., Ltd., 370 pp. 249 ill. 50s.

It is impossible in a book of this size to give full treatment to all aspects of the subject and some selection of material must be made. The author has chosen to devote about half the book to cold cathode tubes used for voltage stabilizing and voltage reference purposes, a subject which has received inadequate attention elsewhere. The collection into one volume of data on cold cathode diodes which were published previously only in the various scientific periodicals is a valuable feature of this book.

The remainder of the book is less detailed. The important valve stabilizer circuits are clearly described and the many modifications and improvements to the basic circuit are mentioned and references given to the original articles. It is unfortunate that the few circuits chosen for detailed explanation were designed before high-stability reference tubes were available.

The chapter entitled "Characteristics of Some Reference Elements" compares the performance of various types of batteries for this purpose. Power supplies for specialized purposes are described under miscellaneous circuits and in a separate chapter on "Power Supplies for Microwave Oscillators."

A chapter on stabilizers employing magnetic saturation is purely descriptive without the design detail and circuit information given earlier in the book.

A very comprehensive list of references is given with over 1,000 entries, together with a cross-reference of authors. Some indication by the author of the more important of these articles would have been useful to the general reader who does not have ready access to the literature, and also to university students and research workers for whom this book is intended. The use of semiconductors both for voltage reference and stabilization purposes deserves fuller treatment than a scant mention in the appendix.

*I.P.O.E.E. Library No.* 1972. R. K. H.

# Telephone Exchange Equipment Shelf Plugs and Jacks with Bimetal Contacts

U.D.C. 621.395.655

### Introduction

IMMEDIATELY prior to the 1939–45 war there was some evidence that poor contact between shelf plug and jack contacts on telephone exchange equipment racks was occasionally experienced, giving rise to circuit failures. This difficulty was traced to mal-alignment between the shelf plugs and jacks causing the contacts on one side of the pairs to be heavily stressed while those on the opposite side were relaxed and gave low contact pressure.

Tests at the time indicated that, at a small extra cost, the use of silver-plated contacts instead of plain nickel silver would give a substantial improvement in contact reliability even at low pressures, and after a short confirmatory test it was decided to redesign the plugs and jacks accordingly. The decision was not carried into effect until after the war and silver-plated plugs and jacks did not appear in the field until 1949. At the beginning of 1950, however, there were failures of these plug and jack connexions, caused by the migration of silver, the failure taking the form of low insulation, or even short-circuits, between adjacent contacts of a pair.[1]

At this stage, therefore, it was decided to revert to the earlier design using plain nickel-silver springs; but with some tightening in the specification of contact pressures, and of the relative position of the plug and jack contacts in the equipment to minimize unbalance in the pressures of the two contacts of each pair. At the same time, the number of plug and jack assemblies to be fitted to one relay set was limited to two, since with normal manufacturing tolerances it is difficult to ensure that each of three or more sets of contact assemblies are sufficiently well aligned to avoid any side bias when mated together. With these conditions met, satisfactory contact pressures are obtained which, in conjunction with the d.c. wetted paths normally provided through shelf jack and plug points, result in satisfactory connexions using nickel-silver contacts.

### Plugs and Jacks with Bimetal Contacts

Although the general position is now satisfactory there are a few circuits where it is not practicable to provide a d.c. path through each contact and, for this reason, a limited number of high-grade contacts utilizing a material of the quality of silver are required. For this application the use of silver-faced (bimetal) contacts appeared to offer a satisfactory solution. To avoid as many as possible of the constructional features that gave rise to the earlier trouble, the following principles were observed in the design of the new plug and jack:—

(*a*) The silver must be applied only in the contact area of the springs and not come into contact with the insulant.

(*b*) The separating insulators must be proud of the contact material, thus increasing the length of the leakage path.

(*c*) Non-tracking materials must be used for the insulating paths.

No increase in spacing of the contacts was permissible, although this would have been an advantage, as it was envisaged that connexions between an old type of jack and a new type of plug, or vice versa, might be necessary.

In the final design, rigid polyvinyl-chloride (p.v.c.) was chosen as the material for the spacing insulators and for the clamping insulator on top of the plugs and jacks, the main body of the plug and jack being an alkyd moulding loaded with glass fibre for strength. Both p.v.c. and alkyd are non-tracking materials and chemically inert. The jack springs and plug blades are stamped from phosphor-bronze strip having a narrow silver inlay along the length (Fig. 1), the position of the silver being such that it appears in just the right position to give a silver to silver connexion between a plug and jack.

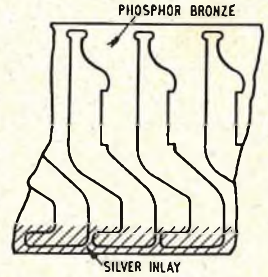



Fig. 1.—Method of Stamping Jack Contacts from Phosphor-Bronze/Silver Bimetal Ribbon.

It is necessary on certain jack springs that adjacent springs make contact when a plug is removed from the jack. For the present standard Shelf Plug and Jack No. 61, etc., various combinations of jack springs suitably "set" in manufacture are used to provide the required facility. With the new type of jack, however, this facility is provided by the setting of a lug on the end of the jack spring (Fig. 2). Only one code of jack is therefore necessary, the appropriate circuit requirements being met by suitable adjustment on site during installation. Jacks and plugs to the new design are already going into service as Jack No. 85A having 4 silver and 28 nickel-silver contacts, and Jack No. 86A having 16 silver and 16 nickel-silver contacts. The corresponding plugs are Nos. 3203 and 3204. The Plug No. 3204 has been designed to permit a degree of self-alignment with Jack No. 86A and at least one of this type will be fitted on large relay sets requiring three plugs, thus removing the earlier limitation.

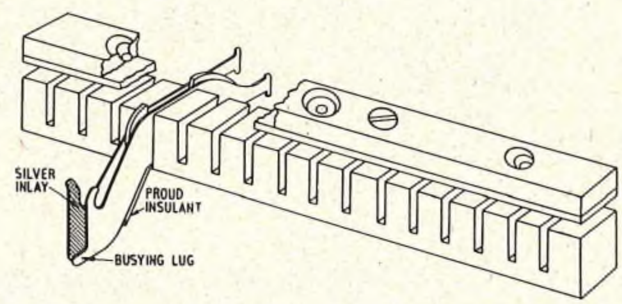



Fig. 2.—Cut-Away View of Jack No. 86A. Pairs of Bimetal Springs are in the Four Positions at Each End.

### Conclusion

Experience with the bimetal construction referred to has shown that it is somewhat expensive. The general adoption of the new design cannot, therefore, be justified economically, although the greater contact reliability which it affords is a very desirable feature. An alternative construction is possible in which silver is plated in the required portion only; the operation of masking and plating contacts individually, however, would probably be no less expensive than the bimetal construction. Long-term investigation is, therefore, being directed towards finding insulants and contact materials that may be cheaply constructed to work safely together and give a performance superior to that of plain nickel silver.

T.F.U.

[1] T. F. Urben. Plastics in Telephone Exchange Equipment. *P.O.E.E.J.*, Vol. 50, p. 148. Oct., 1957.

# The Design and Field Trial of a 12-Circuit Carrier Telephone System for Use On Unloaded Audio Cables

D. TURNER, B.Sc.(Eng.), A.M.I.E.E.,
C. D. THOMPSON, B.Sc.(Eng.), A.M.I.E.E.,
and J. CROSSLEY, B.Sc., A.M.I.E.E.†

## Part 2.—The Line Equipment and Field Trial

U.D.C. 621.395.44 : 621.315.2.029.3

**An account of the problems involved in the application of carrier telephony to audio cables was given in Part 1, together with a general description of the system and a description of the terminal equipment. This, the concluding part of the article, describes the line equipment and the field trial of the system on an audio cable between Elstow and Hendon.**

### The Line Equipment

A BLOCK schematic diagram of the line transmission equipment is given in Fig. 7. This shows that three types of repeater are required, an H–L repeater, an L–H repeater, and a terminal repeater in which frequency translation is required in one direction only, each type requiring a 246-kc/s carrier oscillator. To assist maintenance and replacement, all types of repeater are made identical in construction, differences in function being obtained by internal wiring changes.

Consideration has been given to housing the repeater equipment in roadside cabinets, hence a construction has been adopted that is both compact and designed to minimize gross ingress of moisture.

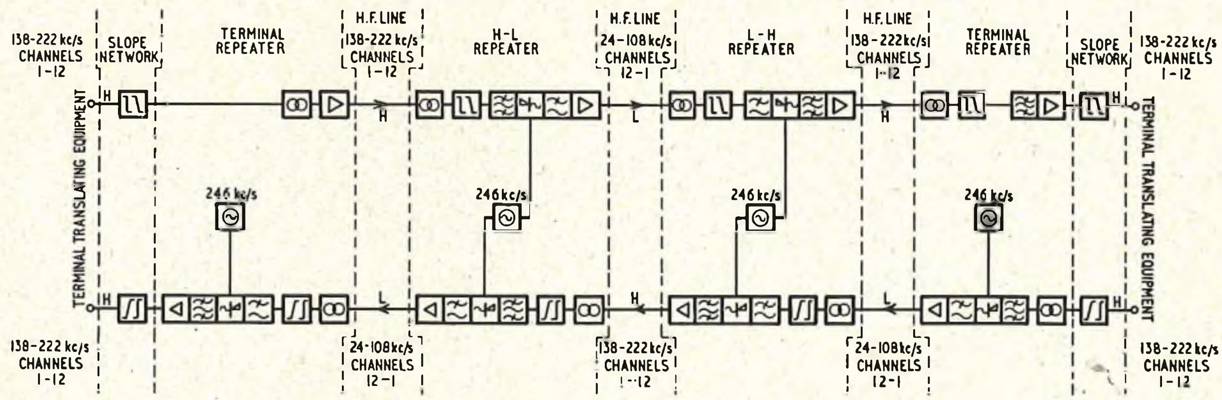



Fig. 7.—Arrangement of Repeater Equipment at Intermediate and Terminal Stations.

*Line Levels and Equalization.*

After consideration of various factors, such as circuit noise to be expected and performance realizable in a repeater with low power consumption, the nominal repeater section length was taken as 6 miles. Attention was first concentrated on a route with uniform 6-mile sections, and the level diagram shown in Fig. 8 was adopted for this hypothetical case. A compromise slope of + 8 db was chosen for the initial slope of test level at the terminal output to ensure that no channel has more than 8 db disadvantage from intermodulation and basic noise with respect to any other. In the hypothetical route of 6-mile sections, the slope* of cable loss for an h.g. section is + 14 db, and that for an l.g. section is — 18 db; thus for the two sections taken together the slope of the overall loss is only — 4 db. Equalization of the route consists in adding, to each section, networks with a loss having a slope of + 2 db. Thus the h.g.-section slope of + 14 db is adjusted to + 16 db by means of an equalizer at the input to the H–L repeater, and the l.g.-section slope of — 18 db is adjusted to — 16 db by means of an equalizer at the input to the L–H repeater. The total loss of cable plus equalizers for a pair of sections is flat and equal to 82 db, and both types of repeater, excluding the equalizers, have a flat conversion gain of 41 db. At the output of a repeater the slope of test level is ± 8 db, and at the input to the following repeater, after the equalizer, it is ∓ 8 db.

To cater for practical conditions in which section lengths will differ from 6 miles a method which commends itself, from the maintenance point of view and in relation to the application of regulation at selected stations, is to fix all repeater output levels at the values (differing as between L–H and H–L stations) given in Fig. 8. This would require the provision of equalizers to adjust the slope of loss over every section to ± 16 db, and appropriate values of flat conversion gain in the repeaters. This method has been adopted in principle, but it has not been thought necessary to adhere to a standard slope of test level at the outputs of the H–L repeaters because there are con-

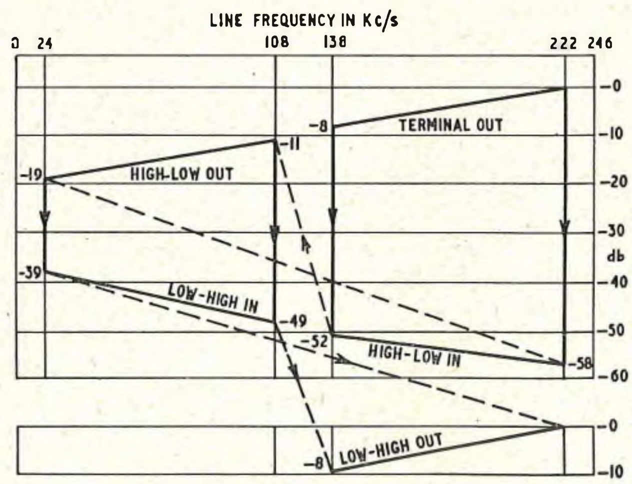



Fig. 8.—Line Test Level Diagram Calculated for Six-Mile Sections of 20-lb. P.C.Q.T. Cable.

† Mr. Turner is a Senior Executive Engineer, and Messrs. Thompson and Crossley are Executive Engineers, Post Office Research Station.

* The "slopes" quoted for various quantities (losses, gains or test levels) represent the value of the quantity at 222 kc/s (or 24 kc/s) minus the value at 138 kc/s (or 108 kc/s).

siderable margins relative to overload and noise at the ends of an l.g. section. The aim in practice is therefore to approximate to the values given in Fig. **8** for the following:

(*a*) The test levels at the frequencies of the central pilot at the outputs of all repeaters, namely − 4 db at 180 kc/s in the h.g. band, and − 15 db at 66 kc/s in the l.g. band.

(*b*) The slope of test level over the h.g. band at the outputs of the L–H repeaters, namely + 8 db.

As consistent slope of level at the outputs of H–L repeaters is not required, sections can be taken in pairs for the provision of slope equalizers; instead of providing at each of the two stations an equalizer (either positive or negative in value) appropriate to the preceding section, only the resultant of the two values is required and this may be divided as convenient. The total bulk of equalization required for the route, and maximum amount of equalization required at any station, are thus reduced.

For the field trial a range of six equalizer sections has been designed for each band. Two sections of negative slope and four sections of positive slope at 1 db intervals have been provided.

Although the slopes of cable losses over h.g. and l.g. sections are of opposite signs, deviations from those slopes due to the curvature of the cable loss/frequency characteristic are of the same sign and result in a bulge of loss. A small amount of bulge correction has been included in the design of each equalizer section.

Provision has been made to mount slope equalizers, and any resistive pads which may be necessary, in a unit that is permanently associated with the cable pair. Additional space has been allowed for mop-up equalization as required.

Since the terminal translating equipment is designed to assemble the channels at a flat test level, in the h.g. band, it is necessary to establish the ± 8 db slope of test level required at the output from each terminal station by means of a network which is included at the input to the terminal repeater. A similar network is necessary at the output of the terminal repeater at the receiving end to restore a flat test level.

*Description of the Repeater.*

The arrangement of the complete repeater is shown in block schematic form in Fig. **7**. Only two designs of filter are provided, the one a low-pass filter to select the l.g. band, and the other a band-pass filter to select the h.g. band. To set up a particular intermediate station the wiring to the filters is arranged appropriately. At terminal stations the wiring is arranged to by-pass the modulator and low-pass filter in the direction of transmission for which frequency-translation is not required. All modulators and amplifiers are identical; the amplifiers give a flat gain over the frequency range 24–222 kc/s and are thus capable of amplifying either band.

For each direction of transmission, the repeater (excluding equalizers) has a nominally flat conversion gain adjustable in steps of 2 db from 35 db to 49 db.

The valve* used throughout the repeater in the field trial equipment has a nominal 20V, 50 mA heater and is suitable for series operation over a cable pair. The h.t. supply required is 10 mA at 130V and the nominal mutual conductance 5 mA/V.

The series heater chain is arranged with the oscillator valve at the high potential end and excess heater-cathode voltage is backed-off by an additional resistor in the cathode circuit. The same measure is not permissible in the case of the amplifier valve next in the chain to the oscillator valve, since the full h.t. voltage is essential. The heater-cathode voltage in this case is the maximum permitted.

*Input Line Transformer.*—The input line transformer serves the double purpose of separating the repeater power supply from the h.f. signal and transforming the 125-ohm balanced line impedance to 3,000 ohms unbalanced. In the equalizers and filters economical unbalanced sections are employed and the higher impedance level is helpful in reducing the physical size of the reactive elements.

*Filters.*—The filter requirements in their stop-bands and in the cross-over region between 108 kc/s and 138 kc/s were specified from consideration of the loss of the various crosstalk paths in conjunction with the requirements that:—

(i) The signal/crosstalk ratio at the "audio out" should be 60 db.

(ii) The use of compandors improves the signal/crosstalk ratio by about 25 db.

(iii) The worst values of near-end crosstalk as measured on 6-mile sections of 20-lb. P.C.Q.T. cable vary from 55 db to 40 db over the band 24 kc/s to 222 kc/s.

(iv) The total loss contributed by the two filters at 123 kc/s should not be less than 10 db.

(v) The filter passing the high group must be of band-pass configuration to reduce the level of the unwanted sideband lying between 270 kc/s and 354 kc/s in L–H repeaters.

(vi) The leak at the frogging frequency (246 kc/s) should not exceed − 40 dbm† at the amplifier input, and attenuation peaks to ensure this could conveniently be included in the filter designs.

(vii) The signal leak through the modulator should not be less than 30 db below the wanted sideband.

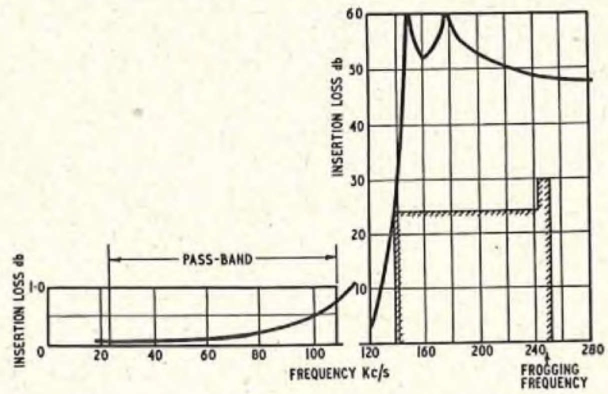



Fig. **9**.—Low-Pass Filter. Design Targets and Performance of a Typical Filter.

The filter requirements and the performances achieved are shown in Fig. **9** and **10**.

*Modulator.*—Tolerable levels of carrier leak are obtained by the use of selected germanium diode quads in a ring modulator together with the loss provided at the carrier frequency in both types of filter.

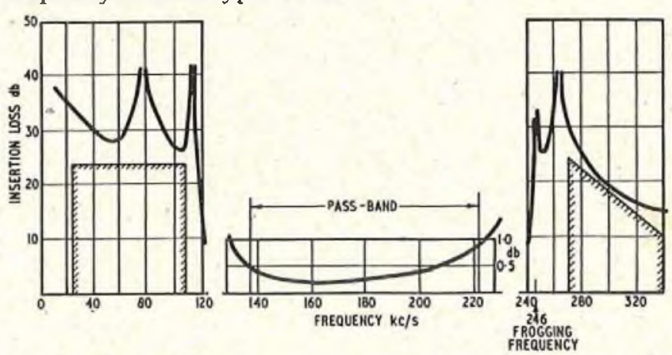



Fig. **10**.—Band-Pass Filter. Design Targets and Performance of Typical Filter.

* The valve is still in the development stage either as the CVX 8116 or CVX 7139.

† Decibels with reference to 1 mW.

The use of a modulator between filters means that the modulator has reactive terminations and the conversion loss is frequency-dependent. The magnitude of this effect is kept low by giving the modulator sides of the filters smoothly varying image impedances in their stop-bands.

The conversion loss of the modulator, with the input and output filter, is substantially independent of frequency and equal to about 5 db for either L–H or H–L translation.

*Amplifier.*—The circuit of the amplifier is shown in Fig. **11**.

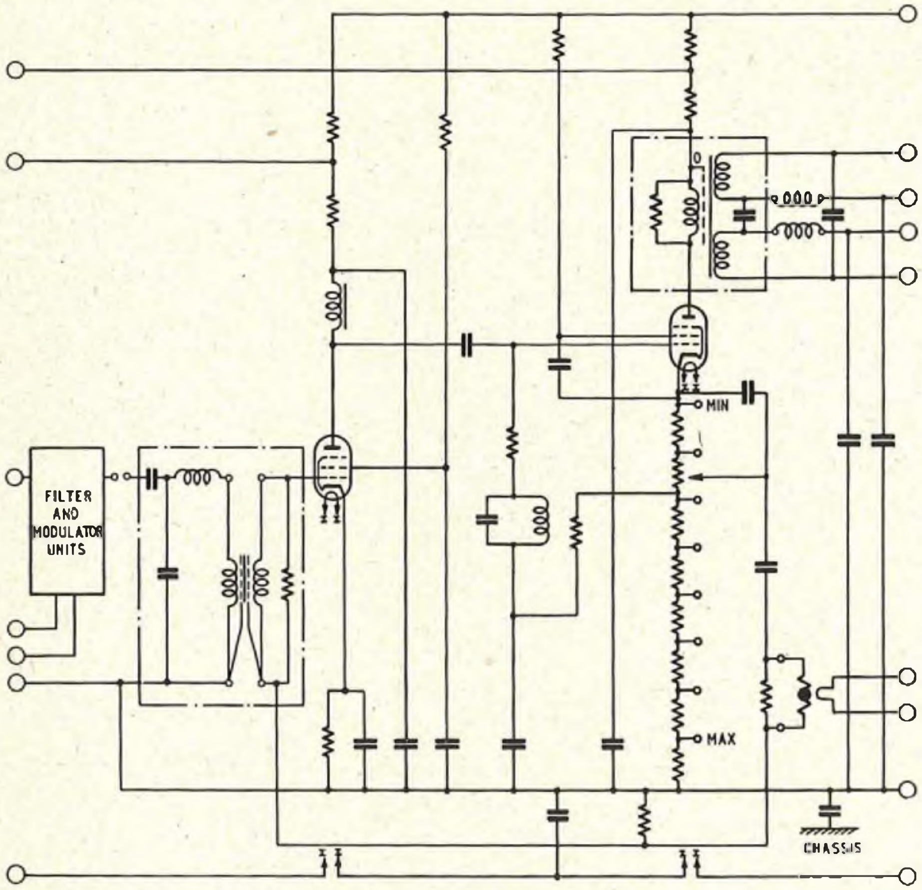



Fig. **11**.—Circuit of Line Amplifier.

The amplifier input transformer is terminated in a 27,000-ohm resistance and presents a 3,000-ohm resistive impedance to the preceding filter. This transformer, in conjunction with the input line transformer, provides a voltage gain of 23 db from the nominal 125-ohm line impedance. A ferrite core is used and the leakage inductance and winding capacitances are absorbed into a low-pass filter section.

The output transformer gives a voltage step down of 22 db from an anode load impedance of 20,000 ohms to the line impedance of 125 ohms. A laminated radiometal core is used and the parasitic reactances are absorbed into a low-pass filter section. This transformer is complementary to the input line transformer in relation to power separation.

There are two valve-stages, and a 3-element Wheeler interstage network with a termination of 39,000 ohms is used with choke feed to the anode of the first stage. Feedback is provided from the cathode of the output stage to the input grid and for gain variation is adjustable in 2-db steps by tapping the cathode resistor of the second stage. The total feedback therefore varies between 34 db and 20 db, and the external gain from 40 db to 54 db, depending upon the gain setting.

Provision is made in the cathode feedback circuit for the inclusion of a thermistor at those power feeding stations where automatic gain control is required. The thermistor resistance is varied continuously under control of a d.c. output derived from the automatic gain control panel.

The amplifier is stable under all conditions of power supply and termination, and overloads at + 22 dbm.

*Oscillator.*—The 246-kc/s carrier supply necessary for the two modulators is provided in each repeater by a common valve oscillator controlled by a CT-cut quartz resonator. Crosstalk between modulators is reduced by using two separate windings on the tuned output transformer; a third winding provides a test voltage.

### *Power Supplies.*

Housing and energizing line repeaters is simplified by supplying power over the cable to dependent repeaters from selected stations at which public supply mains are available. Each repeater requires a power supply of 100 mA at 130V d.c. To offset the voltage drop in the conductors, while not exceeding acceptable voltage limits with respect to earth, power feeding stations are equipped with constant potential power units giving supply voltages of + 130V and − 130V d.c.

For the protection of cable working parties it is necessary to remove all power supplies from a cable section before the sheath is opened; to enable this to be done without interrupting the carrier transmission the power feeding stations have been arranged to supply power to two dependent stations on each side, when required, although under normal conditions only one on each side is fed. The possible power feeding arrangements are shown in Fig. **17**.

Power is fed to the stations adjacent to the power feeding station over the "a" and "c" wires of a quad rather than the "a" and "b" wires. This has been done to reduce the potential difference applied to components in the power feeding path and to reduce the polarization of the line transformers.

Under extended feed conditions use is made of the phantoms of the side circuits over the repeater section between dependent stations to keep the voltage drop in the cable to a minimum.

Power rearrangements are controlled by Cable Power Feed Control units at each power-feeding station for each direction of power feeding. Each power feed control unit contains a three-position switch under the control of three interlocking cylinder lock mechanisms. Each position of the switch corresponds to one of the three power feeding conditions, feed to one dependent, feed to two dependents, and power disconnected.

To clear power from a section it is essential for the cable working party to be in possession of two matching keys (one from each power feeding station) and to have ensured that the correct lamp indication has been given at each power feeding station. Possession of the two keys alone ensures that power cannot be restored to that section.

To reduce the loading of the power control switches power supplies to each carrier system are controlled by a small relay set which also provides lamp supervision and alarm facilities.

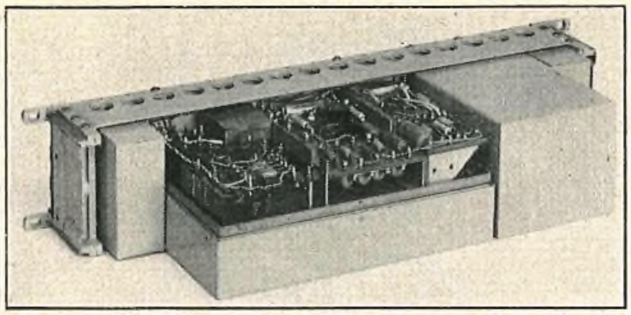


FIG. 12.—REPEATER PANEL. REAR VIEW.

*Mechanical Features.*

The repeater, a rear view of which is shown in Fig. 12, has been designed to mount on a 2-unit 51-type panel. This is not considered to be the most economical form of construction but it was adopted to expedite the field trial and to conform to the form of construction used for the terminal equipment. In those stations where 51-type racksides are not available the repeater is mounted by means of adaptors.

Fig. 13 and 14 show repeater equipment for two 12-channel systems at a dependent station and at a power feeding station, respectively.

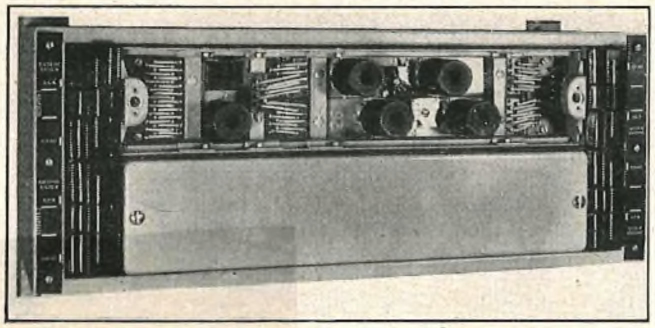


FIG. 13.—LINE EQUIPMENT FOR DEPENDENT STATION.

One repeater has been mounted in a Cross Connexion Cabinet No. 3 to provide some experience of operation under such conditions; such a cabinet is not considered to be suitable for the installation and maintenance of this equipment, and should a cabinet be required a special design will be necessary.

The repeater is physically arranged in the form of a Line Transformer unit, an Equalizer unit, an Amplifier–Translator unit and a common unit which contains the oscillator and auxiliary power supply switching equipment.

The equalizer units, which are hermetically sealed, are mounted on the rackside locators and remain permanently associated with the cable.

The remaining units mount on the panel and are interconnected by short soldered straps. The covers of these units are held against flanges by screw pressure. Additional protection against the ingress of moisture can be provided by the use of suitable sealing compounds at these points.

The construction of the filters and modulators was largely determined by the small amount of space available and the possible need for repeaters to be housed in roadside cabinets. Thus a form of construction was required which was cheap, compact and unaffected by the vibration and atmospheric conditions arising under field conditions. The units were therefore encapsulated in an epoxide resin with the resulting advantages that the mountings for components can be relatively crude and therefore cheap, and in conjunction with the use of the smallest available components the two filters and the modulator for each amplifier–translator unit occupy only 16 in$^3$. In

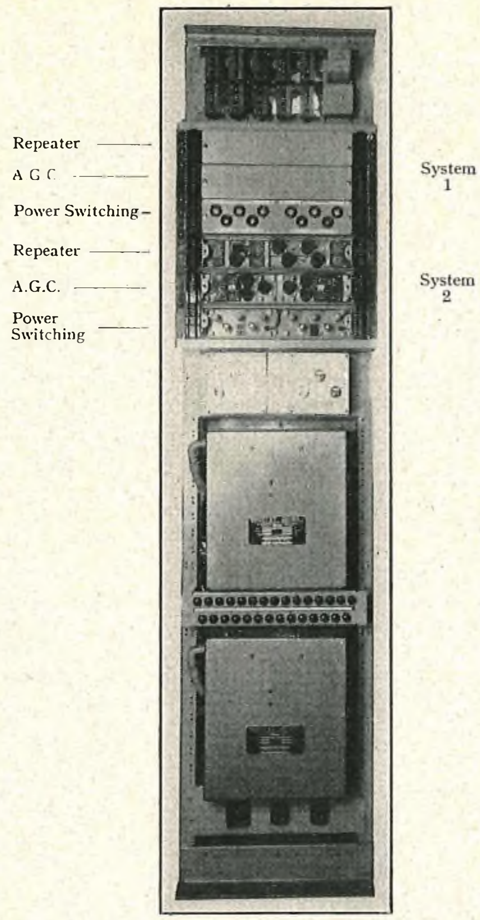



FIG. 14.—LINE EQUIPMENT FOR POWER FEEDING STATION.

addition, components are protected against damage from vibration, mechanical shock, chemical attack and mould growth, and in particular the risks associated with the use of fine-gauge wire under such conditions are largely removed. Altogether some 180 units have been encapsulated over a period of 18 months, and despite considerable handling no failures due to dry joints, broken wires or mechanical failures of components have occurred.

*Performance.*

Fig. 15 shows the insertion gain of a typical amplifier at its maximum gain setting. No provision is made for the fine adjustment of the mean gain of the amplifier and there is some variation, about $\pm 0{\cdot}2$ db, from amplifier to amplifier. The spread of the gain-frequency response of any of the 60 amplifiers tested for the field trial has not exceeded 0·5 db.

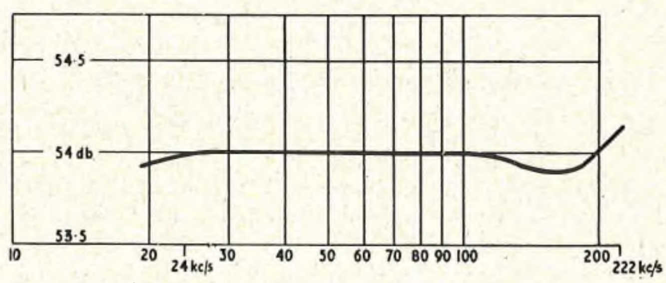



FIG. 15.—INSERTION GAIN OF TYPICAL AMPLIFIER.

Typical conversion gain/frequency responses of L–H and H–L repeaters are shown in Fig. 16. The introduction of two filters and a modulator before each amplifier increases the variation of mean gain somewhat; for 30 repeaters,

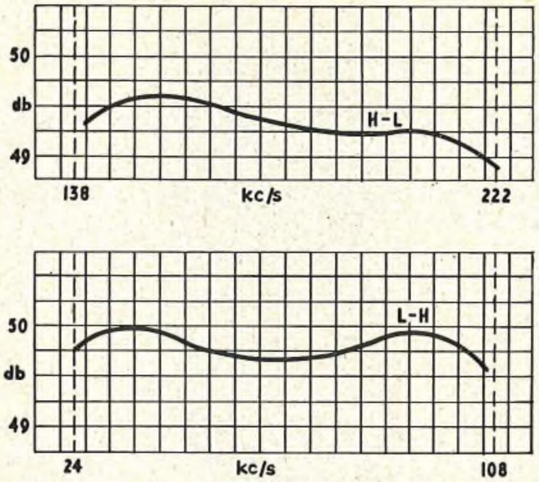



FIG. 16.—TYPICAL REPEATER CONVERSION GAIN/FREQUENCY RESPONSE.

including both types, the mean conversion gain varied from repeater to repeater over a range of $\pm$ 0·5 db. The variation of conversion gain for a change in power supply voltage of $\pm$ 6 per cent did not exceed 0·1 db at the maximum gain setting. The inclusion of germanium diodes in the repeater modulator increases the dependence of the conversion gain on temperature.

Carrier leak at 246 kc/s appears at the repeater output at a level not exceeding $-$ 25 dbm for L–H repeaters and $-$ 40 dbm for H–L repeaters, while the noise power in a 4-kc/s band is not worse than $-$ 70 dbm for either type of repeater.

### THE BEDFORD–LONDON FIELD TRIAL

The Bedford–London route was selected for a field trial of the system with carrier terminals at Elstow and Hendon repeater stations and the circuits extended on audio tails into Bedford and London Toll A Non-Director exchanges.

A group of three quads in an inner layer and another group of three in the outer layer of the Bedford–London MU cable were deloaded and intercepted at the terminal and intermediate stations, shown in Fig. 17. The use of cabinets to house the line equipment at dependent repeater stations had been envisaged but for the field trial it was decided to use existing buildings. This decision partly determined the choice of route and it resulted in some very short repeater sections and a total of nine intermediate stations where theoretically only seven are needed.

The installation consists of a complete 12-circuit carrier system and a spare h.f. line link between carrier terminals, provided to enable system-to-system crosstalk measurements to be made and to ease line maintenance problems during the trial. Line a.g.c. would normally be fitted in each power-feeding repeater station but repeater sections are short at the London end of the route and a.g.c. panels have therefore been omitted at Mill Hill. At Wilstead, the repeater for the spare line only is housed in a cabinet.

*Line Installation and Equalization.*

In normal use the working line is connected to an inner quad and the spare line to an outer quad of the cable. When required, e.g. for crosstalk measurements, either of the h.f. lines can be set up on any of the six quads by appropriate cross-connexions on the test tablet at each repeater station.

The first step in setting up an h.f. line was to set the power supply voltage across each dependent repeater independently by adjusting a series resistor in the power feed circuit at the power feeding station. Then equalizers

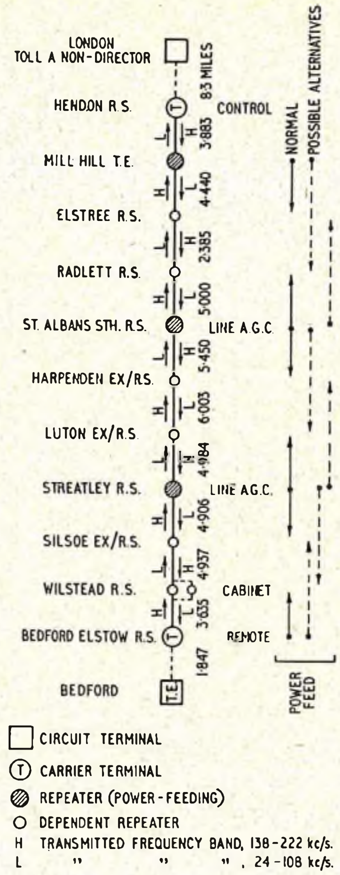



FIG. 17.—FIELD–TRIAL ROUTE; BEDFORD–HENDON CABLE.

appropriate to the repeater section lengths were selected from the range of 12 standard equalizers and fitted at repeater stations. Taking one direction of transmission at a time, and with line a.g.c. inoperative, the terminal was set up to send pilot signals, one at a time, at the correct levels. At the first intermediate station, the line amplifier gain was adjusted to set the level of the centre pilot at nominal $\pm$ 1 db. The levels of the outer pilots were measured as a check on the slope at that point. This procedure was followed successively at each station. The line attenuation/frequency characteristic between terminals was measured to check the slope, and it was usually found that one equalizer needed to be changed for another in the standard series. Three mop-up equalizers were then fitted to correct for excess loss at the edges of the frequency band and a

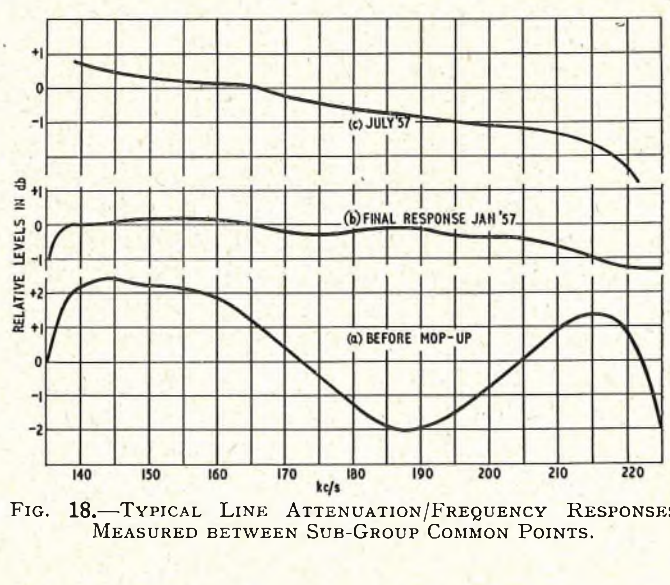



FIG. 18.—TYPICAL LINE ATTENUATION/FREQUENCY RESPONSES MEASURED BETWEEN SUB-GROUP COMMON POINTS.

bulge in its centre due to repeater (Fig. **16**) and cable characteristics. The above procedure was repeated for the other direction of transmission.

Typical line attenuation/frequency characteristics are shown in Fig. **18**.

The setting-up of the terminal racksides and the lining-up of individual channels followed, in the main, conventional repeater station practice.

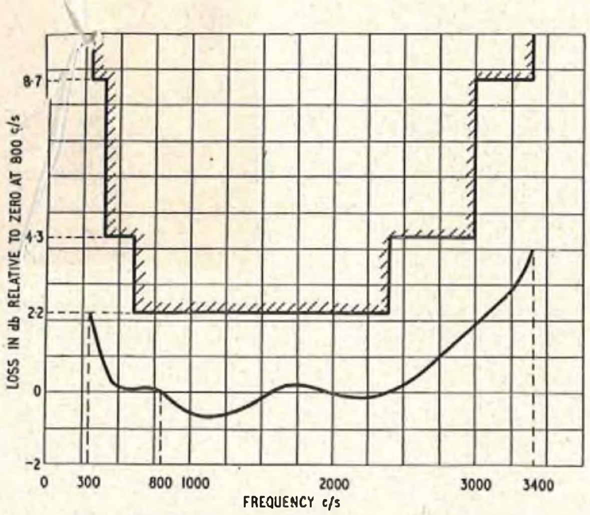
*Performance.*

*Terminal Transmission Equipment.*—The equipment has fulfilled the design requirements though many practical points for improvement have been noted for the future. Some trouble was experienced due to high temperatures arising from a rackside dissipation of 400W. A large part of this dissipation is in the signalling receivers and arises from a decision to operate the exchange relays directly over audio cable tails up to 30 miles long. The interposition of a relay on each channel panel would enable the dissipation to be reduced by 70W.

The main adverse effect of the high temperature has been on the compandors which are operating beyond the limit to which they are properly compensated. In consequence the circuit stability margins are below standard, six circuits having less than 1 db stability (with 2-wire ends open circuit) when lined up to − 4 db. When improved compandors (using transistors) were fitted on the least stable circuit, this circuit was improved to have a 0·75 db margin when lined up to − 3 db.

The high temperatures also increased the incidence of failure of electrolytic capacitors.

A typical audio-audio attenuation/frequency characteristic is shown in Fig. **19**. No target was set other than the




Note.—C.C.I.F. limits for a complete circuit are shown.

Fig. 19.—Typical Channel Frequency Response between Carrier Terminals.

C.C.I.F. limits for a circuit as shown in the illustration, but it was expected that these limits would easily be met. The shape of the characteristic arises from the use of the simplest possible filters. Thus, the increasing attenuation above 2,500 c/s is due to the channel low-pass filters and the roll is due to the channel band-pass filters.

Channel-to-channel crosstalk measurements gave worst figures of 78 db for n.e.x.t. and 69 db for d.e.x.t. At "audio out" the test-level/noise ratio was 76 db on Channel 9 due to r.f. pick-up at 200 kc/s and was better than 80 db on all the other channels. These figures, compared with those below, show that the compandors are very effective in dealing with what would otherwise be very bad interference.

*Signalling.*—The simple low-pass and band-pass filters used proved to be adequate to separate the speech and signalling paths. This was shown by speech immunity tests which measured the number of false signalling operations due to high-level speech and showed that it was negligible. Signalling distortion measurements were also regarded as completely satisfactory.

*Line Transmission Equipment.*—Most faults occurring on the line equipment have been due to valve failures. The valves used in the equipment are still under development and the earlier samples proved unsatisfactory; but those now in use are, so far, giving a satisfactory performance.

It has become clear that the vital point in a frequency-frogging repeater is the stability of the modulator conversion loss, since adequate amplifier gain stability can readily be ensured. The instability arises from two main sources; oscillator level and temperature variations. Some improvement in the former would be needed in further systems of this type. The temperature variations, both daily and seasonal, in buildings are not big enough to cause serious conversion loss changes. In the cabinet at Wilstead the ambient temperature can have a daily range of over 55°F and a seasonal variation of over 110°F, and since conversion gain varies 0·7 db for a change of 55°F this design of cabinet is clearly unsuitable. In an improved cabinet the ambient temperature need not deviate much from the daily mean, but the seasonal range would still be about 35°F.

The drift of frequency of the repeater oscillators has in only two instances been more than 10 c/s over a six-month period and the overall frequency deviation on the h.f. lines has been less than 20 c/s.

The stability of the line attenuation/frequency characteristic may be assessed from Fig. **18** (*b*) and (*c*). The change recorded, while not regarded as unsatisfactory, is largely due to changes in level of the repeater oscillator.

Crosstalk measurements at line frequencies were made using the two h.f. lines, which were set up as required on the six available cable quads. Measurements were made on twelve combinations of quads for system-to-system crosstalk and for six cases of within-system crosstalk. On each measurement, the interfering signal being a steady tone, the crosstalk appeared as a beating tone due to the fact that each crosstalk contribution along the line has a different path through frogging modulators and hence has a slightly different frequency. The crosstalk recorded was the peak amplitude, which gives an adverse assessment. The worst values of crosstalk (peak amplitude) were:—

System-to-system d.e.x.t.
better than 36 db signal/noise ratio.

System-to-system n.e.x.t.
better than 33 db signal/noise ratio.

Within system n.e.x.t.
better than 35 db signal/noise ratio.

The improved crosstalk that should be realized on inner quads of the main cable, was masked by the poor crosstalk on all quads of the small intercepting cables.

Power feeding and switching arrangements have worked very well.

*Maintenance.*

The system contains a number of features that are new to maintenance staff but no undue difficulties have been experienced.

The circuits have been carrying traffic since the end of April, 1957. No traffic faults have been traced to the system and apart from troubles already referred to there has been a satisfactorily low incidence of routine maintenance faults.

### Conclusions

The development and the field trial of the system has already given valuable experience of the application of many new principles. The field trial has demonstrated that a satisfactory 12-circuit system can be set up over deloaded audio cable, though the economic range of use of such a system has still to be settled. The equipment at present in use was built on an experimental basis and may not be suitable in all respects for permanent installation. The trial has indicated a number of points of detail that could receive attention if further equipment is ordered, but the main features of the scheme have worked well and the only points of principle on which changes are recommended are:—

(*a*) Signalling. A receive relay should be fitted on the channel panel.

(*b*) Frequency synchronization. Each terminal should have its own master oscillator.

Easily the most significant fact affecting the design of new carrier systems is the advent of transistors, and although the full possibilities arising from their use have not yet been studied it is possible to estimate their effect on the present system. The carrier terminals, with the possible exception of the frequency generating equipment, could be transistorized without any difficulty. One channel on the London–Bedford system has already been equipped and is working with transistorized compandors. The full use of transistors would,

(i) reduce dissipation to about one-tenth of that of the present rackside, so disposing of all problems due to high temperatures,

(ii) reduce to about one-third the amount of power equipment, and

(iii) give a much improved layout of equipment.

The effect on the economics of the system would, however, be modest since most of the equipment would be unaffected.

With the supply of suitable transistors now within sight, it is to be expected that carrier line amplifiers will be available for experimental purposes within a few months. With such amplifiers all power safety precautions and power switching could be dispensed with, a considerable economy and simplification. A completely sealed form of repeater construction could be envisaged.


### Acknowledgments

The authors wish to acknowledge the assistance and co-operation given by members of the Telephone Development and Maintenance Branch and the Transmission and Main Lines Branch, E.-in-C.'s Office, on various aspects of the development and testing of the system. Thanks are also due to colleagues at Dollis Hill for assistance at all stages in the design, construction and installation of the system and to the repeater station maintenance staff of the Home Counties and London Telecommunication Regions for their enthusiasm and success in coping with the novel features of the system.


# The A.A. Road Service

Following the successful provision of weather and cricket test score information services in London in 1956, these were extended to other parts of the country. In the early part of 1957 local weather services were provided at seven provincial centres, and during last summer the cricket test score service was extended to most of the larger provincial towns. The success of these two information services was followed by a request from the Automobile Association for the provision of a "state of the road" service at a number of towns, the object of the service being to provide the caller with information regarding the condition of the roads within a 50-mile radius of the centre. After detailed investigation of a number of centres it was agreed initially to provide this service in London, Birmingham, Cardiff, Edinburgh, Glasgow, Liverpool, and Manchester for the winter months commencing 1st November, 1957. Information for this service is given to the local recording centre by the local A.A. Area Headquarters who have prepared the message from reports sent in by A.A. mobile patrols in the area.

In a previous article[1] a description was given of the tape recorders originally used on the London Weather Service. These had the disadvantage that long silent intervals could only be avoided by having messages of a fixed predetermined length unless tapes were spliced each time a new recording was made.

To overcome this difficulty, magnetic disc recording machines were used for the provincial weather services, the London installation being changed to similar machines shortly afterwards. These machines have rim-driven turntables on which are placed plastic discs coated with a high coercivity magnetic material. The magnetic head (which is used for both playback and recording) is made to follow a spiral track on the disc as the turntable rotates. The return of the head to the outer edge of the disc is controlled by a contact operated by an adjustable slider which is set by the operator at the end of the recording. The possible range of message length for which adjustment can be made is from 10 seconds to 5 minutes. The amplifier associated with the machine incorporates a simple form of automatic volume control to keep the message level reasonably constant.

When the demand for the A.A. Road Service was received, a new model of disc recorder was available which had an electro-magnetically-operated device for controlling the return of the head to the outside of the disc. This avoids the need for operators to touch the machines and enables recording to be done from a remote position.

At each centre where this new type of machine has been installed, control equipment with an ultimate capacity for three services has been provided. Two announcing machines situated remote from the control panel are provided for each service, one being connected to the service while the other is ready to accept a new message. When a new recording is required, a rotary switch is operated to connect the operator's circuit to the appropriate machine. The operator is then able to erase the existing message, make a new recording and play back for check. If the recording is satisfactory the output from the machine in service is then monitored so that the change-over from the old to the new recording can be made in the short gap between announcements.

G. L. S.

[1] D. J. Manning, The Introduction of a Telephone Weather Service in London. *P.O.E.E.J.*, Vol. 49, p. 47, April 1956.

# A New Conference Repeater

L. J. BOLTON, B.Sc.(Eng.), A.M.I.E.E.,
J. L. HOWSE and P. J. BUISSERET†

U.D.C. 621.395.64:621.395.348.4:621.395.52

**The conference repeater described has been designed primarily to meet the requirements of conference telephone calls over the transatlantic telephone cable. The transmission loss through the repeater is controlled by voice-operated switches which help to maintain stability and reduce the level of side-tone.**

## Introduction

APPARATUS was required in London to enable conference calls to be set up using a transatlantic cable circuit in association with up to five European (including United Kingdom) circuits. The equipment was required to work satisfactorily when connected via a transatlantic cable circuit to conference repeaters already installed on the American continent and also to be suitable for providing conference facilities for the inland network. The repeater was therefore designed on the same general principles as the existing American (Bell System) conference repeater, but using wherever possible Post Office standard items of equipment. Where no such item was available suitable apparatus was constructed.

## General Design Features

*Electrical.*

The distinctive feature of the repeater is the use of voice-operated switching devices, which help to maintain stability, enable a lower transmission loss through the repeater to be obtained and reduce the level of side-tone. Voice-operated control is normally used on three and exceptionally four of the six outlets. Experiment has shown that there is little to be gained from the provision of control on the remaining two outlets.

The principle of the conference repeater is shown in Fig. 1. Each of the six circuits is connected via transformers, filters and amplifiers to a combining network of resistors which interconnects the circuits in such a way that each circuit is terminated by a resistance of 600 ohms. It will be seen that the circuits of the subscribers participating in a conference call must be connected to the repeater on a 4-wire basis. The circuits reserved for use with transatlantic telephone cable calls are equipped with relay sets which enable this to be done. When six subscribers are connected there will be a major reflection of speech energy from each of the five listening subscribers' circuits which produces two undesirable effects, viz.:—

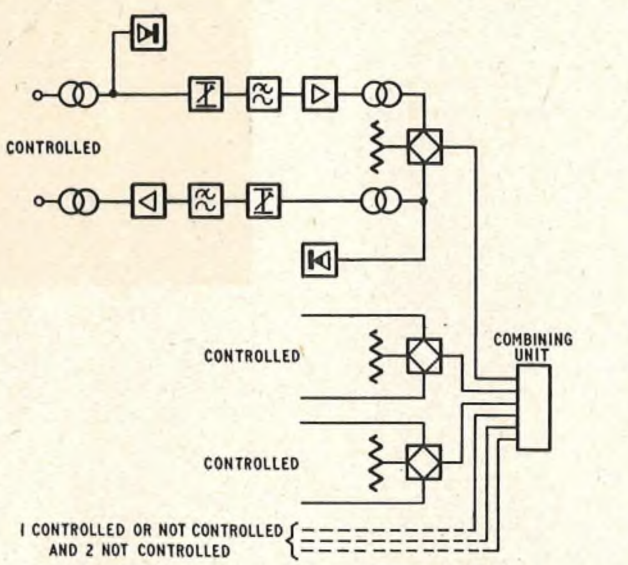



Fig. 1.—Block Schematic Diagram of Conference Repeater.

(*a*) The relatively high proportion of total energy returned to any source tends to produce instability and if oscillation is to be avoided a relatively high transmission loss between telephones is necessary.

(*b*) Signals reflected to the source arrive after a time interval which depends on the length of the path traversed and the velocity of propagation of the circuits concerned. Energy returned after two or more reflections may, therefore, give rise to intolerable echo or near-singing distortion.

When in use the voice-operated switches reduce the transmission loss between a speaking subscriber's telephone and the other telephones and at the same time increase the transmission loss from the listening subscribers' telephones to the speaking subscriber's telephone. The changes in transmission losses are so chosen to give transmission and echo characteristics similar to those normally encountered on direct (i.e. non-conference) connexions.

Other facilities include:—

(*a*) *Broadcast facility.*—By operation of a suitably connected relay, four of the possible six telephones connected to the conference repeater are permitted to receive, but not transmit.

(*b*) *Holding facility.*—To facilitate the setting-up of conference connexions, the operator has a relay-controlled facility which allows all telephones connected to the repeater to receive but not transmit. This allows each subscriber about to participate in a conference to be aware of the operator's progress in establishing the connexions, but prevents conversation between participants already connected. Such conversation, if permitted, might delay the completion of the connexion of the remaining required subscribers. When all the required subscribers are connected, the relay can be released, allowing the call to commence.

(*c*) *Power failure guard.*—In the event of failure of an essential power supply to the voice-operated detectors, passage of all signals through the conference equipment ceases until the supply is restored. This is considered desirable since it is possible that some conference connexions, stable when set up using voice-operated control, would become unstable if this control ceased to function.

*Mechanical.*

The functions of the apparatus associated with a voice-controlled outlet may be considered as falling into three categories:—

(*a*) Amplification
(*b*) Voice detection
(*c*) Control.

The apparatus performing each of these functions fits conveniently on a 2-unit 51-type panel. In order to maintain maximum flexibility the layout was so arranged that the amplifier panel is identical to that employed on an outlet that is not controlled. The control can be taken off any controlled outlet by removing the detector and control panel associated with it.

† Mr. Bolton and Mr. Howse are Executive Engineers and Mr. Buisseret is an Assistant Engineer, Transmission and Main Lines Branch, E.-in-C.'s Office.

However, since it might sometimes be desirable to make this change remotely (e.g. from the switchboard) a relay is included on the control panel which, when operated, disconnects the controlling wires from the associated amplifier panel.

Apparatus for five controlled outlets and four outlets without control is provided. Spare sets of apparatus are provided as shown in Table 1.

TABLE 1

*Working and Spare Apparatus*

| Working | Spare |
|---|---|
| 4 controlled and 2 not controlled | 1 controlled and 2 not controlled |
| 3 controlled and 3 not controlled | 2 controlled and 1 not controlled |

A U-link field is provided on the rack to enable faulty apparatus to be patched out and spare apparatus patched in. A valve-failure alarm panel is provided. The whole conference repeater, including the power panels to enable it to be driven from a.c. mains, occupies one 51-type rack. A general view of the three panels comprising one controlled

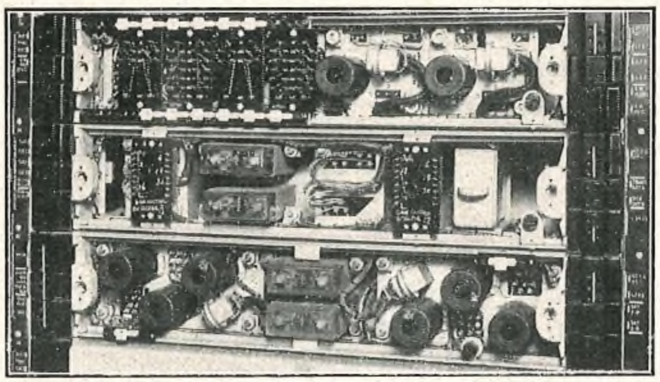


FIG. 2.—GENERAL VIEW OF PANELS FORMING ONE CONTROLLED OUTLET.

outlet is shown in Fig. 2. The top panel is the amplifier panel, the control panel is in the centre, and the lowest panel is the detector panel.

## CIRCUIT DESCRIPTION

*Amplifier Panel and Application of Voice-operated Control.*

The circuit diagram of the amplifier panel is shown in Fig. 3. The low-pass filters are included to avoid the possibility of oscillation at high frequencies which might otherwise occur. The 1 : 1 ratio transformers serve to isolate the transmission equipment from direct current which might flow from the switching apparatus through which the subscriber is connected. The transformers also permit the use of a single change-over contact on a polarized relay to effect control. Without these transformers an intolerable unbalance might be introduced, unless two polarized relays were used.

The operation of the voice control is as follows. In the idle condition relay contacts RLC1 and RLD1 are as shown. If now the subscriber connected to this circuit speaks, energy enters via pair B. Voltage is developed across the input terminals of voice frequency detector No. 2 and if of sufficient magnitude this causes relay RLD (not shown) to operate; contact RLD1 removes the pre-set shunt resistor R7 from one 4-wire winding of the terminating set and connects R6 across the other 4-wire winding. This reduces the transmission loss in one direction and increases it in the other, thus improving transmission between the speaking subscriber and the remainder, whilst reducing the level of side-tone or echo. Operation of RLD1 also short-circuits the input of voice frequency detector No. 1. This feature ensures that relay contacts RLD1 and RLC1 cannot operate simultaneously.

Once operated, contact RLD1 does not release until a finite time (adjustable) has elapsed after the subscriber has finished speaking (see description of the control panel). This hang-over time allows the echoes to die away before transmission in the reverse direction is completely restored.

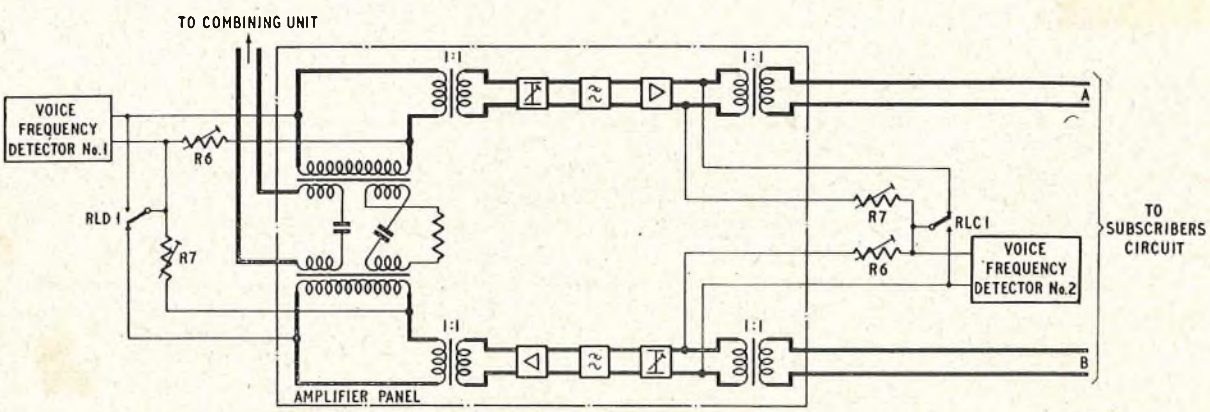
A similar sequence of operations takes place if one of the other subscribers speaks. Speech energy now enters the amplifier via the combining unit and voice frequency detector No. 1 operates relay contact RLC1. This reduces the transmission loss in the speaking path, increases it in the return path and short-circuits the input of voice frequency detector No. 2. The delay-in-release feature also applies to relay RLC.

For clarity the relay and its associated contacts that, when operated, remove the voice control feature from the amplifier are not shown in Fig. 3.

*Detector Panel* (*Fig. 4*).

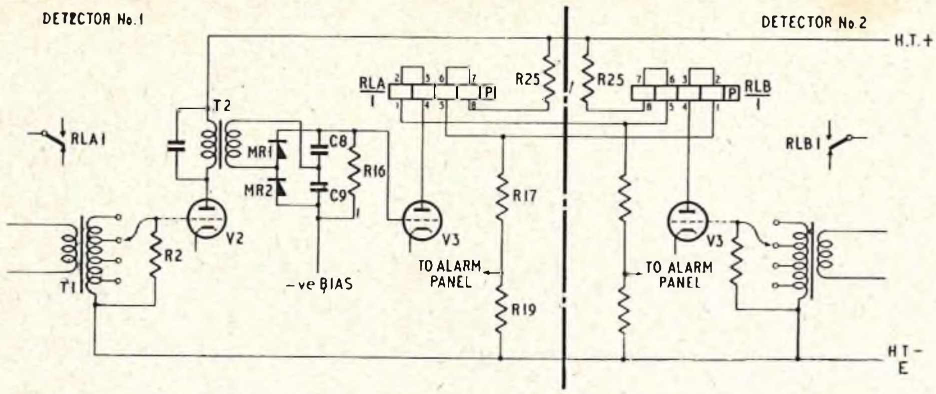
Fig. 4 shows parts of the circuit of the detector panel. Two identical detectors and associated relays, one for each direction of transmission, are provided and therefore only No. 1 will be described.

A high-impedance input circuit is provided by resistor R2 and transformer T1, the secondary of which has tappings to permit adjustment of sensitivity. After amplification, signals are fed to transformer T2 broadly tuned at 1,000 c/s. This tuning is designed to give the maximum




Notes 1. Relay RLC operates when signals enter detector No. 1 and relay RLD operates when signals enter detector No. 2.
2. The detectors have high-impedance input circuits.

FIG. 3.—SCHEMATIC DIAGRAM OF AMPLIFIER PANEL AND VOICE-OPERATED CONTROL CIRCUITS.




Note. The cathodes of valves V3 are connected to the bridge circuits on the control panel (see Fig. 5)

FIG. 4.—SIMPLIFIED CIRCUIT OF VOICE-OPERATED DETECTOR PANEL.

voltage across the transformer from average speech signals. The secondary of transformer T2 is connected to the voltage-doubler rectifier circuit MR1, MR2, C8, C9 and load resistor R16. The rectified voltage developed across R16 reduces the negative potential of the grid of valve V3. In the absence of incoming signals the anode current of V3 is cut off by negative bias (which is provided from a potentiometer across a 24-volt supply).

In the absence of speech signals to T1, there is therefore no current flow through windings 1–2, 3–4 of relay RLA and the relay contact is held in one direction by the current which flows from HT+ via R25, windings 8–7, 6–5 series-aiding, R17 and R19 to earth. Since relay RLA is a plug-in relay, a suitable voltage for operating the valve-failure-alarm panel is provided from the junction of R17 and R19. If for any reason the relay is withdrawn, this voltage disappears and an alarm is given.

On receipt of signals of sufficient magnitude, the voltage across R16 rises sufficiently to overcome the standing bias and valve V3 conducts, the anode current flowing from HT+ via R25 of the other detector, windings 8–7, 6–5 of relay RLB and windings 1–2, 3–4 of relay RLA. The current flowing in the anode of V3 is sufficient to cause the armature of RLA to move to the other contact. This current flows via windings 8–7, 6–5 of RLB but its passage through these windings is in a direction such as to increase further the existing bias current and so there is no tendency for the armature of RLB to move. This interconnexion of the relays associated with each detector tends to ensure that only one armature moves if signals are applied to the inputs of both detectors simultaneously. The possibility of both relay armatures moving at once is further reduced by:—

(a) The provision of other rectifier circuits (for clarity not shown in Fig. 4) the voltage developed across which, as a result of an applied input signal, is applied as negative bias to the grid of the amplifier valve of the other detector, thus reducing its sensitivity.

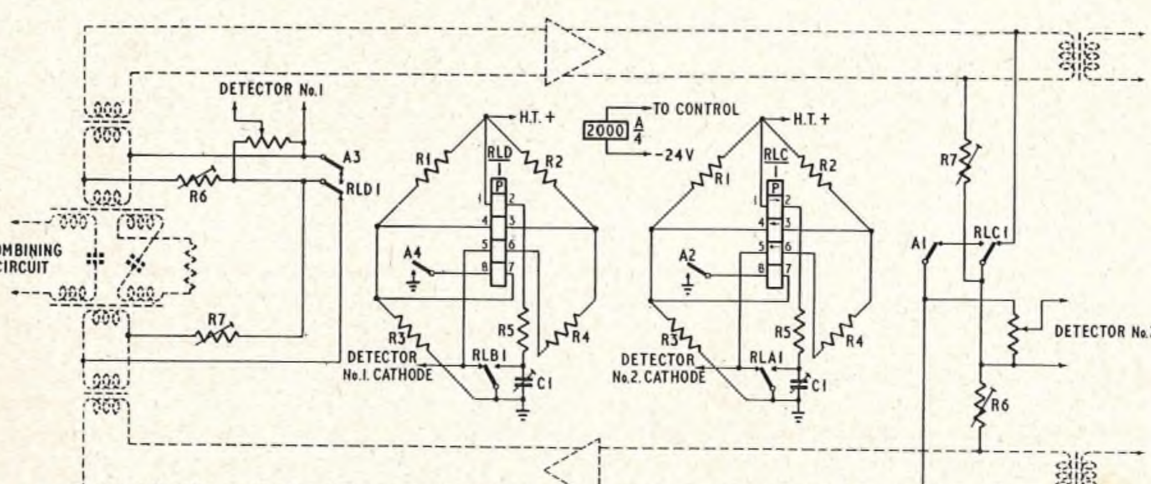
(b) The cathode of the final valve of the detector (V3) is connected to a point in the circuit of the control panel which is at earth potential if the relay of the other detector has not operated, but which is at a relatively high positive potential if it has. This positive potential on the cathode biases the grid of the final valve of the first detector to well beyond cut-off, thus making it impossible for the valve to draw anode current.

It was found in practice that these interconnexions were sufficient to secure the necessary differential action when the detector panel was connected into circuit on the conference equipment.

Each detector has all its components, other than the valves and relays, housed inside one 51-type can. Power connexions are made by means of a plug-and-socket connector. The relays for both detectors are carried on a mounting fitted centrally on the panel and they can be withdrawn for inspection and maintenance if necessary. Suitable connexions to socket terminal strips permit measurements of the cathode currents of the final valves of the detectors to be easily made.

*Control Panel.*

The schematic diagram of the control panel is shown in Fig. 5. In the idle condition the two bridges incorporating the polarized relays are balanced. No current flows through the relay windings 3–4, but current flows through the windings 6–5 maintaining the contacts RLC1 and




Notes 1. R1 and R2 = 75,000Ω, R3 = 16,600Ω, R4 = 16,100Ω, R5 = 43,000Ω.
2. Resistance of each winding of the polarized relays is 500 ohms.
3. Solid lines represent equipment mounted on the control panel.
4. - - - -→ Currents in idle condition } in windings of relay RLC.
——→ Currents when detector No. 1 operates }

FIG. 5.—SCHEMATIC DIAGRAM OF CONTROL PANEL.

RLD1 in the positions shown. Contacts RLC1 and RLD1 connect shunts across the 4-wire paths and so maintain loop stability. The capacitors C1 are fully charged.

When energy enters detector No. 1 (via the combining unit) RLA operates, unbalancing the bridge, and operates RLC. Contact RLC1 removes the shunt from the speaking direction and connects a shunt across the 4-wire path in the other direction. The cathode of the final valve in detector No. 2, which was earthed via RLA1, is now connected via winding 5–6 of RLC to about +70 volts.

When speech ceases, RLA switches back. Current through winding 3–4 of RLC stops immediately, but current through winding 1–2 continues to flow until capacitor C1 is fully charged. Relay RLC thus releases after a finite time (adjustable) determined by the value of R5 and C1.

For speech in the other direction a similar sequence of operations occurs and R5 and C1 of the other bridge govern the hang-over time.

The A relay is used to render the voice-operated control ineffective if the operator desires.

## Performance

The performance of a conference repeater is difficult to assess quantitatively. When all the outlets are terminated by 600-ohm resistors it is possible to make gain/frequency measurements between any two outlets. However, these give little guidance to the performance of the amplifier under working conditions, since multiple reflections, which vary in phase relatively, greatly change the loss through the repeater when its outlets are connected to telephone lines.

It was found, after setting up several conference calls, that most satisfactory results were obtained with the amplifiers adjusted as far as possible to give no transmission loss between circuits connected on a 4-wire basis. The voice control was adjusted so that in the speaking direction the transmission loss of each voice-controlled amplifier was reduced by 1·5 db (i.e. a gain of 1·5 db) and in the reverse direction the loss was increased by 5 db.

With the six 4-wire outlets of the repeater connected to six 2-wire/4-wire terminating units the measured transmission losses between the derived 2-wire outlets at 800 c/s were as shown in Table 2.

TABLE 2
*Transmission Loss (db) in Speaking Direction*

| Sending on outlet | Receiving on outlet | | | | | |
|---|---|---|---|---|---|---|
| | V1 | V2 | V3 | V4 | N5 | N6 |
| V1 | | 4·9 | 5·1 | 5·2 | 10·6 | 5·0 |
| V2 | 4·9 | | 5·1 | 5·1 | 10·5 | 4·9 |
| V3 | 5·5 | 5·5 | | 6·0 | 11·2 | 5·1 |
| V4 | 5·1 | 5·1 | 5·2 | | 10·9 | 5·0 |
| N5 | 10·2 | 10·2 | 10·5 | 10·7 | | 10·2 |
| N6 | 6·0 | 6·0 | 5·9 | 6·0 | 11·2 | |

*Notes.*

1. The losses were measured at 800 c/s with the voice switches operated.
2. V indicates a voice-controlled outlet and N indicates an outlet that is not controlled.
3. With the amplifier gains set to give no transmission loss through the repeater when connected on a 4-wire basis, a loss of 7 db 2-wire to 2-wire should theoretically result but the gains were in fact set slightly higher to compensate for the loss of the tie cables normally in circuit.
4. Outlet N5 is normally reserved for connexion to a transatlantic telephone cable circuit and the transmission loss to and from this outlet is adjusted to be greater than between the other outlets. For non-conference connexions any transatlantic telephone circuit is connected to the inland network via a relay set which introduces a loss of about 5 db. For conference connexions this relay set is not used and therefore the loss has to be introduced in the conference repeater if the same overall loss is to be obtained on conference as on direct (non-conference) connexions.

## Conclusions

From the limited experience to date, it appears that two major difficulties are encountered when voice-operated switches are used in conference repeaters:

A wide range of levels of speech input will be encountered, and to operate satisfactorily on the lowest levels the voice-operated detectors must have adequate sensitivity. If a large signal enters a controlled repeater there will be sufficient leakage to provide an input signal to the detector in the non-speaking direction sufficient to cause it to try to operate. Only one detector can be operated at any one time and so there is a tendency for the one having the shorter operate-time to operate, even though it may be in the wrong path. If the operate-time of each detector varied inversely as the applied input voltage over the whole range of input signals, no difficulty would occur. In practice it was found that the interconnexions between detectors previously described provided sufficient discrimination to ensure correct operation.

If a subscriber interrupts the subscriber who is speaking, causing him to give way, all operated detectors will remain operated until the interrupting subscriber pauses for sufficient time to allow them to release. Until this happens his signals will be transmitted through the repeater with increased, rather than decreased, transmission loss. This difficulty is fundamental and could only have been avoided by making it impossible to interrupt, e.g. by completely preventing transmission in the reverse direction. It was found after experiment that the best compromise was obtained if the transmission loss in the reverse direction in each voice-controlled repeater was not increased by more than 5 db when the detector operated. If the loss was increased by more than 5 db it was found that there was an increased awareness of the presence of voice-operated switches although misoperation of the switches occurring as a result of interruptions was reduced.

The conference repeater described uses many more components and occupies more space than any other previously used by the Post Office. Its performance is superior to types not employing voice-operated switching, in so far as excessively high levels of side-tone are avoided and stability is increased. However, in view of its high cost and complexity it is considered unlikely that any more equipments of this type will be made. Interest in conference facilities is growing and further experiments are being conducted to examine the possibility of producing a cheaper conference repeater which could economically provide a nation-wide service on demand.

# The Lighting of Telecommunications Apparatus Rooms

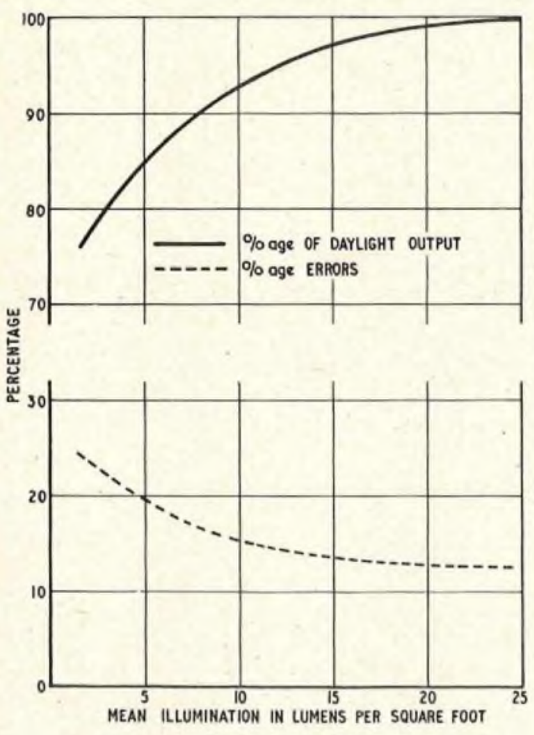
T. J. BENNETT†

U.D.C. 628.977:621.395.72

**The height of telecommunications apparatus racks and interconnecting frames combined with the narrowness of the gangways between suites of racks present special problems in the lighting of apparatus rooms. The advent of fluorescent lighting has enabled a fresh approach to be made to these problems and a comprehensive study has recently been made jointly by the Post Office Engineering Department and the engineering Staff Associations concerned. This article discusses the problems of lighting apparatus rooms, reviews the existing standards employing filament lighting and describes new standards, using fluorescent lighting, that are being introduced in new telephone exchanges and repeater stations.**

## INTRODUCTION

IN the past, interest in lighting has centred on the minimum levels of illumination required for the performance of various tasks, but more recently tests have been carried out to find the effect of varying levels of illumination upon the speed and accuracy of working. The results of one such test,* in which the task consisted of fine manipulations, are shown in Fig. 1. It can be seen




Note: Daylight illumination during the test was of the order of 100 lumens/ft².

FIG. 1.—EFFECT OF ILLUMINATION ON SPEED AND ACCURACY OF WORKING.

that not only did the output increase with illumination but there was a corresponding increase in accuracy. The variations of output and accuracy with level of illumination do not follow straight-line laws and it appears from the curves that eventually the expense of raising the level of illumination further is no longer commensurate with the improvement in output and efficiency gained. Although Fig. 1 applies only to one test and to one particular task, the results are similar to those of other tests and the general form of the relationships can be accepted for other tasks.

In addition to improved output, experience in factories shows that good lighting reduces accidents and takes much of the fatigue out of work.

Before the 1939–45 war a fairly low level of artificial illumination was provided for most accommodation both within the Post Office and in outside industry. This level was of course adequate for the performance of the task, but following proof that efficiency is a function of the illumination level and with the added interest in staff welfare, it became apparent that these levels of illumination could be raised with advantage. There was at first difficulty in providing greater illumination as the use of larger electric lamps was not always possible because of the danger of glare. An increase in the number of lighting fittings necessitated a re-arrangement of the wiring and in many cases the mains themselves were already working to capacity so that no increase was possible without incurring a major expense. The advent of fluorescent lamps, with their increased efficiency, made it practicable to increase the general level of illumination in many individual buildings and the illumination in most types of accommodation in industry has been increased. The Post Office followed the general trend and, with the raising of Treasury Standards of illumination, made a statistical analysis[1] of all general accommodation that was below standard. The lighting of engineering working accommodation was considered to be a special problem and a separate study group was set up to consider it.

Apparatus rooms have always provided a special lighting problem for the Post Office. Wherever telephone equipment is housed, maintenance entails the identification and manipulation of small parts which require accurate adjustment. Also, sources of artificial light must be mounted so that they do not interfere with work in their vicinity and are not themselves prone to damage. In most engineering accommodation outside the Post Office, each employee spends long periods in one particular area, often in the vicinity of a bench or machine; adequate lighting is then provided by a reasonable level of general illumination from a number of light sources evenly distributed over the area, with the addition of local lamps for particular benches or machines. In a telephone exchange or repeater station, although the apparatus racks almost preclude the use of general overhead lighting, good illumination may be required at any time in almost any position on any rack. In consequence, rooms containing apparatus racks have had to receive special treatment.

*Definitions.*

The general principles of indoor lighting, and the terms used in illumination engineering have been discussed in detail in a previous article[2] in the Journal, but for convenience a few of the terms used are also explained briefly here.

*Visual Acuity* is the ability to distinguish fine detail.

*Brightness* is a measure of the light energy reaching the observer's eye per unit projected area of the source.

*Contrast* is the difference between the brightness of an object and that of its background, relative to the brightness of the background.

† Executive Engineer, Power Branch, E.-in-C.'s Office.

* *Lighting in Industry*—British Electrical Development Association.

[1] H. J. JOSEPHS and R. A. HASTIE. Operational Research in the Post Office. *P.O.E.E.J.*, Vol. 50, p. 10, April 1957.

[2] P. E. MARRIOTT. Modern Indoor Lighting. *P.O.E.E.J.*, Vol. 47, p. 68 and p. 148, July and Oct. 1954.

*Glare* is experienced as a visual sensation caused by brightness relationships in the field of view which cause either visual disability or a sensation of discomfort.

*A General Lighting* scheme provides an even illumination over the working plane by means of a number of lighting fittings evenly distributed above the plane.

*A generally diffusing lighting fitting* gives a more or less even distribution of light in all directions, being defined in British Standard (B.S.) 398 as giving not less than 40 per cent and not more than 60 per cent of the total flux from the fitting in either hemisphere.

*A dispersive-type reflector* spreads the light fairly uniformly in one hemisphere.

### Apparatus Room Lighting

The problem of lighting in rooms containing rack-mounted apparatus is that of projecting the light to the apparatus at all levels and procuring an even illumination over the surface of the racks in all directions. In the early days, when racks did not exceed 9 ft in height, a system of general room lighting was provided by means of suspended diffusing fittings, and local lighting was provided by 40W handlamps on counterweighted suspensions in the gangways. This idea was sound in that the lamp could be brought close to the apparatus, but the counterweighted gear was inclined to be a liability as far as maintenance was concerned and was impracticable when travelling ladders were introduced in the gangways between suites of racks. An obvious method of lighting is to associate the lighting fittings with the racks and this principle, which was introduced with the 10-ft 6-in. high racks about 1931, is still followed.

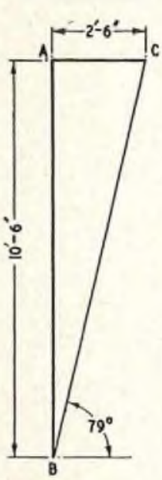



Fig. 2.—Variation of Illumination on Vertical Surface from a Point Source.

The eye adapts itself automatically, but but not instantaneously, to the brightness of the field of vision so that an area can appear light or dark according to its brightness relative to that of the area to which the eye has adapted itself. This difference can cause a loss of visual acuity and, in an extreme case, a feeling of physical discomfort; hence with any form of lighting it is an advantage to keep all large surfaces within the field of vision within reasonable limits of brightness. This is comparatively easy when the light sources are some distance away from the plane to be illuminated, but racks are often 10 ft 6 in. high with 2-ft 6-in. gangways, and a fitting cannot be more than 2 ft 6 in. from a plane 10 ft 6 in. high. The level of illumination on a surface due to a point source is inversely proportional to the square of the distance from the source and directly proportional to the cosine of the angle of incidence of the light.

It can be seen from Fig. 2 that, while the angle of incidence at point A of light from point C is 0° and the distance AC is 2·5 ft, the corresponding figures at B are 79° and 10·8 ft and the illumination at B is

$$\frac{(2\cdot5)^2 \times \cos 79^\circ}{10\cdot8^2 \times \cos 0^\circ} \text{ of the illumination at A } (I_A) = 0\cdot0108\ I_A.$$

Thus the variation of illumination down the face of the rack is 92·5 : 1.

This variation is too high as, apart from the problem of contrast, it is wasteful of light flux at the higher levels of the racks. A solution would be to use a reflector to beam the light towards the foot of the rack. Unfortunately, any reflector that will beam the light from a filament lamp to the desired extent will certainly produce a beam so narrow that wedges of shadow would occur at the top of the rack surface. As in all such cases, a compromise is inevitable and a parabolic reflector was adopted, which gives a reasonable spread with a fair amount of direction to the light.

In apparatus gangways in automatic telephone exchanges the reflectors are mounted at the tops of alternate racks on each side of the gangway, beaming on the racks opposite. The racks on which the fittings are mounted rely mainly on light reflected from the others. The effect of the reflectors is to reduce the variation in the illumination down the face of the rack (Fig. 3) to about 40 : 1.

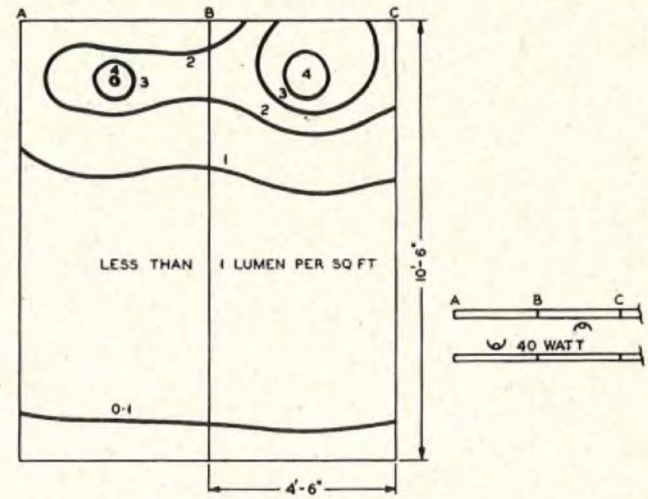



Fig. 3.—Variation of Illumination over the Surface of Two Apparatus Racks from Overhead Filament Lamps.

On the wiring side of the racks there is insufficient room to use the parabolic reflectors and, as it is normally necessary to provide only "corridor" lighting, lamps in steel circular dispersive-type reflectors are centrally mounted over the gangway.

In telephone repeater station apparatus rooms the design of the racks precludes the mounting used in automatic telephone exchanges and the parabolic reflectors are centrally mounted in pairs at high level in the centre of the gangway giving an even greater variation of illumination down the surface of the rack, of the order of 300 : 1.

A study group on the lighting of engineering working accommodation agreed that, in view of the nature of the work carried out in rooms containing rack-mounted apparatus, the level of illumination provided should be raised and the uniformity improved.

*Fluorescent Rack Lighting.*

Fluorescent lamps have become commonplace in offices and working spaces generally and it was natural to look to this form of lamp for a solution to the problem of the lighting of apparatus racks and distribution frames.

The well-known advantages of fluorescent lighting are its greater efficiency and low source brightness. But, there are disadvantages as well: fluorescent fittings are bulky because of the length of the tube and the current limiting "ballast" unit necessary to counteract the negative resistance characteristic of the tube. The diameter of the tube ($1\frac{1}{2}$ in.) is also the minimum dimension of the light source, which makes the use of directional reflectors less effective. There is, in addition, a current surge on starting, which limits the number of fittings on a final sub-circuit to half the number of filament fittings of the same wattage.

The fittings and tubes are relatively expensive, but a long life (5,000 hours) largely compensates for the cost of the tubes, while the higher efficiency—usually quoted in light output (lumens) per watt—not only gives a saving in the cost of power consumed but means also that lighter main cables and switchgear can be installed. A further advantage—often important—is that the lower current consumption means that less heat is released into the working space for a given light output. The order of improvement in efficiency of fluorescent lighting compared with filament lighting is $3\frac{1}{2} : 1$.

After considerable experimentation an anodized aluminium reflector was designed, which gives a certain amount of direction to the light flux. Anodized aluminium was chosen because of its high efficiency as a reflecting surface. The section of the reflector, which is a truncated parabola, gives a reasonable light distribution with a fairly small cross-section.

Fluorescent lamps are now made in this country in a considerable number of sizes, both physical and electrical, ranging from 6W lamps 6 in. long to 125W lamps 8 ft long. The shorter lamps have lower efficiency, and the longer lamps are unwieldy in confined spaces. Of the intermediate sizes the 4-ft 40W lamp has the special advantage that its length is almost the width of a standard telephone exchange apparatus rack, but economics favour the 5-ft 80W lamp, which is in greatest demand.

The choice appeared to be between the use of a 4-ft 40W tube and a 5-ft 80W tube whose outputs are comparable to those of 150W and 300W filament lamps respectively. If 80W fittings are used the same light output can be obtained with half the number of fittings, giving a considerable financial saving as the initial cost of an 80W fitting is only a little above that of the 40W fitting, whereas the cost of maintenance, including cleaning and replacement of lamps is about the same in either case; on the other hand the use of a larger number of lamps will, in general, give more even illumination. There is also the question of brightness; the tubes are of equal diameter and with double the light output for an increase in length of 25 per cent the 80W tube has 1·6 times the brightness of a 40W tube. The glare factor is actually a function of $B^2A$, where $B$ is the brightness and $A$ is the projected area of the source (the tube in this case), so it can be seen that the ratio of the relative glare factors is $1{\cdot}6^2 \times 1/1{\cdot}25 : 1$, or $2 : 1$ in favour of 40W lamps.

The length of the lamps allows little choice in position of mounting, which may be above the centre of the gangway or above the face of the racks with reflectors arranged to beam the light on to the racks opposite. A trial was carried out in a telephone exchange to compare the two methods, 4-ft 40W fittings being mounted over alternate racks in one apparatus gangway and a row of 5-ft, 80W fittings being mounted over the ladder track in the next apparatus gangway. Photometer readings were taken in each gangway and it was found that the installation with 40W fittings gave a variation of illumination (Fig. 4) of about 15 : 1 down the face of the apparatus, whilst that with the centrally mounted 80W fittings gave a variation of about 60 : 1, and the level of illumination at the bottom of the rack in the first gangway was approximately three times that in the second.

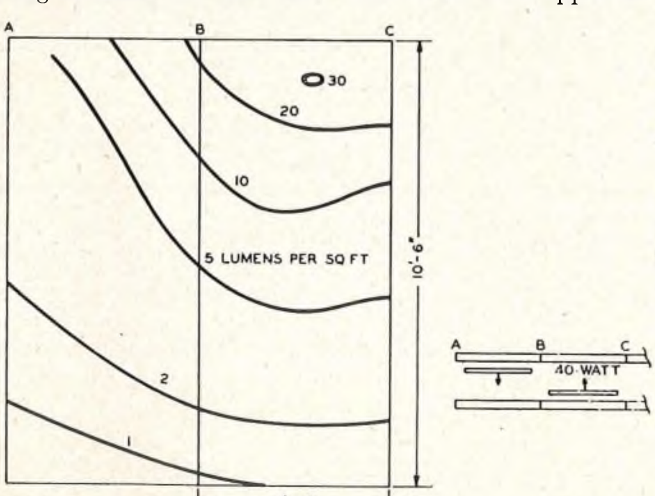


Fig. 4.—Variation of Illumination Over the Surface of Two Apparatus Racks from Overhead Fluorescent Lamps.

The results of this experiment finally settled the size of fitting and its position in telephone exchange equipment gangways, and means of mounting the 40W fittings to the racks were designed accordingly.

This layout of rack lighting leaves the end rack in a suite with a lower level of illumination than those in the centre. For the majority of racks this is unimportant but as a greater amount of maintenance time is spent on uniselectors a fitting is justified on each of the end racks in a suite of uniselector racks, to reinforce the lighting on the end racks.

As little day-to-day maintenance is needed on the wiring sides of the racks sufficient illumination is provided by a few fittings centrally mounted in the gangway.

If the upper part of a room is left in darkness, what is sometimes termed a "tunnel effect" is experienced which is likely to be disturbing for psychological reasons. Therefore, for most types of accommodation, lighting fittings are used that provide a proportion of upward light to illuminate the ceiling. The fluorescent fittings described, with the associated special metal reflectors, give no upward light, and to dispel the tunnel effect reflectors have been omitted from the fittings on the wiring side of the racks. This impairs the effectiveness of illumination downwards, but allows some ceiling illumination.

Repeater apparatus racks are much narrower than telephone exchange equipment racks so that a simple association of lighting fittings with individual racks is not practicable. The pairs of parabolic tungsten fittings may, however, be replaced by 4-ft, 40W fluorescent fittings with anodized aluminium reflectors to reduce the variation in illumination down the face of the racks and to increase the average illumination by 30 per cent.

*Distribution Frame Lighting.*

There is usually a fairly wide gangway around a distribution frame, hence a reasonably even distribution of illumination can be obtained up the face of the frame. Maintenance entails inspection and soldering of wires to tags and it is interesting to note that the Illuminating Engineering Society, a body which recommends standards of lighting for various types of accommodation and types of work, suggests a level of 15 lumens/ft² for soldering. This is quite a high level of illumination to produce over a large vertical surface, and when filament lighting is used, 100W lamps in parabolic reflectors are attached to overhead travelling carriers to minimize the number of lamps necessary. Even so this high value of illumination is not attained. The underside of a mezzanine platform presents a special problem since the floor of the platform throws its shadow over the lower parts the frame and is itself too low to permit the use of normal lighting techniques. This led to the use of a special tubular filament fitting mounted on the underside of the platform.

The travelling carriers are expensive both as regards first cost and upkeep, and this principle has not been perpetuated; in the new designs fixed fluorescent lighting fittings are favoured. As a high level of illumination is required, and the frame is a comparatively small part of the exchange, a continuous row of 4-ft fittings with anodized aluminium reflectors is run parallel to the frame on each side, and to give as even a level of illumination down the face of the frame as is possible, the rows are kept back

Fig. 5.—Illumination of I.D.F. using Fixed Fluorescent Lighting Fittings.

from the face of the frame with the fittings tilted towards it, as shown in Fig. **5**. There is insufficient space to do other than mount a single row of fittings between parallel frames.

Mezzanine platforms present the same problems encountered with filament lighting and the best solution is provided by the addition of a continuous row of 40W fittings at the level of the mezzanine floor, mounted so as to project the light horizontally (Fig. **6**). A continuous reflector (Fig. **7**) has been found successful but this is mainly from a mechanical point of view and to prevent the danger to staff that would be presented by a number of separate reflectors each with two sharp corners at head level. To take care of the upper levels of the frame a row of 40W fittings is provided at high level, similar to that for simple frames, but with twice the spacing between fittings and the fittings themselves tilted so that their planes of symmetry

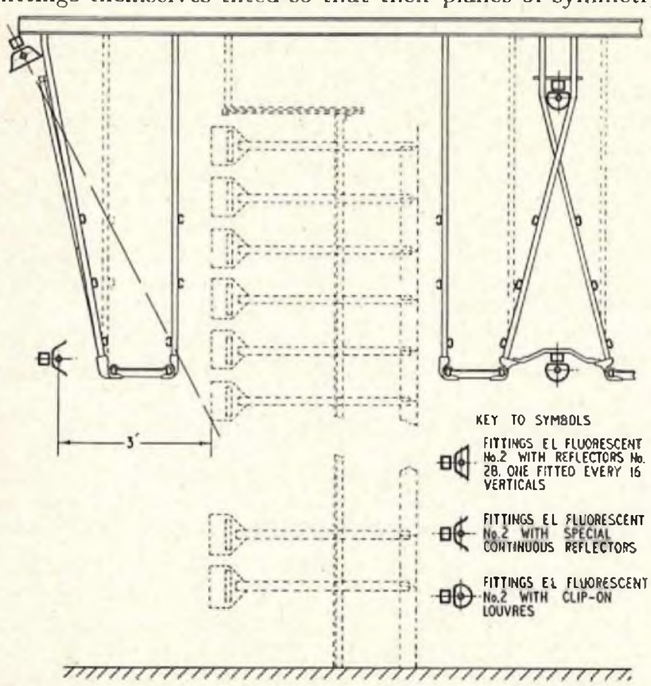



Fig. 6.—Fluorescent Lighting for Parallel M.D.F.'s with Mezzanine Platforms. (To simplify the diagram the right-hand frame has been omitted.)

Fig. 7.—Illumination of Lower Part of M.D.F. with Mezzanine Platform, using Fluorescent Lighting with Continuous Reflector.

pass through the highest connexions below the mezzanine floors as shown in Fig. **6**.

Where parallel frames with mezzanine platforms are used the high-level row of fittings between the frames is almost at the eye level of a man standing on the platform and constitutes a source of glare. To reduce this the reflectors are omitted, cover plates substituted and plastic clip-on louvres attached to the lamps. A similar row of louvred fittings is added to the underside of the platform between the frames as shown in Fig. **8**.

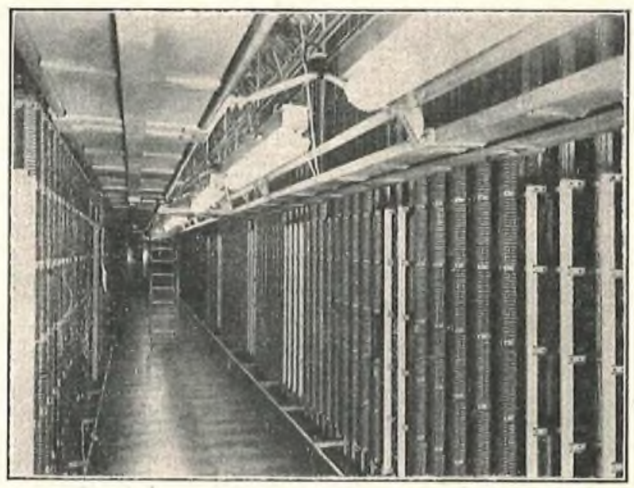


Fig. 8.—Illumination below Mezzanine Platforms using Fluorescent Lighting with Plastic Clip-on Louvres.

*Fluorescent Lighting of Main Gangways.*

Main gangway lighting is provided primarily to permit staff to move around the apparatus room, and consequently a fairly low level of illumination is sufficient. This is provided by 40W fittings, without reflectors, that give a certain amount of light in the upper hemisphere, suspended over the centre of the gangway just below the cable racks, at a spacing of 15 to 20 ft, which is greater than would be permissible for general lighting. Where engineering work is to be performed in the main gangway, additional fittings are necessary locally to ensure a satisfactory level of illumination.

*Local Lighting.*

A mains-operated handlamp is available for local lighting in both telephone exchanges and repeater stations, while a headlamp, operated from the exchange battery, is provided for use in exchanges as lighting by filament rack lamps on its own is insufficient for most tasks. An Anglepoise lamp has been adapted for local lighting in repeater stations with pre-51-type equipment, sockets into which the base of the fitting can be jacked being fitted to the frames at the faces of the racks. This arrangement permits the use of a more powerful light than that provided by the head-lamp without the inconvenience presented by the hand-lamp. Fluorescent lighting will not obviate the need for local lamps but will reduce the frequency at which they are used.

*Test Desks.*

Test desks are illuminated, as are switchboards, by lighting fittings distributed along the board itself so as to give a good level of illumination on the keyshelf with a lower level of illumination, free from shadow, on the vertical face of the board. As with switchboards, care is necessary to prevent dazzling reflections of the fittings being seen by the operators on any part of the keyshelf or multiple.

If sufficient filament fittings are used shadows give little trouble. Where fluorescent lighting is used and the tubes themselves are run parallel to the multiple (as in Fig. 9), the length of the light source itself is particularly useful in preventing the production of shadows. In either case louvred fittings reduce the level of illumination on the display panel without diminishing that on the keyshelf and also reduce the danger of glare. Fluorescent lighting fittings, being essentially of low brightness, rarely give trouble through specular reflexion on the keyshelf, particularly when they are placed back behind the operator; occasionally, difficulty is encountered in this respect with filament lighting and is obviated by the use of special low brightness fittings. General lighting is not normally required in a Test Room but it is essential to have a good level of illumination of the fault card cabinet and to ensure that the fittings used do not materially increase the illumination on the face of the test desk; here again louvred fittings are useful.

Fig. 9.—Illumination of Test Desks by Fluorescent Lighting.

## Future Developments

The fluorescent lighting layouts described for apparatus room lighting are subject to change as the result of further experience and a number of trials are being carried out with the object of making improvements. Other methods of mounting the fittings are under review, both as regards the position of the fittings relative to the racks and the mechanical details of the mountings. Other types of reflector, including the new reflector lamp—a fluorescent tube with a built-in reflector—are being considered. There are other factors in an apparatus room which can be varied to affect the lighting, besides the fittings used; recently a small trial has been carried out in a telephone exchange with cream-coloured equipment covers, the primary objective was to improve the appearance of the room but it was found that the general level of illumination over the racks was raised considerably through the increase in reflected light, and the trial is to be extended.

As far as local lighting is concerned a number of devices have been considered, by which lamps can be fixed to the apparatus racks or equipment covers. An Oddie fastener, various clamps and even a cluster of small magnets, have been incorporated in devices designed for this purpose, which will be tried. It must be appreciated that the governing factor which settles the ultimate fate of such devices is often not the level of illumination derived from the lamp but the mechanical design of the mounting and the ease with which the portable lamp may be set up for use. Nothing is to be gained by the use of a device, the erection of which is a lengthy and difficult business, unless it is to be used for a considerable time at the same setting.

A number of portable, free-standing fluorescent fittings have been obtained for trial as it is likely that they may be useful for construction staff. The fittings are mains operated and are double insulated to reduce the risk of electric shock. Although a number of fluorescent fittings are marketed for operation from batteries, the lamps themselves require a medium voltage, which is supplied in such cases by multi-vibrators or similar means, and so are intrinsically no safer than mains-operated lamps.

## Conclusion

It is certain that the trend will be to use more fluorescent lighting in the future for all types of accommodation and it would appear that in telecommunications apparatus rooms a worthwhile increase in the level of illumination can only be obtained economically by this means. In the designs described each 40W tungsten fitting used on telephone exchange apparatus racks is replaced by a fluorescent fitting whose total power consumption, including the ballast loss, is 50 watts; there is, however, an increase in light output of 500 per cent for an increase in annual charges of 130 per cent. For repeater station apparatus rack lighting there is a saving in power with a corresponding decrease in the heat dissipated when fluorescent lighting is used and there is an increase in light output of 30 per cent with a decrease in annual charges of 20 per cent. As far as distribution frames are concerned, fluorescent lighting gives an increase in light output of 130 per cent for an increase in annual charges of 110 per cent. Balanced against the increase in expenditure is an improvement in working conditions and an increase in efficiency, the economic value of which is difficult to estimate, but which should be substantial. Fluorescent lighting is being introduced, therefore, in telecommunications apparatus rooms of new exchanges and repeater stations. A general change from filament to fluorescent lighting in existing apparatus rooms is being considered.


## Acknowledgments

The new standards of lighting described in this article are the outcome of joint studies by Post Office Engineering Department and Engineering Staff Association representatives who formed the Working Party on Lighting of Engineering Working Accommodation. The assistance of colleagues in the Power Branch, E.-in-C.'s Office, in the preparation of this article is gratefully acknowledged.

# A New Large-Capacity Visual Index File for Telephone Switchboard Operators

U.D.C.686.84 : 654.03 : 621.395.722

The present standard file of routing and charging information provided on auto-manual switchboards has a capacity for about 3,000 entries. As this caters for less than half the national total of exchanges, reference to route and rate quoting (RRQ) positions is necessary on a proportion of calls, which may be of the order of 10 per cent of the total. Attempts have been made to design a comprehensive file, but with the existing space and visibility limitations this has not been possible. It has been necessary, therefore, to compromise on a design which excludes information relating to small exchanges distant more than 125 miles from the originating exchange. With this design, reference to RRQ positions will be reduced to approximately one-half per cent of the total calls handled.

The new file, coded as the Frame, Notice, No. 37A, is shown in the photograph (Fig. 1). The file normally contains 30 indexed loose-leaf card-holders, each of which can hold up to seven routing cards which are printed on each side with exchange routing information for some 30 exchanges. The file is raised $1\frac{1}{2}$ in. at the rear by a spring steel cross-rib, and will normally be fitted into a black polystyrene base of hollow wedge shape (Mounting, Frame, Notice, No. 2A) which is screwed permanently on to the switchboard position in place of the previously fitted Frame, Notice, No. 25A. The notice frame is a push-fit in this moulding, rendering insertion and removal of the file for the addition of routing amendments a simpler procedure than at present. Rubber feet are provided on the file for use when standing on a desk or table top. The file is finished in "hammer grey" which has been chosen to match the present standard grey plastic keyshelves, but is considered equally suitable for use on red or green keyshelves. Fig. 2 shows the design of the moulding and the construction of the file.

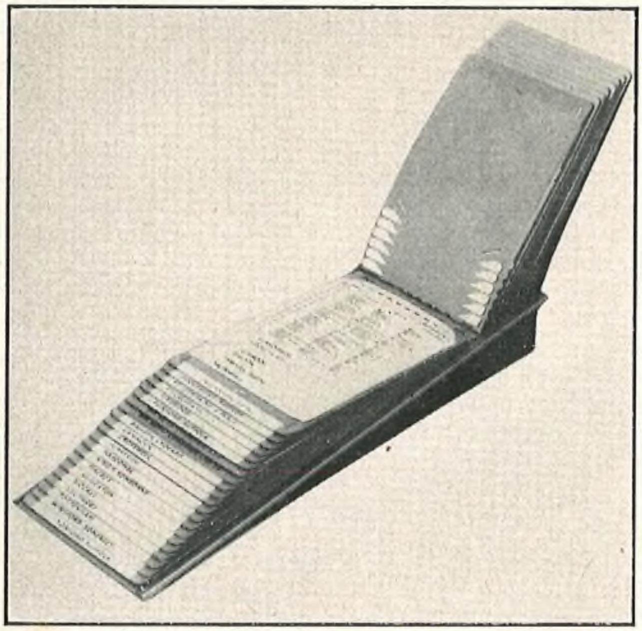


FIG. 1.—FRAME, NOTICE, NO. 37A.

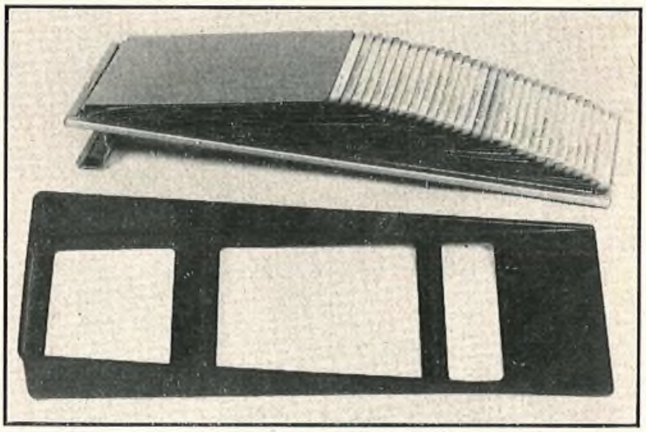


FIG. 2.—INDEX FILE AND MOUNTING.

It is current practice to amend entries on existing files in manuscript when a change occurs in routing or charging arrangements. Such amendments are relatively frequent and time consuming, whilst the legibility of the files is thereby reduced. The individual routing sheets used in the new file are produced by a photographic process which will enable revised sheets to be readily produced for national circulation. The process used is known as "Flexoprinting" and enables the various single-line entries to be rapidly combined on to single sheets.

A program for change-over to the new file at all main auto-manual centres has been prepared and circulated. Conversion has commenced and will continue over the next two years until the file is in general use.

K. E. W.

## Book Review

"The Art and Science of Protective Relaying." C. Russell Mason. John Wiley & Sons. 410 pp. Illustrated. 96s.

This book deals with relays of a type specially developed for the protection of electrical power systems and plant. The material is derived from notes prepared for teaching purposes by the staff of the General Electric Company of America and is described as an elementary approach to the subject.

After describing the fundamental principles of protective relaying, the book proceeds to describe the different types of relays used and their principles of operation and then deals at great length with their application to the protection of circuits, transformers, generators and other electrical apparatus. A section dealing with current and voltage transformers used in conjunction with these relays is included to complete the picture.

The subject is dealt with in considerable detail and the book contains much information on relay design which is not normally available in text-book form.

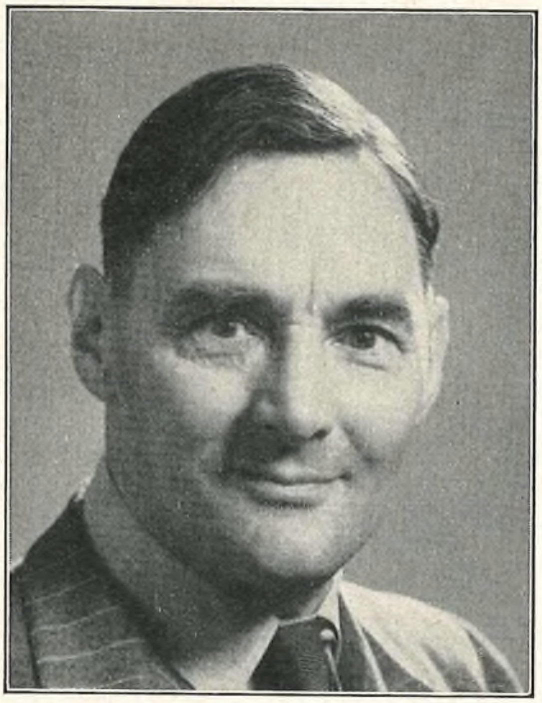
This book can be highly recommended to those students taking courses in electrical engineering at all levels, but despite its so-called elementary nature some prior knowledge is necessary if the subject is to be fully understood and appreciated. This is made all the more necessary by the use of terms and symbols peculiar to American practice. E. A. I.

# Notes and Comments

### Retirement of Mr. W. West, O.B.E., B.A., M.I.E.E.

With the retirement of Mr. West on 31st October, 1957, the Research Station lost one of its best-known and most popular members—almost, one might say, one of its foundation members.

Mr. West was educated at Ramsgate and Oxford, but his studies were interrupted by the 1914–1918 war, and he served for three years in the Royal Artillery in France, Belgium and Germany before taking up residence at Queen's College, Oxford, in 1919. With an honours degree in Engineering Science, he became an Assistant Engineer in the Patent Office in October 1921, and subsequently entered the Post Office by way of the old-style Assistant Engineer Competition in July 1922. He was appointed to the Research Branch, where he was to spend the greater part of his official career on local transmission problems and, more particularly, on original work on electro-acoustics which was to earn world-wide recognition. His early work was concerned with the performance of the Rayleigh Disc in a sound field, and he devised methods of using it for acoustical measurements. He was the first to make free-field calibrations of microphones (*J.I.E.E.*, Vol. 64, p. 1023, 1926) and he discovered surprisingly large differences from the hitherto-used pressure calibrations (*P.O.E.E.J.*, Vol. 21, p. 223, 1928); he later published calculations confirming these differences quantitatively (*J.I.E.E.*, Vol. 68, p. 441, 1930). Another major contribution that he made to the science was the design of the first artificial ear (for measuring the response of telephone receivers) based on measurements made of the impedances of real ears (*P.O.E.E.J.*, Vol. 22, p. 260, 1930).



His career as a research man was interrupted in March 1939, when he was promoted to Assistant Staff Engineer in Radio Branch (now WP Branch). During the war years, 1940–1945, he was transferred to Harrogate with the provisioning section of that Branch. In that period he was responsible for the design and provision in the United Kingdom of emergency and permanent radio stations for overseas and internal communications, and of certain radio links and equipment for the combatant forces. The Post Office high-power transmitting station at Criggion is representative of some of the work carried out under his calm and amiable direction in those difficult days.

In May 1946, Mr. West returned to the Research Station as Staff Engineer and took charge of the newly formed RA Division, where his field not only covered acoustics and local transmission but also included telegraphy, postal mechanization, the engineering workshops and drawing office and (for a time) electronic switching. It was in these post-war years that his earlier acoustical work really brought its recognition. As an internationally known expert on acoustics his services were in demand on various commissions and committees, often as chairman. He became the United Kingdom member of the newly formed International Commission on Acoustics; he was chairman of the Acoustics committee of the International Standards Organization, of the C.C.I.F. Sub-committee on Specification of Quality of Transmission (Fourth Study Group), of the Electro-acoustics Committee of the Medical Research Council, and of the Acoustics Group of the Physical Society.

As a Staff Engineer, Mr. West earned the whole-hearted loyalty and respect of his staff by his never-failing courtesy and kindness, and, above all, by his absolute fairness and impartiality. It was a matter of great regret to all that the last years of his career were overshadowed by ill health, culminating in a long spell in hospital in 1955. Happily, he made a good recovery and returned to his work with undiminished enthusiasm. He carries with him into retirement the heartfelt good wishes of all his staff and colleagues for a continuation of good health.

F. E. W.

### Journal Binding

This issue of the Journal completes Vol. 50 and readers wishing to have the volume bound should refer to p.286 for details of the facilities available.

# Institution of Post Office Electrical Engineers

### Additions to the Library

Books are available on loan to all members and associates. Local Secretaries will be pleased to supply requisition forms and a copy of the Library Catalogue if required, or application can be made direct to the Librarian, I.P.O.E.E., Alder House, Aldersgate Street, London, E.C.1.

2450 *Colour Photography for the Amateur.* M. L. Hall (Brit. 1957).
Intended for the amateur having some knowledge of black and white photography.

2451 *Cathode Ray Oscilloscopes.* J. Czech (Dutch 1957).
An introduction for those who are newcomers to the technology of oscillography.

2452 *Science and the Nation.* E. Appleton (Brit. 1957).
The B.B.C. Reith Lectures for 1956.

2453 *National Certificate Electrical Engineering.* R. Bourne (Brit. 1957).
Covers the basic principles of electrical engineering up to and including O.N.C. or Pt. 1 of the joint examination of the Institutions of Civil and Electrical Engineers.

(*Continued on p.* 286).

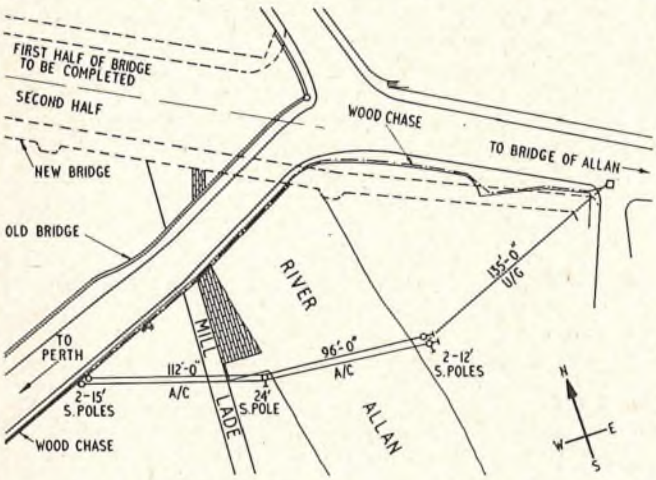
# Regional Notes

## Scotland

### DIVERSION OF MAIN UNDERGROUND CABLES AT BRIDGE OF ALLAN

The road-works necessitating the diversion of Post Office plant at Bridge of Allan consist of the replacement of two bridges and the formation of a new roadway cutting out a notorious bottle-neck on Route A9. Work on the new bridge started in July 1956. The bridge is being built in two halves, the first half necessitating the demolition of the north footway of the existing bridge which carried the main underground plant—two 24-pr., 40-lb carrier cables; one 74-pr., 20-lb C.J. cable; and one 182-pr. 20-lb M.U. cable. A temporary diversion was made by laying replacement cables in a wooden chase constructed partly on the south parapet of the old bridge and partly at the heel of the south footway. It was planned to carry out the permanent diversion by laying replacement plant in the new roadway.

Unfortunately the works did not proceed as initially planned and a stage was reached where the contractors required to have the old bridge demolished before the new roadway could be completed; the problem then arose of shifting the temporarily routed main cables. The most economical solution was to transfer the cables to aerial suspension but this presented quite a problem since the contractor requested that, to permit cranes to work at the point where the new bridge was being constructed, the Post Office cables should be at least 35 yards down-stream from the old bridge. Also, due to the operation of single-line traffic across the bridge and the narrowness of the south footway, it was impossible to lower the cables from the parapet under a controlled tension without seriously interrupting the traffic.

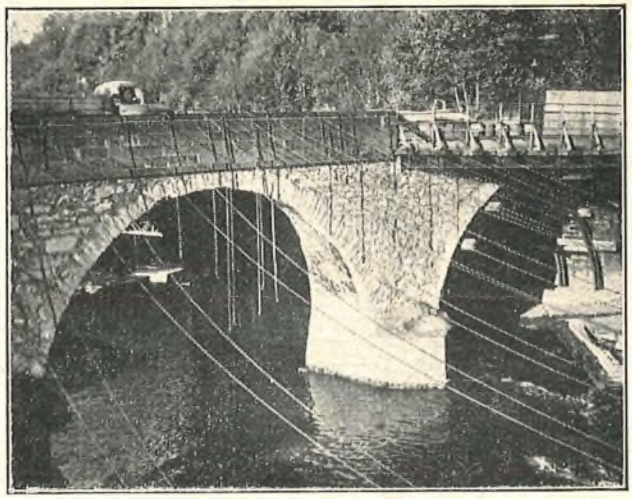



Bridge of Allan Diversions.

The idea of sliding the cables over a cradle of ropes, stretched between the bridge and a pole line, was finally adopted. Preliminary work, carried out by two gangs of four men, consisted of providing a two-span pole line on which to suspend the cables. Five stout poles were used, two at each terminal, and a single intermediate pole. The assistance of the bridge contractor was obtained to brace the poles to the bridge at the terminal on the west side since the poles were placed against the parapet wall making standard staying impracticable.

An auxiliary strand of suspension wire was next erected along the pole route, below the position to be occupied by the lowest cable, to form an anchorage for the ropes forming the cradle. Guy ropes were fastened to the mid-point of the span crossing the river and anchored down-stream to prevent "bellying."

Suitable lengths of $1\frac{1}{2}$-in. rope, to form the cradle, were looped over the auxiliary strand and spaced by the use of sash-line which was also used to draw the ropes along the strand into position. Due to the guys at the centre of the river span, ropes had to be fed from either side towards the centre. To prevent fraying, metal thimbles were used. At the



Old Bridge of Allan with Rope Cradle in position to slew Cables from the Chase on the Bridge Parapet.

bridge the cradle ropes were secured, partly, to a length of suspension wire anchored under tension to the road side of the parapet, the wooden chase having been raised to allow the ropes to pass under it, and partly to a badly corroded hand-rail which had to be strutted with poles as a precautionary measure. In all 1,440 yards of rope were used to construct the cradle, the maximum spacing between adjacent strands being approximately 6 ft.

A length of suspension wire was lashed by hand to each of the four cables and the terminations at the west side were made. The cables were independently anchored to ensure that no tension could be applied to the cable between the suspension wire and the ground. One cable was lifted from the wooden chase, placed on the rope cradle and drawn across towards the poles, using four pulley blocks evenly spaced along another auxiliary wire. Simultaneously, on the east side the final 45 yards of cable were carried and placed in a previously prepared trench. The cable was lifted into its final position on the poles and the suspension strand tensioned and terminated. This operation was repeated for each of the four cables, and they were finally protected in the trench by bits of the wooden chase, before the trench was filled.

A fifth cable was erected by standard methods to replace local cabling occupying a single duct in the south footway of the old bridge.

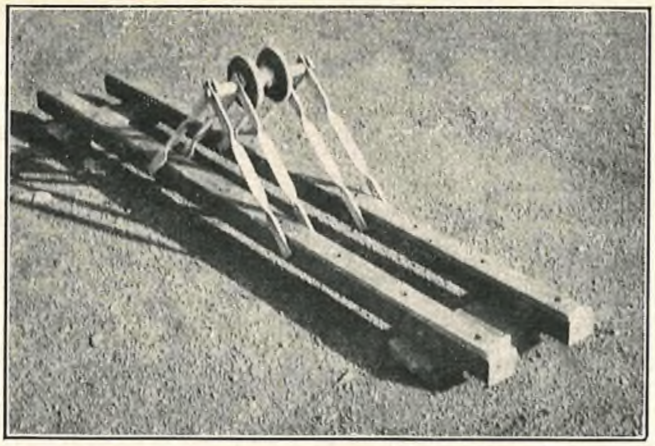
All the cables were transferred in one day by 30 men, most of them being necessary to carry the 45 yards of cable on the east side over a 12-ft high wall in the process of construction, the ground being littered with bridge-construction materials. While the preliminary work was carried out in bright autumn sunshine, heavy rain fell continuously when the cables were slewed across the cradle. Conditions under foot were very bad, but the operation was carried through without accident to men or cables, and without interruption to service.

D. McK. and E. K. B.

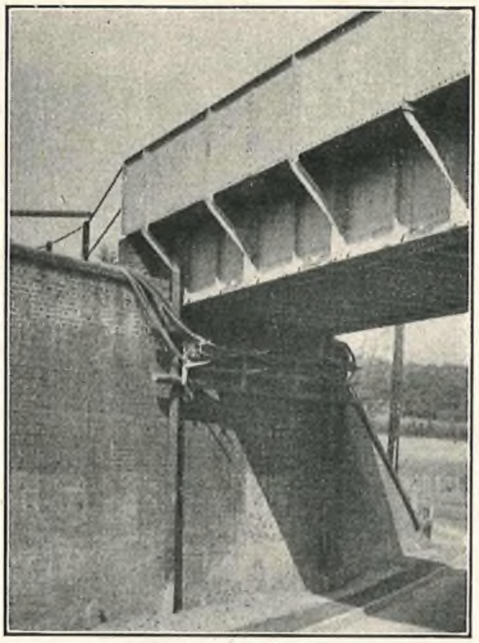
## Home Counties Region

### HANDLING OF ARMOURED INTERRUPTION CABLES

In previous notes, *P.O.E.E.J.*, Vol. 46, p. 98 and Vol. 47, p. 55, details were given of a landslip along the A22 road near Forest Row. It was necessary to interrupt a number of C.J. and M.U. cables over a long distance while the Road Authority dealt with its problem. Heavy-armoured cables were used for interruption purposes. The road has now been stabilized and the Post Office plant has been restored to its normal position. The interruption cables, however, were required at a nearby point to interrupt the same route of cables during extensive road works. Previous experience in handling these long, heavy cables over difficult ground led the local staff to devise rollers to keep the cable well off the ground. The special rollers were improvised from arms, aerial cable rollers, arm braces and arm bolts, and about 50 were constructed locally. The device is shown in the photograph.



Improvised Cable Roller.



Cables passing under Railway Bridge.

In one section of the route, which passed under a railway bridge, there was insufficient room for the interruption cables to lie on the surface and a high-level route was constructed. Here again a very simple device made up of standard items was used. It is shown in the second photograph and consists of a framework of poles carrying cable bearers and brackets on which the cables are laid. The upright poles were set about 12 inches in the ground and their tops secured to the framework of the bridge by stay wires.

A. A. T. R.

## Midland Region

### TRUNK MECHANIZATION IN BIRMINGHAM

On 9th November, 1957, the task began of transferring circuits and traffic from the existing switching units to Anchor, the new mechanical trunk exchange. The existing units consisted of a trunk suite of 200 positions, a toll suite of 146 positions, two trunk-control centres (T.C.C.), each of 70 positions, a 2-position keysender B suite and the trunk director (2 V.F.) exchange. The last two have been closed down by the opening of Anchor, but the trunk director will be rearranged and brought back into service for incoming subscriber trunk dialling.

The mechanical trunk exchange, equipped throughout with motor uniselectors, provides for 3,000 trunk circuits and a similar number of short-distance circuits from selector levels, and from the trunk and T.C.C. suites. Some idea of its size can be formed from the fact that it contains 7,543 motor uniselectors, 2,406 A.C.1 relay sets, 80 M.D.F. verticals, 80 M/R.D.F. verticals and 219 I.D.F. verticals.

The repeater station has a limited number of audio amplifiers but a considerable number of 4-wire terminations. The greater part of the repeater station is taken up with h.f. translating and terminal equipment. It also has provision for a control for B.B.C. and I.T.A. sound circuits.

The exchange power plant is of standard pattern. The repeater power plant is of a "no-break" type incorporating a reversible motor alternator which, in the event of mains failure, is run from a 240V battery until the prime mover supply takes over. Three 400-h.p. diesel engines, one of which is normally arranged for automatic starting, supply 3-phase a.c. to the telecommunications and ancillary plant in the event of mains failure.

Twelve trunk test positions are provided, together with four record positions. Both have "camp-on" busying facilities, whereby a circuit can be prepared for busying while it is carrying traffic and be seized for test as soon as the call in progress is cleared. This facility is also available on the switching panel for E.C. and part-time private wires. The record positions also have facilities for busying the whole of a carrier group in the event of a cable or h.f. fault.

Ten trunk cables have been diverted to Anchor, totalling 4,646 audio pairs and six coaxial pairs. In addition, 19,218 audio tie pairs were provided from Anchor to various points in Telephone House and to Midland exchange, together with 336 h.f. tie pairs. Four new junction cables, totalling 2,168 pairs, were provided direct from Anchor to a number of director and other exchanges.

The transfer was carried out in stages extending over three weeks, beginning with many of the entirely new circuits. Owing to the outgoing multiple on the trunk suite being almost completely occupied only a limited number of dialling-out circuits could be provided into Anchor at this stage. Outgoing routes were next diverted from the trunk suite to Anchor in batches spread over 11 days, and multiple space released was used to provide the rest of the dialling-out circuits. All the zone routes which previously dialled into Birmingham trunk director exchange, together with hundreds of circuits outgoing from levels of that exchange to local exchanges, were changed over on the second Saturday and the remaining incoming routes, mainly from "foreign" groups, were changed over on the last Saturday.

Altogether well over 5,000 circuits of all kinds were changed over, or newly provided, entirely by using the normal test break jacks and arrester spring contacts.

E. W. A.

### JUBILEE JAMBOREE, 1957

During the weeks preceding the Jamboree the world press and radio gave full coverage to the organization and the statistics of what was involved in providing for the needs of 32,000 scouts during their 12-day stay in Sutton Park, Warwickshire. Some notes on the telephone and telegraph services will be of interest here.

From the initial discussion with the organizers, in February 1956, it was evident that very considerable cabling would be needed within the 2,400-acre park to meet the needs of the Boys Scouts Association, the B.B.C. the I.T.A., contractors, shopkeepers and the campers themselves. The local line-plant in the vicinity was quite inadequate for these needs, and it was necessary to advance a major part of Sutton Coldfield line-plant-relief scheme to ensure sufficient pairs between the park and the exchange. Spare line-plant was available from Sutton Coldfield to the centre of Birmingham and elsewhere and, for purposes of B.B.C. television, it was a useful fact that the park is within optical range of their Midlands transmitter. All structures were of a temporary nature and it was impossible to forecast requirements with any precision, but it was decided to provide for 450 lines of all kinds within the park and 220 from the main distribution point to the exchange.

As a result, ten miles of cable were laid in the park, much of it buried and the rest hung from trees, power poles and a few Post Office poles. No less than 25 miles of drop wire were used. In addition, one and a half miles of cable tapering from 1,200 pr. to 300 pr., were provided as the advance part of the local line-plant scheme.

The four-position P.B.X. consisted of modified C.B.S. No. 2 switchboards and it was given the special director designation "JUBilee." Although the switchboard was double the size that the organizers had asked for, it was only by very intense effort by the Rover Scout operators (who were Post Office operators in civil life) that the traffic was dispatched. At times calls were being handled at the rate of over 1,000 an hour.

Twenty standard No. 6 kiosks were erected in various parts of the park and a continuous maintenance patrol was necessary to deal with foreign coins in the coin boxes and to keep the kiosks supplied with directories. Two kiosks were reserved for international traffic, and in addition eight coin box telephones were provided in the press tent. Two T.A.S. teleprinters were installed in the Camp Post Office, and British Railways rented a 25-line switchboard and a Telex installation.

An essential feature of the operation was that as much as possible of the plant should be recovered in a condition fit for re-use. The kiosks were removed to permanent sites in Birmingham and district by the use of the kiosk trailer. Telephone instruments were recovered within 24 hours and the buried cable, which was laid at shallow depth in sandy soil, has been lifted with the minimum of excavation.

The Jamboree was the B.B.C.'s biggest outside broadcast commitment outside London, and 293 hours of programs were transmitted over Post Office music circuits for the Home, Light and General Overseas services, and on behalf of 10 foreign broadcasting authorities; 30 midget tape recorders were in almost constant use, and an elaborate array of editing and play-back machines (and a repair workshop) was required to conduct and transmit the programs.

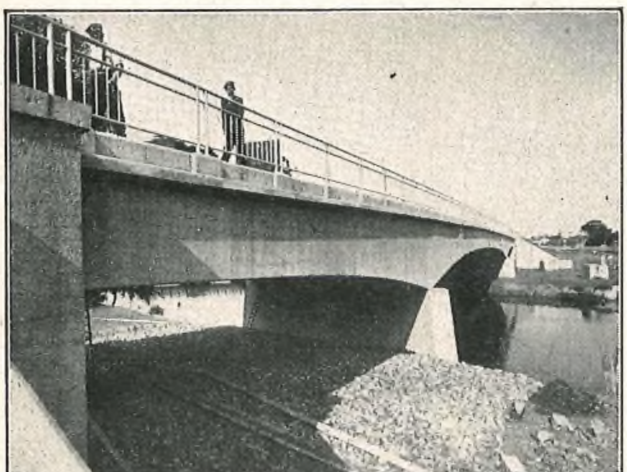
The B.B.C. television unit put on 10 programs for domestic use, and three programs for Eurovision, all via a microwave link to Sutton Coldfield, although a reserve vision circuit was provided at very short notice by the Post Office television outside broadcast team for the opening ceremony. The I.T.A. program contractors put out 11 programs, all via a microwave link to Lichfield.

The amateur radio stations, police, A.A., Midland Electricity Board, South Staffs. waterworks, and the Jamboree contractors all had separate radio communication networks, and so much interference was experienced on the B.B.C.'s radio links for the "Roving Eye" and an outside broadcast from the Rover Moot that one program had to be abandoned.

E. W. A.
J. H. S.

OPENING OF THE NEW CAVENDISH BRIDGE

The recent opening of the new Cavendish Bridge on the London/Carlisle A6 road at Shardlow a few miles south of Derby, recalls an incident that occurred in the spring of 1947 when the old bridge was swept away by the river Trent in the abnormal flooding of that year. The Post Office cables were left suspended in their ducts between the banks, and a photograph of the damage, with a description of the restoration methods, appeared in the Journal, Vol. 40, p. 90, July 1947.



*By courtesy of "Guardian Journal"*

The New Cavendish Bridge.

The origina bridge was quickly replaced by a Bailey bridge constructed by military personnel, which has been in continuous use until the opening of the new bridge, pictured below, in September, 1957.

The Post Office cables which include the London–Derby and London–Manchester carrier cables, are carried over the new bridge in two blocks of ducts located in the footways on either side of the bridge. Each block consists of 12 light fibre ducts set in concrete. The bridge itself is of pre-stressed concrete, with three main spans of cantilever type, each over 80 ft long, and a flexible joint at the centre of the main span, which is 110 ft long. To allow for possible movement of the cables, two inspection chambers have been constructed at the points at which the cables cross the flexible joint of the bridge and a certain amount of slack left in the cables as they pass through these chambers. Existing cables use only the bottom layer of ducts and rest on the floor of the inspection chamber. Subsequent layers will be supported on shelves at these points. The position of the cables has been marked and periodic examinations begun for signs of movement, but none has been observed to date.

FAILURE OF 11-kV CONDUCTOR OVER POST OFFICE CROSSING

The effectiveness of Post Office methods of guarding against high voltage lines was demonstrated at 11.0 p.m. on Sunday, 30th June, 1957, at Gosberton Risegate, Lincolnshire. An 11-kV route crossing over a Post Office polythene aerial cable was struck by lightning, and one conductor, 0·1 in. steel-cored aluminium, was fused at the insulator and fell, the insulator also being shattered. The conductor came to rest over the aerial cable and supporting strand, and remained there, still energized, until the Electricity Board engineer attended the fault at 9.30 a.m. the following morning.

The Post Office cable concerned was 10/20 polythene, lashed to a 4/14 strand insulated at each end of the span. There was no damage to the cable, and only a slight discoloration of the strand where the power conductor had chafed.

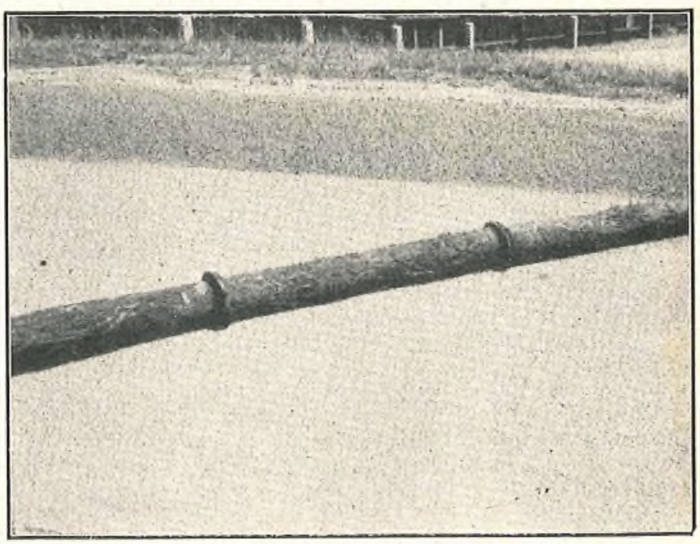
Although tests are made from time to time to ensure the safety of Post Office workmen and plant, it is most reassuring to be able to report that the arrangements work in practice and that, where construction standards are properly observed, they may be relied upon.

J. W. L.

## North-Eastern Region

"CONGESTED" DUCT

An interesting example of the growth of tree roots in an underground duct has recently been found in the Sheffield Area. Whilst it is realized that tree roots have been known to enter Post Office ducts, it is thought the amount of growth in this instance is exceptional. During cabling operations in the residential area of Ranmoor an obstruction was encoun-



Root Obstruction in Ducts.

tered, and on breaking down the duct (3-in. S.A.D.) it was found that three complete Ducts, No. 11 (6 ft × 3 in.) had literally exploded due to the growth of a root from a beech tree adjacent to the ducts. It appears that the root had entered the duct at a damaged collar, travelled for six feet to a farther duct obstruction, and then doubled back, completely filling, and consequently smashing, the duct due to its growth. The photograph of the roots shows the extent of this, and the collar positions are clearly shown. The duct contained 54-pair, 6½-lb and 100-pair, 10-lb cables, and it is estimated that the last cable was drawn in approximately 20 years ago.

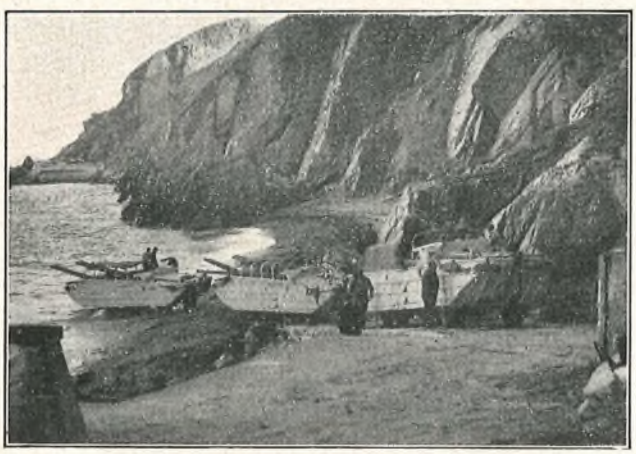
O. G. P.

### South-Western Region

"OPERATION LUNDY"

LUNDY, also known locally as Granite Island—haunt of countless sea birds—lies 24 miles west of Ilfracombe off the North Devon Coast, is roughly 3 miles long and a mile at its widest and rises 400 ft above the Atlantic Ocean. It is said that one fifth of England's shipping passes its rocky coast, and in fierce gales many are glad to seek anchorage off its sheltered eastern side. At night a lighthouse on the extreme north-western point and another on its south-eastern side give 20 mile warnings to these ships of Lundy's dreaded rocks. Other buildings on the island are a church, hotel, farm and the private residence of its owner, Mr. A. Harman.

Communication to the mainland is by radio link from the old lighthouse to Hartland Point (the latter also being the coast guard station), and within the island land-lines on poles extend from the hotel, North Light, Old Light and South Light. These land-lines are rented jointly by Trinity House, the Board of Trade and Mr. Harman, but are owned and maintained by the Post Office. The whole system of inland communication consists of 6 miles of 200 lb copper wire erected on 94 poles from 22 ft to 28 ft high; the wire is bound to each insulator by reinforced binders and was first installed before the 1914-1918 war.



THE ARRIVAL AT LUNDY.

Over the years the gales and salt air have taken their toll and it was recently found necessary to renew 4 miles of wire, 17 poles and 9 stays. This operation involved transporting nearly four tons of stores, tools and plant from the mainland and was quite beyond the capacity of the local craft that make this rather adventurous journey. Adventurous because the one small landing beach at Lundy normally makes it necessary to anchor a quarter of a mile off-shore before transferring men and stores to open boats to make the final landing between huge rocks on to this beach, and even this operation depends upon wind and tide. The transport problem was, however, overcome by a request to the War Office, who granted permission to use an L.C.T. and 3 DUKWs.

By arrangement and with the full co-operation of the Officer Commanding R.A.S.C. (Amphibious Transport), Fremington, the stores, tools, explosives, cement and poles were evenly loaded into 3 DUKWs at Instow by Army and Post Office personnel. After testing for seaworthiness with their unusual load the DUKWs were backed into the L.C.T. at low tide. When the tide eventually floated the L.C.T. the journey to Lundy had begun. So far an easy operation, but the result of much planning, co-operation and timing.

After an unusually smooth crossing, which took about two and a half hours, anchor was dropped half a mile off Lundy at approximately 5 p.m., the ramp was lowered and the 3 DUKWs floated off at approximately 5.10 p.m. The officer in charge of the R.A.S.C. party went ashore in the first craft to navigate a safe course between the large boulders. The Island's tractor and trailer were waiting on the slipway and a few moments after arrival the first DUKW was being unloaded. The contents of two of the craft were transferred to the trailer, making a load of approximately two tons. The tractor then left to dispose of its load at the top of the narrow, winding cliff road.

It was then noticed that the wind had veered East of North and conditions in the bay were worsening. Delay in these circumstances would have been dangerous and it was therefore decided not to await the return of the tractor but to off-load the third DUKW on to the slipway and return to the L.C.T. with all speed. The return journey to the L.C.T. was rough, to say the least, and the entry via the ramp was in itself a test of skill. The order to raise the ramp and weigh anchor at approximately 6 p.m. brought sighs of relief—even from the seasoned crew. The ebb tide made the crossing of The Bar impossible and the L.C.T. therefore dropped anchor off Westward Ho! It was then 8.30 p.m. The 3 DUKWs were floated off, stern first, in complete darkness (rather a terrifying experience to the landlubber) and arrived on Westward Ho! beach at approximately 9 p.m. "Operation Lundy" was successfully completed.

The work on the Island will take about two weeks, when the whole operation will be repeated in reverse, weather permitting.

T. I. P. and C. E. P.

*Correction*

In the note "Recovering Hessian-Protected Cables," Vol. 50, p. 200, October 1957, the amount of water in the solution was incorrectly shown as 4 gallons. The correct quantity of water is 40 gallons.

## Book Review

"Transistors, Circuits and Servicing." B. R. A. Bettridge. Trader Publishing Company. 23 pp. 11 ill. 2s. 6d.

This book is an elementary introduction to transistor circuit applications and is directed at the servicing engineer who encounters for the first time radio receivers using transistors.

The author begins by giving a simple outline description of the circuit properties of transistors and compares them with the properties of valves. Class A and Class B audio-frequency amplifiers are then described, and the author goes on to consider the operation of a receiver of the pocket portable type. A brief account of the use of d.c. convertors in hybrid valve-transistor receivers follows, and the book concludes with a chapter on measurements in transistor circuits and the testing of transistors.

Despite the small size of the book a surprising amount of ground is covered, and useful practical information is given on safety precautions to prevent damage to transistors when making measurements. The amount of information on i.f. amplifiers is, however, rather limited and some practical detail on the important subject of the adjustment of neutralized i.f. amplifiers would have increased the value of the book. A second minor criticism is that beginners, on reading page 7, might gain the impression that all transistors should have an alpha value of 0·98.

Despite the above criticisms, the book is useful as a simple introduction to the subject.

H. G. B.

# Associate Section

## "Telecommunications, Past, Present and Future"—The Silver Jubilee Exhibition of the London Centre

To mark the occasion of the Silver Jubilee of the formation of the Associate Section of the Institution of Post Office Electrical Engineers, the London Centre planned a three-part program:—an exhibition, a lecture, and a special edition of its quarterly Journal.

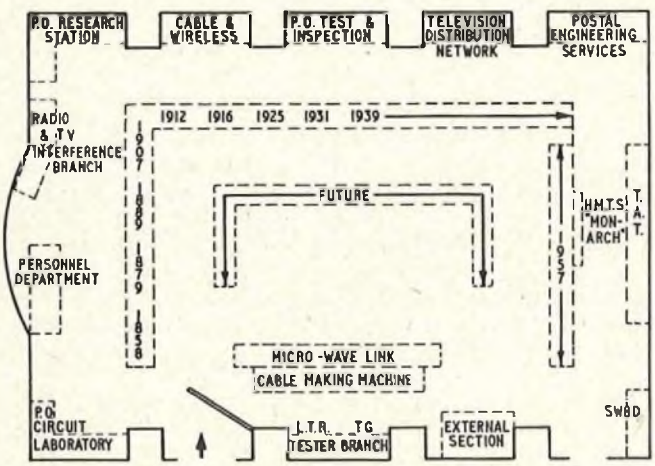
Due to the interest shown by Associate Section members in the Senior Section's Golden Jubilee Exhibition, which very few had been able to see, it was decided to follow the theme set by that exhibition. After preliminary discussions by a sub-committee, three main divisions emerged as the basis of the exhibition. They were:—

- Highlights of the telecommunication world, 1858 to 1957.
- Future trends which are probable, possible and perhaps impossible?
- The activities of various sections of the Post Office Engineering Department in giving a service to the public and thereby keeping this country up to date in the field of "This Telephone Business."

Hence, the title "Telecommunications, Past, Present and Future" was derived for the exhibition.

The dates were fixed for the 2nd, 3rd, and 4th of October, 1957, and because of the difficulty in obtaining suitable premises in the City, to which the public would have access, the ballroom of the Metropole Buildings, Whitehall Place, S.W.2, was hired. Equipment was borrowed from as far afield as the United States of America, the Central Training School at Stone, and as near as Electra House, Victoria Embankment, W.C.2.

An invitation was extended to the President of the Institution, Brig. Sir Lionel H. Harris, K.B.E., T.D., to open the exhibition, but due to prior commitments he was unable to accept. Mr. R. J. Halsey, C.M.G., deputized for him, and in his opening speech remarked how fortunate he considered himself in being associated with research and new developments. He went on to speak of the progress, during the lifetime of the Associate Section, in the field of long-distance transmission, which had been revolutionary. In referring to the replacement of short-wave radio communication by the use of cables for overseas circuits, Mr. Halsey continued—"but radio in the form of microwave relay, with stations spaced at about 30 miles, bids fair to become the normal method of providing large blocks of circuits overland. In the United States, which has a telephone population twice the size of Europe's, one-half of all long-distance telephone, program and television circuits are already carried on such relay systems at frequencies around 4,000 Mc/s, each with a maximum capacity of over 4,000 telephone circuits or 12 television channels." After referring to other items of future development, Mr. Halsey mentioned the opportunities that exist in the Post Office Engineering Department for the technical person, and suggested that anyone interested should look at the Careers Stand in the exhibition, staffed by the Personnel Department. In concluding, he extended the congratulations of the Engineer-in-Chief, Brig. Sir Lionel H. Harris, to the Associate Section on its Silver Jubilee.




Plan of the Silver Jubilee Exhibition of the London Centre.

As the theme was to be Telecommunications, Past, Present and Future, it was realized that to obtain any degree of success continuity must be achieved. To this end the flow of people was directed in that order, starting with a sample of the first transatlantic cable ever laid, which was laid in 1858. The next year chosen was 1879, when the telephone as a means of communication was established; telephones of this period were displayed, including a model of Graham Bell's 1876 telephone.


1879 Section.

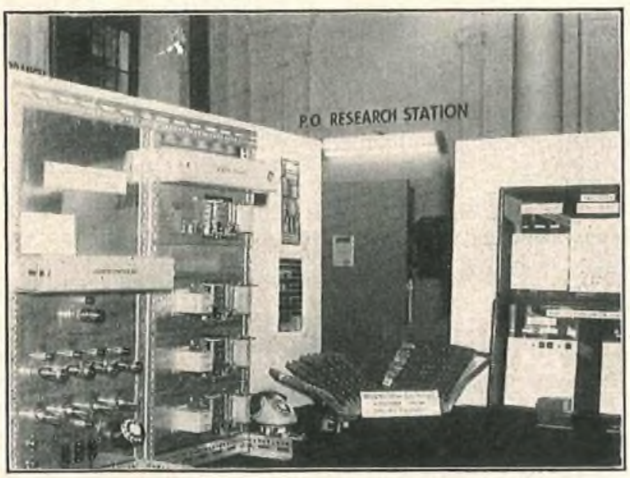
For the year 1889, there was a copy of the first directory, to show the extent of progress of the telephone, and a Hughes telegraph instrument. By 1907 an interesting and enterprising feature which could be used by telephone subscribers as an additional service was the Electrophone. It brought to the home plays, concerts, musical comedies and church services long before radio became established as a medium for entertainment, and here one could see an Electrophone table with receivers, an Angeleni transmitter and a carbon-pencil transmitter.

The year 1912 saw the development of another form of communication, namely radio, and equipment of this period was shown. In the same year the first automatic telephone exchange in this country was installed at Epsom, where Strowger-type selectors were installed; selectors of the period were exhibited in the form of a demonstration unit. Developments during the 1914–18 war were negligible, with the exception of the introduction of loading and the use made of the first valve telephone repeater on the London–Birmingham–Liverpool cable during 1916. The developments in the Post Office services by 1925 necessitated the setting up of a research establishment and a training school (the first President of the Junior Section, Mr. C. W. Brown, was an Instructor at the first school at King Edward Building). Telegraph development had resulted in the first page-printing teleprinter for Press use; one such was exhibited here. The next year chosen to show developments was 1931, for by then the first automatic director exchange had been installed at Holborn, London, short-wave communication now connected the Old and the New Worlds, and a domestic item was the beginning of standardization of equipment used by the Post Office. A coder call indicator display panel and one of the original director units were exhibited, as were photographs of the short-wave aerials at Rugby, and the old and new style racks.

1925–1931 SECTION.

The page-printing teleprinter (No. 7) had been introduced during the 'thirties, and a special display showed how it functioned mechanically and how each character on the keyboard was "built-up" when using the Murray code. In London, automatic telephone exchanges were being provided for a larger number of subscribers, and a demonstration unit showed how a subscriber-to-subscriber call is made in London. Development during the 1939–45 war was very restricted, but between 1946 and 1957 rapid progress was made. Exhibits showing this progress included samples of the London–Birmingham No. 4 and No. 5 cables, post-war uniselectors, the rocking-armature-type receiver, the new Rugby "B" radio station, the island-link radio telephone apparatus, and a section of an electronic director as installed at Richmond exchange. This section of the exhibition ended as it started—with a sample of transatlantic cable—the difference being that this sample had been laid 100 years after the first one.

In accord with the theme of the exhibition, thoughts as to future developments were offered; the use of time-division multiplex in signalling was demonstrated in an electronic exchange developed by the Post Office Research Station, the effect of a regenerative repeater in a distorting telegraph line, a new 5-unit teleprinter automatic-numbering transmitter and associated equipment developed by B.T.R., the latest teleprinter developed by Creeds & Co., Ltd., and the S.E.50 selector. Unusual features were the 3-bank uniselector taking the space of a 3000-type relay, wire relays, transistor amplifiers mounted in the centre of a handset with "built-in" volume control, and a static ringing device to replace bulkier and more expensive equipment at P.M.B.X. switchboards.




PART OF "FUTURE" SECTION.

The exhibits which were really of the future were the low-loss microwave telephone link equipment, which, using circular waveguide transmitting at 8 mm wavelength, has an attenuation of 4 db/mile; the Ericofon, designed by L. M. Ericssons of Sweden, which has the complete telephone (except the bell set) in one piece, the switch hook and dial being housed in the base; and the solar battery apparatus which the Bell Telephone Laboratories kindly lent the London Centre for the occasion, its efficiency could be judged by the driving of a small motor and flag-waving device.

In the final part of the exhibition, the work of the various sections within the Post Office that play a direct or indirect part in giving a service to the public was displayed. A "mock-up" of a manhole, combined with a working demonstration of pair identification by tone, portrayed the part of the external man; telegram facsimile equipment, a subscriber's line tester using a magnetic drum, and a model of a cable-making machine were to be seen working. The Circuit Laboratory showed the extent of "contact bounce" of a 3000-type relay and the processes of printed circuit techniques, the Radio and TV Interference Branch showed the effects of suppression and non-suppression of electrical domestic apparatus, whilst the Post Office Research Station exhibited a unit of "Ernie," a transistorized ringing display, and examples of research into acoustics. The youngest section of the Post Office, Cable and Wireless, were represented by picture telegraph apparatus and multiplex equipment, the Test and Inspection Branch showed the full scope of their work, as did the Television Distribution Network; their display showed how much the viewer is dependent upon the Post Office for the reception of pictures. So far the various branches exhibiting had all dealt with telecommunications in some field, but the Post Office engineer who maintains the equipment used by the postal services should not be forgotten, and their display included a stamp-cancelling machine, an Addressograph machine, and the electronic letter sorter trainer. The final achievement to be highlighted was the transatlantic telephone cable, for this had connected the Old and New Worlds by cable for telephonic communication, an achievement as great as when the Atlantic had been bridged by radio waves. Samples of cable, deep-water repeaters and shallow-water repeaters were displayed, and one had the opportunity to hear an extract of a test transmission of music recorded in this country via the cable. In an adjoining room were examples of high-speed photography taken by the Circuit Laboratory, and a film strip feature "The Story of the Quartz Crystal," lent by the Automatic Telephone and Electric Co., Ltd.

Further demonstrations of the use of electronics and electromechanical devices were to be seen and participated in; a Noughts and Crosses game machine, a car racing game driven by acoustics, and a magnetic drum demonstrating that much could be stored on the drum, in this case, poetry, prose and speeches, etc., which were translated and reproduced on a teleprinter.

Such then was the exhibition that the London Centre of the Associate Section offered. It had been open for 25½ hours, during which approximately 2,000 people had seen the majority of the exhibits. The measure of success is hard to ascertain, 2½ inches of a column in the *Daily Telegraph*, a five-minute broadcast on the B.B.C.'s Overseas network, a mention in several of the monthly technical periodicals, or a few letters and comments of praise; bearing in mind that progress is an accepted part of our existence and that the milestones of developments are soon forgotten, the London Centre feels that the objects of the exhibition have been achieved and is more than satisfied with its success.

P. SAYERS,

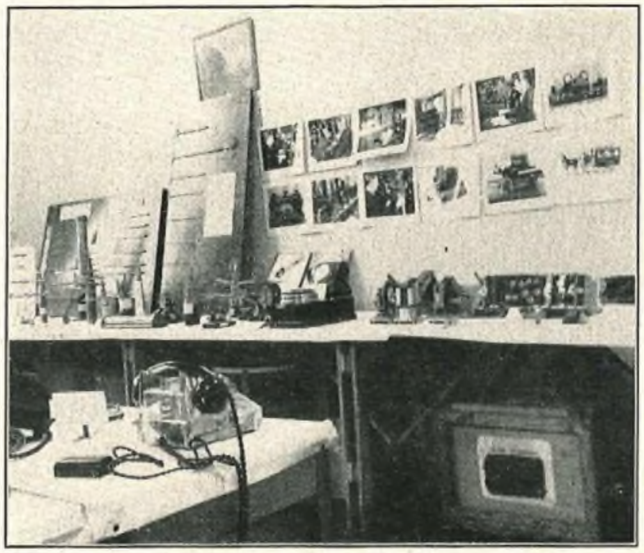
*General Secretary,*
*London Centre, Associate Section.*

## Exhibition to Mark the 25th Anniversary of the Birmingham Centre

On reading the I.P.O.E.E. Jubilee number of the Journal, it was realized that in 1957 the Associate Section would have been in existence for 25 years. Further investigation revealed that the Birmingham Centre itself would also be 25 years old, and, with the Jubilee celebrations still fresh in their minds, the committee decided to arrange an exhibition similar to, but rather less ambitious than, that held at Stone in October 1957 by the Birmingham, Nottingham and Stone-Stoke Centres of the Senior Section.

Having secured the use of the operators' retiring room at Midland exchange for two days, the task of gathering together the exhibits required was started. The staff and Associate Section officers at Stone were most helpful, and exhibits were borrowed from the Auto Museum and the Transmission School's store at Stone, including a working demonstration model of a 4-wire audio circuit. Some of the items borrowed had been almost forgotten, since they are not much needed these days.

Further valuable assistance was given by our Regional Liaison Officer, who, on a visit to London, obtained the loan of a very good selection of photographs and old telegraph equipment from the Engineering Department, and a working demonstration unit of the new rocking-armature receiver from Standard Telephones & Cables, Ltd. From the Regional Training School at Shirley we borrowed cable "trees" and telephones.



Part of the Cable and Telegraph Sections.

Modern Telephone Section. From a Telephone No. 150 to a Telephone No. 700.

Part of the Telegraph Section Showing "ABC" Instrument on left and V.F. Telegraph Panels on right.

Having selected our exhibits, the next problem was presenting them. Here we had the assistance of the local drawing office in preparing the necessary labels and captions. This, together with much hard work on the part of the committee on the night before the exhibition, completed the arrangements for the exhibition. The photographs show the layout of some typical sections of the exhibition.

Attendance was quite good, most of the items being of considerable interest, even to the layman, though some presented a puzzle which, for the uninitiated, could never be quite unravelled.

In conclusion we wish to express our gratitude to everyone who helped in the arranging of the exhibition, and in particular to record our thanks for the assistance and advice given by Mr. R. W. Palmer, Associate Section President; Messrs. H. Baker and M. Snell, of the Central Training School; Messrs. Batty and Boughey, Chairman and Secretary of the Stone-Stoke Centre of the Associate Section; Mr. Bracken, Deputy Telephone Manager, Birmingham; Mr. Cooper, Principal, and the staff of the Regional Training School, Shirley; Mr. Probert, Regional Liaison Officer, Midland Region; and Mr. Taylor, Liaison Officer, Birmingham.

D. F. ASHMORE, *Secretary,*
*Birmingham Centre, Associate Section.*

# Associate Section Notes

### Brighton Centre

Twenty-five years ago, on 20th July, 1932, a small band of enthusiasts gathered to form the then Brighton Junior Section of the I.P.O.E.E.

Several of those founder members are still faithfully serving the Brighton Associate Centre to-day, and the spirit of those early days is being spread to an ever-widening cross-section of the present staff. Like all similar organizations this Centre has had its vicissitudes, but the sense of purpose which animated its founders has served to maintain a continuous existence of 25 years.

This achievement was recognized in a very gratifying way by the invitation of the main Institution to attend their own 50th anniversary celebrations in London on 9th October, 1956. On that occasion our Vice-Chairman, Mr. K. W. Chandler, as a founder member, represented the Brighton Associate Centre.

Shortly afterwards we commenced our own preparations to celebrate the Silver Jubilee of this Centre, and on Friday, 11th October, 1957, a company of 47 met at the Royal Pavilion

Hotel in Brighton to mark the occasion. Modesty forbids that we should enlarge on the success of the evening, but the exhilaration of the event was not due solely to the refreshments provided.

As well as having three founder members present, we were honoured by the attendance of members from the main Institution and representatives from the Post Office and Industry.

With this landmark behind us, we are now in the midst of our winter program of lectures and film shows, having just completed our most active season of visits to a wide variety of works, refineries, mills, factories, etc.

The prospect before us is bright and our efforts will be directed to presenting, to as wide a variety of the membership as possible, the opportunity to extend their knowledge of their own, and the other fellow's, job.

With this aim in view we would ask members to enlist the interest of more external men, as our activities are by no means confined to internal subjects. We find that a visit to a brewery draws as much interest as a visit to a laboratory.

The officers and committee thank members of the Centre for their past support, and members of the Senior Section for their helpful co-operation. We look forward confidently to the next 25 years.

A. T. L.

## Slough Centre

At an inaugural meeting in July, 1957, the Slough Centre was formed. At that meeting we were honoured by the presence of Mr. A. H. C. Knox, Regional Liaison Officer; Mr. E. W. Weaver, Telephone Manager; and Messrs. R. N. Hamilton and L. W. Lovegrove, Area Engineers.

Mr. Knox outlined the aims of the Associate Section of the I.P.O.E.E. and gave us some ideas for our future activities, then he gave a talk on "Some Aspects of Promotion."

At the meeting the following were elected to serve as officers and committee for the coming year:—*President:* Mr. E. W. Weaver; *Chairman:* Mr. N. F. Cloak; *Secretary:* Mr. R. E. J. Goatley; *Committee:* Messrs. A. G. Eagle, R. F. Lambert, F. G. Gemmel, A. J. Green, G. W. Young and J. H. Williams.

Our first paper, "300- and 600-Type Telephones," given by Mr. Spencer, Engineering Department, was a grand start for the Centre, as also was a visit to British Telecommunications Research, Taplow, to see an exchange in which the controlling equipment was electronic.

R. E. J. G.

## Canterbury Centre

The program for 1957–58 started with a visit to Pfizer, Ltd., manufacturers of antibiotic terramysia. The visit was to Folkestone Works on 15th October, and the highlight of the works was a thermo-electric air-purification system.

This visit was followed on 26th November by a film show and lecture by Mr. P. J. Platt, Production Controller of Pfizer, Ltd. Mr. Platt spoke on "Some Engineering Aspects of Antibiotic Production."

On 17th December, 1957, Mr. L. Cockram gave a talk on "Television Receiver Fault Finding and Maintenance."

The program for the second half of the session is:—

21st January, 1958: A talk and discussion by Mr. P. J. Rattue on "Broadband Radio."

18th February, 1958: Mr. Arnold, Area Engineer, Canterbury, will lecture on "Cable Corrosion."

18th March, 1958: Mr. Neate, Area Engineer, Canterbury, will lecture on "Post Office Communications at London Airport."

April, 1958: Annual General Meeting—date to be announced.

All lectures will be at Telephone House, Canterbury, at 7.30 p.m.

The Annual Speaking Contest, open to Associate members only, will be held as usual, but the date will be announced later.

Visits will be announced as they are arranged.

M. S. J. G.

## Medway Centre

The Annual General Meeting was held on 9th October, 1957, the following officers and committee being elected for the 1957–58 session:—*Chairman:* Mr. L. F. Pascoe; *Secretary:* Mr. E. J. R. Scott; *Committee:* Messrs. L. Ford, G. Wilkins, F. Veale, L. E. Studham and A. Simpson.

The winter program presented to the membership for their approval by the retiring committee was as follows:—

October—"Some Further Aspects of Cable Corrosion," by Mr. Arnold.

November—"High Speed Photography," by Mr. Mack and Mr. Hubbard.

December—"Transatlantic Telephone Cable," film.

Janary—"The Post Office Television Switching Network," by Mr. T. L. Newman.

February—"Electronics in Medicine," talk.

March—"Introduction to Transistors," by Mr. D. H. Jones.

April—"The Electronic Digital Computor," talk.

May—"Local Government"—"The Chamber of Commerce," talk.

June—Summer outing and visit to the National Physical Laboratory.

E. J. R. S.

## Colchester Centre

The 1957 summer program of the Colchester Centre aroused such wide interest among the members that ballots were held to decide who should participate in the visits that were organized.

The visits included such places as New Scotland Yard, the Advanced Driving Wing of the Essex County Constabulary, at Chelmsford, and a most interesting visit to Evans Electro Selenium, Ltd., at Halstead, where the manufacture of many instruments incorporating selenium cells takes place. This visit was the most highly discussed by the members as it followed a visit to Cliff Quay Power Station at Ipswich. The transition from kilowatts to microwatts was most noticeable.

The 1957–58 winter session started well with a talk by Mr. R. W. Palmer, President of the Associate Section, entitled "Maintenance in Other Countries." This was followed by Mr. P. J. Whitehead, a Colchester Centre member, taking us deeply into the realms of "High Quality Sound Reproduction."

Coming events include a talk and film show by Remington Rand staff on "Electronic Computers"; a quiz with our newly formed neighbouring centre at Ipswich; a talk on "The Working of an Area Traffic Division," by the Senior Telecommunications Superintendent, Mr. J. J. O'Rourke; and a further talk on the many aspects of photography, by Mr. D. W. Pyle.

J. W. J.

## London Power Centre

The 1957–58 session of the London Power Centre opened with a presentation by Lt.-Col. F. A. Hough of a certificate to Mr. P. J. Froude for a paper entitled "D.C. Machines, Part II," and the reading of another paper by the same author entitled "The Development of the Circle Diagram for Induction Motors." A discussion followed after which it was agreed that motors designed for continuous running as synchronous induction motors with d.c. injection into the rotor windings should be specially designed and this concluded a very interesting meeting.

Other papers to be prepared for presentation during the session include:—

"Overhead Chain Conveyors," by R. New.

"Three-phase Induction Motors as Drives," by C. M. May.

"Clearing Electrical Faults," by I. Berg.

"Electrical Alarm Systems," by H. Marchant.

"Instrument Optics," by J. Doyle.

"Illumination Design Factors," by T. White.

Among visits recently made was one to Messrs. Negretti and Zambra which demonstrated that instruments of first quality could still be made by hand. Another was to Messrs. Peak Frean of Bermondsey, where we were most courteously received and saw the application of mass production techniques. Mr. Berg, Visits Secretary, has a full program of future visits, among which will be visits to Stratford Railway Works, Lyons (Cadby Hall) and Carreras, Ltd.

Recruiting is still going on and membership is now over 300. Correspondence is cordially invited from other centres and copies of papers can be forwarded to any member interested.

P. J. F.

## Ayr Centre

The program for the 1957–58 session commenced with a visit, during September, to J. Walker & Sons, Ltd., Kilmarnock, which proved to be a most interesting and enjoyable start to the activities of the Centre.

The October visit to the Television Servicing Department of J. Paton, Ltd., Prestwick, was well attended. A demonstration of television receiving equipment and test equipment was given, and many of the latest developments in manufacturers' designs and circuity were made available for inspection.

Future activities are a talk on meteorology and visits to Wallacetown Engineering Co., Ltd.; Portland Glass Co.; U.S.A.A.F. Air-Sea Rescue Base and U.K.A.E.A., Calder Hall.

Membership has now reached 80 and it is interesting to note that this has been achieved in a little under two years since the formation of the Centre late in 1955.

The credit for the success of the Centre is due to the hard work of our former Secretary, Mr. A. Edgar, who recently resigned and is now a member of the Senior Section.

L. R. L. P.

## Glasgow & Scotland West Centre

The Glasgow and Scotland West Centre have made a good start in the 1957-58 session. We began with our Telephone Manager's coloured slides taken while on holiday in North America; a repeat of a most successful evening last session. In October we visited the Department of Scientific and Industrial Research at East Kilbride and this proved so interesting that a request has been made for a return visit there. Mr. F. Grimm, of Pye Telecommunications, Cambridge, is giving a lecture on "Transistors" in November, and in December we visit the Glasgow University Observatory and also have a lecture on the stars, with an introduction to the radio telescope, by Dr. Thomas R. Tannahill. In January Mr. G. Marsh, of Mullard, Ltd., will be showing the film of Mullard Valves, while in February Mr. J. R. Atkinson will tell us what the University is doing with the synchrotron beam—then, later in the month, we will visit it and see for ourselves. March brings an innovation to our meetings—we are having a "Matter of Opinion" night and hope for some lively opinions. Another innovation to our Centre is a film show after the Annual General Meeting. We hope to have the Transatlantic Cable film. Our best wishes for the New Year are sent to all our colleagues of other Centres.

J. F.

## Haverfordwest Centre

On 12th February, 1957, a group of interested people got together at Haverfordwest, under the chairmanship of Mr. D. W. Davies, to discuss the possibility of forming an Associate Centre of the I.P.O.E.E.

Their decision reached fruition on 1st March, 1957, when a Centre was formed with an initial membership of 38 (which has since been increased to 58). The officers and committee elected were:—*Chairman:* Mr. R. I. Jenkins; *Secretary:* Mr. J. H. G. Rees; *Committee:* Messrs. E. G. Richards, E. V. George and F. A. Loomes; Mr. D. W. Davies has been appointed Liaison Officer.

The Centre's activities began on 12th August with a conducted tour of R.N.A.S. Brawdy, which proved a very enjoyable and instructive evening. A talk on 10th September about I.P.O.E.E. Associate Section organization by Mr. J. R. Young, Senior Section Secretary for Wales and Border Counties, followed by some very interesting old lantern slides, did much to attract new members.

The committee has drawn up a full and varied program for the remainder of the winter session, and it is hoped that the membership will continue to increase so that the Centre will get well established.

J. H. G. R.

## Darlington Centre

The start of the 1957–58 session was delayed because the speaker on "Atomic Power" was not available and at the moment of writing this talk is still in abeyance. The first meeting was held on 26th November, and there were two talks: "Eritrea P.T.T.," by Mr. W. E. Pearce, and "Eritrea Signals," by Captain W. Howard, Royal Corps of Signals. "Safe Driving" was the subject of the paper given on 10th December by a staff officer from Durham County Police Headquarters.

MR. B. MIDCALF.

In the early months of 1958, for the remainder of the session, it is hoped to have talks to mark the Silver Jubilee celebrations of the Associate Section.

It is pleasing to record that another member of our Centre, Mr. H. Thompson, has received a prize and Institution Certificate for his paper entitled "The Manchester–Leeds–Newcastle Coaxial Cable."

The Centre was sorry to lose the services of Mr. B. Midcalf, the Honorary Treasurer and Librarian, who retired at the end of 1957. Mr. Midcalf had held this position since the re-formation of the Centre and rendered yeoman service at all times to further our activities. We wish him a long and happy retirement.

C. N. H.

## Doncaster Centre

After hibernating for the last few years, the Doncaster Centre has been resurrected and a really live-wire program of events and talks is offered to the members. The program for 1957–58 is as follows:—

25th September—General meeting for election of officers.
31st October—Visit to Briggs Motor Bodies in Doncaster.
13th November—"Printed Circuits," by J. Willmot.
January—Visit (details later).
12th February—"Fundamentals of Telephone Cable Design," by A. C. Holmes.
12th March—"Tape Recorders," by F. S. Brasher.

Mr. Brasher of the Sheffield Telephone Area won an I.P.O.E.E. award for his paper and we are looking forward to his talk.

The Centre's officers for this year are:—

*Chairman:* Mr. C. Smith; *Secretary and Treasurer:* Mr. J. I. Lawson; *Librarian:* Mr. W. Almond; *Committee:* Messrs. F. Darlow, S. Pearson, W. Steele, W. Wilkinson and G. Skelton.

J. I. L.

## Hull Centre

The 1957–58 session opened in October with a film show which included "Research in Engineering" (Metropolitan Vickers) and "Terra Incognita," a film on the electron-microscope made by Phillips, Ltd.

The second meeting was a combined lecture and visit to Marconi's, Ltd., in Hull, on 6th November, when we saw radio, radar and echo-sounding equipment, including the new Fish-scope unit. During the evening there was a talk accompanied by a demonstration on the uses of a Q-meter. Some items of telecommunications equipment made by Marconi Instruments, Ltd., were also on show.

Following a report given by our secretary on his visit to the Associate Section exhibition held in London, we would like to offer our congratulations to all concerned whilst expressing our regret that we ourselves cannot possibly achieve anything on such a scale.

L. J.

## Scarborough Centre

The 1957–58 session got off to a good start on Tuesday, 29th October, the "Any Questions" paper being, as always, a great success. The attendance was quite reasonable despite the appalling weather. Questions were still being answered after 10 p.m. by a panel consisting of the Telephone Manager (Mr. H. A. Clibbon), Mr. T. Jordan (Executive Engineer), and Mr. E. Speechley (Executive Engineer). The Area Engineer, Mr. G. E. T. Thomas, was also to have been a member of the panel but had to withdraw at the last minute; we are looking forward, however, to the pleasure of his company at some future date.

We hope to provide the following program for the remainder of the session and trust it will be as successful as past programs. A cordial invitation is extended to any of our readers who happen to be in Scarborough on the evening that any of the papers are being given, the time and place of all meetings being the Civil Service Club at 7.30 p.m.

28th January—Ten-minute papers, by members of the Centre.

25th February—Films and travel talks, by T. Jordan.

25th March—"Fluorescent Lighting," by W. Bradley.

W. B.

## Sheffield Centre

We are proud to report the success of one of our Chesterfield members, Mr. F. S. Brasher, in the 1956–57 Awards for Associate Section Papers. His paper on "Some Aspects of Modern Tape Recorders" was placed first in order of merit.

Since our last report we have made two more interesting visits. The first was to the glass works of the B.T.H. company. Their products include glass envelopes for all sizes of electric light bulb and for radio valves. These are blown either by hand or by machine, depending on the number required. The manufacture of tubing was particularly impressive; molten glass, poured on to a revolving mandrel with a jet of air through the centre, is drawn 200 yards or so down a shop to cool, and is finally cut to length by a carborundum wheel which moves with the tubing.

The second visit, to Sheepbridge Stokes, proved equally interesting. The centrifugal casting process is used here in making cylinder liners for engines of all sizes from small cars to marine diesels. The castings are machined and the bores are honed by automatic machines capable of working to a few ten-thousandths of an inch. Finally, the liners are put on a machine which simultaneously checks all dimensions and gives a lamp indication of any undersized or oversized measurement.

Our future program includes a lecture on "Printed Circuits," by Mr. Willmott of the Lincoln Area, an open meeting featuring colour films of Derbyshire, and a works visit to follow up a lecture by the technical manager of a well-known magnet-manufacturing company.

We thank our Leeds colleagues for their kind invitation to their lecture on the "Transatlantic Cable." J. E. S.

## Sunderland Centre

On Friday, 27th September, the Centre opened its program with a film show given by Mr. A. V. Jones of the Northern Gas Board. Two of the films were about the production of gas while the others were in more humorous vein and showed the amazing "Mr. Pastry" tackling the family wash without the aid of gas. The film show was the prelude to an intended visit to the Sunderland Gas Works, but unfortunately the visit could not be arranged during daylight and had to be postponed until the spring. Our thanks are due to Mr. A. V. Jones for an enjoyable evening.

The second item in the program was the visit to the Centre of Mr. W. V. Hornsby, an ex-president of the Sunderland Photographic Association. Mr. Hornsby talked for 90 minutes and, in an excellent introduction to a most interesting subject, gave many useful hints on the photographic art. To quote one of the members: "After listening to the lecture I think it is remarkable how I ever managed to take a photograph at all." There were several large-sized photographs (all of exhibition standard) on view to illustrate the talk; some of the shots were local in character and others were of continental scenes. Mr. Hornsby has kindly offered to come again and we look forward to his next talk. D. A. C.

## Leeds Centre

25th November was the date chosen to commemorate the Silver Jubilee of the Associate Section by asking Mr. H. E. Robinson and Mr. B. Ash from the Engineer-in-Chief's Office to give their talk and film show about the laying of the overland section of the transatlantic telephone cable. It is hoped to report on this talk in the next issue of the Journal.

In addition to the events advertised in the program, 12 members will have visited H.M.T.S. *Monarch* at Erith, on the River Thames. About 30 members applied to go, and it was unfortunate that the party was restricted, but whenever the opportunity for a further visit presents itself arrangements will be advertised.

The committee once again wishes to remind members of the facilities available for the circulation of technical periodicals. Anyone who is interested should let the chairman or secretary know.

At the time of writing these notes the membership stands at 184, and we hope to increase the number considerably this session. To non-members we would like to say, here is the opportunity to find out more about our own and other industries. The more members we have the more varied and interesting we can make the program. Why not come along to one of our advertised meetings at the Griffin Hotel as a guest, and see if we provide the sort of thing you like?

A. A. G.

## London Centre

On Tuesday, 1st October, 1957, the London Centre opened its Silver Jubilee celebrations with a lecture entitled "The Progress of Underwater Exploration," given by Mr. J. C. G. Gilbert, in The Institution of Electrical Engineers' lecture theatre at Savoy Place, London. This was the second session that the opening lecture was of a non-technical nature with an open invitation to members' wives and friends and Senior Section members. Mr. Gilbert, who is Consultant to Siebe Gorman & Co., Ltd., and a member of B.B.C. "Inventors Club," gave a brief historical survey of underwater exploration, types of equipment used for shallow and deep diving, communication methods, lighting problems, still and cine photography and underwater television. The lecture was illustrated by examples of equipment, including two life-sized models in shallow-water-diving and deep-water-diving gear, numerous slides, and films in black-and-white, and colour.

The following day saw the opening of the exhibition "Telecommunications, Past, Present and Future" (reported elsewhere in this Journal). Prior to the opening, Mr. Palmer outlined the objects of the exhibition to over a dozen members of the technical press, and at 11.30 a.m. introduced Mr. R. J. Halsey, Assistant Engineer-in-Chief, to the approximately 200 people who had assembled there for the opening. Regarding the exhibition, the London Centre would like to put on record their thanks to everybody who assisted in some way or other, the Post Office, the Contractors, Senior Section and Associate Section members, and many others who helped to stage the exhibition.

The more "far-seeing" members of the exhibition sub-committee had considered that, by A.D. 2000, use would be made of earth satellites to achieve full inter-continental dialling, and to this end a model of such a satellite was constructed and "made airborne" in the exhibition. Its practical use was demonstrated by "beaming" a s.h.f. transmission on to the satellite and "collecting" the reflexions. It hardly raised a murmur amongst the visitors, and was only considered as a humorous touch. Yet the day after the exhibition had closed, Russia launched her satellite into outer space, and following the second one, a correspondent of one of the daily papers said—"World Cable companies can already see the 'bleep, bleep, bleep' of the Russian sputnik translated into telegraph traffic between, say, Britain and Australia."

On the 2nd October, 1957, the London Centre Central Committee entertained Presidents past and present, members of the Senior Section, members of the Post Office Engineering Department, honorary members of the Associate Section, and other people who had assisted with the organization of the exhibition, to dinner. It was a homely and excellent affair held at Waterloo Bridge House; the speakers included Mr. R. W. Palmer, Mr. C. W. Brown and Mr. B. G. Woods. Mr. Palmer "delved" into the future, and took an exhibit from the exhibition as an example of how one could still learn from past developments. Mr. C. W. Brown, who was the first President of the then Junior Section, talked of the early days of the Junior Section and said how pleased he was to be still participating in its activities. An informal touch was added to the evening when Mr. C. Biddlecombe, on behalf of the London Centre honorary members, presented the Chairman of the London Centre, Mr. A. G. Welling, with a gavel and stand suitably marked to commemorate the Silver Jubilee.

For the first time for at least seven years, films were shown at a London Centre meeting at Waterloo Bridge House, on Wednesday, 6th November, 1957, when "Mirror in the Sky," "Foothold on Antarctica," and "The First Transatlantic Telephone Cable" were shown; all three films had been made within the last 12 months, and the latter two had their first private showing. The experiment proved successful for the attendance was in the region of 150.

The meetings for the next three months are given below:—

21st January—"Pulse Techniques in Telephone Exchanges," by T. H. Flowers, M.B.E.

19th February—"The Work of the Royal Observatory," by Dr. A. Hunter, F.R.A.S.

25th March—"Radio-activity and some Peaceful Applications," by K. O. Verity.

P. S.

### Chichester Centre

The 1956–1957 session opened on 12th September, 1956, with two films, "The Oilmen" and "Powered Flight," by courtesy of Shell & B.P. 10th October brought a welcome return of the lecturers from Messrs. L.E.C., with a lecture on "Refrigeration."

In November, Messrs. Shell & B.P. sent the films "Rig 20" and "The Rival World."

Mr. W. C. Jackson came in December to give a talk on "Contracts," which was illustrated by many photographs. In January, Mr. F. J. Gibbs lectured on "Experiences in Portsmouth Area," and as he had also served with the National Telephone Company, a very interesting evening was enjoyed by all members present.

The next lecture was in March on "Free Piston Engines," which was given by Mr. N. L. Fletcher.

Our Annual General Meeting was held on the 10th April, when the following officers were elected:—*Chairman:* R. D. Barrett; *Vice-Chairman:* A. V. Pont; *Treasurer:* A. T. Yardley; *Secretary:* H. S. Pennicott; *Committee:* Messrs. Jackson, Jenkins, Butler and Baldwin.

The attendance during this session was between 50 and 60 per cent of the membership.

For the 1957–58 session many interesting lectures and visits have been arranged and the program for the second half of the session is:—

18th January—"Point of Departure," "Enterprise" and "H.M. The Queen at Wilton." Films by courtesy of I.C.I., Ltd.

12th February—"Planning of Telephone Plant for New Estates." Talk by J. A. Harrington.

12th March—"Trunk Mechanization." Talk by S. Paterson, Senior Telecommunications Superintendent.

10th April—Annual General Meeting and film show.

All meetings are at "The White Horse," at 7.15 p.m., unless otherwise advertised.

H. S. P.

---

## Book Review

"Transmission Circuits." E. M. Williams and J. B. Woodford. The Macmillan Company, New York and London. 156 pp. Illustrated. 30s.

This rather expensive book, by a Professor and an Assistant Professor of Electrical Engineering at the Carnegie Institute of Technology, has been written for the student and is, inevitably, a conventional treatment of the uniform transmission line; from this treatment follows a development of equivalent networks, loading, and an introduction to simple equalizer and filter networks. It differs from the run of books on transmission line theory by considering first the conditions under which the distributed parameter approach is valid. The development of the expressions for voltage and current at any point along a uniform line follows the conventional course but the solution of the differential equations in hyperbolic form instead of the equivalent exponential form makes it more difficult to display to the student the physical significance of characteristic impedance and propagation coefficient and the fact that there are, in general, two waves present on a terminated line, one a direct wave and the other a reflected wave; all these points are more easily brought out by considering the factors in the exponential expressions. It is a pity that the term "constant" is used where the accepted British standard term is "coefficient"; this puts into the student's mind the false idea that the primary coefficients (here called constants) do not vary with frequency and gives him the impression that the "distortionless condition" is capable of practical realization by loading instead of being only a "mathematical" condition. It is this undigested book learning that so frequently gives rise to the answer to a question on loading "loading is added to a line to make it distortionless, i.e. $LG = RC$."

From a practical point of view, the full expressions for the attenuation and phase coefficients of a uniform line are of little importance (except as a first step towards proving the "distortionless condition") and the student should be encouraged to calculate these coefficients from the complex form of the propagation coefficient.

There are excursions from the communication engineer's world into that of the power engineer showing that the one mathematical approach may be used in both worlds and that the two worlds are in fact one. Power transmission lines for direct current transmission and feeders for passing radio-frequency energy from a transmitter to an aerial are dealt with and at frequencies lying between these limits the use of synchronous condensers and carrier systems are briefly mentioned. Transients on a transmission line are investigated by using the repeated reflection of a wave at the terminal discontinuities but the very brief explanation of the formation of echoes on long telephone circuits is almost misleading.

The Smith chart is mentioned in passing, but the explanation is insufficient for a student, meeting it for the first time, to understand how to use it.

There are two appendices. One deals very inadequately with hyperbolic functions; if this elementary treatment is necessary, the numerical evaluation of the hyperbolic functions of a complex quantity and the inverse operation should have been included, and such an addition would be most useful to the many students who can manipulate these functions algebraically but who are unable to use them numerically. The second appendix shows how Maxwell's field theory can be applied to wave-guides.

There are many problems at the ends of the chapters and these are of three types: one type requires little more than substitution in formulae, a second requires the development of aspects of theory deliberately omitted from the text and a third type sets a problem "which will challenge the student's capacity as a developing engineer."

As is usual in American literature the expressions used for frequency are not consistent; megacycles, mc/sec, KC/sec and c.p.s. being some of the variants used. This is a first printing and a few errors have been noted; of these the only one likely to cause some difficulty is that equations (1–3) and (1–4) on p. 8 should in fact be equations (1–1) and (1–2) with steady-state complex values.

F. S.

# Staff Changes

## Promotions

*Area Engr. to Asst. Staff Engr.*

| Name | Region | Date |
|---|---|---|
| Blair, D. C. | H.C. Reg. to E.-in-C.O. | 23.9.57 |

*Senr. Exec. Engr. to Chief Factories Engr.*

| Name | Region | Date |
|---|---|---|
| Urben, T. F. A. | E.-in-C.O. to Factories Dept. | 2.9.57 |

*Exec. Engr. to Area Engr.*

| Name | Region | Date |
|---|---|---|
| Halliday, C. L. | N.W. Reg. | 3.6.57 |
| Tinto, J. M. | S.W. Reg. | 15.7.57 |
| Saxby, F. H. | Mid. Reg. | 20.7.57 |

*Exec. Engr. to Senr. Exec. Engr.*

| Name | Region | Date |
|---|---|---|
| Kent, S. T. E. | L.T. Reg. to E.-in-C.O. | 1.7.57 |
| Mayne, R. T. | N.E. Reg. to E.-in-C.O. | 22.7.57 |
| Wray, D. | E.-in-C.O. | 22.7.57 |
| Harris, L. R. F. | E.-in-C.O. | 2.8.57 |
| Lloyd, H. F. | E.-in-C.O. | 2.8.57 |
| Gearing, A. | E.-in-C.O. | 19.8.57 |
| Hills, A. F. | E.T.E. | 21.8.57 |
| Machen, G. F. | E.-in-C.O. | 5.9.57 |
| Tattersall, R. L. O. | E.-in-C.O. | 20.9.57 |

*Asst. Engr. to Exec. Engr.*

| Name | Region | Date |
|---|---|---|
| Agate, M. S. | E.-in-C.O. to Factories Dept. | 15.7.57 |
| Archer, E. W. | L.T. Reg. to E.-in-C.O. | 26.7.57 |
| Prain, H. | E.-in-C.O. | 8.7.57 |
| Garlick, A. | L.T. Reg. | 12.6.57 |
| Waters, R. E. | L.T. Reg. | 12.6.57 |
| Kraushaar, H. G. | L.T. Reg. | 10.7.57 |
| Dowling, A. G. | E.-in-C.O. | 23.7.57 |
| Holdsworth, F. | N.E. Reg. | 7.8.57 |
| Norris, H. E. | H.C. Reg. | 4.8.57 |
| Punchard, L. C. E. | L.T. Reg. | 11.7.57 |
| King, A. | Scot. | 7.8.57 |
| Lawson, R. | N.E. Reg. | 19.8.57 |
| Barralet, A. F. | L.T. Reg. | 23.7.57 |
| Parsons, R. J. | E.-in-C.O. | 18.9.57 |
| Genna, W. N. | E.-in-C.O. | 1.10.57 |
| Woolford, S. W. | E.T.E. | 27.8.57 |
| Heaton, N. | N.E. Reg. | 15.8.57 |
| Ogden, R. S. I. | N.E. Reg. to E.-in-C.O. | 2.9.57 |
| Woolley, C. E. | Mid. Reg. to E.-in-C.O. | 4.9.57 |
| Fuller, W. | Mid. Reg. to H.C. Reg. | 9.9.57 |
| Foster, H. A. L. | L.T. Reg. to E.-in-C.O. | 2.9.57 |
| Joyce, C. W. | Mid. Reg. | 13.9.57 |

*Asst. Engr. (Open Competition)*

| Name | Region | Date |
|---|---|---|
| Curran, D. A. | E.-in-C.O. | 6.8.57 |
| Hoy, W. | E.-in-C.O. | 2.9.57 |
| True, J. S. | E.-in-C.O. | 2.9.57 |

*Inspector to Asst. Engr.*

| Name | Region | Date |
|---|---|---|
| Hubbard, B. F. | Mid. Reg. | 24.9.56 |
| Chattaway, G. R. | Mid. Reg. | 11.3.57 |
| Phillips, A. | Mid. Reg. | 1.4.57 |
| Turnbull, R. R. | Scot. | 10.6.57 |
| Jones, J. | N.W. Reg. | 4.8.57 |
| Patrick, A. G. | Scot. | 16.6.57 |
| Watkinson, W. | N.E. Reg. | 4.5.57 |
| Bridges, E. W. C. | H.C. Reg. | 19.6.57 |
| Bourne, A. D. | L.T. Reg. | 1.10.57 |
| Jones, W. R. | L.T. Reg. | 4.3.57 |
| Dedmen, F. F. | L.T. Reg. | 1.9.57 |
| Fabian, D. F. | L.T. Reg. | 1.5.57 |

*Tech. Offr. to Asst. Engr.*

| Name | Region | Date |
|---|---|---|
| Chrisp, C. D. | N.E. Reg. | 19.11.56 |
| Donaldson, J. H. | Scot. | 11.5.57 |
| Lloyd, T. H. H. | N.I. | 27.6.57 |
| Stephenson, G. B. | N.W. Reg. | 12.7.57 |
| Kavanagh, J. E. | N.W. Reg. | 12.7.57 |
| Murray, J. | Scot. | 10.8.57 |
| Dorrington, L. A. | S.W. Reg. | 29.12.56 |
| Simmons, R. G. | H.C. Reg. | 16.6.57 |
| Rowland, J. F. A. | H.C. Reg. | 10.5.57 |
| Woods, G. | S.W. Reg. | 6.5.57 |
| Brice, E. C. | E.T.E. | 2.9.57 |
| Rennie, A. J. | E.T.E. | 25.7.57 |
| Leitch, R. | E.T.E. | 25.7.57 |
| Thurlow, C. A. | N.E. Reg. | 26.3.57 |

*Tech. Offr. to Asst. Engr. (continued)*

| Name | Region | Date |
|---|---|---|
| Warwick, F. L. S. | E.T.E. to E.-in-C.O. | 13.8.57 |
| Bauer, E. | N.E. Reg. | 1.4.57 |
| Butler, R. K. | N.E. Reg. | 7.2.57 |
| Cary, L. F. | N.E. Reg. | 18.3.57 |
| Palfreyman, W. | N.E. Reg. | 1.4.57 |
| Hall, R. C. | N.W. Reg. | 14.8.57 |
| Blomley, F. | N.W. Reg. | 12.8.57 |
| Michie, J. C. | Scot. | 1.8.57 |
| Davis, R. W. | S.W. Reg. | 17.5.57 |
| Orton, C. B. | S.W. Reg. | 14.9.57 |
| Dunford, P. F. | E.T.E. | 16.9.57 |
| Ramsbotham, A. E. | N.W. Reg. | 9.9.57 |
| Hedley, A. | H.C. Reg. | 19.6.57 |
| Crampthorn, R. H. | H.C. Reg. | 19.6.57 |
| Pidoux, L. V. | H.C. Reg. | 1.7.57 |
| Roberts, R. J. | H.C. Reg. | 1.7.57 |
| Hampson, K. C. | H.C. Reg. | 1.7.57 |
| Briggs, F. | N.E. Reg. | 21.7.57 |
| Purt, D. A. | N.E. Reg. | 3.8.57 |
| Slater, G. R. | N.W. Reg. | 27.9.57 |

*Tech. Offr. to Inspector.*

| Name | Region | Date |
|---|---|---|
| MacDonald, G. G. | Mid. Reg. | 22.10.56 |
| Shepherd, W. J. | Mid. Reg. | 6.8.57 |
| Wilkins, D. A. | Mid. Reg. | 1.7.57 |
| Waterworth, S. | N.W. Reg. | 12.7.57 |
| Crimmin, R. A. | W.B.C. | 26.8.57 |
| Otway, J. | W.B.C. | 26.8.57 |
| Simpson, W. | N.E. Reg. | 10.11.56 |
| Hughes, J. M. | Scot. | 2.9.57 |

*Tech. I to Inspector.*

| Name | Region | Date |
|---|---|---|
| Price, W. C. | W.B.C. | 3.6.57 |
| Edwards, B. M. | W.B.C. | 13.2.57 |
| Williams, K. F. | W.B.C. | 12.3.56 |
| Lloyd, W. A. | W.B.C. | 22.7.57 |
| Seaton, A. A. | W.B.C. | 18.2.57 |
| Parham, M. R. | S.W. Reg. | 12.11.56 |
| Scott, C. | W.B.C. | 11.6.57 |
| Cowley, A. L. | N.E. Reg. | 30.11.56 |
| Burnett, J. T. | Scot. | 16.8.57 |
| Sheridan, G. H. | N.I. | 6.5.57 |
| Geen, G. A. | W.B.C. | 1.6.56 |
| Clifton, B. M. | N.E. Reg. | 26.6.57 |
| Newberry, L. G. W. | S.W. Reg. | 26.8.57 |
| Fletcher, J. | N.E. Reg. | 5.12.55 |
| Johnson, R. R. | N.E. Reg. | 15.7.57 |
| Starkey, H. | N.E. Reg. | 11.1.56 |
| Birkitt, G. W. | N.E. Reg. | 30.3.57 |
| Smith, R. J. | N.E. Reg. | 20.5.57 |
| LeClere, V. | N.E. Reg. | 12.9.55 |
| Lean, G. | N.E. Reg. | 8.4.57 |
| Roberts, G. | N.E. Reg. | 13.3.56 |
| Kindleysides, J. | N.E. Reg. | 27.2.56 |
| Brayshaw, W. | N.E. Reg. | 15.4.57 |
| Smith, S. | N.E. Reg. | 31.7.57 |
| Grundy, P. N. | N.E. Reg. | 26.9.57 |
| Illingworth, J. D. | N.E. Reg. | 15.7.57 |
| Stitt, J. A. G. | Scot. | 10.6.57 |
| Meech, J. W. | H.C. Reg. | 16.8.57 |
| Parsons, G. E. | H.C. Reg. | 16.8.57 |
| Bone, F. C. | H.C. Reg. | 16.8.57 |
| Low, L. G. | H.C. Reg. | 16.8.57 |
| Sussans, R. H. | H.C. Reg. | 16.8.57 |
| Siddle, G. | H.C. Reg. | 26.8.57 |
| McCormack, V. | N.I. | 9.9.57 |

*Snr. Sc. Offr. (Open Competition).*

| Name | Region | Date |
|---|---|---|
| Daglish, H. N. | E.-in-C.O. | 14.8.57 |

*Exptl. Offr. (Open Competition).*

| Name | Region | Date |
|---|---|---|
| Baker, D. | E.-in-C.O. | 3.7.57 |
| Wells, C. R. | E.-in-C.O. | 18.7.57 |
| Taylor, J. D. | E.-in-C.O. | 19.7.57 |

*Asst. Exptl. Offr. (Open Competition).*

| Name | Region | Date |
|---|---|---|
| Davis, P. | E.-in-C.O. | 4.7.57 |
| Little, D. J. | E.-in-C.O. | 26.9.57 |
| Conen, B. H. | E.-in-C.O. | 26.9.57 |

**Promotions—*continued.***

| Name | Region | Date |
|---|---|---|
| *Asst. (Sc.) (Open Competition).* | | |
| Watson, P. A. | E.-in-C.O. | 17.9.57 |
| *Dsman. to Ldg. Dsman.* | | |
| Bloor, F. | Mid. Reg. | 26.7.57 |
| *S.E.O. to C.E.O.* | | |
| Southgate, A. G. | E.-in-C.O. | 1.8.57 |
| *H.E.O. to S.E.O.* | | |
| Kirby, H. K. | E.-in-C.O. | 3.12.56 |
| Ridland, L. | E.-in-C.O. | 1.10.56 |
| Root, J. M. (Miss) | E.-in-C.O. | 1.8.57 |
| *E.O. to H.E.O.* | | |
| Coe, G. M. M. (Miss) | E.-in-C.O. | 4.10.56 |
| Pearce, J. R. | E.-in-C.O. | 1.2.57 |
| Henderson, H. F. | E.-in-C.O. | 3.12.56 |
| Richart, E. W. T. | E.-in-C.O. | 2.11.56 |
| Elston, V. (Miss) | E.-in-C.O. | 15.7.57 |
| Jackson, W. F. | E.-in-C.O. | 29.7.57 |
| Merrony, A. E. | E.-in-C.O. | 19.8.57 |
| *C.O. to E.O.* | | |
| Offord, E. C. | E.-in-C.O. | 23.5.57 |
| Zeugner, I. (Miss) | E.-in-C.O. | 12.7.57 |
| White, L. A. | E.-in-C.O. | 6.8.57 |
| Rice, V. H. | E.-in-C.O. | 6.8.57 |
| Lockwood, E. R. (Miss) | E.-in-C.O. | 12.8.57 |

**Retirements and Resignations**

| Name | Region | Date |
|---|---|---|
| *Asst. Staff Engr.* | | |
| Helman, S. L. | E.-in-C.O. | 3.8.57 |
| *Regional Engr.* | | |
| Smith, H. S. | H.C. Reg. | 16.8.57 |
| *Area Engr.* | | |
| Jeynes, E. H. | S.W. Reg. | 30.9.57 |
| *Snr. Exec Engr.* | | |
| Thwaites, J. E. | E.-in-C.O. | 9.8.57 |
| Gray, W. D. | E.-in-C.O. | 23.9.57 |
| *Exec. Engr.* | | |
| Worth, W. B. | L.T. Reg. | 16.2.57 |
| Porter, E. R. C. | H.C. Reg. | 2.7.57 |
| Pendry, S. D. | H.C. Reg. | 3.8.57 |
| Mathews, R. F. | L.T. Reg. | 27.8.57 |
| Larner, F. L. | E.-in-C.O. | 31.8.57 |
| Gregory, G. | E.-in-C.O. | 30.9.57 |
| Perkins, F. T. | L.T. Reg. | 30.9.57 |
| Crank, F. G. (*Resigned*) | E.-in-C.O. | 31.8.57 |
| de Wardt, R. H. (*Resigned*) | E.-in-C.O. | 13.9.57 |
| Stretton, F. C. (*Resigned*) | E.-in-C.O. | 18.9.57 |
| Gravett, K. W. E. (*Resigned*) | E.-in-C.O. | 30.9.57 |
| *Asst. Engr.* | | |
| Moulds, H. | N.E. Reg. | 1.4.57 |
| Fox, H. | N.E. Reg. | 25.5.57 |
| Davis, J. H. | L.T. Reg. | 1.7.57 |
| Coles, F. S. | S.W. Reg. | 3.7.57 |
| Hellings, H. C. | L.T. Reg. | 12.7.57 |
| Vause, W. G. | N.E. Reg. | 20.7.57 |
| Leedham, F. V. | N.E. Reg. | 23.7.57 |
| Thompson, E. | N.W. Reg. | 25.7.57 |
| Lethbridge, S. W. | L.T. Reg. | 28.7.57 |
| Topham, C. L. | Mid. Reg. | 7.8.57 |
| McKenzie, W. H. | Scot. | 1.8.57 |
| Bridger, F. L. | L.T. Reg. | 14.8.57 |
| Tuck, R. F. | Mid. Reg. | 18.8.57 |
| Bent, G. P. | N.W. Reg. | 21.8.57 |
| Farmery, C. B. | N.E. Reg. | 30.8.57 |
| Worrall, R. | L.T. Reg. | 31.8.57 |
| Hill, J. | N.E. Reg. | 31.8.57 |
| Bottomley, J. K. | N.E. Reg. | 31.8.57 |
| Corbett, G. | N.E. Reg. | 31.8.57 |
| Rice, S. G. | H.C. Reg. | 2.9.57 |
| Williams, T. G. (*Resigned*) | E.-in-C.O. | 31.8.57 |
| Foulkes, R. T. (*Resigned*) | E.-in-C.O. | 31.7.57 |
| Neal, J. D. | H.C. Reg. | 31.8.57 |
| Rowell, G. | N.E. Reg. | 11.9.57 |
| Matthews, C. J. | E.T.E. | 11.9.57 |
| Whiteley, A. | N.W. Reg. | 18.9.57 |
| Ramsey, K. L. | N.W. Reg. | 23.9.57 |
| Rafferty, J. S. | W.B.C. | 24.9.57 |
| *Asst. Engr. (continued).* | | |
| Frankland, A.M.P.H. | H.C. Reg. | 30.9.57 |
| Morris, W. G. | E.-in-C.O. | 30.9.57 |
| Rawson, P. | N.W. Reg. | 30.9.57 |
| Daines, W. J. J. | H.C. Reg. | 1.10.57 |
| Kennedy, J. A. | N.W. Reg. | 11.10.57 |
| Dawson, P. R. (*Resigned*) | H.C. Reg. | 31.8.57 |
| Campbell, G. M. (*Resigned*) | E.-in-C.O. | 3.10.57 |
| *Inspector.* | | |
| Hollingworth, T. | N.E. Reg. | 8.4.57 |
| Charlesworth, E. | N.E. Reg. | 27.7.57 |
| Newman, J. W. | L.T. Reg. | 27.7.57 |
| Causton, R. K. | E.-in-C.O. | 4.8.57 |
| Horwood, A. A. | L.T. Reg. | 4.8.57 |
| Russell, W. S. | Scot. | 16.8.57 |
| Prosser, F. | L.T. Reg. | 31.8.57 |
| Morris, A. | N.E. Reg. | 31.8.57 |
| Montgomery, D. | Scot. | 1.9.57 |
| Robbins, W. S. | Mid. Reg. | 11.9.57 |
| Chapman, R. W. | L.T. Reg. | 12.9.57 |
| Vessey, W. | L.T. Reg. | 13.9.57 |
| Found, L. | N.E. Reg. | 25.9.57 |
| Hillier, E. | H.C. Reg. | 28.9.57 |
| Hill, G. H. | L.T. Reg. | 11.10.57 |
| *Sc. Offr.* | | |
| Rowe, T. J. (*Resigned*) | E.-in-C.O. | 30.9.57 |
| *Exptl. Offr.* | | |
| Reynolds, A. E. (*Resigned*) | E.-in-C.O. | 30.9.57 |
| *Asst. Exptl. Offr.* | | |
| Stringfellow, K. (Miss) (*Resigned*) | E.-in-C.O. | 25.9.57 |
| *Tech. Asst. (Sc.)* | | |
| Pasmore, D. J. (*Resigned*) | E.-in-C.O. | 4.10.57 |
| *Ldg. Dsman.* | | |
| Plumb, W. A. | E.-in-C.O. | 12.7.57 |
| Tennant, T. M. | E.-in-C.O. | 11.8.57 |
| Grinstead, P. A. | H.C. Reg. | 21.8.57 |
| *C.E.O.* | | |
| Glover, G. | E.-in-C.O. | 31.7.57 |
| *E.O.* | | |
| Spencer, W. S. | E.-in-C.O. | 2.7.57 |

**Transfers**

| Name | Region | Date | Name | Region | Date |
|---|---|---|---|---|---|
| *Asst. Staff Engr.* | | | *Asst. Engr.* | | |
| Leckenby, A. J. .. | E.-in-C.O. to H.C. Reg. .. | 19.8.57 | Sandeman, W. P. .. | E.-in-C.O. to Malaya .. | 14.12.51 |
| Knight, N. V. .. .. | E.-in-C.O. to Singapore .. | 1.10.57 | Rawsthorne, A. L. .. | E.-in-C.O. to Turkey .. | 7.8.57 |
| | | | Randall, J. J. .. .. | E.-in-C.O. to Board of Trade | 12.8.57 |
| | | | Lucas, J. .. .. | E.-in-C.O. to L.T. Reg. .. | 15.8.57 |
| *Exec. Engr.* | | | Watters, T. J. A. .. | E.-in-C.O. to Ethiopia .. | 26.8.57 |
| Mitchell, F. J. H. .. | E.-in-C.O. to Factories Dept. | 1.8.57 | Macmahon, P. J. .. | E.-in-C.O. to L.T. Reg. .. | 23.9.57 |
| Hartley, A. L. .. | E.-in-C.O. to H.C. Reg. .. | 22.8.57 | | | |
| Gregory, A. R. .. | Scot. to E.-in-C.O. .. | 8.7.57 | | | |
| Widdicks, J. A. .. | E.-in-C.O. to Turkey .. | 24.7.57 | | | |
| Gaukroger, J. .. .. | E.-in-C.O. to N.W. Reg. .. | 29.7.57 | | | |
| Harrison, M. .. .. | Scot. to N.E. Reg. .. | 1.8.57 | *T.A. II.* | | |
| Leedham, R. V. .. | E.-in-C.O. to Ministry of Supply | 16.9.57 | Mountenay, G. H. .. | E.in-C.O. to H.C. Reg. .. | 30.8.57 |
| | | | Bignell, G. C. .. .. | H.C. Reg. to E.-in-C.O. .. | 30.8.57 |

**Deaths**

| Name | Region | Date | Name | Region | Date |
|---|---|---|---|---|---|
| *Exec. Engr.* | | | *Asst. Engr. (continued).* | | |
| Miller, H. .. .. | N.E. Reg. .. .. .. | 20.6.57 | Hodkinson, A. A. A. .. | N.E. Reg. .. .. .. | 31.8.57 |
| Goman, L. V. .. .. | E.-in-C.O. .. .. .. | 26.7.57 | Watson, W. C. .. .. | N.W. Reg. .. .. .. | 11.9.57 |
| | | | West, T. .. .. | N.E. Reg. .. .. .. | 16.9.57 |
| | | | Layton, C. .. .. | L.T. Reg. .. .. .. | 24.9.57 |
| *Asst. Engr.* | | | *Inspector.* | | |
| Smith, L. .. .. | Mid. Reg. .. .. .. | 22.7.57 | Parfitt, W. .. .. | N.E. Reg. .. .. .. | 30.7.57 |
| Watkins, R. .. .. | S.W. Reg. .. .. .. | 23.8.57 | | | |

## Book Review

"Fundamental Principles of Transistors." J. Evans, B.Sc., Ph.D., A.K.C. Heywood & Co., Ltd. xii + 255 pp. 45s.

The Preface and Foreword of this book explain that the work is aimed, in the main, at the recent graduate (presumably in physics or the "light" branch of electrical engineering), and that the book itself is based upon experience in lecturing in various technical colleges to such students. The approach to the many new ideas that must be introduced is a direct one, mainly descriptive, with many apt verbal illustrations and clear diagrams. There are 11 main chapters, commencing with the basic properties of semiconductors and their measurement, and the theory and preparation of p–n junctions. Chapter 6 gives a rapid survey of the basic properties of the p–n–p junction transistor, and of some of the possible special types of transistor. Essentially, the whole of the next chapter is devoted to the point-contact transistor. It is doubtful whether so much space should be given to this topic in view of the dominant position now occupied by the junction transistor as a practically mass-producible component—though the discussion of minority carrier trapping effects in this chapter is admirable.

Although the book explicitly keeps clear of the subject of transistor applications, it cannot avoid the consideration in some detail of the circuit properties of the transistor itself and the methods of measurement of these properties. The sketchiness of the approach here in Chapter 8 is disappointing and is not fully excused by the breadth of the field to be covered, as claimed in the first paragraph of the chapter. The breadth can be exaggerated, and the student unnecessarily scared away. One would surely expect the students to whom this book is directed to learn how to interpret the chief "users" parameters in terms of the elementary physics and technology of the transistor as a component. In the reviewer's opinion this chapter could usefully be expanded in the next edition, for example, to give the exact relations between the physicist's alpha, beta and gamma and the ohmic base resistance on the one hand, and the user's $\alpha_{ce}$, etc., on the other hand, and to include a more thorough consideration of equivalent circuits than that given in Chapter 6. In the next chapter, on device technology, it is surely unnecessary nowadays to mention (let alone to show two separate graphs related to) the use of the turnover voltage of a point-contact for estimating the resistivity of an ingot of germanium. The photograph of the slicing machine in Fig. 105 could well have been omitted. Some of the remarks, e.g. at the top of p. 181 relating to the degree of air purification necessary in an assembly plant, are refreshingly frank in their admission of ignorance of the degree of control that matters. Unfortunately, very little is said about encapsulation. The chapter on Special Types is in the nature of a postscript bringing the book up to date—and some of it is unfortunately already dated.

An intriguing Appendix, entitled "Teaching Transistor Physics," is rather a summary of a set of very simple laboratory demonstrations, qualitative rather than quantitative in nature, that will undoubtedly help the beginner to grasp the basic effects upon which the transistor depends for its operation. The second appendix, comprising a series of extracts from commercial data sheets, could have been omitted without loss: in view of the different bases upon which the different makers have hitherto rated transistors, e.g. their power outputs and collector voltages, it seems best to leave the student to look up the data for himself in the commercial publications or better, when available, in the appropriate CV specification.

A great deal of thought has clearly gone into the detailed wording of those parts of this book that deal with the physical processes involved in transistor action, and students will benefit from reading the book.

*I.P.O.E.E. Library No.* 2472. F. F. R.

## Book Received

"Wireless World Diary, 1958." T. J. & J. Smith, Ltd., in conjunction with *Wireless World*. 80 pages of reference material plus diary pages of one week to an opening. Size $4\frac{1}{2}$ in. × $3\frac{1}{8}$ in. Leather, 6s. 3d.; Rexine, 4s. 6d.; postage 4d.

The comprehensive reference section includes general information, such as abbreviations, screw sizes and weights and measures, and information on radio topics such as addresses of radio organizations, licence regulations, frequency allocations and v.h.f. sound and television broadcasting stations; over half the reference section is occupied by miscellaneous circuits, formulae and general circuit-design data.

# Post Office Electrical Engineers' Journal

## Volume 50, April 1957—January 1958

# INDEX

**I.P.O.E.E.** (*continued from p.* 269).

2454 *The Management Approach to Electronic Digital Computers.* J. S. Smith (Brit. 1957).
Describes in everyday language the way computers work and puts them in proper perspective as important tools for management.

2455 *Handbook of Semiconductor Electronics.* Ed. L. P. Hunter (Amer. 1956).
A thorough, comprehensive guide and reference for all concerned with the design and application of semiconductor devices.

2456 *Mathematics and Computers.* G. R. Stibitz and J. A. Larivee (Amer. 1957).
Covers the field of applied mathematics, with particular attention to automatic digital computers as useful tools in the increasingly important applications of mathematics to science, technology and business.

2457 *The Theory of Networks in Electrical Communication and Other Fields.* F. E. Rogers (Brit. 1957).
Presents those principles of network theory that are of first importance to students of final-year Engineering Degree or Diploma standard.

2458 *Probability and Scientific Inference.* G. S. Brown (Brit. 1957).
An analysis of what the author considers to be wrong in scientific statistical calculations; the remedies; and a discussion on the wider issues of scientific knowledge.

2459 *The Inhabited Universe.* K. W. Gatland and D. D. Dempster (Brit. 1957).
Covers the whole subject of the evolution of intelligent beings throughout the universe, from the present Stone Age of groping awareness on this earth to the now calculable future of this and other worlds.

2460 *Atmospheric Electricity.* J. A. Chambers (Brit. 1957).
A comprehensive treatise, including the phenomena of fine and disturbed weather.

2461 *Physics for Science and Engineering.* R. L. Webber, M. W. White and K. V. Manning (Amer. 1957).
Aims at assisting technical students to acquire a precise understanding of the important physical principles that are the foundations of all advanced work in science and technology.

W. D. Florence,
*Librarian.*




**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 3s. Subscribers can have their copies of volumes bound, at a cost of 10s. 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.

**Back Numbers**

The price of the Journal, which is published quarterly, is 2s. 6d. (3s. 3d. post free) per copy, or 13s. per annum, post free. Back numbers can be supplied, subject to availability of stocks, at 2s. 6d. (3s. 3d. each post free) except for Vol. 49, Part 4 (January 1957), the Transatlantic Telephone Cable issue, the price of which is 12s. 6d. (post free). Orders for back numbers may be sent to the *P.O.E.E. Journal*, Engineer-in-Chief's Office, Alder House, Aldersgate Street, London, E.C.1, or to the Publishers.
Employees of the British Post Office can obtain the *Journal* through Local Agents at the reduced price of 2s. per copy.

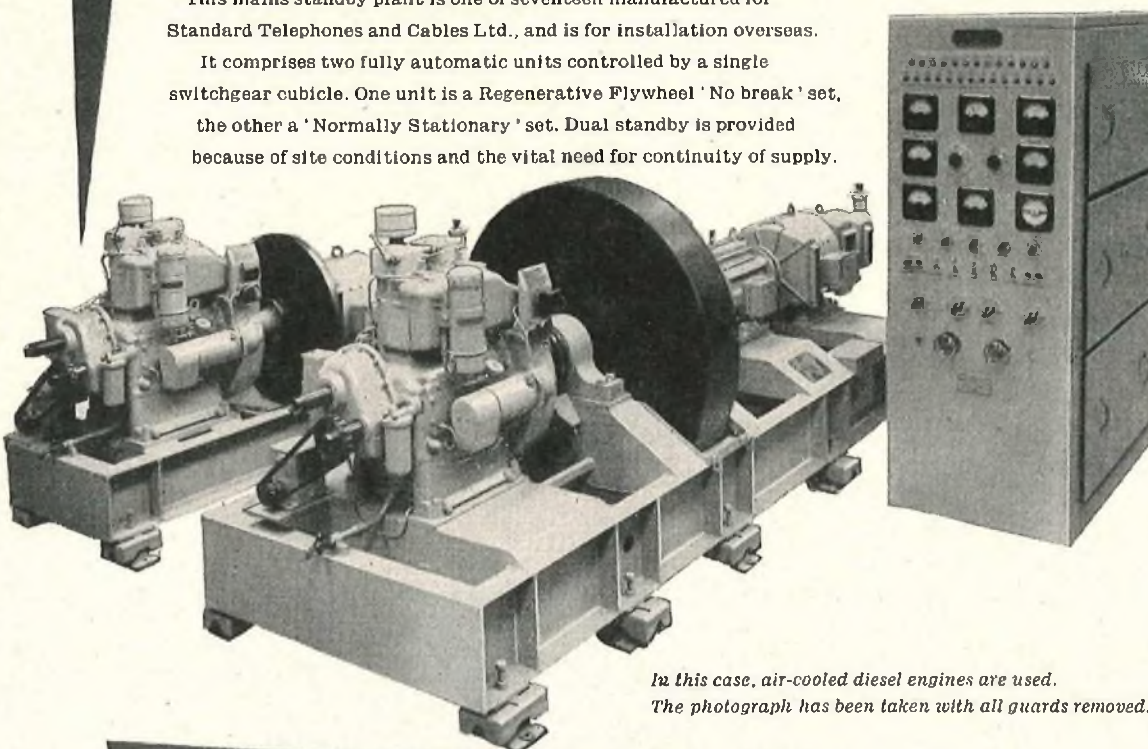
**Advertisements**

All communications relating to space reservations should be addressed to the Advertisement Editor, *P.O.E.E. Journal*, Alder House, Aldersgate Street, London, E.C.1. Communications regarding advertisement copy, proofs, etc., should be addressed to the Publishers, Messrs. Birch & Whittington (Prop. Dorling & Co. [Epsom] Ltd.), Depot Road, Epsom, Surrey.

## INDEX TO ADVERTISERS

# Power without fail
# —AUTOMATICALLY

This mains standby plant is one of seventeen manufactured for Standard Telephones and Cables Ltd., and is for installation overseas. It comprises two fully automatic units controlled by a single switchgear cubicle. One unit is a Regenerative Flywheel 'No break' set, the other a 'Normally Stationary' set. Dual standby is provided because of site conditions and the vital need for continuity of supply.



*In this case, air-cooled diesel engines are used. The photograph has been taken with all guards removed.*

## This is what happens

1. *Mains within limits.* The three-phase electric motor drives both flywheel and alternator of the 'No-Break' set (foreground), the alternator supplying regulated single phase current to the telecommunications equipment.
2. *Mains outside limits.* The electric motor is disconnected, the diesel engine starts automatically and when up to speed is connected to the alternator by the magnetic clutch. During this cycle, stored energy in the flywheel drives the alternator, thus maintaining a continuous power supply within the closest limits of frequency and voltage.
3. *Mains restored within limits.* The electric motor is automatically reconnected and resumes the drive, the magnetic clutch opens and the diesel engine shuts down.
4. Should the 'No-Break' set develop a fault, the 'Normally Stationary' set (background, left) starts and takes over supply to the equipment. The sets are designed to restrict the supply interruption to the minimum possible under the circumstances of the fault. Manual paralleling of the two sets is provided for maintenance periods.

CONTROL. Automatic controls and indicators are provided to ensure reliable operation in accordance with designed limits.

*Austinlite*

**AUTOMATIC POWER PLANT**

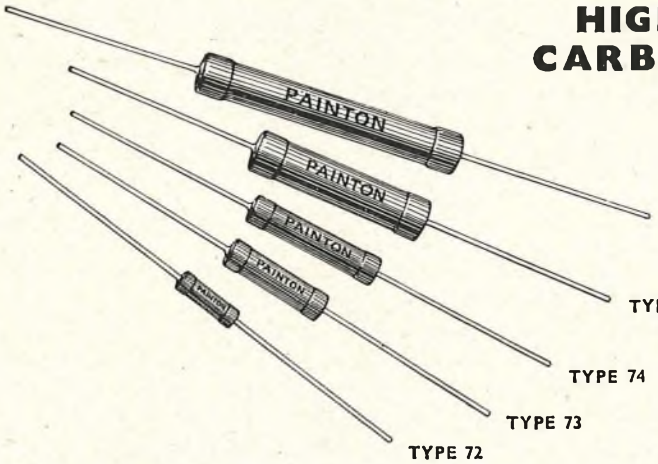
**Tailor-made by**
**STONE-CHANCE LTD.**

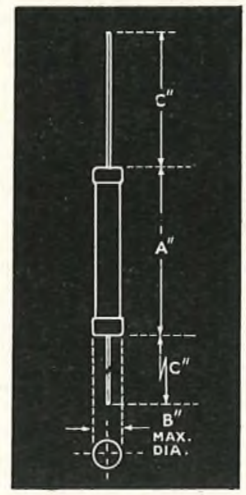
(makers of Sumo Pumps and Stone-Chance Lighthouses)
CRAWLEY, SUSSEX.

PAINTON

*By Appointment to the Professional Engineer*

# HIGH STABILITY CARBON RESISTORS




## ELECTRICAL CHARACTERISTICS

The electrical characteristic of a High Stability Carbon Resistor depends upon the physical size of the units and upon the ohmic value. All the data given below relates to the Type 73 Resistor. To obtain the equivalent ohmic values to which the information is applicable in the other four sizes of Resistor the following factors should be applied :

Type 72 x ½ Type 74 x 2 Type 75 x 4 Type 76 x 8

### FULL LOAD STABILITY

Up to 100 K.ohms the resistance change at full load with an ambient temperature of 70°C. is less than 0·75% (average 0·25%) after 1,000 hours operation. At 1 Megohm the change is less than 1% (average 0·75%).

**N.B.** On D.C. loading the maximum voltages stated in RCL 112 should be observed.

### AGEING AND SHELF DRIFT.

Up to 100 K.ohms the average change is 0·25% in 12 months (never greater than 0·75%). For 1 Megohm resistors the average change is 0·6% in 12 months (never greater than 1·25%).

### CLIMATIC

Exposure to the two cycles of H.I. humidity as laid down in RCS 112 shows a change of less than 0·7% (average 0·4%) up to 100 K.ohms. At 1 Megohm the change is less than 1% (average 0·7%).

### TROPICAL EXPOSURE

Eighty-four days exposure to the standard 25°C./35°C. 100% humidity cycling shows a change of less than 1% (average 0·5%) up to 100 K.ohms. At 1 Megohm the change is less than 2% (average 1·6%).

### TEMPERATURE COEFFICIENT

The temperature coefficient is less than 0·04%/°C. up to 100 K.ohms. At 1 Megohm the coefficient is approximately 0·055%/°C.

### NOISE

Noise which is generated in a resistor, as the result of a direct voltage applied across it, varies according to the ohmic value of the resistor, the noise decreasing as the ohmic value increases. The noise is also influenced by factors such as the size of the resistor.

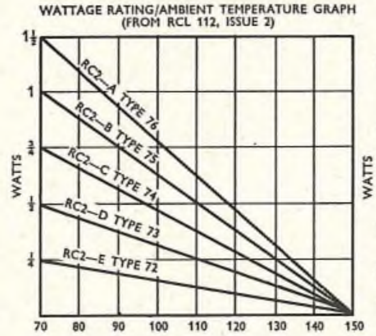
For noise which falls within frequency range of 0 to 10 Kc./sec., the Painton high stability resistors have noise levels which are between 0·05 and 0·4 microvolts of noise per applied direct volt, when the resistor is dissipating power at its maximum wattage rating.

### VOLTAGE COEFFICIENT

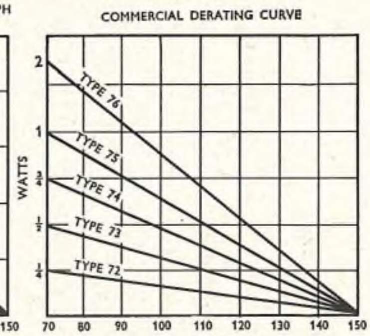
Not exceeding 0·002% per volt D.C.

DERATING FOR AMBIENT TEMPERATURES EXCEEDING 70°C.

WATTAGE RATING/AMBIENT TEMPERATURE GRAPH (FROM RCL 112, ISSUE 2)




COMMERCIAL DERATING CURVE




| TYPE | RESISTANCE RANGE (ohms) | VALUES OUTSIDE THIS RANGE MAY BE QUOTED FOR SEPARATELY. | |
|---|---|---|---|
| 72 | ±1% 4 — 700K | ±2% 4 — 1·0M | ±5% 4 — 2·5M |
| 73 | ±1% 4 — 1·0M | ±2% 4 — 2·0M | ±5% 4 — 5·0M |
| 74 | ±1% 20 — 2·0M | ±2% 20 — 4·0M | ±5% 20 — 10·0M |
| 75 | ±1% 20 — 3·0M | ±2% 20 — 5·0M | ±5% 20 — 10·0M |
| 76 | ±1% 20 — 5·5M | ±2% 20 — 9·0M | ±5% 20 — 50·0M |

| | TYPE | 72 | 73 | 74 | 75 | 76 |
|---|---|---|---|---|---|---|
| | Normal Commercial Rating 70°C—watts | ¼ | ½ | ¾ | 1 | 2 |
| | R.C.S.C. style | RC2-E | RC2-D | RC2-C | RC2-B | RC2-A |
| | R.C.S.C. Rating at 70°C—watts | ¼ | ½ | ¾ | 1 | 1½ |
| | R.C.S.C. Rating at 100°C—watts | ⅛ | ¼ | ½ | ⅝ | ¾ |
| DIMENSIONS IN INCHES | A | ½ | 13/16 | 1 1/16 | 1⅜ | 2 1/16 |
| | B | 5/32 | 7/32 | 5/16 | 11/32 | 11/32 |
| | C | 1½ | 1½ | 1½ | 1½ | 1½ |

**PAINTON**

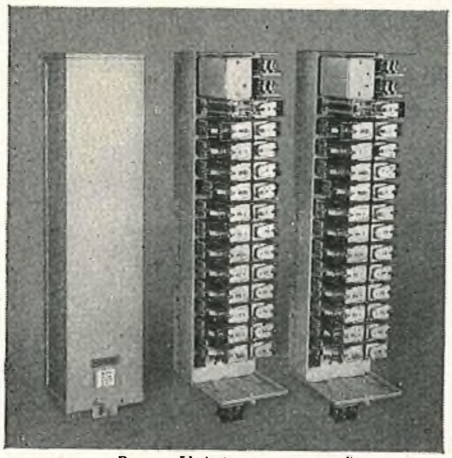
*Northampton England*

J3221

# SUBSCRIBERS' LINE CONCENTRATOR

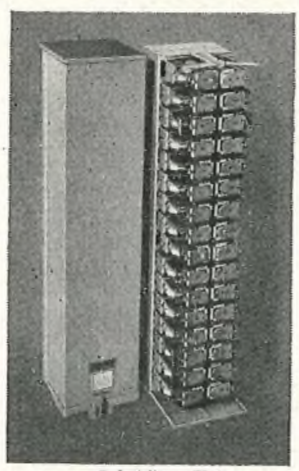
TMC TRADE MARK

## An all-relay communication system which provides Telephone Service for TEN subscribers over TWO connecting links to an EXCHANGE

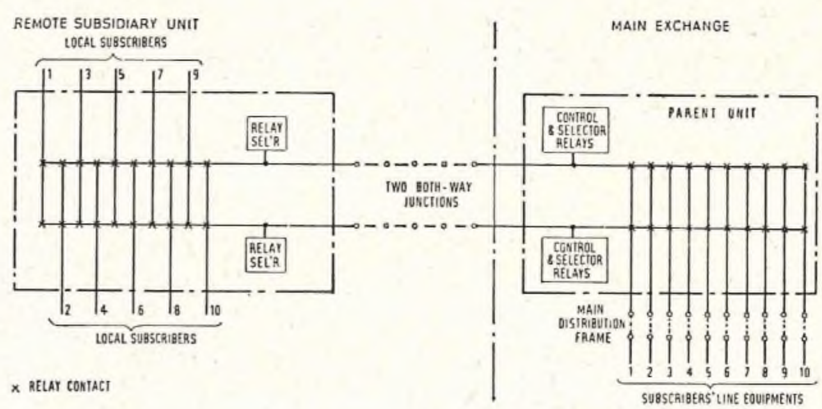


*Parent Unit (cover removed)*

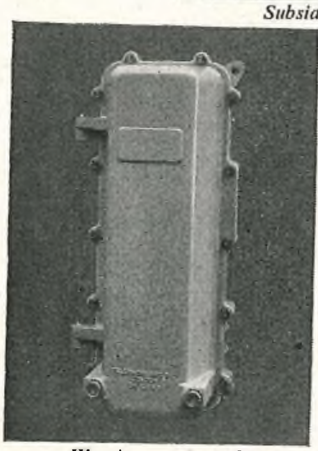
The TMC Subscribers' Line Concentrator is *not* a Party Line — subscribers are operationally indistinguishable, in all respects, from directly connected lines. It is fully secret and standard subscribers' telephone sets are used.
Plant costs are drastically reduced by its use, without any sacrifice of facilities. A complete system can be installed in a few hours, with a minimum of internal construction work, whether for permanent or temporary installation.
Batteries or power leads are not necessary at the remotely located Subsidiary Unit, nor are premises required for housing it.
Maximum reliability, with negligible maintenance requirements, is ensured by the use of 3000-type relays throughout. Visual and audible alarms are provided in the Parent Exchange to indicate line faults, and a faulty junction is automatically taken out of service.
The system is supplied to the British Post Office and the Corporation of Kingston-upon-Hull, in England. Overseas it is in use in Australia, British Guiana, Jamaica, Nyasaland, Singapore and Hong Kong.



*Subsidiary Unit*




A call at either end of the system causes the selecting relays to hunt. The corresponding outlets at each end of the junction are selected simultaneously and tested for *calling* and *busy* conditions. When the calling condition is located the hunt action is arrested, and interconnection between the subscriber and the subscribers' line equipment is provided by the junction. The call then proceeds in the normal manner according to the type of Parent Exchange.



*Weatherproof case for subsidiary unit*

*The scheme can also be used to provide a variety of services, e.g.—*
Night service for selected subscribers connected to an Exchange with restricted hours of attendance . . . Release of cable pairs to fully loaded D.P.'s . . . Release of pairs on cable routes pending provision of new plant . . . Service to blocks of residential Flats, as an alternative to a P.B.X. . . . Service for short duration events such as Exhibitions and Race Meetings by making pairs available without additional plant.

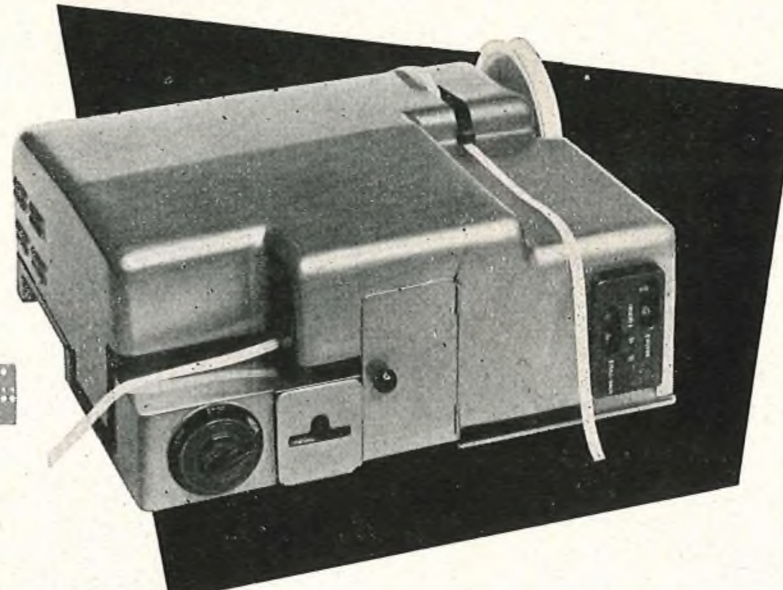
*Write for full technical data to:*

# TELEPHONE MANUFACTURING CO LTD

HOLLINGSWORTH WORKS · DULWICH · LONDON S.E21

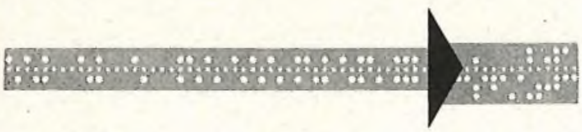
TELEPHONE: GIPSY HILL 2211

# G.N.T. CONVERTERS

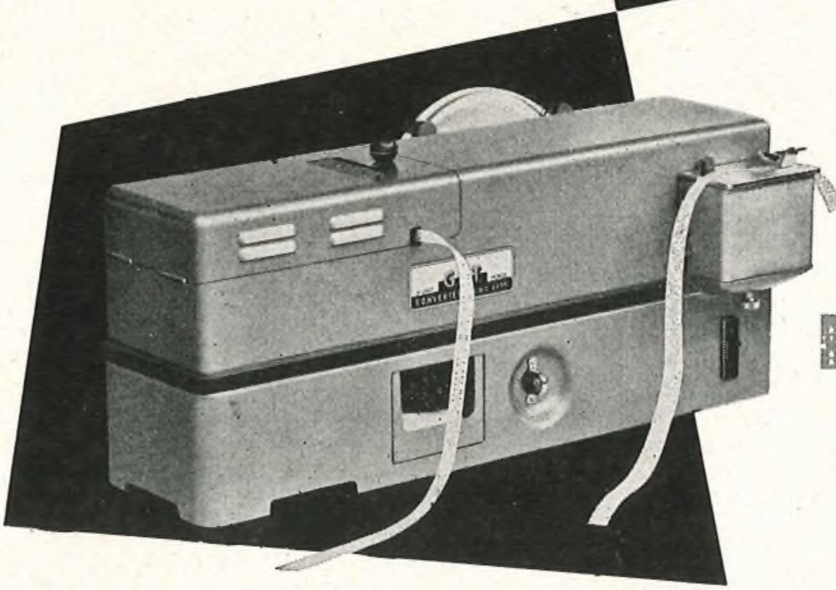


**MODEL 2201**

FOR CONVERSION OF MORSE CODE OR CABLE CODE PERFORATED TAPE TO 5-UNIT SIGNALS OR 5-UNIT PERFORATED TAPE AT TELEPRINTER SPEED

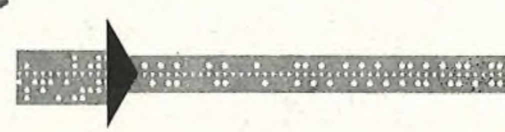


DIMENSIONS: 23″ × 21″ × 10″

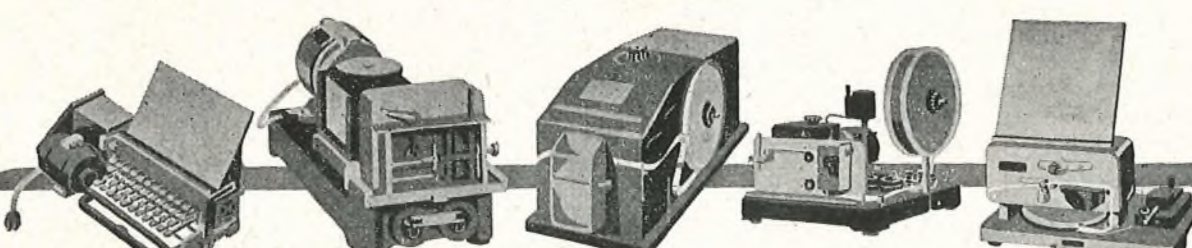


**MODEL 2206**

FOR CONVERSION OF 5-UNIT PERFORATED TAPE TO MORSE CODE OR CABLE CODE PERFORATED TAPE, AT THE RATE OF 650 CHARACTERS PER MINUTE



DIMENSIONS: 26″ × 12″ × 12″



## GREAT NORTHERN TELEGRAPH WORKS

**DIVISION OF THE GREAT NORTHERN TELEGRAPH CO. LTD.**

4, SYDHAVNS PLADS
COPENHAGEN SV, DENMARK

LONDON OFFICE: 5, ST. HELEN'S PLACE
LONDON E. C. 3.

*Cut your costs with*

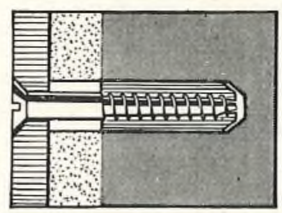
# 21 RAWLPLUG FIXING DEVICES

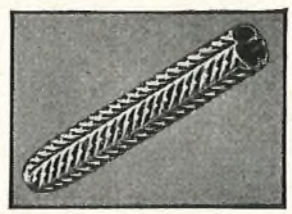
## FOR SPEEDY FIXING IN ANY MATERIAL

No more trouble or costly delay because the material was 'difficult'! Whether it's concrete or plastic, breeze or sheet metal, cavity brick or lath and plaster, there's a Rawlplug Fixing Device that makes firm screw or bolt fixings quickly, easily and economically. The speedy answer to *every* fixing problem is one or other of the 21 different types of Rawlplug Fixing Devices. Write for illustrated brochure.

## *Screw Fixings*

Use the famous RAWLPLUG for neat, firm fixings in brick, stone, etc. All sizes up to $\frac{3}{4}''$ diameter Coach Screws. Rawlplugs are waterproof and unaffected by climatic conditions.

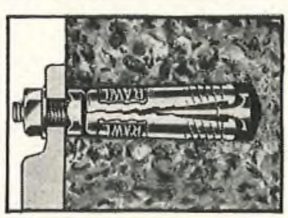


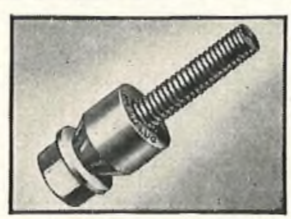


Rawlplug WHITE BRONZE PLUGS are specially suitable when the fixing is subject to very high temperatures, such as the outer brick coverings of furnaces. Use also for under-water fixtures.

## *Bolt Fixings*

For bolting down machines, use RAWLBOLTS, a dry fixing that grips by expansion. No cold chiselling, no waiting for cement to harden. Sizes up to 1″ bolt diameter.

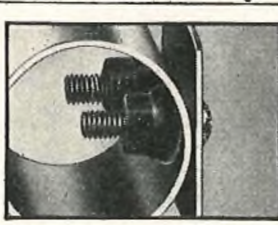


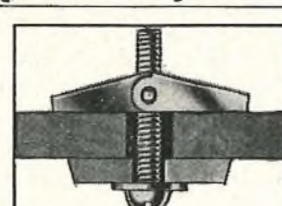



Use Rawlplug BOLT ANCHORS for bolting down in extremely wet or corrosive situations. Caulking completely seals the anchorage. Use also for anchoring Diesel Generators, Power Hammers, etc.

## *Cavity Fixings*

Screwed up from the front the amazing RAWLNUT forms its own rivet head behind the material—airtight, watertight, vibration-proof, squeak-proof! For all thin or hollow materials.





For ceilings of lath and plaster, plasterboard, etc., use Rawlplug SPRING TOGGLES. The inserted Toggle springs open behind the material, spreading the load over a wide area.

**USED BY THE MILLION THROUGHOUT INDUSTRY**

RAWLPLUG WALL PLUGS

FIXING DEVICES

21 *different types of fixing devices for Speed and Strength*

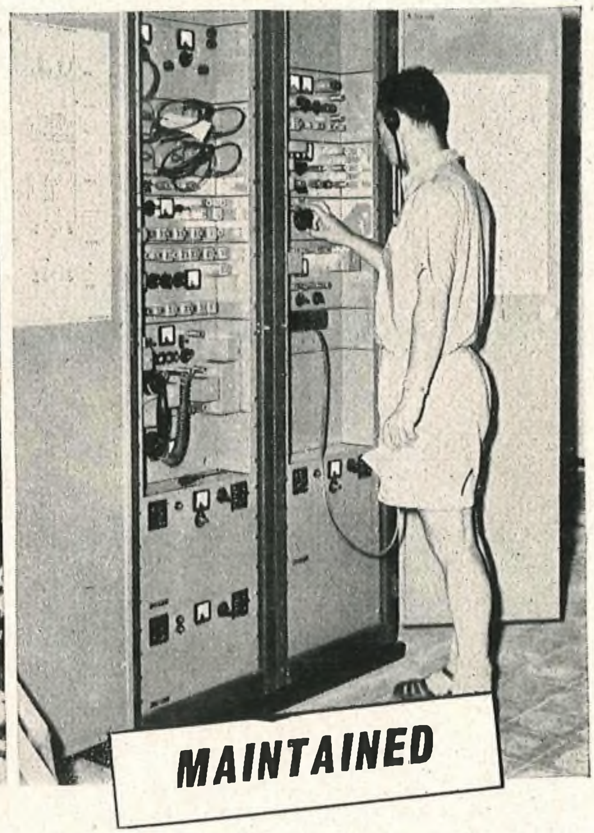
5559

Made by THE RAWLPLUG CO. LTD., CROMWELL ROAD, LONDON, S.W.7
*The World's largest Manufacturers of Fixing Devices.*


# MARCONI

**MULTI-CHANNEL SYSTEMS** VHF radio telephony was welcomed in its early days as an economic means of providing communication over inhospitable or undeveloped terrain. Today, such is the flexibility and reliability of multichannel radio equipment, that radio links carrying up to 600 telephone channels or a colour television programme are recognised as being preferable to the use of line or cable systems in many instances on grounds of performance as well as installation cost.

# COMPLETE COMMUNICATION SYSTEMS — *all the world over*


**MARCONI'S & A.T.E. Co-operation between Marconi's and Automatic Telephone and Electric Co. Ltd., now brings together an unrivalled wealth of knowledge and experience for the benefit of all whose work lies in the field of telecommunications.**

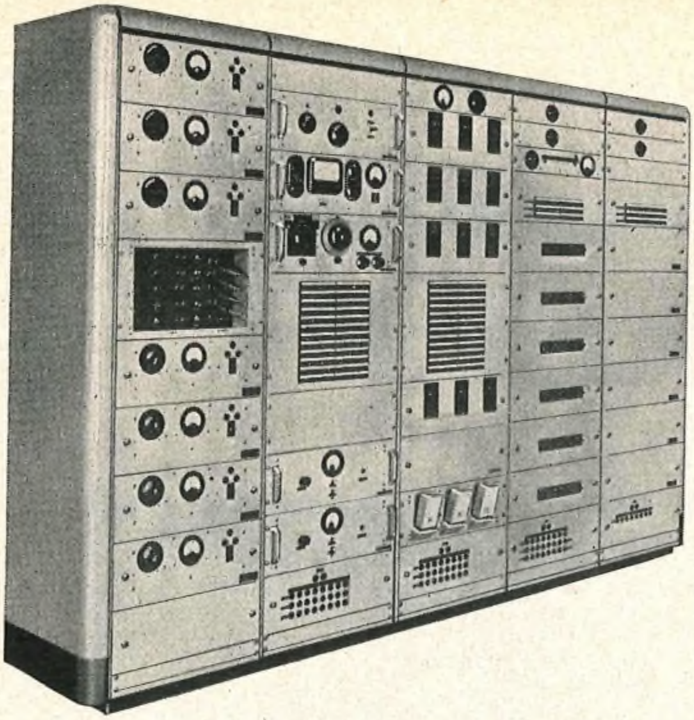
The Lifeline of Communication is in experienced hands

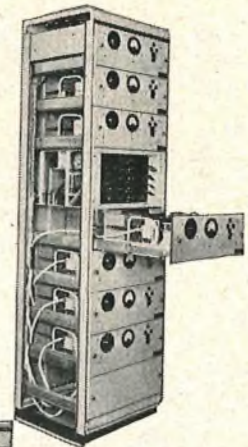
# MARCONI

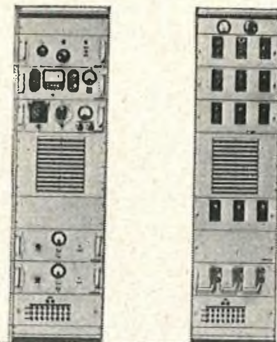
## Complete Communication Systems

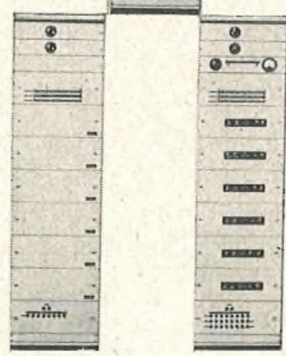
MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX

LC I









# telegraph speeds of 280 bauds

The overall performance of long distance radio link telegraph systems can, in many cases, be greatly improved by the introduction of Siemens Ediswan Frequency Modulated Voice Frequency Telegraph Equipment on the land line circuits feeding remotely located radio transmitters or receivers. This equipment provides six channels, five of which will each handle telegraph traffic at speeds up to 280 bauds and one for medium speed traffic up to 140 bauds.

Developed by Cable & Wireless, this telegraph system is now in extensive use by the British Post Office and various overseas administrations.

The equipment is completely self contained and includes full testing facilities for lining up and routine maintenance. The equipment practice employed facilitates removal of individual units. As an alternative, equipment can be supplied which provides 12 channels for handling telegraph traffic at speeds of up to 140 bauds.

The F.M.V.F.T. equipment may be used on any 4-wire circuit capable of transmitting the band 300 c/s to 3400 c/s.

*Further information will gladly be sent on request.*

**extending → the frontiers of telecommunications**

SIEMENS EDISWAN

**SIEMENS EDISON SWAN LTD** *An A.E.I. Company*

Telecommunications Transmission Division, Woolwich, London SE18, England

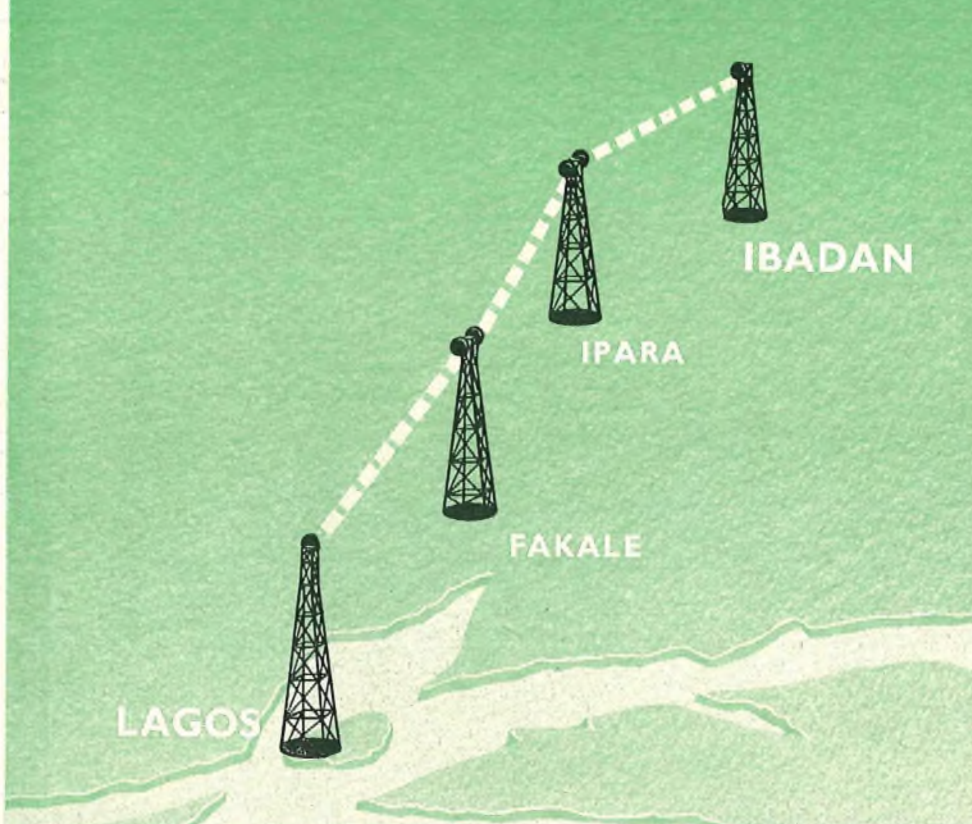
*Cables: Sieswan London*



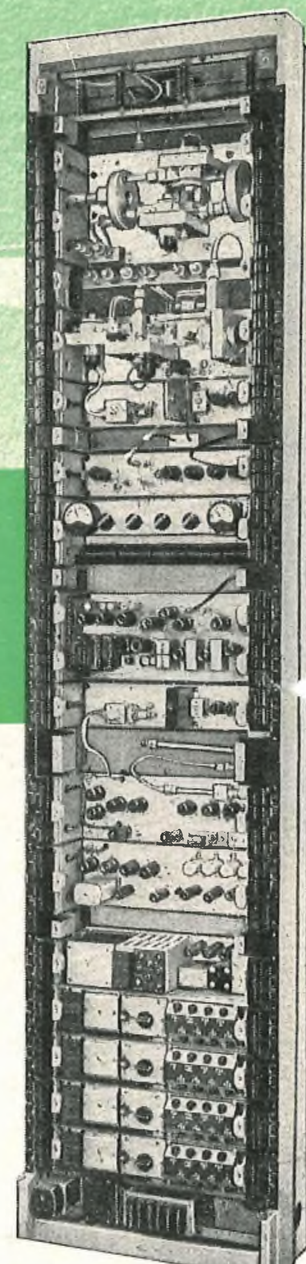



F

# Nigeria's First Microwave Link




G.E.C.



Continuing its progressive policy of telephone communications development, the Government of Nigeria has ordered a G.E.C. microwave radio-telephone system to provide service between Lagos and Ibadan. G.E.C. 240-circuit 2000 Mc/s radio-relay equipment, together with G.E.C. carrier-telephone equipment, will provide 480 speech circuits and a spare radio channel arranged to give automatic standby facilities. A complete radio transmitter and receiver is mounted on one 7′ 6″ rackside.

*For further information please write for Standard Specifications S.P.O. 5501 and 1370.*

**THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND**

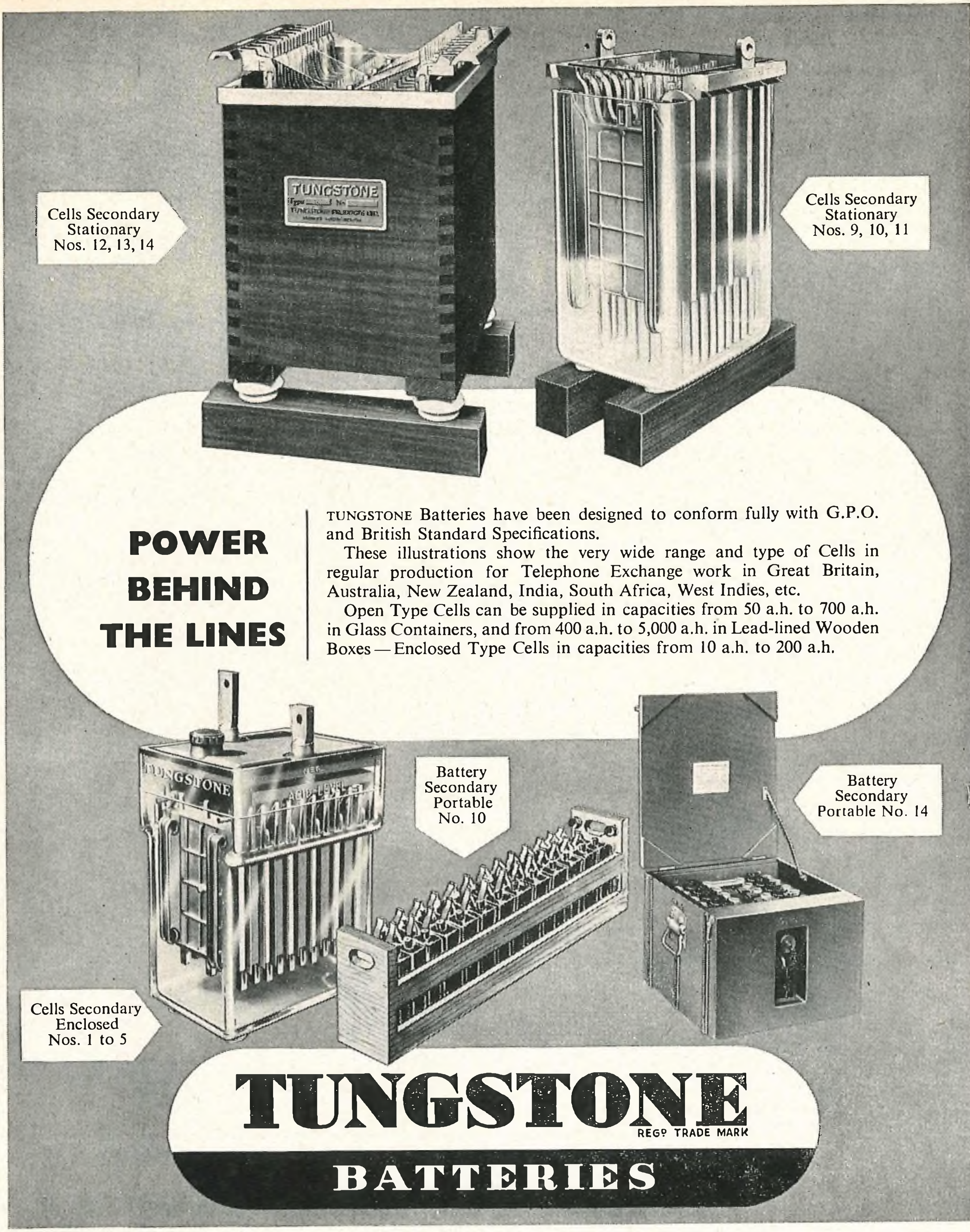

THE G.E.C. '1000' TELEPHONE

THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND


THE G.E.C. SE 50 SELECTOR

TELEPHONE, RADIO AND TELEVISION WORKS, COVENTRY

G.E.C.4




TUNGSTONE PRODUCTS LIMITED

10 SALISBURY SQUARE · LONDON, E.C.4 · FACTORY · MARKET HARBOROUGH · LEICS · ENGLAND

TC18

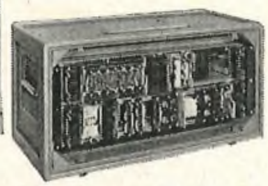
## TRANSISTORISED THREE-CIRCUIT CARRIER SYSTEM

*Six F.M. Carrier Telegraph Circuits*

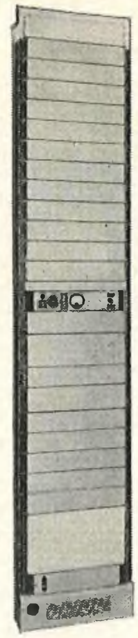
*Two complete terminals on one Rackside*

## TRANSISTORISED CARRIER TELEPHONE SYSTEM FOR RURAL SERVICE

*up to ten circuits*



## TRANSISTORISED 12-CIRCUIT 2-WIRE CARRIER-ON-CABLE TELEPHONE SYSTEM Type SCT-12



*'Frogging' (frequency changing) Repeaters*

*Two complete terminals on one Rackside*

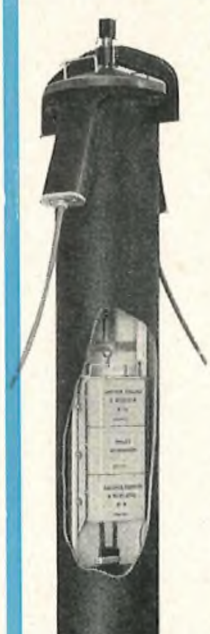
# -12-24-60-120-240 Circuits

## FREQUENCY-MODULATED S.H.F. RADIO SYSTEM 7300 Mc/s to 7500 Mc/s

*For multi-channel telephone transmission.*

*Has a capacity of several supergroups of standard frequency-division multiplex*

## 240-CIRCUIT, SMALL DIAMETER COAXIAL CABLE Telephone System



*New Transistorised Repeater*

*4-mm coaxial tubes*

## RADIO LINK EQUIPMENTS

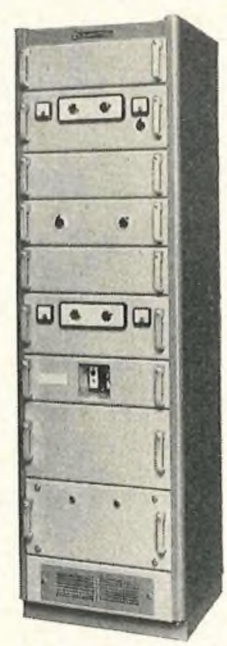
### F.P.I Series

*Designed to operate in association with standard multi-channel carrier systems.*

### F.P.II Series

*Mounts in a single cabinet a complete radio transmitter and receiver, channelling, signalling and terminating apparatus for 6 channels together with a common power supply unit.*

***Frequency Range***
*F.P.1 and F.P.11 equipments can be supplied for operation in any one of the frequency bands 156-184, 184-235, 235-328 or 328-420 Mc/s, but equipments with other frequency ranges can be considered.*

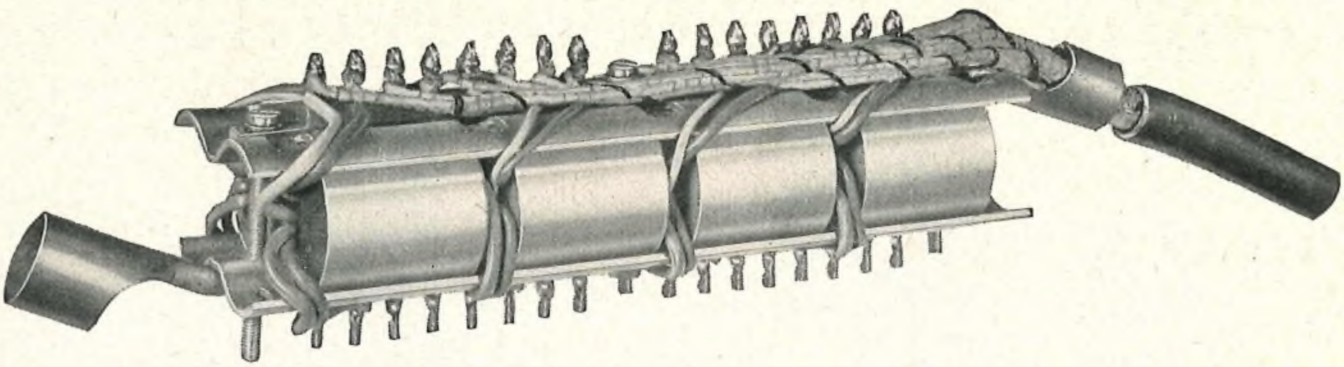


*d Telephones and Cables Limited*

Registered Office: Connaught House, Aldwych, London, W.C.2

ON DIVISION: NORTH WOOLWICH · LONDON E.16

# Improved splice loading with the L219

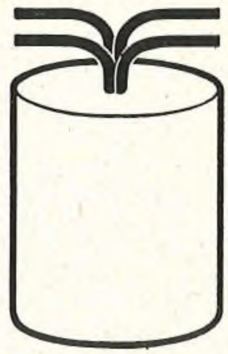


## The new economical loading coil

Arising from the increasing demand for a smaller coil which can be employed in splice loading, Mullard have developed the L219. In the design Mullard were assisted by their own production experience and information given by overseas users. The result is a simple, low cost component (to grade 3 spec.) suitable for small or large splice loading units.

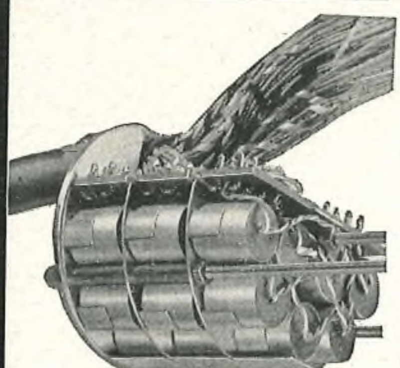
## Smaller construction

By using a new grade of Ferroxcube pot core the overall volume of the coil is considerably reduced. The coil is resin sealed in a small cylindrical aluminium canister ensuring complete protection from climatic effects. The windings of the coils are brought out on flying leads.



LIFE SIZE COIL
L219

## Permits smaller splices



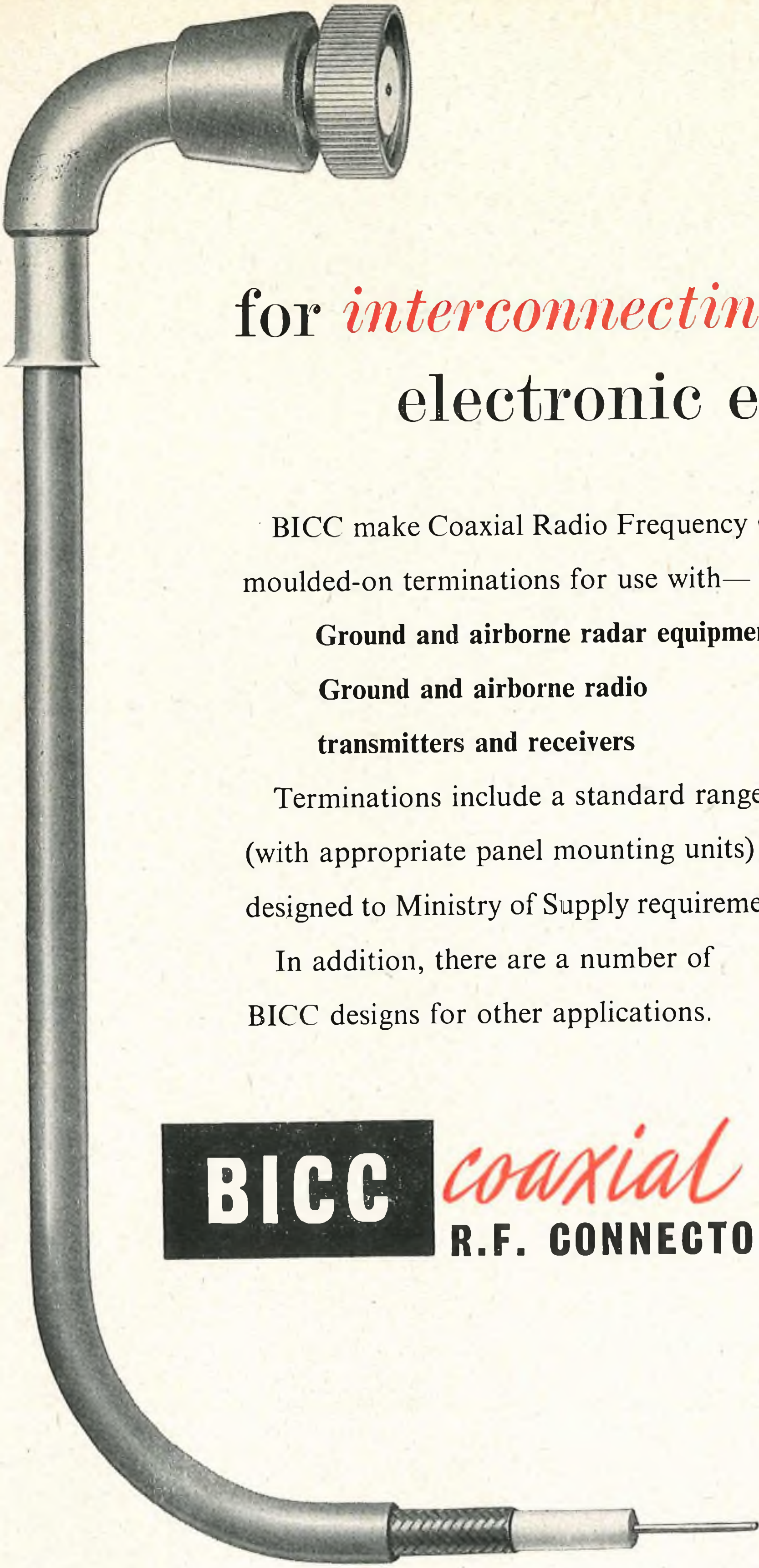
Key factors in this development are the clamping arrangements which, with the new coil, permit much smaller splice housing. On small cables, coils are mounted lengthways in pairs with great compactness. For larger cables, coils are mounted radially, each mounting plate accommodating up to seven coils. Clamping plates, coils, etc. can be supplied as kits.

Please write for full details of the new Mullard loading coils

**Mullard**
SPECIALISED ELECTRONIC EQUIPMENT

MULLARD LIMITED
EQUIPMENT DIVISION • MULLARD HOUSE • TORRINGTON PLACE • LONDON • W.C.1 • TEL: LANGHAM 6633

ME614a



# for *interconnecting* electronic equipment

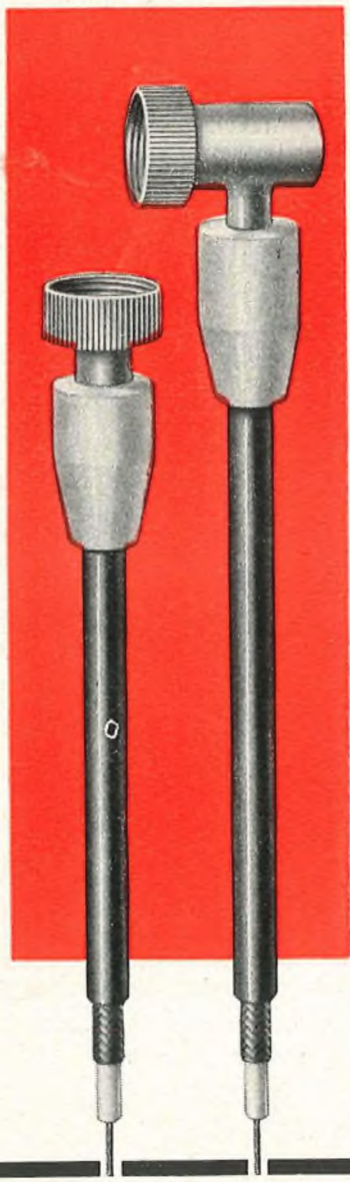
BICC make Coaxial Radio Frequency Connectors with moulded-on terminations for use with—

**Ground and airborne radar equipment**

**Ground and airborne radio transmitters and receivers**

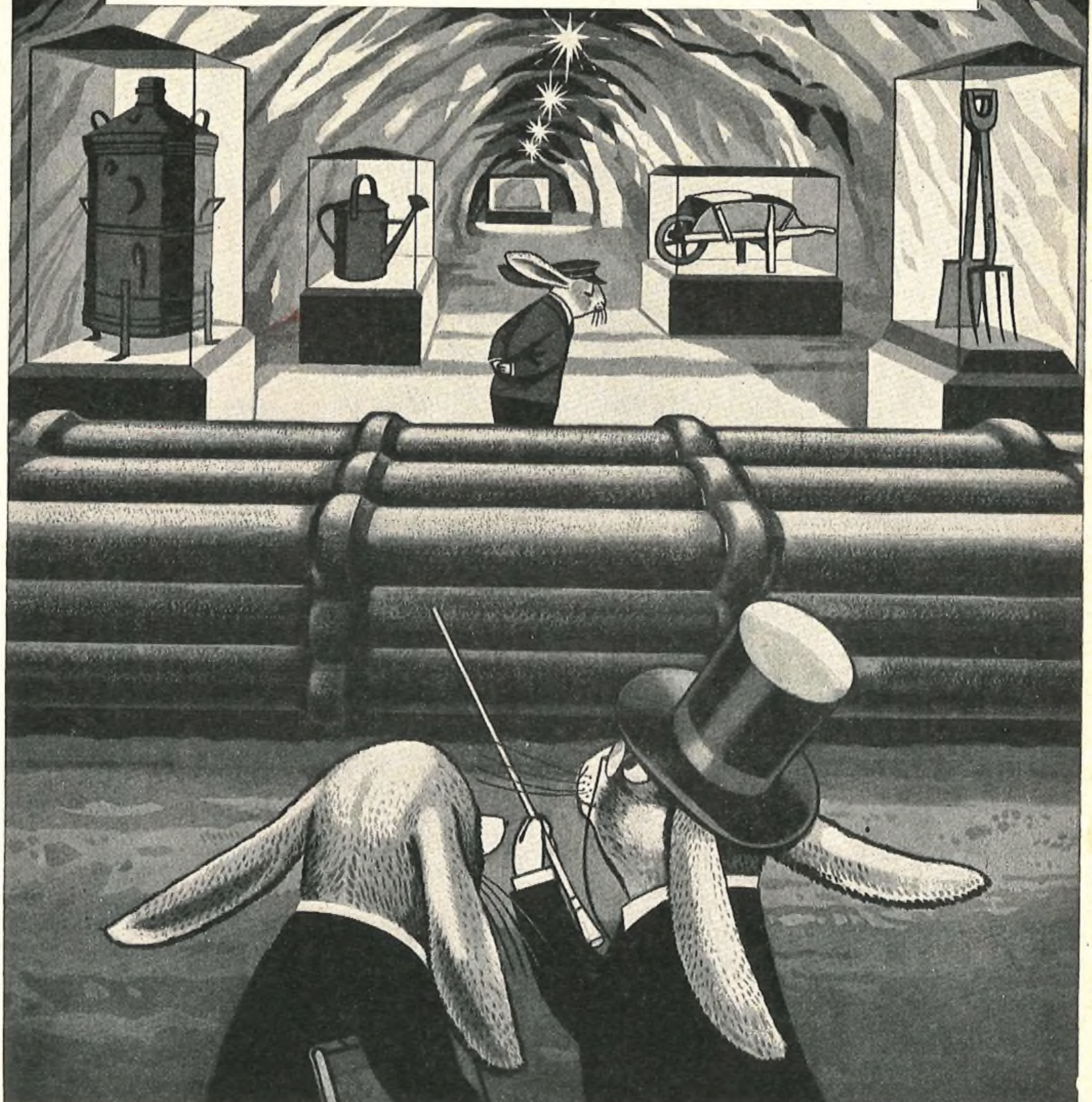
Terminations include a standard range (with appropriate panel mounting units) designed to Ministry of Supply requirements.

In addition, there are a number of BICC designs for other applications.



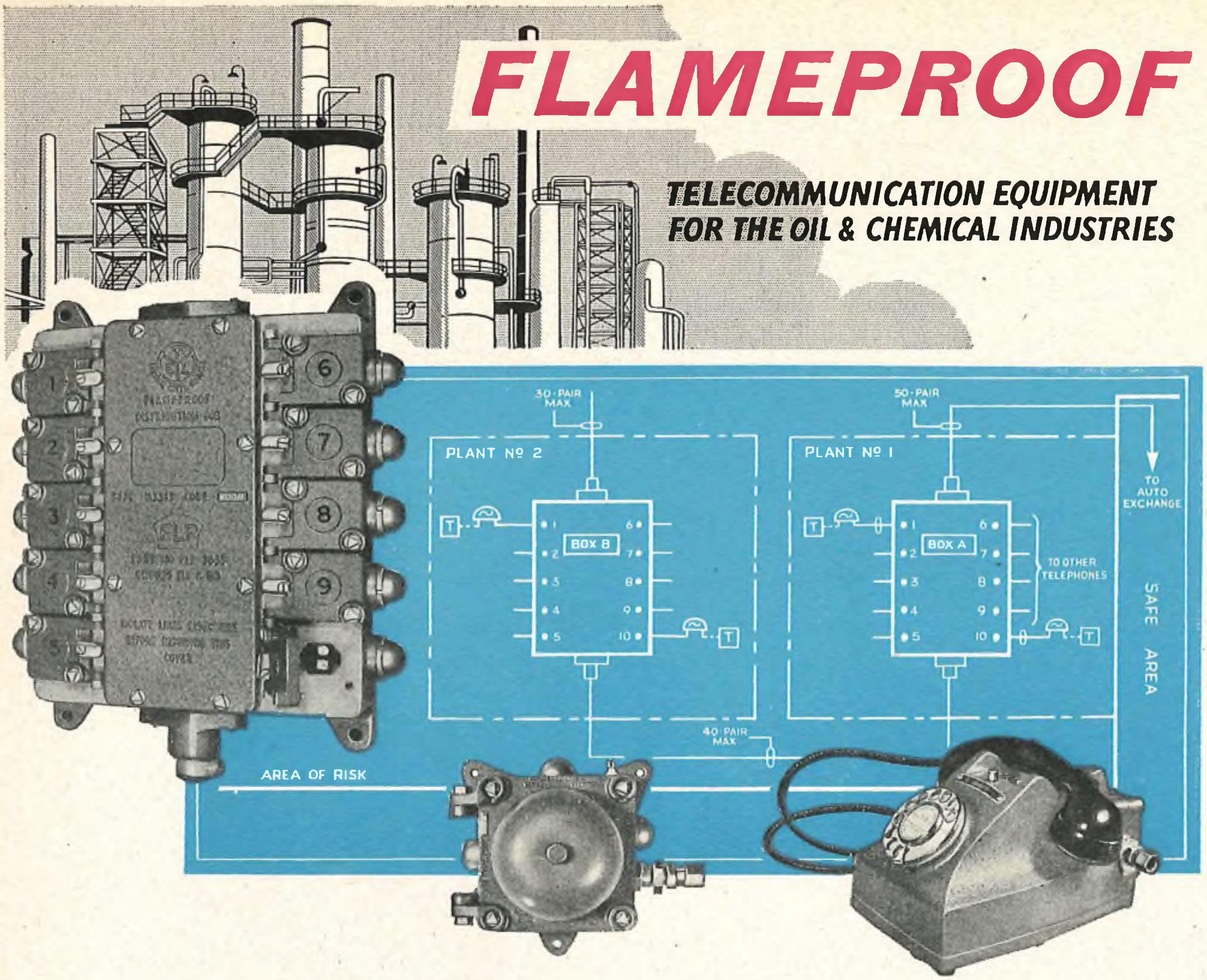
**BICC** *coaxial* **R.F. CONNECTORS**

BRITISH INSULATED CALLENDER'S CABLES LIMITED,
21 Bloomsbury Street, London, W.C.1



# FLAMEPROOF

## TELECOMMUNICATION EQUIPMENT FOR THE OIL & CHEMICAL INDUSTRIES




FLAMEPROOF TELEPHONE SYSTEMS that are as versatile as their standard counterparts, are today an essential requirement of all modern Oil Refineries and Chemical Plants. The development and manufacture, by Ericsson Telephones Ltd., of this class of equipment represents an important contribution towards safety in industry.

The Desk Telephone, incorporating the latest B.P.O. 1000 Ω loop circuit, may be used on Auto or C.B. systems. A push button can be provided for operator recall, etc.

The Telephone Bell, which constitutes a separate unit, also serves as the rigid line termination point and is provided with four entries, one of which is used for the desk cord connection to the instrument. The unit may also be used as an extension bell, in which case blanking plugs are supplied for the unused entries.

The Distribution Box, with its main cable chamber and ten individually switched outlets provides positive line isolation together with easy and economic line distribution. The capacity of the box is 10 pairs for local distribution and 40 pairs for looping through to other boxes. The line terminal chambers can be opened only with the switch in the 'OFF' position, which cannot be moved to 'ON' while the chambers remain open.

With the exception of the main chamber sealing gland, all glands are threaded for ¾ in. conduit entry. The range covers the following permissible cable connections:—Conduit, Single wire armoured cable, Tough rubber sheathed and Mineral insulated.

Illustrated above is a block schematic showing a typical telephone system based on this new equipment.

FLP

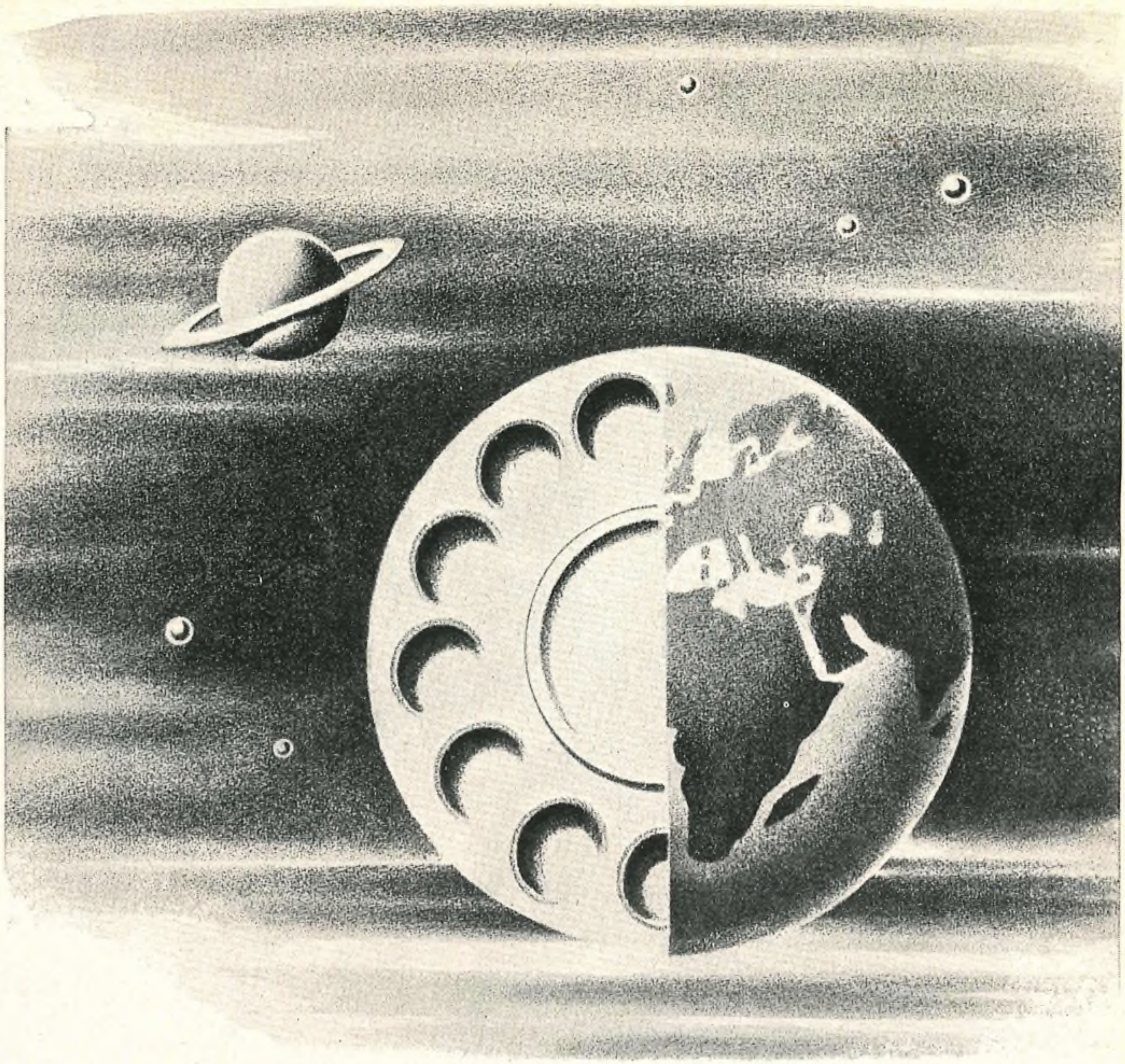
Certified by the Ministry of Power
FLP. 3651
FLP. 3652
FLP. 3653

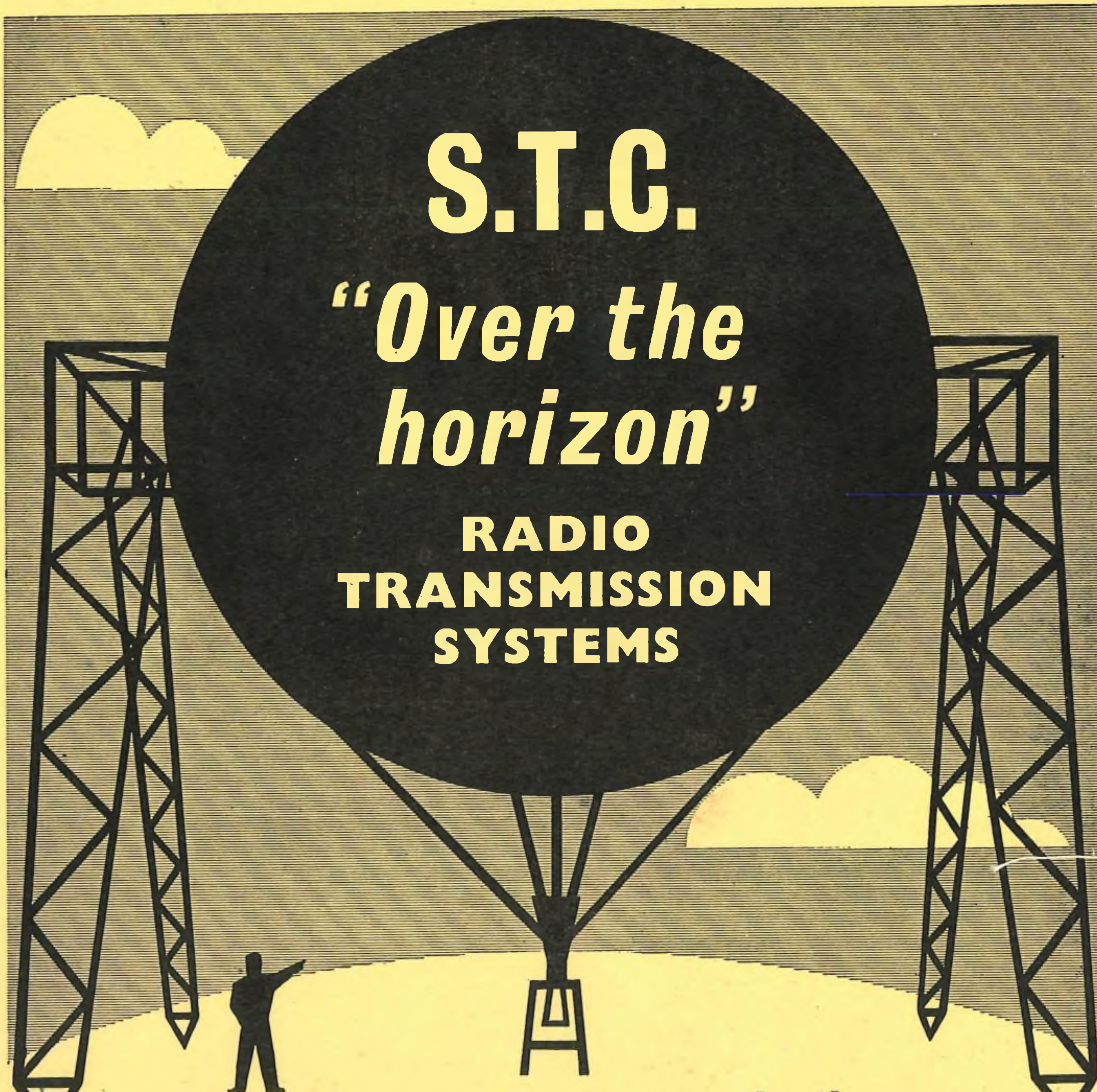
This equipment conforms to B.S.S. 229. The Telephone and Bell/Terminal Unit are accepted by the B.P.O. as their Type Nos. N.266 and N.69.A respectively.

## ERICSSON TELEPHONES LIMITED

HEAD OFFICE: 22 LINCOLNS INN FIELDS, LONDON, W.C.2. TEL: HOLBORN 6936
WORKS: BEESTON, NOTTINGHAM & SUNDERLAND

E01





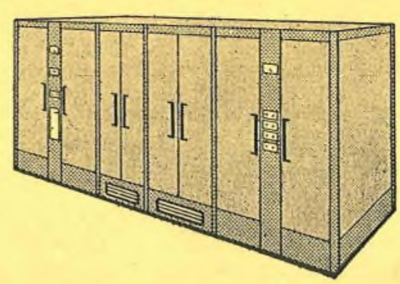

## A new advance in telecommunications . . .

The new S.T.C. "Scatter" equipment allows the transmission of telephone, telegraph and television signals over *distances of 180 miles or more*. In appropriate conditions *up to 120 telephone circuits* can be transmitted on a single radio circuit.

The basic S.T.C. equipment provides *dual space-diversity reception*, but other diversity arrangements can be supplied.

Aerials consist of 30 ft. or 60 ft. eliptical reflectors, specially designed to overcome wind-loading problems. Station equipment, which uses the most modern planar waveguide techniques, is totally enclosed in a suite of neat metal cubicles.

*Advice on systems planning and propogation testing can be obtained from*



**Standard Telephones and Cables Limited**

Registered Office: Connaught House, Aldwych, London, W.C.2

TRANSMISSION DIVISION: NORTH WOOLWICH · LONDON · E.16

Printed by SANDERS PHILLIPS & CO., LTD., The Baynard Press, Chryssell Road, London, S.W.9, and
Published by BIRCH & WHITTINGTON (*Prop. Dorling & Co. (Epsom), Ltd.*), Epsom, Surrey