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The Place of V.H.F., U.H.F. and S.H.F. Radio Links in a Developing Area

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U.D.C. 621.396.65

The paper on which this article is based formed part of the United Kingdom contribution to the United Nations Conference on the application of Science and Technology for the benefit of the less developed areas (UNCSAT). The Conference was held in Geneva in February 1963, and was attended by over 2,000 delegates from over 100 countries. The paper is reprinted here with the agreement of the Department of Scientific and Industrial Research under whose direction, and the leadership of Sir William Slater, the United Kingdom delegation attended. Whilst many points in the paper may not be of immediate concern to practice in the United Kingdom, the extrapolation of the techniques and practice developed in the United Kingdom can form an important part of the aid that the United Kingdom can give to the developing areas of the world.

INTRODUCTION

In a developing area there is a demand for early provision of reliable telecommunications. Without this the growth of administration, of development of national resources, of law and order, of transportation and of social services may be impeded. In this article, the part that v.h.f., u.h.f. and s.h.f. radio can play in providing links in the trunk network and links to individual subscribers is described.

It is assumed throughout this article, for simplicity, that the telecommunications service to be provided is an integrated national service embracing all possible users, e.g. public, utilities, "common carriers," etc. There are arguments for and against this view, which are outside the scope of this paper, but no matter what the form of the service, the points made here about the role and practical problems of radio are valid.

THE ROLE OF V.H.F., U.H.F. AND S.H.F. LINK SYSTEMS

The Place of Radio in a Telephone Network

In a public telephone system, each subscriber has, in general, an individual pair of wires to a nearby exchange which serves a defined area of a country or city, such as a township or a rural district. Exchanges are connected to each other, directly or in groups, by means of trunk circuits, which are, of course, not provided on a "per subscriber" basis but rather on a "per exchange" basis. A long-distance telephone call can take place over several trunk circuits connected together in tandem. Direct trunk circuits are usually, however, provided between any two exchanges if there is sufficient community of interest between the areas they serve.

Exchange lines can consist of a pair of insulated copper wires in an underground or aerial cable, an open-wire pole route, or in fact a simple radio link. Trunk circuits can also consist of individual pairs of wires provided in cables or on open-wire pole routes, or of separate radio links. Where the number of trunk circuits is more than a very few, it is cumbersome and expensive to have to provide and maintain along the route a separate pair of wires or radio link for each circuit. In these cases "carrier" techniques can be used. These enable a large number of conversations to take place on the same single transmission path. This path can be a cable, a coaxial-pair cable, an open-wire pole route, or a radio-relay system.

Main Trunk Systems

Radio-relay systems operating in frequency bands between 1,000 and 12,000 Mc/s (microwave frequencies) are extensively used throughout the world to provide high-capacity trunk communications systems. Such systems mostly use stations spaced 25–30 miles apart, low-power transmitters (less than 10 watts) and highly-directional beamed aerials, and can carry up to 1,000 or more telephone conversations on a single radio carrier.

Radio systems operating at frequencies between 30 and 1,000 Mc/s (v.h.f. and u.h.f.) are particularly appropriate when relatively few, say, up to 60 or 120, circuits are required. These lower frequencies have the advantage that stations can sometimes be more widely spaced, say, 60–70 miles, and equipment may often be cheaper.

Exceptionally, beyond-the-horizon tropospheric-scatter radio links are sometimes used where up to a few dozen circuits are required between widely separated points and the intervening terrain is inaccessible or the provision and maintenance of intermediate radio-relay stations would be very costly or difficult. Such systems need very high-power transmitters, e.g. 10 kW, and very large aerial systems.

Advantages and Disadvantages of Radio

The choice between radio-relay or cable for a main trunk route will depend on a number of economic and

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practical factors. No hard and fast rules can be given; each case needs to be studied on its own merits. For example, in some less developed countries, shortage of available capital may result in low initial cost being a determining factor, rather than long-term running costs or annual charges such as interest payments, depreciation and maintenance charges. Or again, developed urban areas in such countries tend to be widely separated, and the intervening terrain is often sparsely populated with little need for telephone service. These factors tend to favour the use of radio-relay links. Speaking generally, however, radio-relay systems may be compared with cable systems as follows:

Advantages of radio-relay links—

(*a*) The cost is less, in many cases, than that of line systems of comparable capacity and performance.

(*b*) They can often be installed more quickly than line links.

(*c*) Once established, additional circuits can be provided quickly and cheaply.

(*d*) They are of particular use in sparsely populated, mountainous or densely wooded areas.

Disadvantages of radio-relay links—

(*a*) Radio-relay stations have to be placed so that their aerials surmount all local obstacles and "see" each other. This makes station siting difficult and often critical.

(*b*) Because of this, the building of access roads, power-supply provision and maintenance organization are often difficult.

(*c*) Short-distance circuits to intermediate exchanges or intermediate subscribers along a main route are less easily provided than by cable.

(*d*) Occasional adverse propagation conditions cause a deterioration of performance due to fading.

Local and Subscriber Systems

Single-channel radio links operating in the v.h.f. band can be used to give a telephone service to a subscriber or an isolated community where only one telephone is all that is needed and where conventional line methods are impracticable or prohibitively costly, e.g. routes across water, swamp, jungle, or on hilltops where lightning is frequent and may damage cables. Such links can operate from a battery, wind-driven generator, solar cells, or mains power supply. There is, of course, little problem in providing the radio link itself. Much technical ingenuity is, however, needed to enable the link to be connected to an exchange network and to allow calls

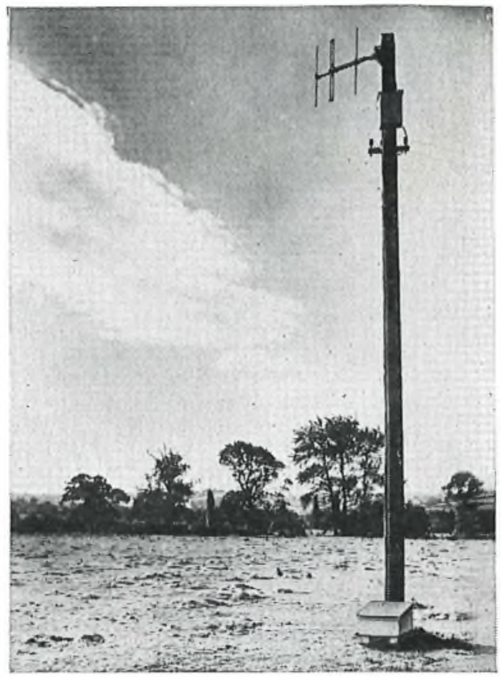
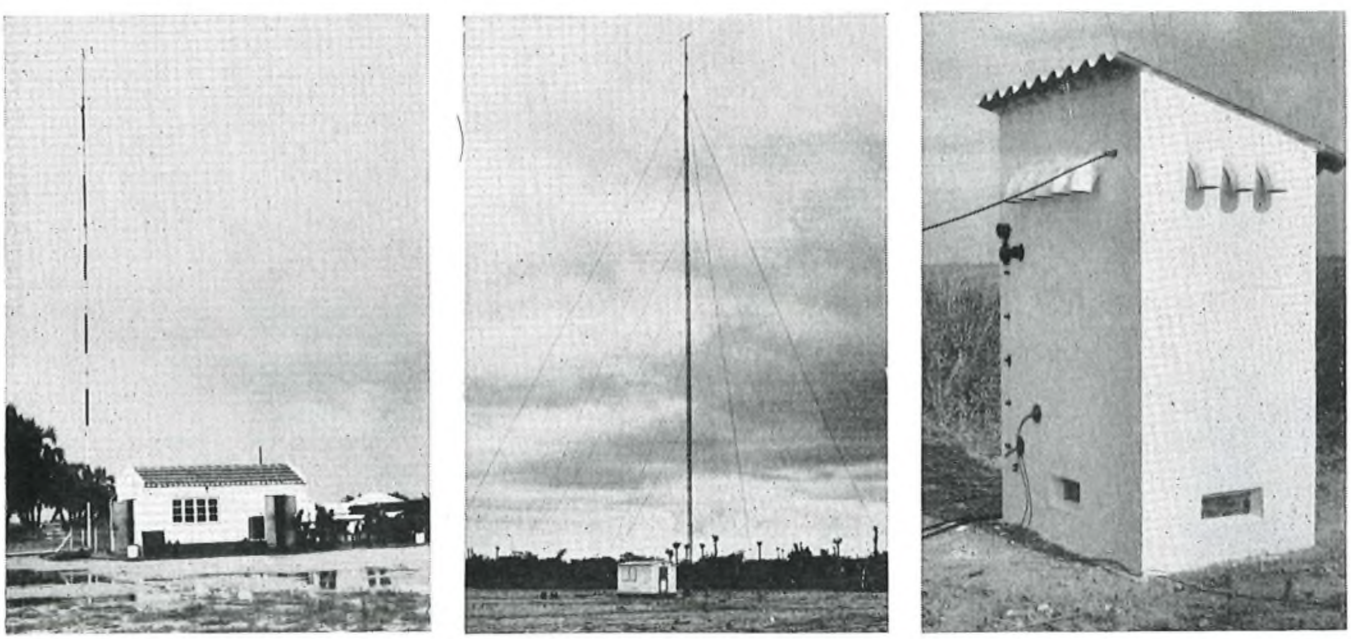


FIG. 1—SUBSCRIBER'S RADIO-TELEPHONE EQUIPMENT COMPLETE WITH AERIAL AND POWER SUPPLY



(*a*) Central Station

(*b*) Out-Station with 150 ft Mast

(*c*) Typical Out-Station Building (note the ventilating system giving an upward air current round the internal equipment)

FIG. 2—LOCAL-LINE RADIO SERVICES IN PORTUGUESE ANGOLA

from any part of that network full access to the radio-link subscriber and at the same time avoid making undue demands upon, for example, the power supply if the equipment operates from batteries. Such links are, however, available, and they can provide a valuable means of connecting otherwise isolated subscribers, either singly or in groups, to an exchange and so to the national network. Fig. 1 and 2 show examples of systems of this type.

BASIC TECHNICAL PROBLEMS OF LINK-SYSTEM PLANNING

General

When planning a radio-relay link the choice of system will be influenced by:

(*a*) the type and amount of traffic to be carried, i.e. telephony or television, or both,

(*b*) the likely growth of such traffic,

(*c*) the type of country and terrain on the route of the link,

(*d*) the climate,

(*e*) the quality of transmission required,

(*f*) the degree of reliability required, and

(*g*) economics.

In general, where a high-capacity system is required capable of providing the highest standards of transmission, then a line-of-sight microwave radio-relay system operating at frequencies above 1,000 Mc/s would be recommended. Where the need is for a relatively low-capacity system with relatively small growth in traffic and where low costs are a prime consideration, then a link operating in the u.h.f. or v.h.f. band may be more appropriate. In some cases, stations may be established to serve both types of system. Fig. 3 illustrates a station in Nigeria at which both v.h.f. and u.h.f. services are installed.

Yagi aerials for a v.h.f. radio-relay system are mounted at the top of the tower; parabolic-dish aerials for a u.h.f. system are fitted lower down

FIG. 3—TYPICAL RADIO-RELAY STATION IN NIGERIA

Radio-Relay Systems above 1,000 *Mc/s*

Radio signals using frequencies above about 1,000 Mc/s behave in very much the same way as visible light. For example, they may be considered to travel in straight lines and be subject to reflection and refraction effects. Or, in common with light waves, radio signals will be diffracted over and around obstacles on or near the direct transmission path.

Microwave radio signals do not, however, always travel in a straight line in the atmosphere, because this is far from homogeneous. There is a definite change of refractive index with height above ground. Although this change is very small, it nevertheless can produce significant bending of the path of radio waves. Furthermore, these conditions fluctuate and change with changing weather. In fact, propagation conditions occasionally arise where the gradient of the atmospheric refractive index is such as to cause the wave path to be bent towards the surface of the earth, giving the effect of obstruction from hill-top ridges that are normally well clear of the path. Thus, wide variation in received signal level (fading) can be experienced.

Fading is influenced by link topography and local climate. The risk of fading on a proposed link can be assessed with reasonable accuracy provided local-climate records are available. These can then be used to examine the behaviour of existing links in comparable conditions.

The effect of fading can be reduced to negligible proportions, however, if, and only if, sites for microwave radio-relay link stations are located with care and precision and after considerable appraisal both of the particular characteristics required of the link and local terrain and climate. Practical requirements must, of course, also be satisfied, such as access throughout the year, suitability of ground for buildings and the practicability of mast or tower construction.

Radio-Relay Systems below 1,000 *Mc/s*

Although there is no sudden transition in propagation conditions at 1,000 Mc/s, propagation below 1,000 Mc/s in the v.h.f. and u.h.f. ranges is somewhat less restrictive (especially in the v.h.f. range). Clear-cut optical paths are not so essential in order to achieve an adequate performance and, even though much careful thought needs to be given to system planning, the requirements are less rigorous and performance estimates can be made somewhat more empirically.

Radio-Frequency Usage

The radio-frequency spectrum which has to bear these link systems is needed at the same time for many other developing services—land, air and marine mobile services, broadcasting, radio-location, and navigational aids, to name only some. The amount of radio-frequency spectrum available for fixed point-to-point links is only a small proportion of the whole. The precise bands that can be used in any particular country need to be decided by the national frequency authority in accordance with the general provisions of the relevant international regulations. Standardization of these bands has obvious benefits, and the bands likely to be available in any country might well be not greatly different from those indicated in the table.

An Example of Nationally-Allocated Frequency Bands

Band	Frequency (Mc/s)	Usage
V.H.F.	60–90 130–280	1-, 6-, 12-, 24- and 48-channel telephony links.
U.H.F.	420–470 1,700–2,300 2,500–2,700	Up to 60-channel telephony links. Line-of-sight links for television or multi-channel telephony with capacities of several hundreds of channels. Tropospheric-scatter links.
S.H.F.	3,700–4,200 6,400–8,000	Broadband line-of-sight links for television or multi-channel telephony.

While the v.h.f. band and the lower u.h.f. bands are suitable for low-capacity point-to-point links, these are also particularly well-suited from a propagation point of view for mobile services and for broadcasting. Since these other services cannot operate so effectively at higher frequencies, the use of this part of the spectrum by fixed links should be curtailed as far as possible. Mobile services, incidentally, though not discussed in this paper, may play an important part in the developing stage of a territory, in that, as illustrated by the equipment shown in use in Fig. 4, communications may be extended readily

FIG. 4—BOOT-MOUNTING MOBILE RADIO-TELEPHONE

over a wide area by techniques not demanding special operational skill.

International and National Regulation of Radio-Frequency Allocations

The importance of making proper national arrangements for sharing out the radio-frequency spectrum so that the needs of each service can be met has become emphasized in recent years with the growth of existing and new radio services which are an integral and inescapable element of developments in communication, transportation, and social and cultural services. Radio signals do not recognize national boundaries and the problems of radio-frequency allocation are obviously international and have to be tackled on a world-wide basis.

The allocation of the radio-frequency spectrum to all the various services in general terms is in fact the subject of international agreement and is contained in the Table of Frequencies in Article 5 of the Radio Regulations of the International Telecommunication Union (I.T.U.). Only those bands allocated in the table to the "Fixed Service" may be used for radio-relay systems. Very few bands are allocated exclusively to this service and in most cases the bands for the fixed services are shared with other services. It is thus necessary for each country to decide its own sub-allocation plan for these bands to meet the needs of its own radio services and to co-ordinate its radio-frequency allocation policies with those of neighbouring countries. Experience has shown the need for a well-founded administrative and executive national organization for this work. Such an organization is an essential element of the growth of radio in a developing country.

Technical Standardization of Radio Systems

In planning to satisfy the telecommunications needs of local communities it must be remembered that the grand objective is that man shall be able to speak to man, regardless of nation or distance. Local telephone services are but parts of the whole-world communication network. For the grand objective to be achieved there must be international agreement on standards and procedures. The International Telecommunication Union is the body charged by the United Nations to secure agreement and understanding in the field of international telecommunications. The frequency-allocation function of the International Telecommunication Union has already been mentioned. Its technical functions are undertaken by the International Radio, and the International Telegraph and Telephone, Consultative Committees (C.C.I.R. and C.C.I.T.T.) which are the bodies responsible for the study of technical questions related to radio and line communication. The rapid growth of world-wide communications with interconnexions across international boundaries requires standardization of systems performance. In practice, this is achieved by using the recommendations of the C.C.I.R. and C.C.I.T.T. as the bases of performance planning not only for international links but also for each component section of the national systems, however modest, within the frontiers of the individual countries into which these international links operate.

PRACTICAL PROBLEMS IN LINK PLANNING IN A DEVELOPING AREA

General Planning

Consideration must now be given to some of the down-to-earth, practical problems that face an administration that has to consider augmenting its telecommunications system by using radio-relay systems.

First it must be assumed that a planning organization exists, either within the administration or through external consultant help, that is capable of dealing with technological and economic matters on a broad basis. Only in this way can the specific needs of the area be defined and an ordered plan developed and implemented to meet those needs.

There will need to be a study of the existing rural and urban growth and development. Industrial, commercial and agricultural development, including any projects under consideration, must be analysed to provide the necessary basic information. From this analysis an estimate of the required traffic capacities of the various parts of the system can be made. From these data a network plan is developed which is compatible both with the national plan, with any regional plan that may have been developed by the C.C.I.T.T., or with any international connexions, e.g. submarine cable, satellite, h.f. radio or microwave link schemes, that may be planned.

In formulating the outline plan of the telephone network, consideration needs to be given to the budget available and the plan may have to be split into phases compatible with the availability of funds. Of obvious importance is the choice of the order in which routes are to be provided. This would normally take account of routes on which the quickest increase in traffic is to be expected, linking important population centres in expectation that it would prove to be an immediate economic success. In this event the flow of capital for further sections would be considerably augmented due to increased income.

On the other hand, social or administrative reasons may play an important part in determining priorities. Whatever the factors involved, firm and far-seeing decisions are needed at this stage which, once taken, should be adhered to. It is at these stages that the choice between radio and cable is made, generally on the basis of broad budgetary costs that take into account not only both capital and annual charges but also the many other factors that have been outlined above.

Radio-Route Planning

Assuming that a radio-relay system is to be considered, then the problem of route planning resolves itself into attempting to satisfy the following criteria:

(*a*) Minimum number of stations consistent with acceptable out-of-service (outage) time due to fading on the paths (thus achieving minimum capital and maintenance costs).

(*b*) Maximum accessibility for maintenance staff (thereby reducing capital and maintenance costs and reducing out-of-service time).

(*c*) Minimum distance from stations with traffic access to associated local exchanges (minimum cable-tail costs). By traffic access is meant stations where radio signals are demodulated for onward connexion to cable systems.

Since the overall performance of a radio-relay system is determined partly by the parameters of the equipment itself and partly by the manner in which the equipment is applied to the system, it is imperative that both the route and installation of the equipment be properly planned. Route planning will have to take into account the propagation characteristics of the paths between possible stations, the extent to which these characteristics may be affected by atmospheric variations or changing vegetation throughout the seasons, the extent to which signals from one section may "overshoot" and interfere with another section, and many similar points.

Some consideration will also have to be given to the extra facilities that will have to be provided in order to ensure the reliability of the final system. For instance, it may be necessary to have standby channels, switching being done automatically, leaving the faulty channel free for servicing. The amount of standby equipment to be provided is determined to some extent by the type and importance of the traffic carried by the link. It is also determined by the scale and type of maintenance facilities foreseen. At unattended radio stations a fault would have to await the arrival of staff from their local base; in some locations this could mean a three-hour drive or more. At attended stations there would be no such delay. Risk of breakdown (and this can be very low with some radio systems) has thus to be balanced against cost and difficulty of maintenance attention on the one hand and cost of standby channels on the other.

Station-Site Selection

Having worked out these criteria, it is now necessary to select tentative sites which meet these conditions, and, in addition, are accessible and capable of accommodating a station building and antenna mast or tower.

A profile chart of the intervening terrain between the suggested sites must be made to ensure that adequate path clearance is achieved. This means using contoured topographic maps, backed by a visual survey of the path to check the height of trees or other obstructions. Where maps are not reliable, additional field survey work is necessary. By using a transit or theodolite the depression angle to high points may be measured from both ends of the path and the information plotted on the profile chart. If maps are not available, then an aerial photographic survey may be essential. Several specialist contractors exist for such work, but costs may be high, depending upon how far from his home base the contractor has to move aircraft and equipment to carry out the work.

Once path-profile charts have been prepared and tentative sites selected, the engineer responsible for the radio-route planning and the civil engineer who will be responsible for access roads and buildings should visit each site. In developing areas, this can be both arduous and time-consuming. A helicopter can enable sites to be visited easily, and often old forgotten tracks and footpaths leading to the high points can be recognized from the air; this helps to plan access roads to the site. Some indication of the difficult terrain encountered in practice may be gathered from Fig. 5, which illustrates a microwave repeater station in Malaya.

The ground survey should aim to secure the following facts:

(*a*) Distance and approximate cost of access road from site to existing road or track.

(*b*) Availability of reliable commercial power supply and the cost of extending the supply to the site.

(*c*) Estimate of deforestation and levelling to enable station and tower to be built.

(*d*) Type of subsoil, and assessment of work and cost of preparing station and tower foundations.

(*e*) Examination of foreground in the directions of the radio beams to ensure freedom from obstacles which could reflect or diffract the signal.

(*f*) Local meteorological information (e.g. prevalence of ice and high wind velocity will affect the design of tower to be provided; the range of ambient air temperatures will decide whether the building needs heating or air-conditioning; likelihood of lightning).

(*g*) Availability of water supply and fuel supplies for standby diesel alternator sets.

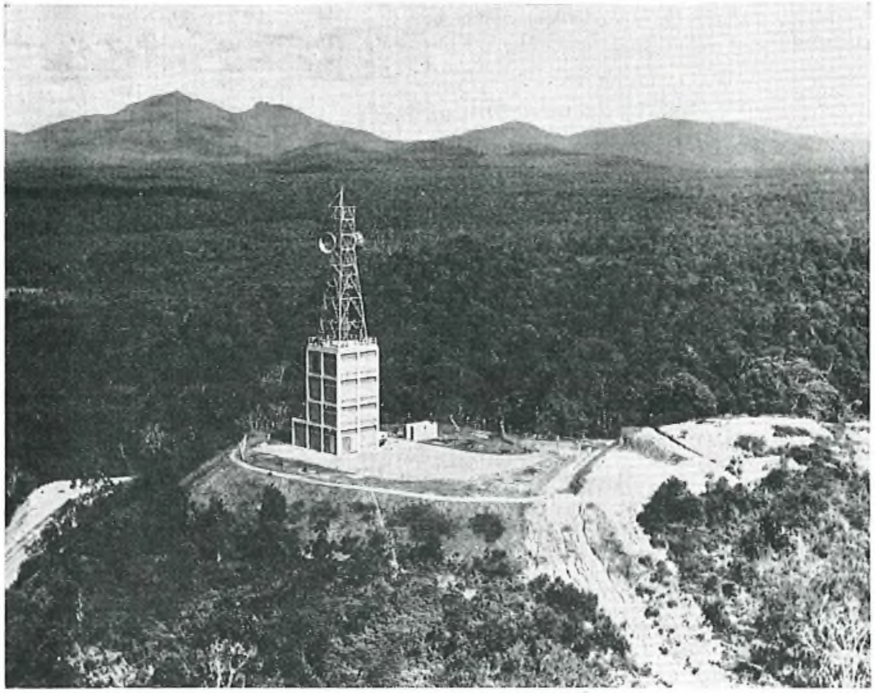


FIG. 5—MICROWAVE REPEATER STATION IN THE MALAYAN KUALA LUMPUR-SINGAPORE NETWORK

Although specialist contractors may be employed for all or part of the above works, engineers and technicians from the administration should be on site at all times to gain experience, particularly during the final stages of system testing and commissioning when overall tests are made to demonstrate that the scheme meets its contractual requirements.

Operation and Maintenance

Carefully planned and constructed links employing modern v.h.f., u.h.f. or s.h.f. equipments have an extremely high degree of reliability. The reliability of such links is improved further by the use of standby equipment which is automatically switched in to replace an operating channel that becomes faulty or whose performance is degraded beyond acceptable limits. Radio-link maintenance is also helped by extending alarms from unattended relay stations to the nearest staffed stations. All stations need to be visited at regular intervals for routine checks of the equipment, and sufficient test gear to enable these routine checks to be made should be held at each station. Apart from the routine tests, which will be performed approximately every four weeks, it will be necessary to carry out more comprehensive tests on the whole system about twice a year. Typical small-capacity junction radio equipment being maintained in North Borneo by local staff is illustrated in Fig. 6.

At the end of the ground survey the planning engineer may still feel not entirely satisfied. For example, he may not feel satisfied about the accuracy of a path profile because of continuous poor visibility. In these cases, radio transmissions may have to be made to assess the characteristics of the radio path. This work normally takes between one and three days for each path, depending upon time taken to set up a test mast and test gear; in difficult cases tests may have to be conducted over a longer period to include that period of the year when fading conditions can be expected to be at their worst.

At the end of these preliminary planning stages, however, sufficient information should be available to specify the system requirements, to invite tenders, and place contracts for the equipment and civil works.

System Installation

At the earliest possible moment a program must be prepared for all works connected with the building and installation of the radio network. This should take into account local climatic conditions, such as heavy rains, snow, etc., during which site operations may be severely hampered.

A typical program would include the following stages:

(*a*) Build access roads, clear site and construct tower and building foundations.

(*b*) Erect towers, install antennas, waveguides or feeders, start erecting buildings.

(*c*) Orientate antennas and check path loss.

(*d*) Install power plant in buildings.

(*e*) Install radio equipment. If there is to be an auxiliary link for service communications this should be installed before the main-link equipment to provide inter-site communications.

(*f*) Align and test equipment in each station.

(*g*) Test station to station.

(*h*) Test overall route.

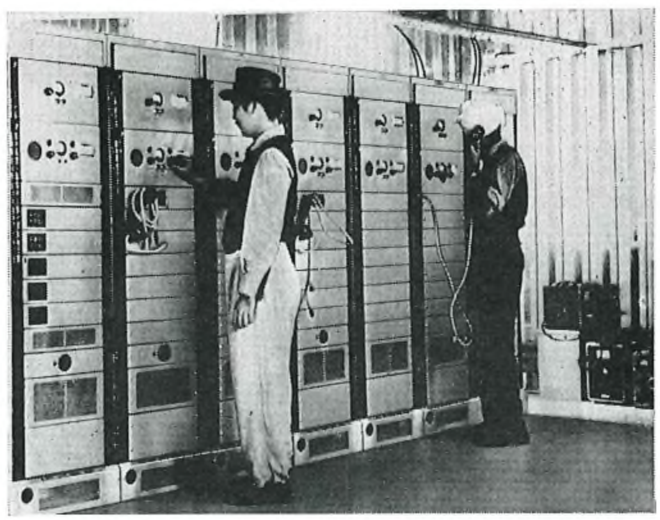


FIG. 6—FIVE-CIRCUIT JUNCTION RADIO EQUIPMENT INSTALLED IN NORTH BORNEO

A point to be considered by the administration is the maintenance procedure to be adopted. If skilled maintenance technicians are at a premium it would probably be wise to restrict the work carried out at a relay station to valve replacements and minor repairs. If anything more serious has to be remedied, then this work would be carried out at a central workshop equipped with the necessary test equipment and staffed by the highest-grade technicians available. A plan of this sort makes possible the optimum utilization of available staff. It does mean, of course, that spare equipment has to be held in stock at strategic points, but this may be justified by the saving in skilled technicians.

As the distances involved in a large system are great, some of the responsibility for the maintenance of the system may have to be decentralized to local areas, and in some cases sub-areas, controlled and supplied from a central headquarters. This would call for staff that includes not only engineers and technicians but also fitters, riggers, clerks and drivers, etc.

Staff Training and Selection

Three main levels of employment will be required:

(*a*) Professional-grade posts, normally filled by ex-students who have studied and qualified abroad, or by graduates from local colleges who then proceed abroad for post-graduate training (often with the large radio-manufacturing organizations), since the numbers required are small and adequate training facilities are difficult to provide on the spot.

(*b*) Technical-officer posts, filled by men after they have been given vocational training in one or more crafts, using courses of comparatively short duration.

(*c*) Technician-grade posts. These demand a more long-term approach, since the intention will be to select candidates who have reached credit standard in science, mathematics and the official language in local secondary schools and train them so that they will be able to maintain s.h.f., v.h.f. and h.f. radio equipment and carrier equipment without constant supervision. This has been found to warrant a four-year course with periods of intervening field training.

In many developing areas the recruitment of suitable maintenance staff is a serious problem. Even where technical high schools exist it may be preferable for the administration to establish its own training school and admit to it those students who have the appropriate school-leaving certificate in general education and show an aptitude for technical subjects.

These problems of selecting and training staff should not be underestimated. It may prove essential at the outset to secure the services of trained personnel from abroad, who will not only set up the necessary maintenance centres and carry out the maintenance work, but may also have to introduce the necessary recruiting and training facilities so as to ensure that, as soon as possible, local personnel will be able to organize and carry out the work themselves.

TECHNICAL ASSISTANCE

There are a variety of ways in which technical assistance can be provided. The principal methods are as follows:

"Turn-key" Contracts

One contractor is given the bare requirements of the network and must then engineer the system, install all equipment, provide all civil works and hand the whole system over to the administration in full operational order. If required, the contract can be extended to cover maintenance for a period during which the administration train the staff who ultimately take over and maintain the system.

Employment of Consultants

The consultants can commence at the same stage as the contractor mentioned above, or can assume responsibility for the initial outline planning, or can help the administration in formulating the basic plan. The consultants would normally prepare, for each part of the project, the specifications against which contracts would be placed. The extent of the administration's participation is a matter for agreement with the consultants.

United Nations Technical Co-operation

Technical and economic assistance under United Nations auspices is available to all countries through the following schemes of U.N. Technical Co-operation. Full details about how to apply for such assistance can be obtained from the U.N. Technical Assistance Board (TAB) Resident Representatives, who are stationed in most major cities of the world, or through the U.N. Specialized Agencies, e.g. the I.T.U.

(*a*) *U.N. Expanded Program of Technical Assistance (EPTA)*. EPTA arranges for experts to visit, for periods up to four years, and advise countries on technical problems and, where necessary, to train local staff. It also awards Fellowships enabling students to attend technical establishments in the more developed countries.

(*b*) *U.N. Special Fund*. The Fund finances major projects by the provision of staff, experts, equipment, supplies and services. It does not, however, finance capital investment.

(*c*) *International Bank for Reconstruction and Development (IBRD)*. The bank facilitates the investment of foreign and private capital by arranging loans on normal interest terms.

(*d*) *International Development Association (IDA)*. IDA supplements the lending operations of the IBRD (with which it is affiliated) by providing development funds on easier terms than those prescribed for IBRD loans.

CONCLUSIONS

V.H.F., u.h.f. and s.h.f. systems have, in many parts of the world, demonstrated their ability to provide reliable and valued links in national and international telecommunication networks. In developing countries their particular virtue is the fact that they can be installed relatively quickly, and can form a sound basis for a growing national telecommunication network either as elements of the trunk system, or as connexions to individual isolated subscribers. A second, but none the less important, factor is that the use of radio enables some of the natural obstacles to rapid development, such as swamp, jungle, forest and desert, to be overcome.

However, as this paper seeks to show, these virtues have to be bought at the price of the consequences of using techniques that, though immensely rewarding and profitable, are very demanding both in human skills and ingenuity. Provided, however, radio systems are planned upon a firm technical basis, with due regard not only to internationally agreed performance standards but also to the factors that should determine the siting of the stations and aerials, their subsequent installation, operation and maintenance should not present undue difficulty or make undue demands upon the resources of a developing nation. The need for this planning to be undertaken with full knowledge of C.C.I.T.T. and C.C.I.R. performance standards, and in full compliance with the Radio Regulations of the International Telecommunication Union, cannot be too strongly emphasized.

Lastly, there exists, not only in the administrations and commercial organizations of the more developed nations but also in the various organs and agencies of the United Nations, a body of expertise which is available for the assistance and guidance of the developing areas, should it be needed, in this important and rewarding work of radio-link planning.

ACKNOWLEDGEMENTS

An integrating paper such as this, must draw upon many sources of experience, skill and knowledge. Acknowledgement is gladly and gratefully given to many colleagues, both in British industry, in overseas administrations and in the General Post Office, whose views and experience have been brought to account in the preparation of this paper.

Acknowledgement is also given to Automatic Telephone & Electric Co., Ltd., Marconi's Wireless Telegraph Co., Ltd., Pye Telecommunications, Ltd., Standard Telephones & Cables, Ltd., and General Electric Co., Ltd., for the provision of illustrations.

New Key-and-Lamp Desk Unit

L. R. DAVEY†

U.D.C. 621.395.721.1 : 621.395.331.3

Many large organizations require special facilities for dealing with incoming telephone calls or to enable one operator to supply information simultaneously to a number of subscribers. A standard key-and-lamp desk unit has been designed that can be used in conjunction with auxiliary relay units for many of these special applications.

INTRODUCTION

IN many firms and large organizations much of the telephone traffic falls into a regular pattern, and it is expedient to handle such traffic by separate sections of the staff. Travel agencies, air lines, telephone-order departments of large stores, and the police, fire and ambulance services are all typical examples.

The basic requirement for the type of service referred to above is speed in answering, and at the type of installation concerned a group of lines, which can be exchange lines, switchboard extensions or private circuits, is connected to each of a number of keyboards arranged for ancillary working. A call appears simultaneously at all positions, to be answered by the first free operator; acceptance of the call is indicated at all positions by a visual engaged signal. Such a system is termed order-table working, and there is an increasing demand for it.

Since the legalization of betting-shops, a very considerable increase has occurred in requests for speech-broadcast (or multiphone) systems in which one operator can supply information to a number of recipients at the same time. Sporting news-agencies and bookmakers in particular require this service, and it is not unusual to find offices supplying 200 or 300 subscribers with up-to-the-minute racing information.

In the past, the two systems mentioned above have been catered for by various types of keyboards with lamps, or disk, "drop-flap" or "dolls-eye" indicators, as well as a variety of specially-made non-standard units. In considering the provision of modern equipment for such installations, it was decided to separate the switching and relay elements from the desk unit. By so doing it was possible to produce one standard desk unit that not only meets the requirements of both order-table and speech-broadcast working but also provides a ready-made basic unit for numerous non-standard requirements. The relay and switching elements are provided by a range of auxiliary apparatus units.

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DESCRIPTION OF NEW DESK UNIT

The associated photographs (Fig. 1 and 2) show that, in appearance, the new desk unit (Key and Lamp Unit No. 2A) resembles the recently introduced cordless P.M.B.X.[1,2] The French-grey case is moulded in a co-polymer of acrylonitrile, butadiene and styrene, and the key-panel has an elephant-grey stoved textured

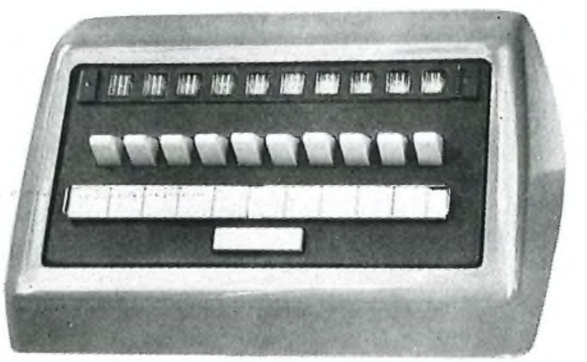

FIG. 1—KEY-AND-LAMP DESK UNIT

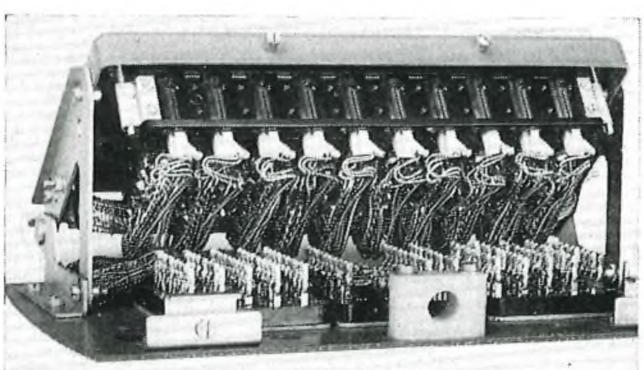

FIG. 2—INTERIOR OF DESK UNIT

vinyl finish.* The panel carries 10 lamps, 10 1,000-type keys[3] and a separate key-bar operating a micro-switch. Each key has basic wiring for one line-circuit, but the 10th key has additional springs wired to a tag-block to enable this key to be used for purposes other than as a line-key should it be necessary. The micro-switch may be used for connecting a ringing signal or for P.B.X. operator recall.

The key-and-lamp unit is to be stocked as a complete item but its component parts will also be available to facilitate incorporating it in subscribers' furniture, consoles, etc. Previously such a requirement entailed special construction work or considerable modification of standard units.

The components of the operator's telephone circuit and the associated instrument jack are contained in a separate unit (Jack-Unit No. 1A) fitted to the underside of the desk. The unit is shown in Fig. 3, and Fig. 4, which is the unit with its cover removed, shows

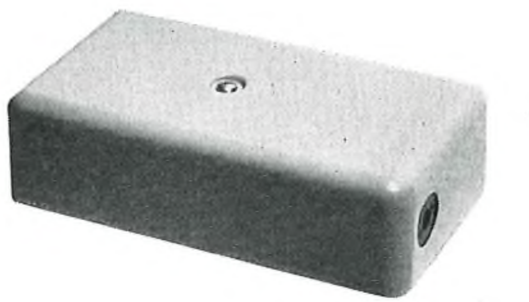

FIG. 3—JACK-UNIT No. 1A

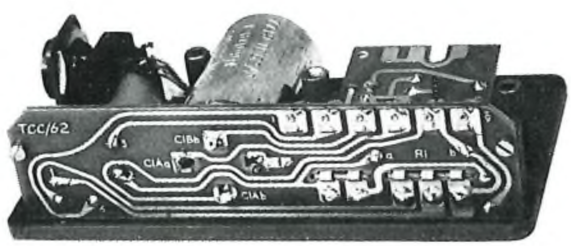

FIG. 4—JACK-UNIT No. 1A WITH COVER REMOVED

clearly the components mounted on a printed-wiring board having a circuit arrangement similar to that of the Telephone No. 706.[4] A drawer-mounted dial can be fitted alongside the unit if required, or the two items can be replaced by a separate telephone instrument.

The associated auxiliary apparatus units are made up as 19 in. strip-mounted units suitable for rack or wall mounting.

*Stoved textured vinyl finishes are tough and leathery in appearance, with a very good adhesion. The metal is zinc-plated and passivated, an organosol primer is applied and then stoved for 10 minutes. Elephant-grey organosol paint is sprayed on the primed plate in a horizontal position to avoid sagging, allowed to "flash off," i.e. the solvents are given a few minutes to evaporate, and a further 10 minutes stoving at 300°F completes the process.

Order-Table Working

In the 10-line unit most frequently used for order-table working at present, each line-circuit has separate lamps for the calling and engaged signals. In the new keyboard, the same lamp is used to indicate both a calling and an engaged circuit, a flashing signal changing to a steady glow at all positions when the call is answered by any operator.

Every installation requires one auxiliary apparatus unit comprising five line-circuits and lamp-flashing equipment with 20 outlets. Smaller units of 5-line capacity but without the flashing equipment are also available, and a 10-line system requires one unit of each type; larger installations can be built up by adding further small units.

The power supplies are 50 volt d.c. and 6 volt a.c. (for lighting the lamps), both derived from the mains.

Speech-Broadcast Working

In the speech-broadcast system one operator can supply information simultaneously to a number of subscribers or deal with the lines individually for enquiries. The lines may be private circuits or exchange lines, and such news-agencies as the Exchange Telegraph Company use both in large numbers. If the queries are few, one operator may control several keyboards.

The calling signal is a steady glow, but there is no supervisory signal, as a recall-during-broadcast facility is provided. Loop-calling on omnibus circuits is impracticable, and the keyboard is therefore signalled by battery potential or earth potential applied to both wires of the calling line. Battery potential applied to both wires of a line, or a.c. ringing, is used for outgoing signalling. As no relays are operated during broadcasting, which may last for several hours, considerable economies in power consumption are effected.

Auxiliary apparatus units are provided on the basis of one per five lines.

A 24-volt d.c. power supply is required and in the majority of installations this will already exist.

ACKNOWLEDGEMENT

The author wishes to thank the Telephone Manufacturing Company, Ltd., who as liaison manufacturers have worked in close co-operation with the Post Office in this development.

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Housing of Repeater Equipment Underground

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U.D.C. 621.395.724:621.315.233

To take full advantage of the use of transistors in line transmission systems it is desirable to employ a relatively large number of closely-spaced amplifiers. Such intermediate repeater equipment can conveniently be housed in containers that are suitable for placing in underground jointing chambers. Features of a Post Office design of repeater equipment case for use in such circumstances are described.

INTRODUCTION

THE difficulty of finding and buying sites for intermediate-repeater equipment along a cable route has resulted in many studies of the problems of placing such equipment either in cabinets or in jointing chambers.* The use of cabinets is not entirely satisfactory, since there are still some site problems and the temperature rise in a cabinet exposed to the sun can be excessive. The need for high power-feeding voltages precluded the use of underground mounting with valve circuits, but the introduction of transistors has now solved this problem. Relative to valves, transistors are low power-consuming and low power-handling devices, and the natural way of using such devices in line systems is to have a large number of closely-spaced amplifiers and to feed power to these amplifiers over the cable pairs. To use amplifiers in this way does not call for high output powers, and minimizing the level difference between the input and output of the amplifier makes it easier for the designer to reduce the effects of cable crosstalk. Thus, a suitable means of mounting transistor amplifiers in jointing chambers has become necessary.

Most of the main transmission-equipment manufacturers in the United Kingdom as well as abroad have now produced designs of repeater mounting-cases suitable for use in jointing chambers. Although all the cases are different in detail, all are similar in principle, as would be expected because the basic needs are the same. One of the earliest designs produced used a vertical tube, the lower half being buried in the ground to enable some measure of temperature stability to be achieved. This method of mounting was not acceptable to the Post Office as a standard because of the congested roadway conditions in this country. The French propose to build special cable chambers for repeater equipment.

Details of the Post Office standard repeater equipment case now being developed and the reasons for the various features of its design are discussed in the following paragraphs. The case is illustrated in the accompanying photograph.

REPEATER EQUIPMENT CASE

Size

The volume of equipment space required in any jointing chamber is difficult to assess as it depends on the number of amplifiers and the quantity of associated equipment. For small-diameter coaxial cables it is reasonable to mount the total equipment for four coaxial pairs in one housing as it is expected that this will be the most commonly used size of cable. For carrier systems on deloaded audio pairs there is no obvious fixed limit, although at the present time there is a limit of one system per balancing group.

REPEATER EQUIPMENT CASE FOR USE IN JOINTING CHAMBERS

The size of the manhole entrance sets an upper limit on the size of the equipment case if it is to be used in existing manholes. The smallest entrance that is likely to be commonly met is the 2 ft diameter cover of a carriageway joint-box, hence this was accepted as governing the upper limit of the size of the case. The design is such as to make it possible to pass the equipment case end-on through the 2 ft diameter manhole entrance or through the 1 ft 11 in. × 2 ft 2 in. standard manhole cover.

It has been found possible to standardize one size of equipment case giving an equipment volume of 17 in. × 7½ in. × 10½ in., in which it is expected to be able to house either

(*a*) equipment for a 4-tube coaxial cable,
(*b*) equipment for two pairs for 2-wire-type carrier systems on deloaded audio cable,
(*c*) equipment for four pairs for 4-wire-type carrier systems on deloaded audio cable, or
(*d*) equipment for 10 pairs for pulse-code-modulation systems on deloaded audio cable.

Equipments (*a*), (*b*) and (*c*) have been developed, but the design of the equipment for (*d*) has not yet been attempted.

Materials

The requirements for loading-coil containers and for repeater equipment cases under joint-box conditions are similar in many ways; the main difference lies in the lower weight of the repeater equipment. In a flooded manhole any tendency for the case to float could place excessive strain on the lead-out cables and joints. Thus,

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*ENDERSBY, J. C., and BUFFIN, J. D. Temperature Tests for Transmission Equipment Located in Footway Joint-Boxes. (In this issue of the *P.O.E.E.J.*)

although mild-steel loading-coil containers are standard, cast iron had been used successfully for many years and was discarded mainly because of its excessive weight when full of coils. For the repeater equipment case this weight could be used to advantage. Other materials were considered; amongst them the most promising were corrosion-resistant cast nickel-irons. These, however, are more costly, and ultimately it was decided to use the cheaper standard cast-iron case with a zinc spray or galvanized coating and finished with a bituminous lacquer, a standard that has given good service in the past.

Sealing and Clamping

Although it is hoped that transistor equipment will have a long life, it is necessary to arrange for some, not too difficult, access. This is partly for tests on the equipment and also for cable-fault locating, since the repeater cases replace the intermediate repeater stations on a conventional coaxial-cable route.

There is no need for very rapid access since it may take many hours to locate the fault and drain the manhole before repair of the fault can commence, but it is essential that any seal and clamping device should not take too long to open, yet it should not easily be mis-operated. A simple method of clamping by using studs or bolts is quite attractive but has some disadvantages. The nuts or bolts need to be tightened in a definite pattern to ensure sealing without excessive torque, and this method is thus dependent on the individual operator. Again, excessive tightening could lead to damage of the seal and might also cause the whole case to move, throwing strain on the lead-out cables. It was, therefore, decided to use a cam-action clamp to ensure uniform controlled pressure all round the seal.

To seal the lid of the equipment case it is proposed to use a natural-rubber grommet fitted into a dovetail-shaped groove in the lid and compressed by a rib cast on the edge of the case. The seal is similar in principle to that employed in the cabinets used in the local-line networks. It is recommended that the seal should be checked at a pressure of 10 lb/in^2, and a Schrader valve is provided to enable a compressed-air cylinder (or failing this a foot-pump) to be coupled to the box for this test. The cam-action clamp is designed to prevent the lid flying off should it be released without first reducing the pressure.

Cable Entry

The cable tails used have to be sufficiently robust to withstand conditions in a manhole or joint-box, and consequently it was recommended that cables of less than $\frac{3}{4}$ in. diameter should not be used. Fortunately, for other reasons, it has been agreed that small-diameter coaxial cable will in future have a lead sheath, and it was thus permissible to design the cable entry to cater for lead-sheathed cables only.

As it has now been decided to gas-pressurize all cables, including the tail cables into the repeater case, it is essential that the cable air supply should not be drained when a case is opened. It is therefore necessary not only to seal the cable entry in the casting against water getting into the equipment case but also to prevent gas entering the case from the cable core. This double seal in the repeater case is achieved by gas sealing the cable into a terminating box and then sealing the tail with a water-tight gland into the main casting.

To enable straight joints to be made on small-diameter coaxial cable between the ends of the tails and the main cable, it is necessary to have two types of cable tail, one having clockwise lay and the other having an anti-clockwise lay, to permit jointing to the "up" and "down" sides, respectively. The terminating boxes of both tails are arranged to be interchangeable so that the box can be in any position in the jointing chamber and still be made to match the direction of lay of the cable.

Internal Equipment Design

The equipment to be fitted in the cases is mostly of the type that will in future be mounted on printed-wiring or similar cards in repeater stations. It is proposed that the basic type of card should be retained, so that units similar to those used in the terminal stations can be used in the underground intermediate repeaters. It is, however, very likely that the cards will be handled with grimed hands and may be accidently put down in mud or wet grass. The cards should therefore be protected by a screening and splash-proof cover.

The units will be of the plug-in type, so that soldering irons will not normally be needed, and gold-plated plugs and sockets will be used to prevent contact corrosion.

Test Points

So that the equipment should not be excessively complicated, pilot-level deviation alarms are provided only at points where the pilot is detected and a d.c. current is provided to regulate the system. Thus, other than for power failure, the supervisory system does not give a precise location of every fault. Experience has shown that considerable time would be spent in pumping and drying manholes if measurements could be made only after opening the repeater cases and it is desirable to be able to measure repeater output levels and to communicate with the terminal stations without access to the repeater case. The case has therefore been provided with a test lead that can be used to extend the test points and the speaker circuit to a readily-accessible point; this could be located in either a test pillar, a small footway box or above the water-line in the manhole entrance.

CONCLUSIONS

The repeater case described is in the first stage of development. Field experience will no doubt dictate many changes and modifications.

It is expected that equipment size will continue to decrease, with, for example, the introduction of micro-module and solid circuits. This may result in the unit becoming even more like a loading coil and so be solidly plumbed into the cable in the same manner that a uni-coil is enclosed in a joint. Nevertheless, at the same time as the equipment size decreases the numbers of repeaters required will be increased, and it is possible that the total equipment volume required will remain constant. If this does happen, the number of pairs that will require to be terminated will increase.

ACKNOWLEDGEMENT

The designers of the Post Office repeater case have had the kind co-operation of, and have learned from the experience of, many engineers in the telecommunication industry. The authors gratefully acknowledge the help given by their colleagues in industry and within the Post Office.

Temperature Tests for Transmission Equipment Located in Footway Joint-Boxes

J. C. ENDERSBY, A.M.I.E.E., and J. D. BUFFIN†

U.D.C. 536.5:621.395.465:621.315.233

Because of the increasing need to place intermediate repeater equipment in underground joint-boxes or manholes, tests have been made to ascertain the likely daily and seasonal temperature changes to which equipment would be subjected in such circumstances. The possibilities of limiting these temperature changes have also been investigated.

INTRODUCTION

DUE to the growing number of applications requiring the siting of transmission equipment in underground jointing-chambers, a series of tests has been carried out to ascertain the daily and yearly changes likely to be encountered by the equipment and to explore the possibilities of restricting these variations.

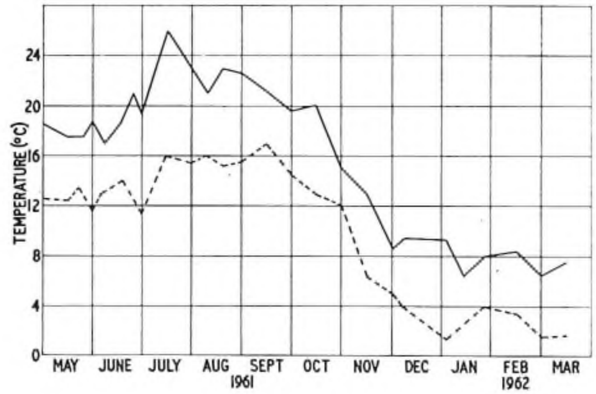
UNDERGROUND TESTS

The tests were conducted in footway joint-boxes on the Eastbourne–Hastings small-diameter coaxial-cable route.[1] In order to obtain the greatest possible range of temperature readings the route was surveyed to find a repeater point in a well-exposed position and a footway joint-box, AP2, on the Pevensey Marshes was chosen.

Two maximum and minimum thermometers were fitted, one inside the repeater case[2] and the other by the cable-entry port of the joint-box itself. Readings were made every fortnight during the 11 months from May 1961 to March 1962; the results are shown in Fig. 1. It is interesting to note that the temperature readings taken approximate to the average maximum and average minimum air temperature readings taken at Eastbourne from 1921–1950 and that the greatest rates of change occur during spring and autumn. The temperature range measured outside the repeater case but within the joint-box is from 1°C to 26°C and inside the case from 3°C to 23°C.

Further experiments were started in May 1962 to explore the possibilities of reducing temperature excursions within the joint-box by means of a heat shield. In order to conduct this test it was necessary to select two footway joint-boxes of the same size and in very similar terrain; joint-boxes AP2 and AP3 were chosen, both of which are in exposed sites on the Pevensey Marshes and only 4,000 yd apart. A $\frac{1}{2}$ in.-thick foamed-polystyrene slab mounted in a wooden framework was fitted in joint-box AP3, leaving an air gap of approximately 1 in. between the slab itself and the lid of the joint-box in order to reduce the amount of direct radiation from the cover. The heat shield was detachable to facilitate access to the repeater case. Joint-box AP2 was used as the control and was left uninsulated.

Clockwork temperature-recorders were placed inside the repeater cases in each of the joint-boxes. These recorders gave a continuous 7-day record and enabled direct comparison to be made between temperatures

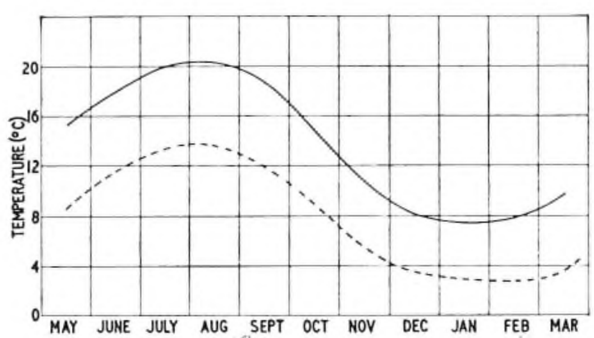


—— Maximum temperatures
- - - Minimum temperatures

(*a*) Maximum and Minimum Temperatures Outside Repeater Case but Inside Joint-Box

—— Maximum temperatures
- - - Minimum temperatures

(*b*) Maximum and Minimum Temperatures Inside Repeater Case



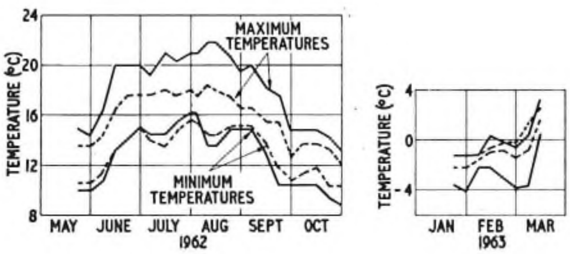
—— Average maximum air temperature
- - - Average minimum air temperature

(*c*) Average Air Temperatures at Eastbourne (1921–1950)

FIG. 1—COMPARISON OF TEMPERATURE EXCURSIONS INSIDE FOOTWAY JOINT-BOX BUT OUTSIDE REPEATER CASE WITH THOSE WITHIN CASE AND WITH AVERAGE AIR TEMPERATURES

†Main Lines Development and Maintenance Branch, E.-in-C.'s Office.

within the insulated and uninsulated repeater cases. The maximum and minimum temperatures recorded each week are shown in Fig. 2, and a typical week's record during the summer is shown in Fig. 3. The readings were suspended during November and December, 1962, and restarted in January, 1963. During January and February when the weather was intensely cold the



—— Temperatures within repeater case in joint-box without thermal insulation
– – – Temperatures within repeater case in joint-box with thermal insulation

FIG. 2—TEMPERATURE EXCURSIONS INSIDE REPEATER CASES IN FOOTWAY JOINT-BOXES

insulated box remained warmer, the lowest temperature recorded in the insulated box being approximately – 2°C (30°F) whilst the minimum recorded in the uninsulated box was approximately – 4°C (25°F).

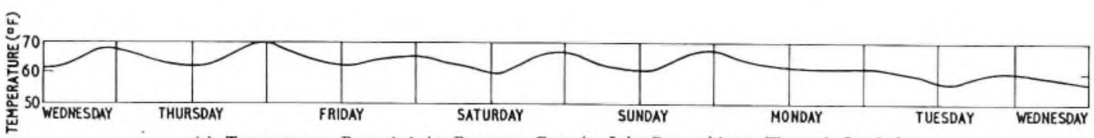
ABOVE-GROUND TESTS

Tests were also carried out to find the temperature variation to be expected if the repeater case were mounted above ground, e.g. on a pole or on the roof of a building. A repeater case was therefore placed on the roof of a Post Office Engineering Department laboratory in London, and a circuit was set up to record the temperature, using a thermistor and a recording voltmeter. The results obtained are shown in Fig. 4. The tests have so far extended for only a few months and, as was expected, much greater excursions of temperature have been recorded than those measured in the joint-boxes. No attempt has yet been made to insulate the roof-mounted repeater case.

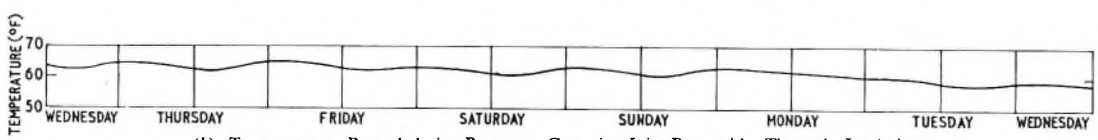
CONCLUSIONS

The results show that it is possible to reduce the overall temperature excursions in footway joint-boxes by a simple device; diurnal variations are reduced and the boxes are cooler in summer and warmer in winter than they would otherwise be.

Although ambient temperature changes are less important now that silicon transistors are more widely used, new wideband line transmission systems on small-diameter coaxial cable (174-type) will use large numbers of amplifiers, and the use of a simple thermal shield might well result in a significant improvement in line-system stability.

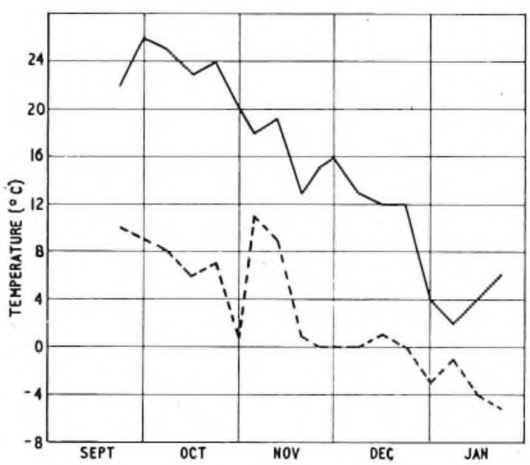


(a) Temperatures Recorded in Repeater Case in Joint-Box without Thermal Insulation



(*b*) Temperatures Recorded in Repeater Case in Joint-Box with Thermal Insulation

FIG. 3—TEMPERATURES RECORDED WITHIN REPEATER CASE DURING ONE WEEK



—— Maximum temperatures
– – – Minimum temperatures

FIG. 4—TEMPERATURES RECORDED WITHIN REPEATER CASE MOUNTED ON ROOF OF BUILDING

ACKNOWLEDGEMENT

The authors wish to thank the staff of the Eastbourne Repeater Station for their help and co-operation.

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Dialling into the United Kingdom Telex Network Over Long-Distance Radio Circuits

W. A. ELLIS, A.M.I.E.E.†

U.D.C. 621.395.636.1: 621.394.342: 621.371

Radio telegraph circuits having automatic error-correction equipment cannot transmit signals corresponding to dial pulses, and, for telex, it is therefore necessary to use teleprinter signals corresponding to the digits required for numerical selection at the distant end. The equipment provided in the United Kingdom to convert these signals to dial pulses is described.

INTRODUCTION

MUCH inter-continental telex traffic is routed over radio links equipped with automatic error-correction devices.[1] The special signalling codes that are an essential feature of the automatic error-correction systems do not permit the direct transmission of dial pulses, and it is necessary to use only teleprinter signals for numerical selection purposes. To enable calls to be dialled into the United Kingdom network over such radio links it has, therefore, been necessary to provide equipment at the London (Fleet) Telex exchange to convert the appropriate teleprinter signals to dial pulses. Calls completed by means of this equipment also include transit traffic to certain European countries.[2]

Operator control of outgoing telex traffic over radio circuits incorporating automatic error-correction will be required for some time, because the timing pulses that determine the duration and charge for a call are derived from the terminal error-correction equipment and are suppressed during periods when the equipment has detected errors and the signals are being repeated. Fully-automatic working over such circuits remains, therefore, a question for study by the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.).

†Telegraph Branch, E.-in-C.'s Office.

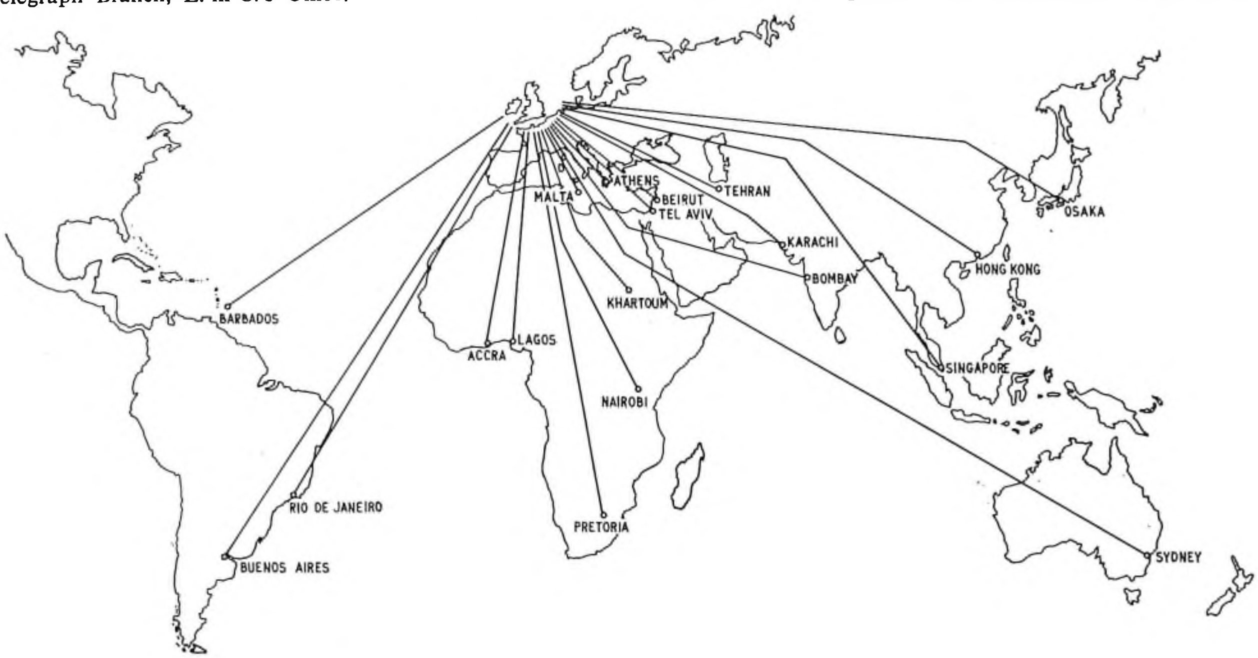
The 5-unit code to dial-pulse conversion equipment was first brought into use in December 1961, and all radio telex circuits have been changed over to incoming semi-automatic working. Fig. 1 shows the routes that have been converted.

SIGNALLING REQUIREMENTS

As already mentioned, a special self-checking signalling code is employed in conjunction with the error-correction equipment used for inter-continental radio circuits, and as a consequence it is difficult to transmit dial-pulse trains or any of the pulses associated with the two ranges of signals (termed type A and type B) corresponding to the two basic forms of signalling used in national telex systems[3] and standardized for use on international circuits routed over multi-circuit voice-frequency telegraph systems. The C.C.I.T.T. have therefore qualified their recommendation that a calling country should conform to the signalling system of the called country, and, for radio routes having error-correction equipment, a special range of signals has been standardized. These signals are shown in the table, which also includes the corresponding type-B signals used for the signalling system in the United Kingdom network and to which the radio telex signals have to be converted.

OPERATION OF EQUIPMENT

Fig. 2 is a block schematic diagram of the equipment provided in London for bothway radio circuits incorporating error-correction. The equipment provides facilities for an operator at a radio-control position to



Routes between the United Kingdom and the following places are projected: Aden, Cairo, Cyprus and Bahrein

FIG. 1—RADIO TELEX ROUTES TO LONDON

Signalling on Telex Radio Circuits Incorporating Error-Correction and on United Kingdom Telex Circuits

Signal	Signalling on Radio Circuits with Error-Correction	Type-B Signalling Used in United Kingdom Network
Call confirmation	Transition from combination α to combination β on the backward-signalling path. Reception of two consecutive β signals to be interpreted as a call-confirmation signal.	25 ms pulse of stop polarity on the backward-signalling path.
Proceed to select	One or more teleprinter signals on the backward-signalling path.	25 ms pulse of stop polarity on the backward-signalling path.
Selection	Teleprinter signals.	Dial pulses or teleprinter signals.
Call connected	One or more teleprinter signals over the backward-signalling path.	Stop polarity for at least 2 seconds on the backward-signalling path.
Clearing signal	Reception of two consecutive α signals will be interpreted as a clearing signal.	Reversion to start polarity for at least 300 ms.
Clear confirmation	Reception of two consecutive α signals on one signalling path will be interpreted as a clear confirmation when a clearing signal of eight α signals without a request for repetition has been transmitted on the other signalling path.	Reversion to start polarity on one signalling path in response to clearing signalling on the other signalling path.

Combination α corresponds to a permanent start-polarity.
Combination β corresponds to a permanent stop-polarity.

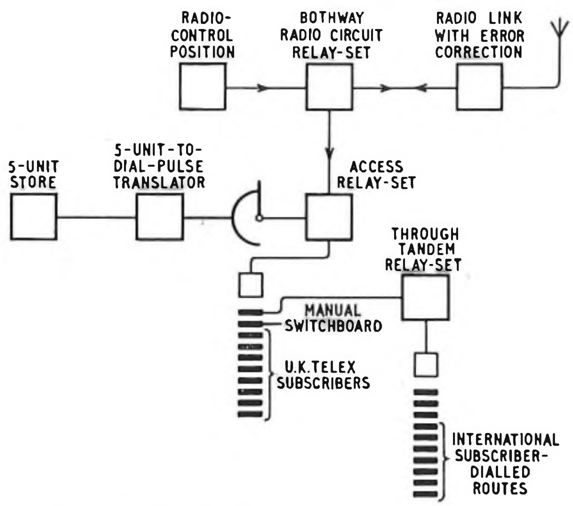


FIG. 2—TRUNKING OF BOTHWAY RADIO TELEX CIRCUITS

make an outgoing call, and for a distant telex operator to set up a call to this country automatically by using the teleprinter keyboard to transmit the required number.

Effective Incoming Call

When a calling signal is received from the distant operator, the access relay-set immediately returns a call-confirmation signal and hunts for a free translator. Seizure of the translator is indicated to the distant operator by a printed proceed-to-select (PTS) signal, and the operator then teleprints the required subscriber's number.

It has been specified by the C.C.I.T.T. that telex numbers published internationally should not contain letters; the receipt of the figure-shift signal by the translator is therefore recognized as the commencement of the subscriber's number, and all teleprinter signals that follow are converted to dial pulses without waiting for the complete number to be received.

When the called station is seized, a call-connected signal (type-B) is returned to the access relay-set, releasing the translator and initiating the who-are-you (WRU) signal to obtain the answer-back signal of the called subscriber. Receipt of this signal in the access relay-set disconnects the WRU signal and switches the line through.

The call-connected condition is signalled to the caller by the automatic return of the answer-back signal, but, since there may be a requirement in the future for the call-connected condition on fully-automatic calls to be signalled by a specific group of teleprinter characters in addition to the answer-back code, provision has been made to allow a group of teleprinter signals to be inserted before the answer-back signal in anticipation of the adoption by the C.C.I.T.T. of a standard requiring such signals.

On completion of the call either subscriber can release the connexion.

Ineffective Incoming Calls

Non-Receipt of the Answer-Back Signal. The access relay-set provides facilities for automatically checking the receipt of the answer-back signal, and the caller receives service signal OCC (subscriber engaged) if the answer-back signal is not received within 10 seconds from the transmission of the first WRU signal. This period of 10 seconds caters for the longest delay between the call-connected and answer-back signals that is likely to occur on a transit call to a country using type-A signalling.

Non-Receipt of a Call-Connected Signal. Due to the use of mixed numbering schemes in the telex service it is difficult to determine when the complete routing information has been received, and facilities have been provided to hold the translator until a call-connected signal has been received—normally 1–2 seconds after the translation of the last digit on a call to a country employing non-register type-B signalling. However, on calls to countries employing type-A signalling, or type-B signalling with registers, a considerable period can occur before a call-connected signal is received. To cater for these two conditions and to prevent unnecessary holding of common equipment, arrangements have been made to forcibly release the translator 30–60 seconds after seizure if no call-connected signal has been received during this period. The caller is advised of this by the receipt of service signal NP (spare line or spare level).

Receipt of Service Signal from the Telex Exchange. The access relay-set provides facilities for delaying the application of the WRU signal until the stop signal has persisted for 350–450 ms. This is to check whether the stop signal is part of the call-connected signal or the 300 ms stop signal preceding the text of printed service-signals, and so determine whether to transmit the WRU signal. The upper limit of 450 ms ensures that the specific group of teleprinter signals previously mentioned, if required on fully-automatic calls, would be transmitted before the answer-back signal is received.

Clearing Signal

In the United Kingdom the release of a connexion is controlled by the clearing or clear-confirmation signals on the forward path, and therefore, for an incoming call, the United Kingdom equipment is dependent upon the signal from the distant equipment. This introduces a problem on radio circuits with error-correction in that the return of the clear-confirmation signal is subject to delays when the signals on the radio channel are being repeated due to an error having been detected, and during this delay a called subscriber would be unable to clear the connexion.

Arrangements have, therefore, been provided on radio circuits for the clear signal on the backward path from the United Kingdom equipment to be recognized in the bothway-circuit relay-set and for this relay-set to return the clear-confirmation signal to release the connexion. The radio channel is then automatically busied until the clear confirmation has been received from the distant equipment.

Congestion

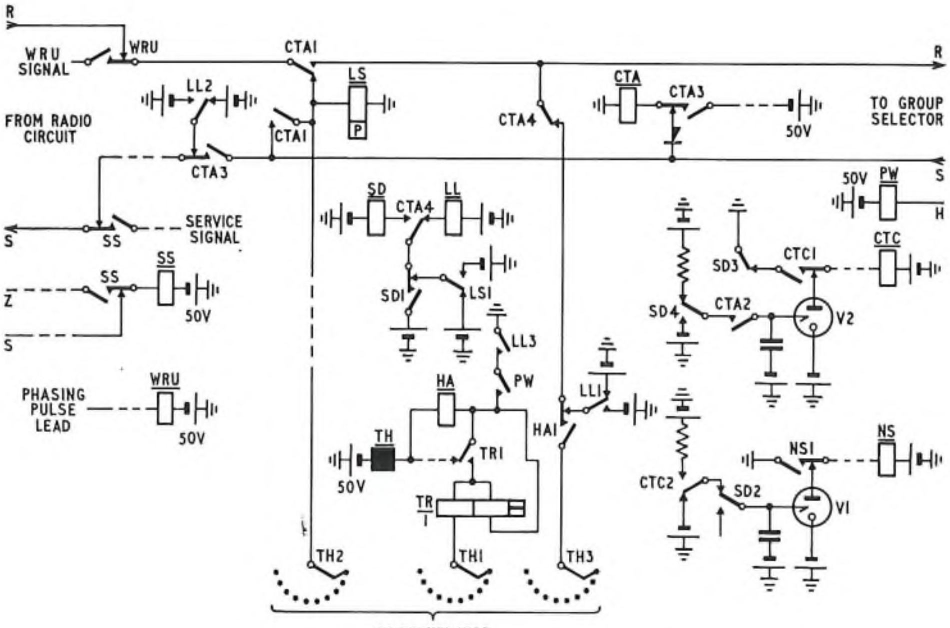
Immediately all translators are busy a signal is passed to all access relay-sets, and when an access relay-set is seized the caller will receive the NC (trunk busy) signal.

CIRCUIT OPERATION OF ACCESS RELAY-SET

Effective Call

The circuit of the access relay-set is shown in simplified form in Fig. 3. Receipt of a calling signal operates relay LS, which in turn operates relay LL to return the call-confirmation signal to the calling operator. Contact LL1 extends a −80-volt signal to seize the group selector, which returns earth potential on the H-wire to operate relay PW and so complete the drive circuit for the translator hunter, TH. On seizing a free translator (indicated by a 50-volt negative potential on TH1 bank) relay HA operates and phasing-pulse relay SS is connected to the S-pulse lead. Relay SS operates on receipt of the first S-pulse and holds during the transmission of the PTS signal to the caller. The calling operator, on receiving PTS, teleprints the required subscriber's number, and the teleprinter signals are connected to the translator via the access relay-set. These signals are then translated into dial pulses by the 5-unit code to dial-pulse translator and passed to the group selector via the TH3 bank and contact HA1 in the access relay-set.

When the translation of the routing digits is completed a call-connected signal will be received from the called station to operate relay CTA. Relay CTA, in operating, releases relay LL followed by relay HA, so releasing the translator for the next call. Contact CTA2 connects + 80 volts to the trigger of tube V2, via a capacitor-resistor circuit, and ionization of the tube is delayed for a period of 350–450 ms. When tube V2 ionizes, relay CTC operates and contact CTC2 applies +80 volts to the trigger of tube V1 via a second capacitor-resistor circuit that delays the ionization of the tube for 5–10 seconds.



Unless otherwise indicated, the battery voltages are 80 volts.

FIG. 3—SIMPLIFIED CIRCUIT OF ACCESS RELAY-SET

Operation of relay CTC connects relay WRU to the phasing-pulse lead and so allows the WRU signal to be transmitted to the called subscriber.

On receipt of the answer-back signal from the called station, the polarized relay LS responds and contact LS1 changes over to operate relay SD, so releasing relays CTC and WRU and connecting the receive line through. The receipt of a clear signal from either subscriber will be recognized outside the relay-set and the earth from the H-wire will be removed to release the relay-set.

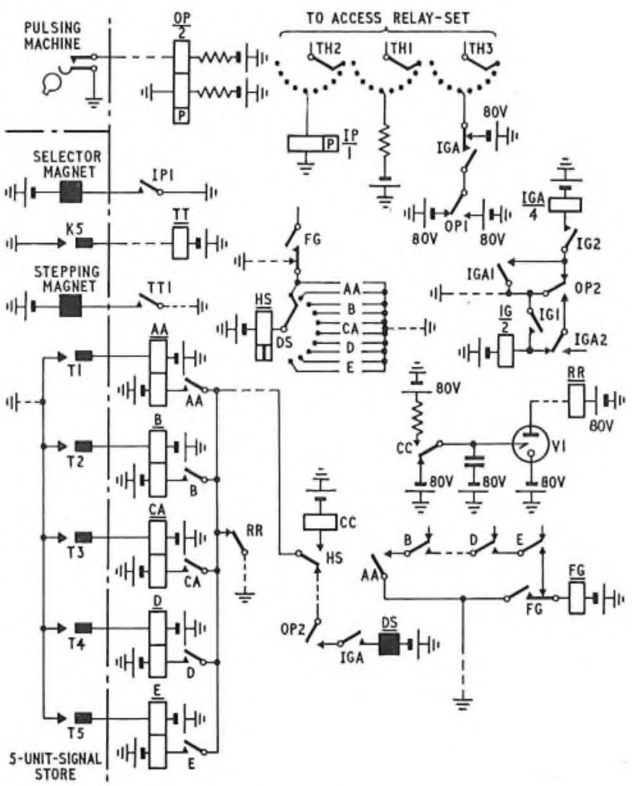
Ineffective Call

Non-Receipt of Answer-Back Signal. On receipt of a call-connected signal, the WRU signal is transmitted to the called station, and if the called station fails to return the answer-back signal within 10 seconds tube V1 will ionize and operate relay NS. A contact of this relay connects the S-pulse to relay SS, and the OCC service signal followed by a clear signal is transmitted to the caller.

Receipt of a Service Signal. A service signal is preceded by a negative potential for approximately 300 ms, and the first positive element of the service signal will arrive before tube V2 ionizes. The receipt of the first positive element of the service signal causes relay LS to change-over, and contact LS1 operates relay S.D.; contact SD4 re-applies —80 volts to the trigger of tube V2. Relay CTC is therefore unable to operate and the WRU signal is not sent.

OPERATION OF TRANSLATOR AND 5-UNIT STORE

On seizure of a free translator the access relay-set extends the incoming teleprinter signals to relay IP (Fig. 4), which repeats the signals as single-current pulses to the selector magnet of a Siemens Halske T Loch 15A reperforator-transmitter used as a store for 5-unit-code signals. This machine punches a tape with the 5-unit-code teleprinter signals and when this operation is completed contact K5 on the reperforator-transmitter closes and operates relay TT. Contact TT1 completes the operate path for the stepping magnet and so causes the tape to move forward to the sensing peckers. The tape is then examined by the peckers, and, assuming the teleprinter character is figure shift, the pecker-controlled contacts T1, T2, T4 and T5 close to operate their associated relays followed by relay FG, which locks and prepares for the translation of the succeeding teleprinter signals.



Unless otherwise indicated, the battery voltages are 50 volts.
Fig. 4—SIMPLIFIED CIRCUIT OF 5-UNIT CODE TO DIAL-PULSE TRANSLATOR AND STORE

On examination of the next teleprinter signal, code relays associated with contacts T1–T5 again operate to mark outlets on the DS bank, and the output of a dial-pulse machine is connected to relay OP. Relay OP, in pulsing at 10 pulses/second transmits double-current pulses to the exchange equipment via the access relay-set, following the operation of the guard relay IGA.

During the transmission of the positive pulses, uniselector DS is energized, and when the wipers step to an outlet marked by the code-relay contacts, relay HS operates to release relay IGA and so terminates the transmission of pulses to the exchange. An inter-digital pause of 600–900 ms is provided by the capacitor-resistor circuit associated with tube V1, and at the end of this period relay RR operates to release the code relays and prepare for the translation of subsequent teleprinter signals.

The translation of the teleprinter signals takes place as described, but as the transmission of a Strowger pulse-train takes longer than the receipt of an equivalent teleprinter signal, the tape, when punched, is stored in a loop before reaching the sensing peckers. While this occurs, contact K5 remains closed, indicating that punched tape is available for sensing; arrangements are made to operate the stepping magnet at the end of each inter-digital period until all tape has been sensed and translated and relay TT releases.

If on seizure of a translator the first teleprinter signal is not a figure shift, relay HS will operate immediately the code relays operate and no translation will occur; all teleprinter signals that follow will be absorbed in a similar manner until a figure-shift signal is received.

CONCLUSION

The provision, from December 1961, of facilities for semi-automatic working over radio circuits, incorporating automatic error-correction, on telex calls incoming to the United Kingdom telex network marked a further step forward in the automation of this network and followed closely the full automation of the inland telex network (December 1960) and the introduction of international subscriber dialling to European countries during 1961.

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Pipe-Laying in Tidal Rivers and Harbour Crossings

W. D. PRIESTLEY†

U.D.C. 621.315.232:621.315.28

A description is given of techniques that have been used to provide pipes and cables across tidal rivers and harbours which prevent the application of the usual procedures used when laying duct overland.

INTRODUCTION

AROUND the coastal regions of the British Isles and often far inland, there are many waterways, harbours and inlets which present a natural barrier to the provision of a duct route to carry cable networks. The more formidable of these barriers are those that are subject to daily tidal flow, and, in addition, are navigable by fairly large vessels.

It is not uncommon for the water level in these places to rise and fall by 10 ft or more and to attain this change the incoming and outgoing tidal current has necessarily to be quite fast. This rapid flow of water, coupled with the silty nature of many river beds, presents a problem in opening a trench, or clearing the silt from a pre-excavated trench, and keeping it open long enough to lay the duct cable in the short slack-water time available.

Because of this difficulty, natural barriers of this type have usually been crossed by sub-aqueous cable. To protect these cables from damage by ships' anchors, attempts have been made to dredge the best possible trench and to mark the cable crossing by a system of marker beacons. At best under these conditions the trench is not a true trench but a shallow basin, which in one instance extended for 40 yd on both sides of the cable position. A cable at the lowest point of a depression in the river bed of this type may be covered over by normal silting or may just as likely remain on the surface. Cables laid in this way have given reasonably satisfactory service, due mainly to respect for the beacons which mark the cable's position rather than the physical protection of a trench, but there have been times during bad weather when ships have been forced to drop anchor to prevent collision. The cables have then been caught by the anchors and damaged.

The replacement of damaged cables and the provision of additional cables involves the cost of dredging operations each time a cable is laid, and there is an economic advantage to be gained by using a method of laying a pipe that will cater for cabling requirements for a number of years. The relative economy depends on the route concerned, but it is estimated that, provided the cost of laying pipes is similar to the cost of laying two sub-aqueous cables, there is in general a substantial saving over the years by using pipe.

THE PROBLEMS OF LAYING PIPES AND CABLES

The difficulty of keeping a long trench open in the conditions described prohibits the use of a simple system using a continuous pipe, welded from short sections, which could be floated out and sunk into a trench.

The depth of water also makes the pipe-laying work a diving operation which has to be undertaken during the time when the tidal flow permits the divers to work on the river bed without being swept away. During this time the divers have to excavate a portion of trench sufficiently deep to give protection to the pipe, the pipe has to be lowered and positioned in the trench, and then jointed and protected at the joints by concrete.

Even with the aid of a partially pre-excavated trench, the silt clearing and pipe-laying operations allow only two pipes about 35 ft long to be laid per tide. It is this tidal time limit, coupled with the need to keep the diving staff to an economic minimum, which leads to the use of large-diameter pipes for this type of crossing. When accommodation for a large number of cables is required one method of design could be to lay singly a series of small pipes. To do this in the tidal conditions described is not possible since as the nest of pipes grows a stage would soon be reached when the whole of the working time would be taken up clearing away silt and no further pipe laying would be possible before the tide returns and silts the pipes over again.

The methods used on three separate works to overcome these difficulties have been tried since the Lowestoft Harbour work* and the cost of the new schemes has proved to be approximately twice that of installing a sub-aqueous cable in a trench.

At Althorpe on the River Trent, Lancaster on the River Lune and at Poole Harbour the method has been to choose pipes, laid in pairs where necessary, with a sufficiently large diameter to cater for all foreseeable development. The pipes laid at these locations were a pair of 6 in. diameter pipes, a pair of 12 in. diameter pipes, and a single 6 in. diameter pipe, respectively. At all three locations plain-ended steel pipes were used, and these were joined by divers using the Johnson couplings as shown in Fig. 1.

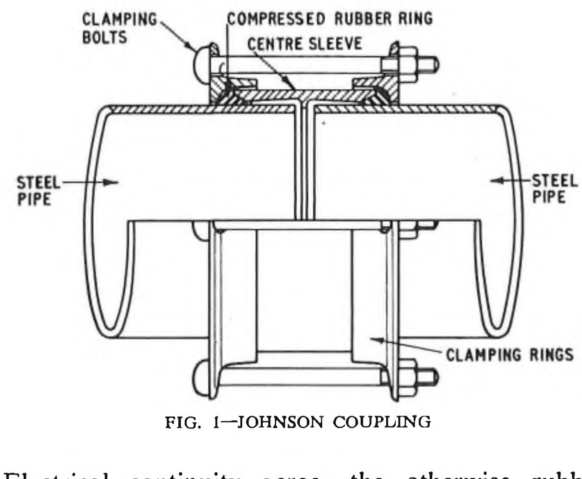


FIG. 1—JOHNSON COUPLING

Electrical continuity across the otherwise rubber-insulated coupling is achieved by bolting a mild-steel strip to set bolts, which are welded to the pipe ends clear of the coupling. By giving close tolerances to the set-

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

*JENNINGS, S. W., and PRIESTLEY, W. D. A Novel Way of Providing a Cable Route Across a Busy and Congested Water-Way. *P.O.E.E.J.*, Vol. 51, p. 94, July 1958.

bolt position and fixing holes, the bonding strip also serves as a gauge to ensure that the pipe is pulled fully home into the joint.

The procedure followed was for a diving survey to be made to check obstructions, determine the best line of the pipe route and to anticipate excavating problems. The river-bed contour along the line of the pipe route was then determined by sounding and was reproduced to scale on a cross-sectional drawing. To ensure that the pipe would be adequately covered a smooth curve was drawn under the bed contour on the cross-sectional drawing and this curve was used as the work proceeded to check the depths of excavation from the water level, the height of which was related by a visual depth board to ordnance datum level and to the drawing.

EXCAVATING TECHNIQUE

On each of the three works mentioned above, a different excavating technique was used.

The River Trent was at all times deep enough to float a dredger and was navigable well upstream from the crossing point. This consideration led to the use of a dredger grab jib for the excavation of the trench.

The River Lune, when below half tide, was shallow enough to allow the contractor to build out a causeway of hard stone, as shown in Fig. 2, from which a back-

FIG. 2—THE DRAGLINE EXCAVATOR ON THE CAUSEWAY AT THE RIVER LUNE CROSSING

acting bucket excavator was operated and followed later, when approaching mid stream, by a dragline excavator. The causeway was recovered after reaching just over halfway across the river and rebuilt from the other shore.

The most unusual method of excavation used was at Poole Harbour where the harbour bed was found on survey to consist of gravel and clay. A trench averaging 4 ft deep was excavated in this material with an air-lift pump. This was a simple piece of equipment (see Fig. 3) consisting of a metal cylinder with two air-line connexions welded into the walls about 12 in. from the

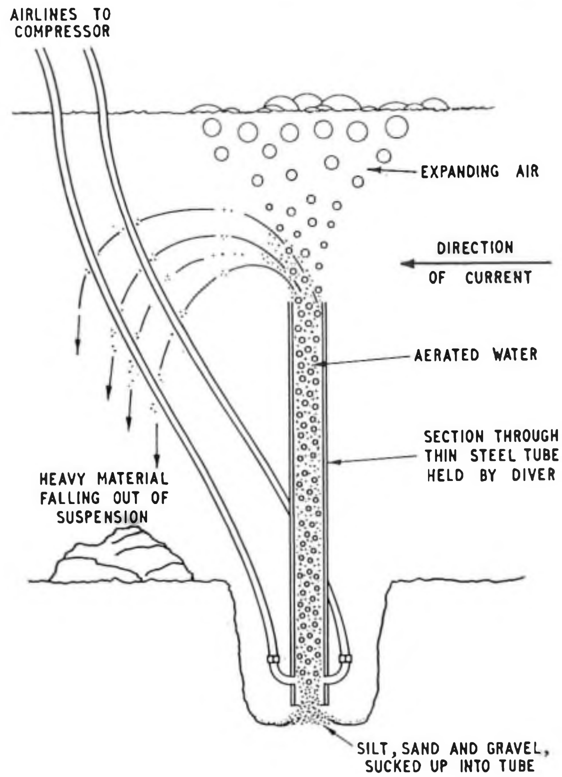


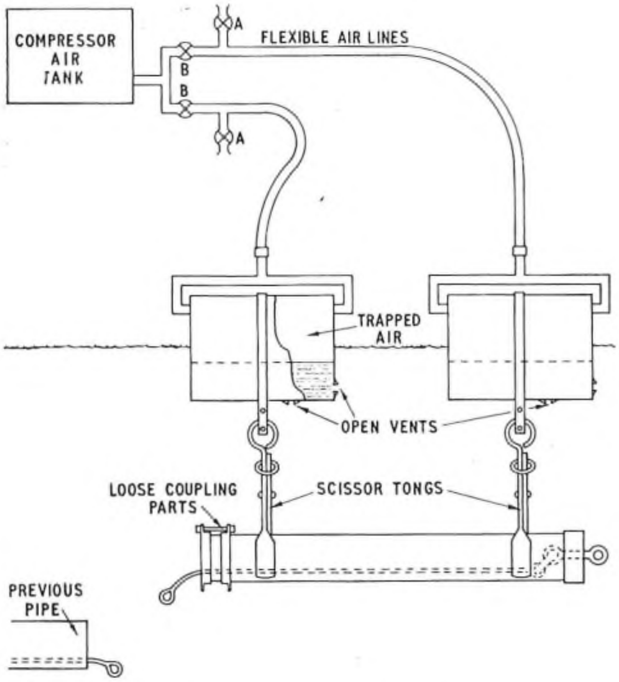
FIG. 3—THE AIR-LIFT PUMP

open bottom end. Compressed air was fed to these connexions at a rate of 210 ft^3/min and the open end was lowered near to the harbour bed. The air entering the pipe violently aerated the water inside the pipe and, as the mixture of air and water inside had a much lower specific gravity than the water outside, there was a continuous displacement of the inside column of aerated water by water rushing in at the bottom end.

The force of this in-rushing water acted in a similar manner to a large vacuum cleaner and sucked up clay and stones as large as 2 in. in diameter, carrying the material up the tube and dispersing it into the surrounding water sometimes upstream, sometimes down, depending on the tidal flow. Compacted clay and gravel was first loosened by a high-pressure water jet. For excavating in a mixture of small gravel and clay this method was the cheapest of the three.

LOWERING THE PIPES

On the River Trent and Lune crossings the pipes were lowered with the aid of the heavy excavating equipment. However, at Poole Harbour, heavy equipment was not used for excavating and to save the cost of hiring it for pipe lowering the pipes were manhandled into position by a novel flotation method using two oil drums attached to the pipe with quick-release tongs (see Fig.4). Each drum was fitted with an air line attached to the top side and connected to a compressor via a T-release



With valve A open and valve B closed the drums sink.
With valve B open and valve A closed the drums rise.
FIG. 4—PIPE-LOWERING METHOD USED AT POOLE HARBOUR

valve. The water was allowed to enter the drums via the open vents at the bottom and a balance of pressure between the trapped air and the incoming water established.

In this stage the drums and pipe were buoyant and were towed out from a launching jib until over the laying position. The T-valves were then opened allowing air to escape, water to enter and the whole assembly to sink. It was not easy to gauge the point at which to stop air escaping, due to the fact that, when once the sinking process was started, increasing water pressure forced more water into the drums, causing a cumulative rise in sinking speed. If the pipes sank too quickly, air was blown back into the drums from the compressor thus giving complete control of rate of sinking and, if necessary, enabling the drums to be refloated.

PIPE-LAYING TECHNIQUE

The pipe-laying method adopted was essentially similar on all the works.

The first pipe had a steel hawser or steel-cored rope passed through it and terminated on an end cap, which served to keep out silt from the laying end until a new pipe length was ready for laying in position. The coupling parts were loosely assembled and temporarily fitted on the near end of the next pipe. The draw rope was then transferred through this pipe and the coupling parts by a short draw wire (see Fig. 4) and reterminated on a cap end at the distant end. This work was done either above the water or by the diver, depending on the pipe-handling system and access to the laying site. With the prepared pipe lowered into position on the river or harbour bed, the coupling parts were placed on their respective pipe ends and the new pipe pulled home into the coupling under the direction of the diver. The coupling and bonding strip were then bolted up tight. Mechanical protection to the couplings and, at Poole, to the complete pipe, was effected by covering them with a dry mixture of concrete lowered to the diver in $\frac{1}{2}$ cwt sand-bags.

CABLE LAYING

Where a large-diameter pipe is used to carry a number of cables there are two principles that can be employed to place cables inside the pipe. A pipe can be chosen that has sufficient spare capacity to allow all the cables to be laid one on top of the others, abandoning the percentage that develop faults over the years and leaving them in situ possibly trapped under the weight of subsequent cables. Alternatively, the pipes can be filled with other types of smaller duct and the cable drawn into these.

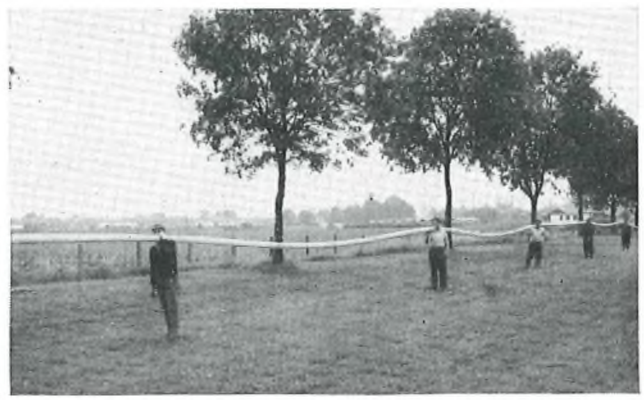


FIG. 5—CONTINUOUS LENGTH OF P.V.C. DUCT

The method employed on the river Lune crossing was a combination of these two principles. Three p.v.c. ducts were jointed together in one continuous length above ground and were drawn into one of the 12 in. diameter steel pipes. This type of duct has remarkable strength and handling properties when jointed in this way, as shown in Fig. 5. The joints are of the spigot

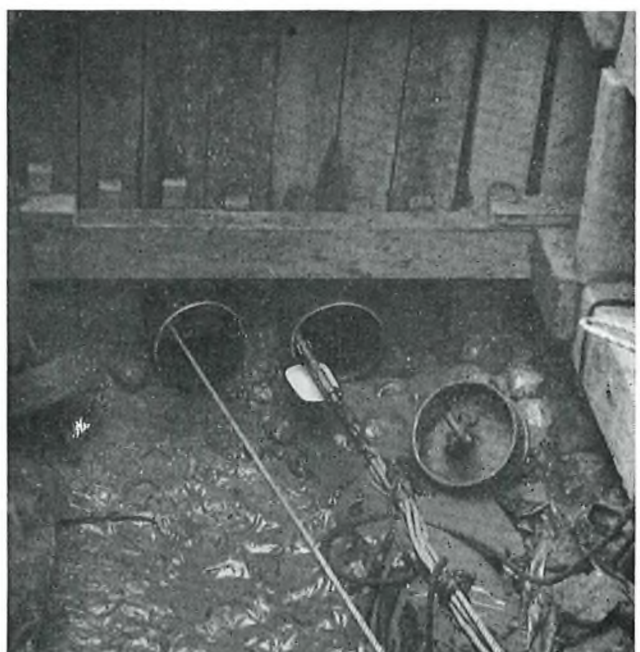


FIG. 6—SWIVELS AND ATTACHMENT PLATE USED TO PREVENT DRAW ROPES TANGLING

and socket type, very similar to the standard Post Office steel duct No. 70, except that there is a slight taper on the joint which ensures a close fit, essential to the making of a watertight joint.

The pulling-in of multiple cables or multiple ducts presents a problem in a large pipe. Rodding for the second and subsequent cables leads to weaving of the rods between the cables or pipes which are already in place and may result in the cables becoming tangled. If the initial laying rope is used to pull in a replacement plus a cabling rope similar twisting would result. Trials with glass ducts, through which it is possible to observe this effect, have shown that all types of pulling-in ropes twist under load and this torque is transferred by normal swivels to the following ropes or cables. After experiment, a method of avoiding this problem was devised for the River Lune crossing. A non-rotting polythene rope designed to be left permanently in the pipe was drawn in behind the laying ropes and formed into a continuous loop passing through one pipe, round snatch-blocks and back through the other. The ends were made off on two special swivels which were designed to turn easily under high-load and low-load cabling conditions. The swivels were joined together by a weighted plate designed to form an attachment for pulling in ropes and, due to the pendulum action of the weight, not to rotate with the polythene-rope ends. The swivels and attachment plate are shown in Fig. 6 and proved, repeatedly, to be satisfactory in pulling in draw ropes for each of three p.v.c. ducts which were installed inside one of the pipes.

CONCLUSION

The methods of pipe-laying described give flexibility in planning and are worthwhile considering as an alternative to bridge crossings which have attendant problems, e.g. expansion joints, spans which open.

Corrosion of the steel is expected to be comparable with the Post Office duct No. 70, and by estimating the wall thickness required or by employing cathodic protection, if deterioration is found to be more rapid than estimated, a useful life of 60 years is expected.

Book Reviews

"Printed Circuits—Their Design and Application." J. M. C. Dukes, M.A., D.I.C., A.M.I.E.E. Macdonald & Co., Ltd. xii + 228 pp. 90 ill. 40s.

The term printed circuit is so often used when etched wiring is meant, that it is refreshing to find that this book, while not neglecting the widely used etching process, does attempt to describe the aspects of printed circuits in general that are likely to concern circuit and equipment design engineers.

The first part of the book, "Manufacture," deals with all the well-known processes and many lesser known ones, including diestamping, painting with silver ink, pressed powder wiring, vacuum processes, electroplated circuits, and mechanical engraving as well as chemical etching. For the last named, details of depositing the appropriate resists are given.

The chapter on associated circuit and panel fabrication includes post-cured silver-printed laminates, embossed wiring, transfer plating, the double foil transfer process, and the deposition of metal into grooves on an insulating panel.

The remainder of the part on manufacture deals with components for printed circuits, automatic assembly machines, dip soldering and protective coatings.

The second part, "Design and Application," covers preparation of circuit information, materials for printed circuits, printed components, strip transmission lines, and printed microwave systems.

In addition 7 pages of testing procedures and specification information are given, together with about 170 literature references.

Allowing for the compression necessary in dealing with so many subjects in just over 200 pages this is a useful book for electronic engineers who are concerned with the design and application of "printed circuits."

A.A.N.

"Mathematical Methods for Technologists." Arranged by Margaret N. Strain, M.A. The English Universities Press, Ltd. viii + 584 pp. 160 ill. 50s.

This book is an attempt to cover in a single volume the principles and techniques of mathematics required for a Diploma in Technology course in mathematics, and to this end Miss Strain and her co-authors have achieved a good measure of success.

At the present time Dip. Tech. courses vary from college to college, particularly in the proportion of the academic rigour of the mathematical analysis that is included, as distinct from the teaching of mathematical techniques.

The first two chapters of this book, "Limits and Their Applications" and "Integration" are a necessary inclusion and compensate for the emphasis that is placed on learning technique in the subsequent chapters.

The following three chapters on the solution of ordinary and partial differential equations are presented in a most comprehensive manner; particularly good are the worked examples showing the derivation of differential equations from physical considerations of electrical and mechanical engineering problems.

The treatment of vector algebra and vector analysis is thorough; so too is the treatment of the complex variable theory. However, the approach to the Laplace transform appears to be too facile for such an important topic, and the omission of the Fourier transform is a serious one.

A welcome inclusion in a textbook of this kind are the two chapters on "Non-Linear Differential Equations" and "Numerical Methods." Being able to apply numerical approximation to practical problems is an essential part of the task of the present-day mathematician.

The use of this book will be by no means limited to Dip. Tech. students. It will serve as a useful reference book for all mathematics and engineering students. It has many worked examples in the text, and each chapter has many questions for the student to attempt. A complete set of answers is provided.

B.G.B.

Pressurization of Telecommunication Cables

Part 4—The Operation of Gas-Pressure Systems and Fault-Locating Techniques

R. A. M. LIGHT, A.M.I.E.E., and H. P. BROOKS†

U.D.C. 621.315.211.4:621.317.333.41

The final part of this article deals with maintenance methods applicable to pressurized cables. Routine inspections are discussed. A general description is given of the various instruments used and particular emphasis is given to the sensitive equipment required for pin-pointing faults in cable lengths and to the various correction factors necessary to compensate for height and barometric changes. Finally, a description is given of fault-locating techniques using tracer gases of the halogen type.

INTRODUCTION

IN the first part of this article, the differences between static and continuous-flow gas systems were explained, and reasons were given for the use of continuous-flow systems on local-distribution cables and static systems on trunk-type cables. Maintenance of these two types of system calls for different techniques and testing equipment and these will now be considered.

PRESSURE-INDICATING DEVICES AND ALARM CIRCUITS

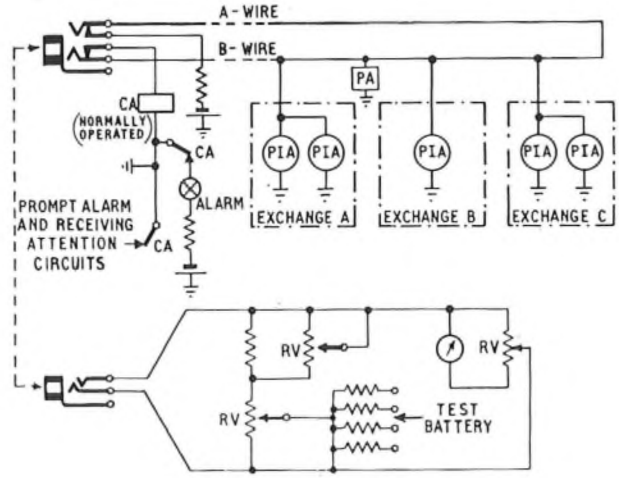
Local Cables

Loss of pressure is generally brought to notice by alarms operated by pressure-sensitive switches. For local cables, these switches take the form of 3 in. diameter, 0–10 lb/in^2 pressure gauges installed in cabinets, which are usually the termination of a local-cable pressure scheme. Occasionally, however, if the system is extended beyond the cabinet, the gauge can be housed in a wooden box on the distribution pole. A spare pair in the cable is used for the connexion of the pressure-gauge alarm contacts to the alarm circuits of the cable-pressurizing equipment in the exchange. There is provision on this equipment for receiving alarms from up to four points on any distribution cable, the actual point being identified by the operation of keys that disconnect each alarm circuit in turn.

Audio and Coaxial Trunk Cables

For trunk-type cables in which spare wires can be made available for alarm purposes, arrangements are less straightforward than for local cables. Often a number of cables follow a common route, and, as it is important to avoid the unnecessary use of high-revenue-earning pairs, alarms from indicating devices along a route are commoned on to a single alarm circuit serving a group of cables. While, therefore, each trunk cable remains a separate pneumatic entity, an alarm received at a controlling station conveys the information that a leak fault is indicated at a particular remote building. A visit to that building is then required to find out which individual cable is faulty.

Further economy in alarm-circuit pairs is achieved by arranging as far as possible for an alarm circuit to be available at all points along a route. The operation of a pressure-indicating device connects an earth to the B-wire of the 2-wire circuit, and this gives an alarm at the controlling station. The point at which the alarm originated is then located by a Murray test. A simplified schematic diagram of the arrangements is shown in Fig. 21, in which it will be noted that at two stations



PA.—Contactor
PIA—Gauge with alarm contacts

FIG. 21—SIMPLIFIED DIAGRAM OF ALARM CIRCUIT AND MURRAY BRIDGE

gauges from other cables are commoned on to the circuit. The design of the bridge circuit permits discrimination between alarm contacts separated by 2 per cent of the length of the test circuit—closer than they would normally be in practice. The use of the Murray test eliminates errors due to temperature changes in the resistance of the conductors, the position of an operated gauge or contactor being found as a fraction of the total electrical length of the alarm circuit.

Carrier Cables

Arrangements very similar to those described for audio cables are employed for carrier cables, except that a phantom is used for the alarm circuit. Contactors are normally necessary on carrier cables, and the phantom circuit has therefore to be derived at the point at which the contactor is to be fitted. This is done by using a centre-tapped bridging inductor of sufficiently high impedance at carrier frequencies to introduce negligible tapping loss. Two 88 mH ferrite unicoils have been found satisfactory for this purpose.

SPACING OF PRESSURE-INDICATING DEVICES ON TRUNK CABLES

A close spacing of pressure gauges or cable contactors would ensure a very early warning that a leak in the cable had developed. However, with the exception of direct mechanical damage, large and potentially dangerous leaks do not generally develop suddenly. It is considered that catastrophic mechanical damage to the cable would be made apparent by immediate circuit failure, and for these reasons a fairly wide spacing of gauges or contactors has been adopted. These are not usually required more

† Main Lines Development and Maintenance Branch, E.-in-C.'s Office.

closely than at 5-mile intervals and may be separated by as great a distance in miles as three times the diameter of the cable in inches, this latter provision applying to the larger cables through which a more rapid flow of air is possible.

In adopting this fairly wide spacing, a compromise is made between the slight risk of water entering the cable if a large leak should develop rapidly and the expense of providing many more gauges or contactors. Moreover, using this spacing, the natural separation of exchanges and repeater-station buildings along routes frequently allows all the indicating devices to be gauges installed in buildings, and the use of contactors is avoided entirely. Incipient faults can be more easily detected in their early stages from the routine reading of the gauges.

ROUTINE MAINTENANCE

Local Cables

Routine maintenance on local-cable systems is restricted to the observation of flow gauges from time to time. The alarm gauge at the end cabinet of a route is set to operate at 2 lb/in²; those along the route are set at higher values depending on the slope of the pressure/distance gradient from the exchange to the end of the cable.[1] The provision of fairly closely-spaced pressure gauges eliminates the need for more detailed routine measurements.

Trunk Cables

The alarm-circuit arrangements for trunk-type cables are intended to give warning of a fault developing fairly rapidly. It is important, however, that the pressure gauges should be read from time to time to confirm that the absolute pressure is not falling more quickly than the maximum rate permitted for the length of cable involved.

The expense of providing a barometer at all gauge installations is not considered justified, and the barometric pressure recorded on a centrally-based instrument is taken as applicable for gauges installed in an area having a radius of about 50 miles around the barometer.

FAULT LOCATING

When the pressure in a cable can no longer be maintained within the permitted limits, measurements are made to determine the pressure distribution along its length and so locate the point of lowest pressure.

The pressure-measuring instruments required for this fall into two categories—general-purpose instruments suitable for locating faults at jointing points, and precision instruments for locating faults in cable lengths. The accuracy of location obtained with these instruments depends largely on the pneumatic resistance of the cable concerned, but the former type can normally be expected to give a location within 30 yd of the fault and the latter type within 3 yd.

LOCATING FAULTS AT JOINTING POINTS

For locating faults at jointing points three general-purpose pressure-measuring instruments are used.

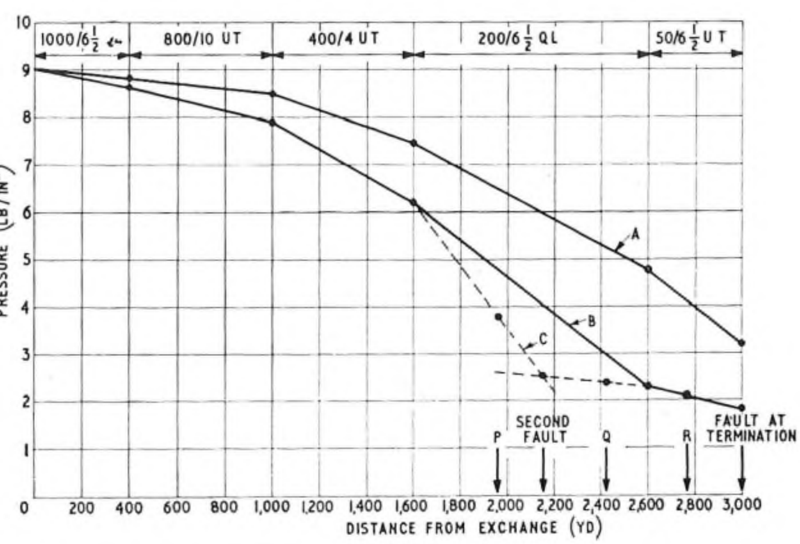
(*i*) *Manometer No. 1B.* The Manometer No. 1B is the basic instrument used to determine the pressure distribution in a cable. It is a single-limb mercury manometer constructed from a solid perspex block, and has a range of 0–9·5 lb/in² and a sensitivity of 0·02 lb/in². The instrument is portable and robust, and is considered to be more reliable and sensitive than a moderately-priced pressure gauge.

(*ii*) *Manometer No. 2A.* When an approximate location of a fault has been made with the mercury manometer and the fault cannot be found at the jointing point nearest to the location, the direction of gas flow in the cable is determined by measuring the pressure drop across nearby joints with a Manometer No. 2A. This is a sensitive, inclined, differential pressure gauge having a range of ± 0·2 in. water gauge (w.g.) and a sensitivity of 0·005 in. w.g. The latest version of this instrument is made from a perspex block and uses a low-specific-gravity oil to indicate the pressure. Connexion to the cable is made by means of temporary test-valves soldered to the sheath. These valves enable a hole to be bored in the cable sheath without loss of air.

(*iii*) *Barometer No. 1A.* As the Manometer No. 1B is sensitive to changes in atmospheric pressure, a barometer is required under certain conditions to record the atmospheric pressure at each measurement point. The barometer used (Barometer No. 1A) is a small watch-type aneroid mechanism having a sensitivity comparable with that of the Manometer No. 1B.

Faults on Local Cables

As mentioned in Part 1, for local cables it is only necessary to trace and locate major leaks, i.e. those leaks that prevent a terminal pressure of 2 lb/in² being maintained or cause an excessive flow of air at the exchange. The pneumatic resistance of local cables is high, and, therefore, the position of a leak can be determined readily with the instruments described, provided the cable is of uniform size and type. However, long lengths of cable of uniform size are rarely found in the local network and, as will be seen from Fig. 22, the determina-



Curve A—Pressure distribution due to leak at termination
Curve B—Pressure distribution due to leak at second point
Curve C—Pressure distribution measured at additional points to locate fault
1,000/6½ QL—1,000-pair, 6½ lb/mile, quad local cable. 400/4 UT—400-pair, 4 lb/mile unit twin cable. 200/6½ QL—200-pair, 6½ lb/mile, quad local cable. 50/6½ UT—50-pair, 6½ lb/mile, unit twin cable

FIG. 22—LOCAL-CABLE PRESSURE DISTRIBUTION

tion of the position of a leak is not straightforward. Curve A shows the pressure distribution due to a leak at the termination. No action would be taken to clear such a fault, as the pressure would be considered adequate. When a further fault develops, the pressure distribution changes to that shown by curve B. The terminal pressure falls below the safe value, causing the alarm to operate at the exchange. To locate such a fault additional test valves must be fitted to the cable at points P, Q and R to determine the true shape of the curve, as shown by curve C.

In general, no corrections for barometric pressure changes are necessary, as these are small compared with the pressure changes in the cable. Also, since the pressure source is constant, the pressure distribution does not change with time and no allowance need be made for the pressure falling whilst the measurements are being made.

Faults on Trunk and Junction Cables

Whilst the principles of fault locating on trunk and junction cables are the same as for local cables, a number of refinements in the techniques are necessary. Since these cables are required to be almost gas-tight, the size of leak located is frequently smaller than that found in local cables, and the pressure gradients to be measured may be very much smaller. As mentioned previously, most leaks occurring at jointing points can be located with a mercury manometer by measuring the pressure at the test valves attached to the cable and so determining the pressure distribution in the vicinity of the fault. For this to be done as accurately as possible certain corrections must be applied to the pressure measurements.

(*i*) *Time*. As there is no constant-pressure source, the pressure throughout the cable will fall continuously due to a leak, and an incorrect location will be obtained if no allowance is made for this fact. The time factor is overcome quite simply by taking two sets of pressure readings on the cable in opposite directions and at fixed time intervals. The mean values of the pressures are then taken and plotted against distance on a graph. This and other tests have been described elsewhere.[2]

(*ii*) *Atmospheric-Pressure Changes due to Weather*. Atmospheric-pressure changes that take place during a series of pressure measurements can cause incorrect readings of instruments which are open to the atmosphere. However, the changes which occur during such a series of measurements are not normally sufficiently large to affect the accuracy of the mercury manometer to a noticeable extent although this source of error will be dealt with later when considering precision instruments.

(*iii*) *Atmospheric and Cable-Pressure Changes due to Altitude*. When measuring cable pressure, corrections must be applied to readings taken at different altitudes if the readings are to be related to one another. The reason for this can best be illustrated by reference to Fig. 23.

Column X represents a cable which rises H feet between two measurement points. Column Y represents a column of free air of the same height outside the cable.

Let the atmospheric pressure at the base $= B$,

and the gauge reading $= G$.

Then the absolute cable pressure is $B + G$.

With a rise of H feet between the two measuring points, the fall in atmospheric pressure $= b$

Thus, at the top of column Y,

the atmospheric pressure $= B - b$ .... (1)

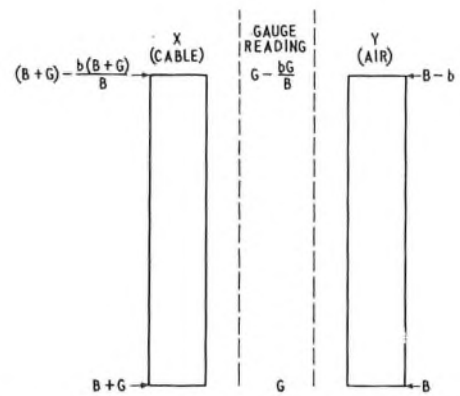


FIG. 23—EFFECT OF ALTITUDE ON CABLE PRESSURE

Similarly, the absolute pressure in the cable will fall due to the height of the column of air in the cable. As the air pressure in the cable is higher than the air pressure outside the cable, and as a consequence the air density in the cable is greater, the corresponding fall in pressure in the cable will be greater than that outside by the ratio of the pressures, i.e. by $(B + G)/B$.

Thus the absolute cable pressure at the top of column X becomes

$$(B + G) - b\left(\frac{B + G}{B}\right)$$

$$\text{or } (B - b) + G - \frac{bG}{B} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

The difference between the pressures given by equations (1) and (2) is, $G - (bG/B)$ and is the difference, at height H, between the absolute cable pressure and the atmospheric pressure. It can be seen, therefore, that the pressure gauge will read bG/B less at the top of the column than at the base.

In a perfectly leak-free cable, pressure gradients will exist due to altitude changes, and, in order that the pressure distribution due to a leak may be determined, all gauge readings must be related to a common altitude if the corrections applied will materially affect the measured slope of the pressure gradient. These corrections are normally obtained from a chart.

LOCATING FAULTS IN CABLE LENGTHS

The technique of locating faults between jointing points on pressurized cables has been described in an earlier article.[3] The principles of determining the pressure distribution are very similar to those described above, but as the distances between measurement points are decreased so also do the pressure differences become smaller; more-sensitive measuring apparatus is therefore required. The instrument previously described is a low-density-liquid U-tube manometer having a range of 0–5½ lb/in². This instrument, whilst serving a very useful purpose, has a number of limitations:

(*a*) Being 10–15 ft long it is cumbersome in use.

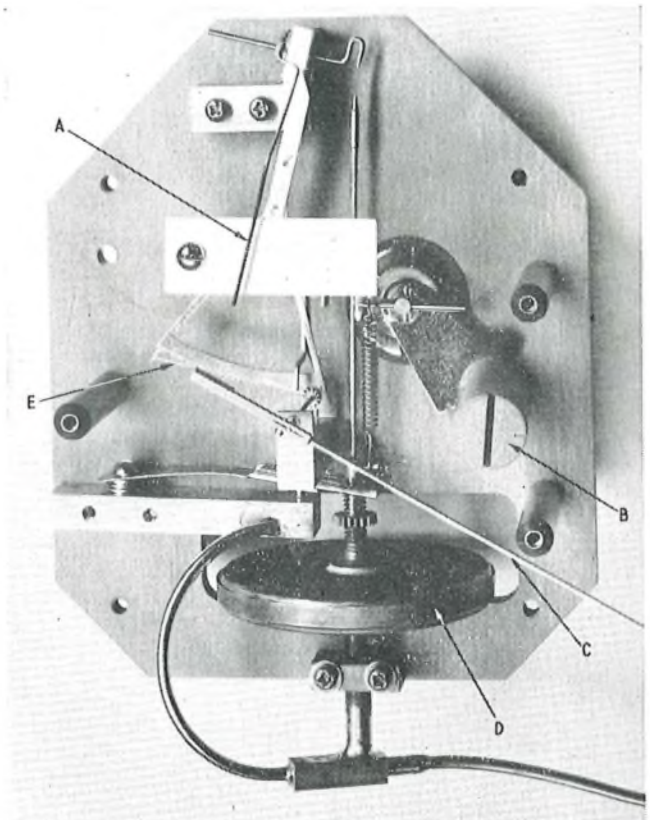
(*b*) The readings are affected by changes in atmospheric pressure.

(*c*) It is difficult to protect the instrument from direct sunlight, which causes expansion and evaporation of the liquid.

(*d*) Corrections for changes in barometric pressure due to altitude changes cannot be made without a barometer of comparable sensitivity.

(*e*) The cable pressure must fall below 5 lb/in^2 before measurements can be made. This results in a reduced pressure gradient in the cable.

Despite these limitations the spirit manometer has been used with considerable success during the early stages of pressurizing existing cables, i.e. when locating the major leaks. During normal maintenance the leaks to be located are much smaller than during the initial pressurization, and barometric pressure changes assume greater significance, sometimes causing errors of location of 20–30 yd. This is obviously unsatisfactory, and if pressure gradients of, say, 1 in. w.g. in 400 yd are to be measured accurately many of the disadvantages of the spirit manometer have to be overcome.



A—Revolution indicator. B—Zero-adjusting stud.
C—Pointer with knife edge. D—Evacuated capsule.
E—Back-lash eliminator.

FIG. 24—MECHANISM OF PRECISION ANEROID MANOMETER

As a result of recent development work a pressure gauge has been introduced which overcomes most of these disadvantages. The gauge has an aneroid mechanism similar to that of a barometer, and has a range of 360–610 in. w.g., absolute, and a sensitivity of 0·02 in. w.g. Each instrument is individually calibrated for two revolutions of the pointer at approximately 1,250 points. A mirrored ring, concentric with the scale, enables parallax errors to be eliminated. The mechanism, which is contained in a pressure-tight aluminium case 10½ in. in diameter, employs a lever system connected to an evacuated capsule by flexure pivots, thus eliminating much of the friction usually associated with the dial-type pressure gauges. Fig. 24 shows the mechanism.

A second type of aneroid gauge is under trial at present. In this instrument, which is smaller than the dial gauge, the displacement of the evacuated capsule is measured by a micrometer connected to a 5-figure digital counter. The point of contact between the capsule lever and the micrometer spindle is detected by means of a battery-operated cathode-ray tuning indicator.

The chief advantages of these instruments are:

(*a*) Portability.

(*b*) The instruments are unaffected by atmospheric pressure when connected to a cable.

(*c*) As the instruments are barometers they can be used to determine barometric-pressure changes due to height with the same sensitivity as cable pressure.

Corrections for height changes are still required and, in fact, are of greater significance when using an absolute pressure gauge than with a normal gauge. Referring to Fig. 23, an absolute gauge will read $(B + G)$ at the base and $(B + G) - \frac{b(B + G)}{B}$ at the top of the column, or $A - (bA/B)$, where A is the absolute pressure at the base

TYPICAL PRESSURE MEASUREMENTS AND CORRECTIONS

Valve No.	1		2		3		4		5		6	
Cumulative Distance (yd)	0		166⅓		291⅓		543⅓		668⅓		835⅓	
Time	10.43	11.33	10.48	11.28	10.53	11.23	10.58	11.18	11.03	11.13	11.08	11.08
Measured Cable Pressure (in. w.g.)	572·35	572·09	569·49	569·47	567·65	567·09	565·41	564·75	565·99	565·05	566·95	566·95
Mean Cable Pressure (in. w.g.) A	572·22		569·48		567·37		565·08		565·73		566·95	
Barometric Pressure (in. w.g.) B	406·88		406·60		406·36		405·68		405·87		406·24	
Barometric Pressure Differences Due to Height (in. w.g.) $\pm b$	0		− 0·28		− 0·52		− 1·20		− 1·80		− 0·64	
$\frac{A}{B}$ (Valve No. 1 only)	1·406		1·406		1·406		1·406		1·406		1·406	
Correction $C = -b \cdot \frac{A}{B}$	0		+ 0·39		+ 0·73		+ 1·69		+ 1·52		+ 0·90	
Corrected Cable Pressure $A + C$	572·22		569·87		568·10		566·77		567·25		567·25	

of the column. Thus the reading at the top of the column is reduced by bA/B, which is a greater correction than is needed when using a gauge open to the atmosphere.

To determine the value of b at each valve point, the barometric pressure is measured before or after the cable measurements have been taken. The measurements are taken in quick succession to eliminate the possibility of weather changes giving false altitude measurements. The corrections are calculated from the above formula as the use of a chart would not be sufficiently accurate.

The table shows typical pressure measurements and corrections. The corrected values are, in practice, plotted on graph paper, using a distance scale of 1 in. = 20 yd. Owing to its size it is not possible to reproduce a typical graph, but if the readings shown in the table were plotted it would be seen that an error of 36 yd would be obtained if correction were not made for altitude changes. The cable for which the measurements in the table were made was on a hill of gradient 1 in 18.

USE OF TRACER GASES FOR FAULT LOCATION

Tracer gases are used for the exact location of faults when use of the usual bubble-forming liquids is not suitable. A brief description of tracer-gas techniques and their special application to locating a fault in a length of cable follows.

Arcton Mixer

A tracer gas of the halogen group, dichlorodifluoromethane (CCl_2F_2) known commercially as Arcton 6 or Freon, is used. This gas, which is available in liquid form in sealed tins, is diluted to approximately a 3 per cent mixture in air by a special mixer, the schematic details of which are shown in Fig. 25. The mixer includes

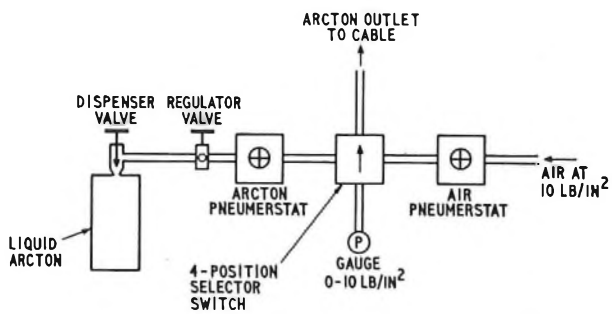


FIG. 25—DIAGRAM OF ARCTON MIXING APPARATUS

capillary tubes calibrated to give the correct dilution.

In the pneumerstat (Fig. 26) a calibrated capillary tube bridges a spring-loaded diaphragm separating primary and secondary chambers connected, respectively, to the gas inlet and outlet. Gas is admitted into the primary chamber up to the point at which the build-up of pressure causes the inlet valve to close. The capillary tube then meters the flow into the secondary chamber. As the pressure at the outlet port builds up, however, the pressure on the secondary-chamber side of the common diaphragm "biasses" the inlet valve to remain longer in the open condition. Hence, up to the point when the outlet (cable) pressure is equal to the gas-supply pressure, the rate at which gas is delivered by the pneumerstat remains almost constant. A pneumatic selector switch enables the air, Arcton or cable pressure to be measured as desired.

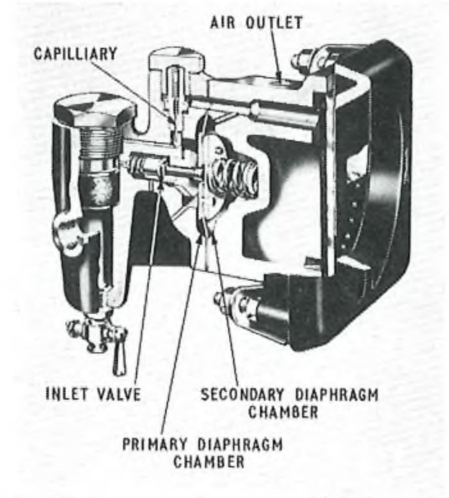


FIG. 26—SECTIONAL VIEW OF PRESSURE PNEUMERSTAT

Detection of Halogen Gases

The halogen group of gases comprise fluorine, chlorine, bromine and iodine; Arcton 6, the gas used for tracer purposes, is a fluorine compound.

It is a property of a halogen gas to stimulate the emission of positive ions from a heated surface with which it is in contact. In the practical detector an inner platinum cylinder is maintained at a temperature of about 800°C, and a potential is applied between it and an outer cylinder. The increase in current resulting when a halogen gas is drawn between the surfaces is measured by a control device that can be arranged to operate a meter, vary the rate at which clicks occur in a loudspeaker or, in a simple version, operate a buzzer. The sensitivity of the detector is such that a leak of 0·02 oz, or 100 cc, of pure Arcton per year can be detected.

In use, the Arcton-air mixture is injected into the cable near to the suspected position of the leak, and the cable, sealing end, or other component, is examined with the probe of the Arcton detector. Such methods are of value when a leak is suspected in a piece of apparatus that cannot easily be tested with a bubble-forming solution.

The equipment used for this purpose by the Post Office is shown schematically in Fig. 27. A small pump

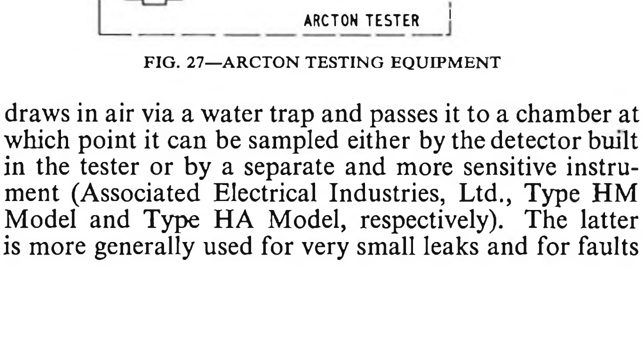


FIG. 27—ARCTON TESTING EQUIPMENT

draws in air via a water trap and passes it to a chamber at which point it can be sampled either by the detector built in the tester or by a separate and more sensitive instrument (Associated Electrical Industries, Ltd., Type HM Model and Type HA Model, respectively). The latter is more generally used for very small leaks and for faults in lengths of cable, because a metered and audible indication is given of the Arcton concentration present.

Faults in Lengths of Cable

Tracer-gas methods are of particular value when it is desired to confirm the position of a fault in a length of cable. A pressure/distance gradient location is first made as already described. If the point of the fault appears to be at least 20 yd from a jointing point, an excavation is made at the location. Arcton is then injected into the cable at a convenient point and the core of the first valve beyond the fault is removed to encourage the flow of gas towards the leak. Observations are then made with the detector to see from which of the exposed duct mouths the Arcton appears. This determined, it remains to establish how far away the point of leakage actually is.

The procedure is, firstly, to blow air into the duct from the excavation using a small industrial blower of 60 ft^3/min capacity. The tester inlet is extended with $\frac{1}{4}$ in. outside-diameter polythene tubing, the end of which is placed just inside the duct mouth. An observation is then made of the time taken by the Arcton to diffuse back to the duct mouth from the leak. Further observations of time are then made with the probe at different distances into the duct, the duct line being entirely cleared of Arcton by the blower between each test.

At the point of the fault, the time taken for the Arcton to give a reaction on the detector will be a minimum and will rise only slightly when the end of the probe is beyond the fault. This time will in effect be the time of passage of the gas through the length of tubing in use, a constant determined by experiment before the tests commence. A graph of the form of Fig. 28 can be drawn to deduce the fault position.

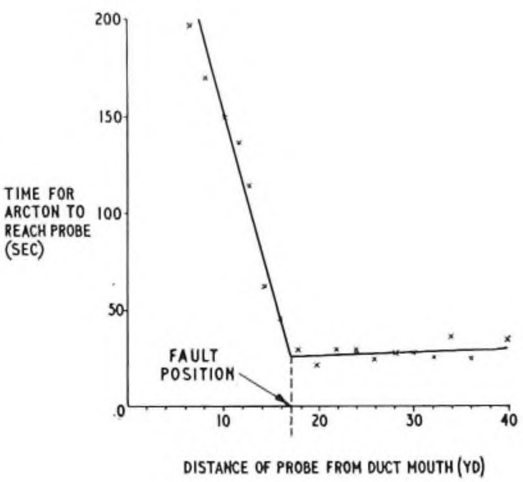


FIG. 28—PIN-POINTING FAULT POSITION BY TIMING ARCTON DIFFUSION

It has been stated that an excavation will be made if the fault location is further than about 20 yd from a jointing chamber. This distance varies with the extent to which the bore containing the faulty cable is occupied. If the location is within probing distance of the jointing chamber, the Arcton tests are made from the chamber itself.

In general the pressure/distance measurements will achieve an accuracy of within two or three yards. Subsequently the fault can be pin-pointed to within a few inches by Arcton. An initial location is essential, however, as searching for Arcton without an approximate prior indication of the fault position can be a time-consuming and unrewarding occupation.

CONCLUSIONS

Experience has shown that a substantial improvement in maintenance can be achieved by pressurization of telecommunication cables. The improvement in service is shown by the 1962–63 fault returns: 69 per cent of all faults on non-pressurized cables affected service, while only 9 per cent of faults on gas-pressurized cables did so and these were mainly individual wire faults and cases of mechanical damage.

A large proportion of the cost of providing a gas-pressure installation is incurred in tracing and clearing leaks in sheaths; in future much of this cost should be saved by specifying a high standard of gas-tightness for all new cables.

The present program of pressurization should result in the larger distribution cables being pressurized at all the larger exchanges in the next 3–4 years and in the provision of the major items of pressurization equipment. Extension of the system to smaller exchange areas may follow; for this the development of smaller compressor-desiccator units may be necessary. Pressurization of trunk and junction cables is also proceeding, and completion over a period of 10 years should be achieved.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the co-operation of the staff of the Cambridge Telephone Area in providing facilities for much of the experimental work. Fig. 24 is produced by permission of Messrs. Wallace and Tierman, Ltd., and Fig. 26 by permission of Messrs. Williams and James (Engineers), Ltd.

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The Effect on Service During 1962–63 of the Pressurization of the Trunk Cable Network

U.D.C. 621.317.333.41:621.315.211.4

FOR the 1962–63 fault year it has been possible, for the first time, to produce figures substantiating the practical advantages of gas pressurization of the United Kingdom trunk cable network. A report is made, to the Post Office Engineering Department, on each main trunk (MU) cable fault which occurs, and from 1 April 1962 these reports have indicated whether the cables concerned were, or were not, pressurized and whether the faults have caused service failures. The criterion of a service failure has been taken to be the affecting in any way of one, or more, public or private circuits—a most stringent requirement.

For the 39,624 sheath-miles of MU cable which are not pressurized the overall fault rate (faults per 100 sheath-miles per annum) was a little under 10·5, but 7·25 of these caused some service interruption.

For the 5,772 sheath-miles which have been brought under gas pressure, whilst the overall fault rate was somewhat higher at 11·1 only 0·97 of these affected service in any way. The higher fault rate on pressurized cables is to be expected, for all sheath faults which occur must come under immediate notice; with non-pressurized cables a sheath defect may occur and remain unnoticed until such time as rain or flood water enters the duct track or jointing chamber, causing a serious breakdown.

Gas pressurization cannot, of course, prevent all faults liable to affect service—the bulldozer which tears the cable out of the ground, the failure of a coaxial-cable conductor joint, etc., but it is believed that a national service-affecting fault rate of the order of 0·75 per 100 sheath-miles per annum is a distinct possibility for a fully pressurized network, compared with the rate of 7·25 per 100 sheath-miles per annum which has been the usual figure in the past.

Apart from this impressive improvement in service given by pressurized cables, there is another very important aspect. A high proportion of faults in non-pressurized cables necessitate renewal of cable lengths—the national figure is of the order of one new cable length for every three faults which occur—but on pressurized cables many of the sheath defects can be repaired in situ, the cable core is unaffected and only a sheath repair is called for. Precision location of the fault point, digging-down to and exposing the cable, and completing the repair, is very much cheaper than replacing the cable length.

In the one Telephone Area (Cambridge), where over 90 per cent of the MU cable network is already under gas pressure, in the 1962–63 fault-year only one new length of cable was required for every 18 faults found. Admittedly this particular area is predominantly rural and digging-down is not a difficult matter, but, even if a reduction in length renewals of this order may not be possible nationally, a reduction from one length renewed per three faults to one length renewed per six faults would relieve the MU renewal burden of some £250,000 annually.

A.F.G.A.

Books Received

"Charles Babbage and His Calculating Engines. Selected Writings by Charles Babbage and Others." Edited by Philip and Emily Morrison. Dover Publications, Inc., New York, and Constable & Co., London. xxxviii+400 pp. 11 ill.

"His name has emerged from obscurity in the past generation because it has become increasingly clear that he was a man far ahead of his time." Just how succinctly this sentence in the introduction expresses Charles Babbage's position in the comparatively brief history of modern computing machines is revealed in this selection of writings by Babbage and his contemporaries.

By way of introduction the editors have provided a brief biography of Babbage, a note on the history of punched cards and a bibliography. These are followed by selected chapters from Babbage's autobiography "Passages from the Life of a Philosopher" (published in 1864), the largest part of which is devoted to his engines. For the second half of this book the editors have selected papers from "Babbage's Calculating Engines" (published in 1889) which according to its title page is "A Collection of Papers Relating to Them, Their History, and Construction," and have added a short appendix of miscellaneous papers.

"Physics for Electrical Engineers." W. P. Jolly, B.Sc., A.M.I.E.E. The English Universities Press, Ltd. xii + 308 pp. 123 ill. 21s.

The original Physical Science Text series were planned for the Advanced or Scholarship level of the General Certificate of Education. The series has now been extended beyond this educational standard; this book covers specifically the Engineering Physics syllabus of the Institution of Electrical Engineers, and, in addition, much of the material should be of value to students preparing for the Graduate examination of the Institution of Physics and for Higher National Certificate in Physics and Applied Physics.

The subject matter is laid out in four main sections, each subdivided into chapters, as follows. Section I: The structure of matter, starting from the fundamental particles and proceeding via nucleus, atom, and molecule to the properties of large aggregates of molecules, i.e. gases, liquids and solids. Section II: The electrical properties of matter, dealing with the free electron and other charged particles in applied fields, the classical picture of electrical conduction, and the quantum picture of conductors, insulators, and semiconductors. Section III: Energy and its radiation, dealing with the wave nature of electromagnetic and acoustic radiation, black-body radiation, interference, diffraction, and polarization. Section IV: The relation between heat and work, concerned with the principles and applications of thermodynamics.

A Decade of Growth in the Trunk Telephone Network, 1952–62

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U.D.C. 621.395.741

Between 1952 and 1962 the size of the public trunk telephone network was almost doubled. The new types of equipment that were used to achieve this expansion are reviewed and the growth is analysed to show how the proportion of the network provided by high-frequency plant increased in relation to the overall expansion.

INTRODUCTION

BY 1952 the long-distance public trunk telephone network in the United Kingdom had been brought up to nearly twice its somewhat meagre strength in 1945; it totalled some 18,000 lines of over 25 miles length, and its size was within 10 per cent of that required to carry the expected volume of traffic—a creditable achievement amidst the difficulties of the post-war years.

Except for its size, however, the trunk network in 1952 still resembled the pre-war network. The voice-frequency trunk-dialling system was of pre-war ancestry;[1] traffic via the zone centres was manually switched; and line equipment—audio, carrier and coaxial—was mostly of the kind introduced before or during the war.

Since 1952 a decade has passed and much has changed. Trunk mechanization at the zone centres, beginning with London (Faraday and Kingsway) in 1954,[2,3] is well advanced and has paved the way for subscriber trunk dialling. The increasing proportion of modern line plant in the network has allowed the introduction recently of a new standard dialling system, Signalling System A.C. No. 9,[4] using a single voice-frequency (2,280 c/s).

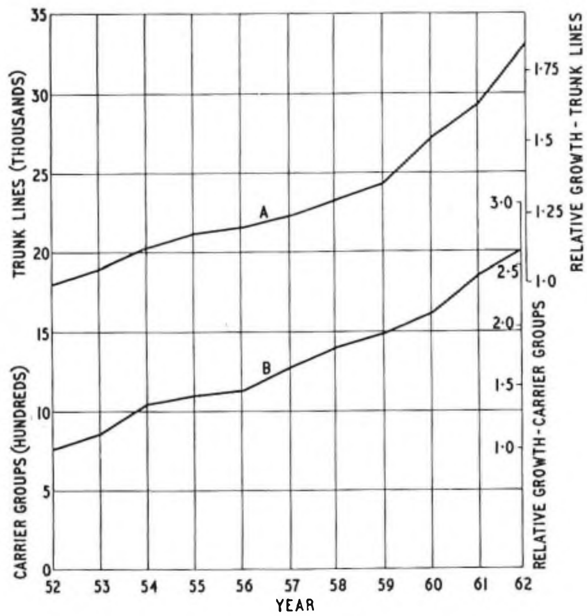
In the realm of line equipment major advances have also taken place. The advent of the transistor has ended the 21-year reign of the 4-wire audio amplifier, Amplifier No. 32.[5] The widespread use of a standard loaded cable (88 mH at 2,000 yd) has brought the 2-wire amplifier out of retirement in a transistor version of its traditional form; for the shorter lines the even cheaper negative-impedance amplifier[6] has been developed. The conversion of 12-circuit carrier quad cables to 24-circuit working[7] has been virtually completed and, although the future of carrier quad cables is limited, a 60-circuit system[8] has been introduced. The main growth of the high-frequency (h.f.) network has been provided by coaxial-cable systems using a modernized version, Coaxial Equipment, Line (C.E.L.), No. 6A,[9] of the single-broadband form, i.e. having a bandwidth of 4 Mc/s. For new schemes, however, this is now superseded by a system (C.E.L. No. 8A)[10] of much greater bandwidth (12 Mc/s) accommodating three broadbands. Recent years have also seen the introduction of the "small-tube" coaxial cable which, in conjunction with buried transistor-type amplifiers,[11] power-fed over the cable, has eliminated the need for the inconvenient surface-type intermediate station; this highly developed system will provide the greater part of the h.f. cable needs.

Finally, multi-circuit radio links will in future share the expansion of the h.f. network and the first links are already in service.

SIZE OF THE NETWORK

In the midst of these technical advances the size of the United Kingdom trunk network has continued to expand, recently at a much increased rate, and the remainder of this article analyses this expansion over the past decade.

Curve A, Fig. 1, shows the overall growth of the public trunk network in terms of the number of lines,



A—Total number of trunk lines (over 25 miles).
B—Total number of carrier groups.
FIG. 1—GROWTH OF THE UNITED KINGDOM TRUNK-LINE AND CARRIER-GROUP NETWORKS

and also the relative growth, between March, 1952, and March, 1962. This, of course, follows the traffic trend as lines were provided to meet the demand. From the relative growth scale it can be seen that in 10 years an expansion of 83 per cent took place, which is equivalent to a uniform growth of just over 6 per cent of the previous year's figure per annum. Progression, however, was not uniform, and whereas until 1959 it was equivalent to about 4½ per cent per annum, there has since been a marked rise following an unexpected upsurge in traffic; the figure became 9½ per cent per annum for 1959–61, and 1961–62 showed a further rise to 13 per cent.

Growth of the H.F. Network

A substantial part of the whole network is carried by h.f. systems working over coaxial or carrier-quad cables; the growth of the former can be broadly gauged

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by a comparison of Fig. 2 and 3 showing the coaxial cable routes in 1953 and 1962, respectively. These systems are utilized to provide carrier groups, usually of 12 circuits, and thus another measure of growth is the increase in the number of carrier groups in service, as shown by curve B of Fig. 1. In 10 years, an expansion of 160 per cent has occurred, equivalent to a uniform 10 per cent of the previous year's figure per annum; the rise, however, was not uniform but followed, as might be expected, roughly the trend of curve A of Fig. 1, with a steep increase over the last 2 years, the number of groups in service increasing by some 25 per cent in this period.

Comparison of curves A and B of Fig. 1 shows that the number of carrier groups has grown faster than the number of trunk lines, i.e. that an increasing proportion of the trunk network employs h.f. routing. This increase is approximately evaluated in Fig. 4, which shows that the proportion has risen in 10 years from about 40 per cent to over 60 per cent (the dips in the curve in 1960 and 1962 are related to temporary shortages of h.f. plant). This trend will continue as most of the growth of lines over, say, 50 miles long is now provided on h.f. systems, which are also progressively finding greater use for shorter distances (down to about 30 miles route length).

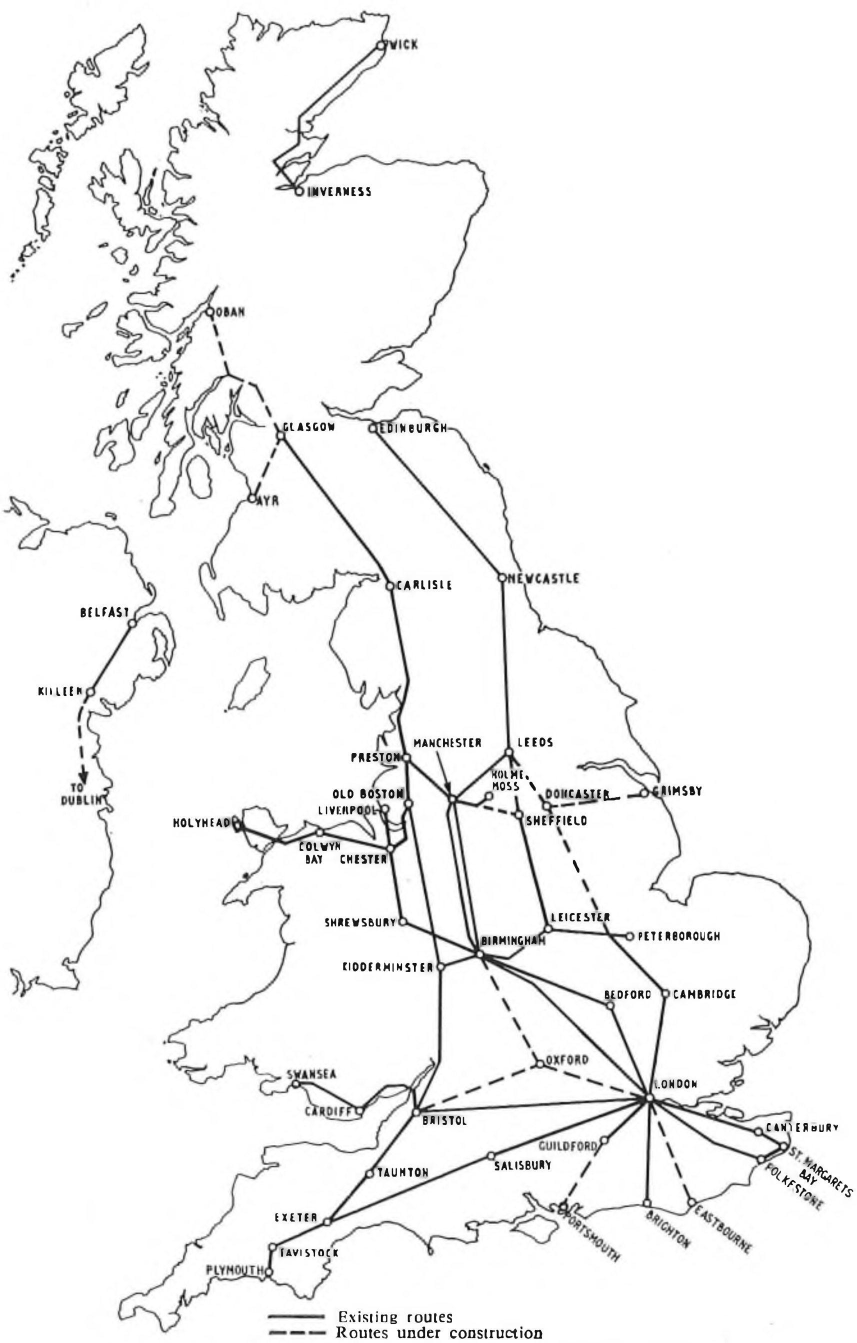

FIG. 2—UNITED KINGDOM COAXIAL-CABLE ROUTES, 1953

The trend is intentional because h.f. systems provide long-distance lines more cheaply than audio-frequency and in a typical year about 250 existing carrier groups and perhaps 1,500 existing trunk lines may have been

——— Existing routes
— — — Routes under construction
•••••• Routes planned (March, 1962)

FIG. 3—UNITED KINGDOM COAXIAL-CABLE ROUTES, 1962

plant. It must not, however, be overlooked that in the transition period there is a certain price to be paid in carrying out the rearrangement of the network; the longer lines are progressively being transferred from audio to h.f. routings, thereby releasing audio plant for use on shorter routes; also the correct utilization of new coaxial systems may require the rearrangement of carrier groups from existing cables that have been replanned to assume a different role. All this entails much work that is not directly productive of new lines, rearranged for such reasons. The cost of this work is, however, amply covered by the economic advantages of h.f. working.

Route-by-Route Pattern

The foregoing paragraphs have analysed the overall expansion of the network. This expansion was not by any means uniform from one traffic route to another. Table 1 shows the position for a number of routes radiating from Newcastle, a typical zone centre. Al-

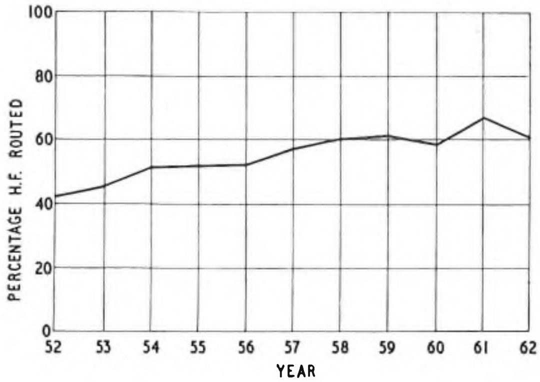

FIG. 4—PROPORTION OF TOTAL NUMBER OF TRUNK LINES ROUTED ON H.F. NETWORK

TABLE 1
Some Traffic Routes Radiating from Newcastle

Route to	Type of Route*	Approximate Number of lines		Percentage Increase
		Jan. 1952	Jan. 1962	
Alnwick	Z-G Basic	32	45	40
Berwick	Z-G Basic	13	15	15
Birmingham	Z-Z	30	76	154
Bristol	Z-Z	13	30	131
Cardiff	Z-Z	7	19	172
Carlisle	Z-Sub Z Auxiliary	28	47	68
Darlington	Z-G Basic	74	108	46
Edinburgh	Z-Z	28	45	61
Glasgow	Z-Z	36	85	136
Hartlepools	Z-G Basic	34	55	62
Hull	Z-G Auxiliary	16	28	75
Leeds	Z-Z	57	118	107
Leicester	Z-Z	8	23	188
Liverpool	Z-Z	25	37	48
London	Z-Z	128	297	132
Middlesbrough	Z-G Basic	87	160	84
Manchester	Z-Z	46	116	152
Total		662	1,304	82

* Z=Zone centre. G=Group centre.

though the range of increase varies from as little as 15 per cent to as much as 188 per cent—compared with the national average of 83 per cent—no particular pattern is discernible except that growth on zone–zone routes was usually well above the average. This list contains large and small routes, and basic and auxiliary routes, but the degree of growth is not apparently associated with these distinctions. It appears that trunk traffic is related only to the random community of interest between various towns, but it may be affected by redistribution of traffic consequent on, for example, changes in auxiliary routes.

Table 2 shows the growth on routes radiating from London, and it will be seen that, as might be expected, this growth was generally well above average.

TABLE 2
Some Traffic Routes Radiating from London

Route to	Type of Route*	Approximate Number of Lines		Percentage Increase
		Jan. 1952	Jan. 1962	
Birmingham	Z-Z	442	832	88
Bristol	Z-Z	187	371	98
Glasgow	Z-Z	164	373	127
Leeds	Z-Z	228	410	80
Leicester	Z-Z	118	278	136
Manchester	Z-Z	383	973	154
Newcastle	Z-Z	128	297	132
Horsham	Z-G Basic	71	140	97
Ipswich	Z-G Basic	97	138	43
Lincoln	Z-G Auxiliary	22	44	100
Peterborough	Z-G Auxiliary	32	72	125
Oxford	Z-G Basic	98	182	86
Total		1,970	4,110	109

* Z=Zone centre. G=Group centre.

CONCLUSION

Since 1952 notable technical advances have been made and the long-distance trunk network has become predominantly routed by h.f. plant. This has been accompanied by an increase in the number of lines, which has nearly doubled the size of the network in 10 years; it is expected that it will redouble in the next seven years.

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Electric Underfloor Heating

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U.D.C. 621.365:697.27:69.025.3

The availability of electricity supplies at reduced rates during off peak periods makes it economically attractive to use electric underfloor heating in suitable buildings. The factors affecting the design of underfloor heating systems are discussed and a heating-control system for a standard telephone exchange building is described.

INTRODUCTION

SEVERAL Post Office buildings including telephone exchanges, a sorting office, a Telephone Manager's Office and a motor transport workshop have been or are being provided with electric underfloor heating. In addition, this form of heating has been chosen for the standard H-type and K-type of telephone exchange building.

The use of electricity for whole-building heating cannot, in general, be justified economically, and its use is confined to those applications where convenience outweighs cost. However, "off-peak" supplies are available that are about one-half to one-third of the cost of commercial supplies at ordinary rates. These off-peak supplies are usually available between 7.0 p.m. and 7.0 a.m. and in many areas for about 2 or 3 hours between 2.0 p.m. and 5.0 p.m. as well.

Taking account of the small amount of maintenance required and a capital cost considerably less than that of a conventional heating system, a form of electric heating that uses the cheaper off-peak supplies becomes very attractive and has therefore been chosen for the buildings mentioned above.

A brief description is given in the following paragraphs of the way in which underfloor heating is incorporated in a building, and the factors that need to be taken into account in the design of such a heating system are reviewed. The method of controlling underfloor heating used in the standard H-type building is also described.

UNDERFLOOR HEATING SYSTEMS

Physical Arrangement

Heating cables, or conduits to receive the heating cables, are placed within the floor structure during the building of the floor. To take advantage of off-peak supplies, it is essential that the heating system should be capable of storing sufficient of the heat produced in the heating cables while the electricity supply is on and of giving it out again in sufficient quantity during the period the supply is off. Experience has shown that a $2\frac{1}{2}$ in. screed of cement covering the heating cables provides adequate storage if laid on a conventional base. An underfloor heating system will therefore consist of heating cables, which may or may not be enclosed within conduit, covered by $2\frac{1}{2}$ in. or more of cement screed, the cables and screed being laid on the base floor, which, if it is a ground floor, will consist of several inches of concrete (Fig. 1(*a*)). If it is an intermediate floor, the base will be of pot-tiles or similar construction (Fig. 1(*b*)).

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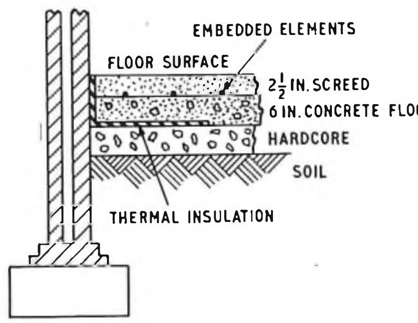
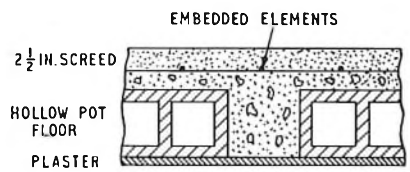
Floor Temperatures

It has been found that people standing or sitting with their feet in contact with a heated floor for long periods



(*a*) Ground Floor



(*b*) Intermediate Floor

FIG. 1—TYPICAL FLOOR CONSTRUCTION

will experience discomfort if the floor temperature is at 80°F or above. A floor temperature of 78°F is generally regarded as the upper limit for a heated floor in such circumstances and, to be on the safe side, a temperature of 75°F has been adopted as the upper limit in Post Office buildings. In such places as entrance halls where people do not normally stand for any length of time a temperature up to about 85°F can be safely used if necessary.

The limitation of floor temperature is a most important factor in the design of an underfloor heating system It imposes a limit on the permissible heat loss from the building and thus dictates the degree of thermal insulation that must be achieved in order to design an acceptable installation. This is illustrated by Fig. 2, which

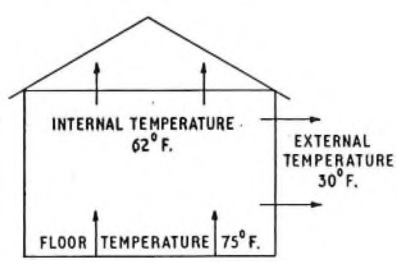


FIG. 2—HEAT FLOW FROM BUILDING

depicts a building in which the internal air temperature is 62°F, the floor temperature is 75°F and the external temperature is 30°F. If the floor is the only source of heat, then, for equilibrium conditions, the amount of heat given up by the floor into the building must equal the amount of heat escaping from the building through the walls, ceiling and windows, and by ventilation.

The amount of heat that passes through unit area of the building fabric is proportional to the difference in air temperatures each side of the fabric; in this example $K(62°F - 30°F) = 32K$. The factor K for any given material is designated the "U" value of that material, and U-values for a large number of building materials have been published in B.t.u.s per hour per ft^2 per degree F difference.

The amount of heat given up by the floor into the room is, similarly, proportional to the difference in temperature, which in this instance is (75°F − 62°F), i.e. 13°F. For a heated floor, the factor of proportionality has been found to be about 1·75 B.t.u.s per hour per ft^2 per degree F difference. Ignoring heat losses due to ventilation, the following relationship holds:

$$1{\cdot}75 \times 13 \times A_f = U \times 32 \times A_w,$$

where U = average U-value for building fabric,
A_f = floor area, and
A_w = area of external walls and ceiling.

If it is assumed in this example that the area of walls and ceiling is three times the area of the floor, then

$$22{\cdot}75A_f = U \times 96A_f,$$

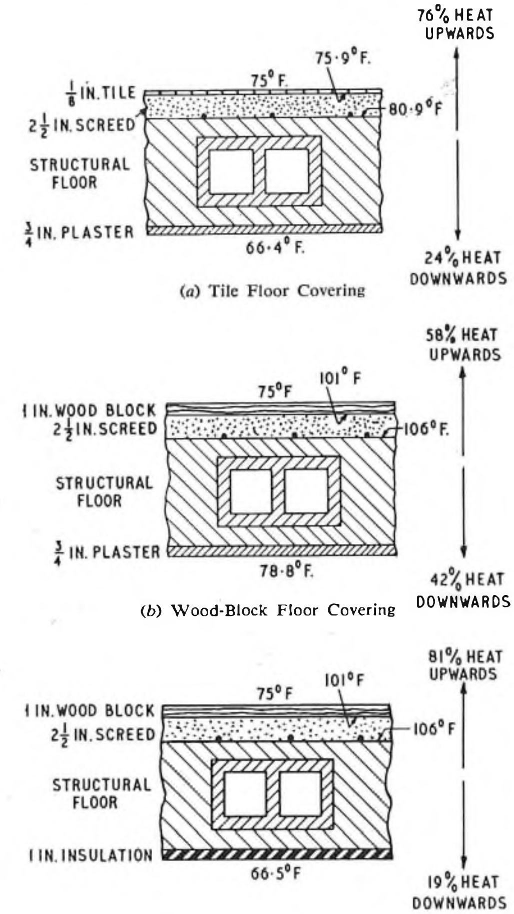
i.e. $U = 22{\cdot}75/96 = 0{\cdot}237$.

The average U-value so obtained indicates a fairly high degree of heat insulation; the U-value of an 11 in. cavity brick wall, for example, is 0·34, and for single glazing it is 1·0. If the heat loss due to ventilation is taken into account as well as the poor U-values for windows, then a U-value considerably less than 0·237 is required for the walls and ceiling. In the two standard H-type and K-type buildings U-values of approximately 0·1 have been achieved for the non-glazed portion.

The temperatures within the floor are of interest, particularly the temperature at the level of the heating cable. Many heating cables have p.v.c. sheaths, and it is important that the cable temperature should not exceed the safe working temperature of the covering. Fig. 3(*a*), (*b*) and (*c*) show typical temperatures within the floor with various types of floor covering, and also illustrates, for an intermediate floor, the effect that the floor covering has on the amount of heat passing to the room below. In each example the floor surface temperature is 75°F.

Fig. 3 clearly shows the need for consultation with the designer of the heating installation in the matter of floor covering. Fig. 3(*b*) shows that a wood-block finish not only increases the average temperature at the cable by 25°F, but almost doubles the fraction of heat transmitted downwards into the room below, compared with the construction shown in Fig. 3(*a*). If the room below is occupied by another tenant, then it is undesirable that he should enjoy the benefit of heat paid for by the tenant above. If a carpet and underfelt are placed on the wood blocks then more than half the heat put into the floor will flow into the room below. This state of affairs can be remedied by placing a substantial layer of heat insulation on the ceiling below, and Fig. 3(*c*) shows the effect this has. A further effect of floor insulation is to increase the average temperature of the floor, increasing the amount of heat stored in order to give the permissible surface temperature and so increasing the time-constant of the system. The heat stored in the floor of Fig. 3 (*b*) relative to a room temperature of 62°F is more than double that of the floor in Fig. 3 (*a*).

Some heat will always flow downwards through the floor. In an intermediate floor this can be counted a



(*a*) Tile Floor Covering

(*b*) Wood-Block Floor Covering

(*c*) Wood-Block Floor Covering and Heat Insulation on Ceiling Below

FIG. 3—EFFECT OF DIFFERENT FLOOR COVERINGS

heat gain to the room below, and allowed for in the design. Only in the example mentioned above, or where the ceiling is obstructed in some manner, is this effect undesirable. It means that in a multi-storey building the designer must start his design at the top floor and work downwards. On the ground floor, however, most of the heat transmitted downwards through the floor is lost and it is desirable to minimize this. Most of the heat so lost escapes around the perimeter of the floor slab, and in order to reduce this loss it is usual to provide thermal insulation extending horizontally for about 2–3 ft inwards from the edge of the floor slab and vertically for the depth of the slab and the screed (see Fig. 1 (*a*)). On a damp site it is necessary to provide thermal insulation to cover the whole floor area, as well as a damp-proof membrane.

Room Temperatures

When properly controlled, underfloor heating is capable of maintaining the designed room temperature to within 2 or 3°F over a period of 24 hours. During normal occupied hours, the temperature variation will be less than this.

Fig. 4 shows the temperature gradients that exist with different forms of room heating. It is generally recognized that for comfort the temperature at floor level

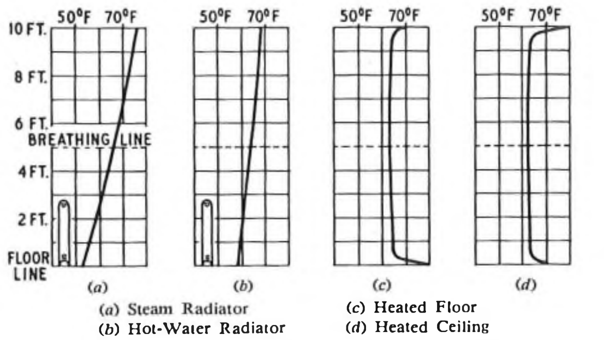


FIG. 4—VERTICAL TEMPERATURE GRADIENT IN ROOMS WITH VARIOUS TYPES OF HEATING

should not be less, or only a degree or two less, than that at head level. It will be seen that floor heating fulfils this requirement.

Control of Underfloor Heating Systems

The intake of electricity has to be limited to the off-peak periods offered by the supply authority, and this is achieved by means of a time switch, provided and sealed-off by the authority. The control of temperature is achieved by means similar to those employed with normal central-heating systems, i.e. by means of room thermostats or some form of external controller. In addition, floor thermostats may be needed to guard against local overheating of the floor in the event of failure of the controlling thermostats.

An external controller, mounted on the outside of the building, will delay the time of switch-on of the supply in accordance with the external temperature; it functions as follows: a cam, driven at one revolution each 24 hours, is so shaped that the cam-follower operates through a link to close a pair of contacts at the beginning of the off-peak period and opens them at the end of the period, usually at 7.0 a.m. The gap between the contacts is, however, varied by a temperature-sensitive element, being increased with increase of external temperature, thus delaying the closing of the contacts. The controller can be adjusted so that when the external temperature is 30°F at 7.0 p.m. a full charge is taken; with a night-time temperature of about 55°F, the charge is delayed until about two hours before the end of the off-peak period.

UNDERFLOOR HEATING IN AN H-TYPE BUILDING

The H-type building is a small standard telephone exchange building designed to be unattended for the first several years of its life and attended thereafter.

During the unattended period heat is required

(*a*) for background heating in winter, the heating also guarding against high humidity in the apparatus room, and

(*b*) for humidity control in the apparatus room during the summer.

During the attended period the requirements are:

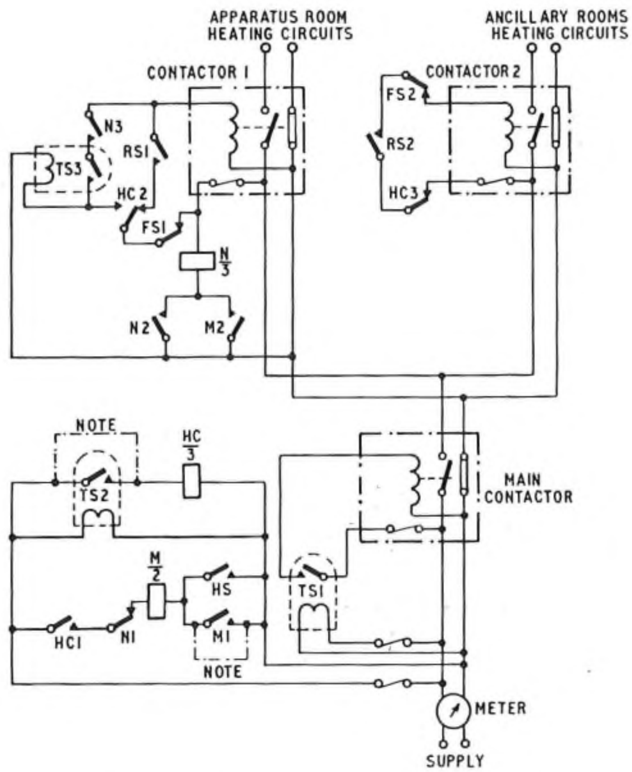
(*a*) full heating in all rooms, Monday to Friday, during the winter, and

(*b*) humidity control in the apparatus room only, at week-ends and throughout the summer.

Heating-Control Circuit

The heating programs are catered for by the control circuit shown in Fig. 5, and the circuit operation is described below.

Full-Heating Program. Contact TS2 is assumed to be open. Contact TS1 closes at the commencement of a charging period and completes the circuit for the operate coil of the main contactor, which extends the supply to the subsidiary contactors 1 and 2. Contacts FS1 and FS2 (floor thermostats) are normally closed. When the room-thermostat contacts RS1 and RS2 close they complete the circuits for the operate coils of subsidiary contactors 1 and 2, respectively, and these contactors, on closing, connect the supply to the heating circuits. During this charging period, power intake is under the control of RS1 and RS2; should either of these



Note: For background heating and humidity control, contacts TS2 and HS are strapped out; in summer only contact TS2 is strapped out

FIG. 5—SIMPLIFIED DIAGRAM OF HEATING-CONTROL CIRCUIT FOR H-TYPE STANDARD BUILDING

thermostats fail to operate, the floor thermostats will come into operation, cutting off the supply.

Humidity Control. Contact TS2 is closed to give humidity control, and relay HC is operated via TS2. Contact HC1 prepares an operating circuit for relay M, contact HC2 breaks the operating circuit of contactor 1 via RS1 and prepares an alternative circuit via TS3 and N3, and contact HC3 disconnects the operate coil of contactor 2, thus cutting off the heating power supply to all accommodation except the apparatus room.

At the commencement of the charging period the main contactor closes as explained above. When the humidistat contact, HS, closes with rise of relative humidity, relay M operates via contacts HC1 and N1. Contact M1 provides a holding circuit for relay M, relay N operates via contact M2, and contact N2 provides a holding circuit for relay N. Contact N1 releases relay M. When contact TS3 closes, the operate coil of contactor 1 is energized via contacts N3, TS3, HC2 and FS1 (which is normally closed); contact TS3 is opened and closed at regular intervals, as explained below. Charging will therefore continue intermittently until the end of the charging period, which occurs when contact TS1 opens.

Should the humidistat close after the closing of contact TS2, but before the commencement of the charging period, relay M will operate via contact HC1 operated, contact N1 normal and contact HS closed, and will hold via contact M1. When the charging period commences the main contactor closes and relay N operates. Subsequent operation is as described above. Thus, should the relative humidity rise above the set value of the humidistat at any time outside the charge period, a circuit is prepared and held that will ensure that a charge is taken when contactor TS1 closes.

Background Heating (Including Humidity Control). During the winter, contacts TS2 and HS are strapped out. Operation is therefore as described above when contact HS closes before the commencement of the charging period. In this instance, the amount of charge taken is controlled by contact TS3. This time-switch is arranged to operate for any set period during one hour. If it is set to close, say, for 15 minutes each hour, then the apparatus-room heating circuit will receive one quarter of its full charge. This will be sufficient to maintain the temperature of the apparatus room at an average of about 7°F above the outside temperature, and will prevent the relative humidity in this room from rising above an acceptable figure.

During the summer season, contact TS2 only is strapped out. Relay HC is permanently operated and operation of the circuit is as described above under Humidity Control.

CONCLUSION

Operating experience gained so far with the few completed underfloor heating installations in the Post Office has shown that this form of heating is satisfactory and acceptable, and economic compared with conventional heating systems.

New Training Schemes for Post Office Engineering Youths

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U.D.C. 331.86

New training schemes for engineering Youths-in-Training in the Post Office have been introduced. The new schemes apply to Youths to be trained for telecommunications duties in Telephone Areas and to those to be trained for motor-transport duties. Details are given of the training programs, which are intended to occupy 3 years. The new scheme will also be extended to apply to Youths employed on other duties.

INTRODUCTION

In 1962 final agreement was reached on two new training schemes for Youths-in-Training in the British Post Office: the first, for telecommunications Youths in Telephone Areas, became operative on 1 January 1963 and the second, for motor-transport Youths, was introduced during the summer of 1962. The extension of the first scheme to include Youths employed on External Telecommunications Executive (E.T.E.) duties and power duties, as well as Youths employed in the Engineering Department on laboratory duties and in the Radio and Test and Inspection Branches will be brought into operation during 1963.

The new training program for telecommunications Youths increases the period of formal training from 2 to 3 years, and this change, if fully implemented in 1963, would result in a complete absence of trained output to the Technician grades in 1965. To avoid this obvious difficulty, it was arranged that the 1963 intake of Youths should commence on either the old 2-year scheme or the new 3-year scheme and that the size of the intake should be augmented by about 50 per cent above the normal recruitment level; this would ensure that an adequate output of trained Youths would be available for regrading as Technicians in 1965. There was evidence of an increase in the numbers of Youths recruited in 1962 and, hence, the further increase of 50 per cent for the 1963 intake was considered to be sufficient to meet the demands of the organization until the new scheme becomes stabilized during 1966. The Youths chosen to follow the old 2-year training program commencing in 1963 were to be those whose academic background and apparent aptitude for telecommunications work indicated that they were more likely to reach an acceptable standard for regrading as Technician in the shorter period. From 1964 onwards all Youths recruited would follow the new 3-year training program.

In 1962, also, a new training scheme for Youths in the motor-transport organization of the Post Office was introduced. In the years prior to the second world war there was a training scheme for Youths in this field of departmental activity but it had fallen into disuse until the new scheme was introduced. As with the scheme for telecommunications Youths, the motor-transport training scheme, which has been the subject of correspondence and agreement with the National Joint Industrial Council for the Motor Vehicle Retail and Repairing Trade, will be of 3 years' duration. The first intake of Youths for the new training scheme was from amongst young men leaving school in the summer of 1962, but the initial numbers recruited were somewhat lower than would be expected for the subsequent intakes when the scheme becomes stabilized.

TELECOMMUNICATIONS YOUTHS-IN-TRAINING

The object of the new training programs for telecommunications Youths is the production of more versatile Technicians competent to undertake the duties of the grade immediately after regrading, and, to achieve this aim, the final 9 months of training has been pro-

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grammed to be spent on "live" work in the field of activity to which the ex-Youth would be appointed.

Training Program

The new 3-year training program for Youths in Telephone Areas has been divided into three sections:

(*a*) A 15-month common training course mainly concerned with construction work on external, internal and subscribers' plant.

(*b*) A 12-month period of semi-specialization in one or other of the following fields of Telephone Area activity:

(*i*) Internal construction.

(*ii*) Internal and subscribers' apparatus maintenance.

(*iii*) External planning.

(*iv*) Telegraphs.

(*v*) Subscribers' apparatus fitting and P.B.X. installation.

(*vi*) Overhead construction and subscribers' apparatus fitting.

(*vii*) Plumbing and jointing.

For Youths following (*b*) (*i*) to (*iv*), the second stage of training would comprise a common course of 6 months' duration on telephone exchange and repeater station maintenance, followed by 6 months on a comprehensive program in one of the particular fields of activity listed under (*b*) (*i*) to (*iv*). Youths following (*b*) (*v*) to (*vii*) would spend 8 weeks on internal maintenance and then continue on a comprehensive program in the selected field.

(*c*) A final 9 months on live work under supervision.

Training Courses

An induction course of 2 days' duration will be held in the Telephone Area for the Youth recruits with the object of introducing the young men to the Post Office, giving them an idea of what is done and how the Post Office and the Area in particular is organized, and explaining details of their training programs and technical education. During the 3 years of training each Youth will take the appropriate A (1st year) and B (2nd year) courses, and, in the final year, a course at the Central Training School or Regional Training School related to the particular duties he will undertake when regraded to Technician.

Technical Education

Youths will follow the amended scheme of technical education, details of which were given in a recent issue of this Journal.* Youths recruited with a minimum of four passes in suitable General Certificate of Education (G.C.E.) O-level subjects will undertake the first year (O.1) of the 2-year Ordinary National Certificate (O.N.C.) course, whilst those without this qualification will embark upon the General Engineering Course on a 1-year or 2-year basis, depending upon their educational standards. The Youths' A course syllabus has been suitably amended to cover the syllabus of Elementary Telecommunications Practice, which would not be taken by students who are exempted from the first year of the City and Guilds of London Institute Telecommunication Technicians' Course or who follow the O.N.C. course of study. Depending upon the standard of achievement in their technical studies Youths will continue on the O.N.C. and H.N.C. course or the City and Guilds course. Provision has also been made for Youths recruited with exceptional G.C.E. O-level successes or with A-level successes to proceed along the G.C.E. A-level to B.Sc. degree path.

*WATKINS, A. H. "Better Opportunities in Technical Education." *P.O.E.E.J.*, Vol. 56, p. 13, Apr. 1963.

Age Limit for Recruitment

The age limits for recruitment as a Youth-in-Training are 16–18 years, but some relaxation of the lower age limit is possible. Any Youth recruited before his 16th birthday would not commence formal training until he reached that age but would undertake suitable pre-course training.

Youths not Covered by the Foregoing

The details given above do not apply to certain categories of Youths; these are Youths employed on E.T.E. and power duties, in the Engineering Department on laboratory duties, and in the Radio and Test and Inspection Branches. The details of the training program for each of these categories will be different, but the basic outline of training, education and departmental courses will be unchanged.

MOTOR-TRANSPORT YOUTHS-IN-TRAINING

The object of re-introducing a Youths-in-Training scheme for the motor-transport organization of the Post Office was to make the organization less dependent upon the recruitment of suitable skilled mechanics. Recruiting is difficult in certain parts of the country, and with a growing fleet of vehicles, together with the prospect of increased losses due to retirements, a process of training staff to fill the vacancies produced was considered necessary. Unlike the corresponding scheme for training in telecommunications, there is in existence a well-established industrial scheme for training motor-vehicle mechanics, and the 3-year program adopted by the Post Office has been agreed with the National Joint Industrial Council for the Motor Vehicle Retail and Repairing Trade.

Motor-transport Youths-in-Training are required to take the City and Guilds of London Institute 3-year course in motor-vehicle mechanics' work at a local technical college.

The rate of recruitment of motor-transport Youths in the early stages of the scheme is necessarily restricted to supplying part only of the total requirement of mechanics because of the need to consider such factors as the practicability of employing the Youths, on completion of training, in workshops near their homes, the availability of suitable technical colleges within reasonable travelling distance and the suitability of particular workshops for comprehensive training. It is hoped, however, that the scheme will be extended when experience of its operation has been gained.

The age limits for recruitment as motor-transport Youths-in-Training are 15–18 years and, although a Youth commences training immediately after recruitment, the 3-year period of formal training does not begin before his 16th birthday.

Exchange-Line Costing Study

J. R. GOLDSMITH and H. D. HEWSTONE†

U.D.C. 657.47:621.395.743

It is necessary for the formulation of financial and engineering policy to reassess periodically the composition of the local-line-plant component of exchange connexions. This article describes a study being carried out to assess the costs of the various types of exchange connexion and the quantities of plant in use.

INTRODUCTION

TELEPHONE service to a subscriber depends, among other things, upon the provision of a pair of wires from that subscriber's premises to the exchange. The pair of wires can be for the exclusive use of the subscriber or it can be shared by others. Although very simple in terms of circuit design the local-line plant network is physically complex because of the manner and circumstances in which it is provided, and the actual utilization of the plant to provide service varies considerably within individual networks and between networks.

The cost of providing and maintaining all the plant has, however, to be recovered from subscribers. It is therefore incumbent upon the Post Office to ensure from time to time that the charges made for the use of the plant are not only fair and reasonable but also provide an adequate return on capital. It is thus necessary for the determination of tariffs of an exchange connexion and associated circuits, and for the planning and control of engineering expenditure, to have a sound knowledge of the quantities and types of existing plant.

Records exist in many forms, but each one is specifically designed for a particular function and they do not provide answers to the following questions:

(*a*) What is the cost of an exchange connexion?

(*b*) What are exchange connexions like in terms of length and plant composition?

(*c*) How much of each of the different types and sizes of plant exist?

(*d*) What are the trends in plant provision?

HISTORY

Previous studies have been carried out to revise the answers to the above questions. The last full study was made in 1946, and since then costs have been periodically reassessed to take account of price changes. Broadly, this study consisted of obtaining the total local-line plant composition of 22 exchange areas selected as representative of all the exchange areas in the United Kingdom. It provided information of the total plant existing in those areas and the cost of the plant was calculated from this information. Values for the average exchange connexion were then derived by dividing the total cost and plant quantities by the number of existing connexions in the 22 areas. This method suffers from the general disadvantages that the choice of the representative exchange areas is not statistically sound and the amount of plant used jointly with circuits other than exchange connexions, e.g. junctions and private circuits, cannot be assessed very accurately. Nevertheless, the 1946 study was the best that could be made without automatic data processing, for such an exercise carried out on recognized statistical principles involves a tremendous number of calculations.

Since 1946 considerable changes in techniques have been introduced, such as the use of cabinets, pillars and small-gauge conductors, and it was decided in 1956 that a revised study of the costs of an exchange connexion should be carried out. The new study is known as the Exchange-Line Costing Study.

†Local Lines and Wire Broadcasting Branch, E.-in-C.'s Office.

NEW COSTING STUDY

Basis of the New Study

The basic principle of the new exchange-line costing study is that each exchange connexion should carry its share of the cost and quantity of common plant used to provide that connexion.

The setting up of a sampling frame* of exchange multiple numbers in 1956 by the Accountant General's Department (Chief Statistician's Division) made it possible to select a random sample of exchange connexions from the total telephone population and to carry out the study based on the above principle by enabling a plant analysis to be made of individual connexions. The plant analysis enables the actual cost and plant quantities of individual connexions to be assessed by apportioning to each one the costs and quantities of plant used. The sampling design permits the calculation of sampling errors, so that estimates of average conditions with known accuracies can be produced.

In order to apply this principle of apportionment, a detailed survey of each section of the route of a sample connexion is necessary, since the number of working lines (exchange connexions, private circuits, power leads, etc.) varies from section to section. It is also necessary for the apportionment to be assessed in three ways in order to provide the cost of the sample connexion, the cost of the spare plant attributable to the connexion, and the quantity of plant attributable to the connexion.

Preliminary Work

The planning and organization of a study based on a detailed survey of individual connexions presented a number of problems, and it was decided to organize a pilot study in order to assist in deciding the following:

(*a*) What size sample would be required.

(*b*) How much of the required information could be obtained from local records and how much would necessitate a field survey.

(*c*) How much time would be needed by a local-line planning team to survey each sample line.

(*d*) What types of form would be most suitable for collecting the information.

For this study a random sample was chosen, large enough to give 25 connexions in each of four selected Telephone Managers' Areas, three provincial and one in London. The 100 connexions chosen were surveyed in

*Exchange-connexion sampling frame—the sampling frame constitutes a record, on punched cards, of equipped multiple numbers, both working and spare, and from it can be obtained random samples of exchange connexions.

detail and the cost of each determined. This gave an indication of the variation in the cost per connexion to be expected. The number surveyed was relatively small but was the maximum that could be dealt with in a reasonable time and was sufficient to show that a large sample would be required to obtain results in which a high degree of confidence could be placed.

The pilot study indicated that quite a large proportion of the information could be obtained from records, but a field survey for each connexion would be necessary and that it should be possible for each external planning team to carry out a detailed survey of two sample connexions per year as part of their normal duties. As there are approximately 700 planning teams in the country, the size of the sample that could be surveyed per year would be limited to 1,400 exchange connexions.

The size of the sample also indicated that the costing and apportioning of every important item of plant for each section of the route on all sample connexions would involve an immense number of calculations and some machine processing would be essential. The London Electronic Agency for Pay and Statistics (LEAPS) computer offered the most convenient facilities for processing the data; all details of the study had, therefore, to be prearranged in a manner suitable for automatic processing and this emphasized the need for specially-designed forms.

Aims of the Study

It was obvious from the pilot study that the operation, even by sampling, would require great effort and, to justify this, the maximum information possible should be derived from the study. It is hoped to obtain the following information initially on a national basis, but as the study proceeds and if confidence limits are within acceptable figures, regional values should also become available:

(*a*) The average inclusive capital cost of an exclusive line, under various plant sub-heads for business and residential connexions separately.

(*b*) The average inclusive capital cost of a shared line, under various plant sub-heads for business and residential connexions separately.

(*c*) The annual costs, derived from (*a*) and (*b*).

(*d*) The total amount of in-situ plant. This will be presented in plant groups, and the information will be given in total and for various sizes of exchange.

(*e*) The composition of an average mile of plant for the various types of construction.

(*f*) The average route and radial length of an exchange connexion for all and for various sizes of exchange.

(*g*) The average route length of an exchange connexion in various parts of the network, e.g. exchange to cabinet.

(*h*) The relationship between the average route and radial distance, in radial-milage steps.

(*i*) The percentage of exchange connexions served by each type of construction, e.g. open wires from ring-type distribution poles.

(*j*) The margin of spare plant for (*i*) cable expressed in pair-miles for each part of the cable network, and (*ii*) duct expressed as the milage of single-way ducts with an occupancy of less than 5 per cent.

(*k*) The percentage of exchange connexions served by one, two, three, et seqq., spans, of open wire.

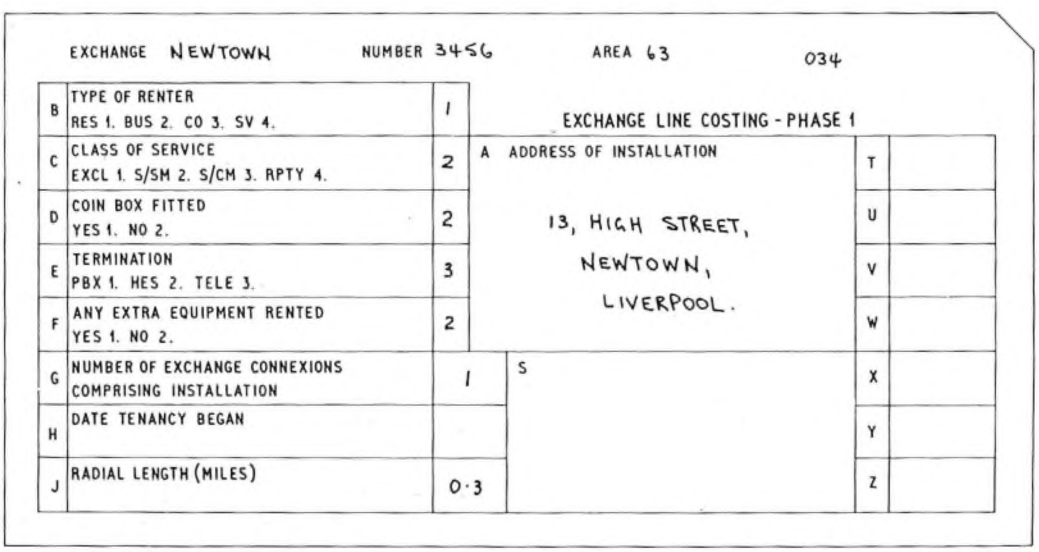
(*l*) The percentage of exchange connexions served from the main distribution frame to the subscriber (*i*) direct, (*ii*) via cabinet and pillar, (*iii*) via cabinet only, and (*iv*) via pillar only.

(*m*) The average transmission equivalent resistance* and signalling resistance in radial-milage steps.

METHOD OF CARRYING OUT THE STUDY

The pilot study indicated that a large sample of exchange connexions would be required, and, in order to reduce the size and so the cost of the study as far as possible, great care had to be taken in the design of the sample. The sample size could be considerably reduced by the adoption of a stratified design, but the initial information that was necessary to carry out the stratification was not available. So the method adopted was the technique of double sampling in which an initial large sample is used to produce a smaller sample stratified according to radial length. This method re-

*Transmission equivalent resistance—the transmission equivalent resistance of any line of given length and gauge is defined as the d.c. resistance of a $6\frac{1}{2}$ lb/mile line having the same grade of transmission.



EXCHANGE NEWTOWN NUMBER 3456 AREA 63 034

EXCHANGE LINE COSTING - PHASE 1

B	TYPE OF RENTER RES 1. BUS 2. CO 3. SV 4.	1	
C	CLASS OF SERVICE EXCL 1. S/SM 2. S/CM 3. RPTY 4.	2	A ADDRESS OF INSTALLATION 13, HIGH STREET, NEWTOWN, LIVERPOOL.
D	COIN BOX FITTED YES 1. NO 2.	2	
E	TERMINATION PBX 1. HES 2. TELE 3.	3	
F	ANY EXTRA EQUIPMENT RENTED YES 1. NO 2.	2	
G	NUMBER OF EXCHANGE CONNEXIONS COMPRISING INSTALLATION	1	S
H	DATE TENANCY BEGAN		
J	RADIAL LENGTH (MILES)	0·3	

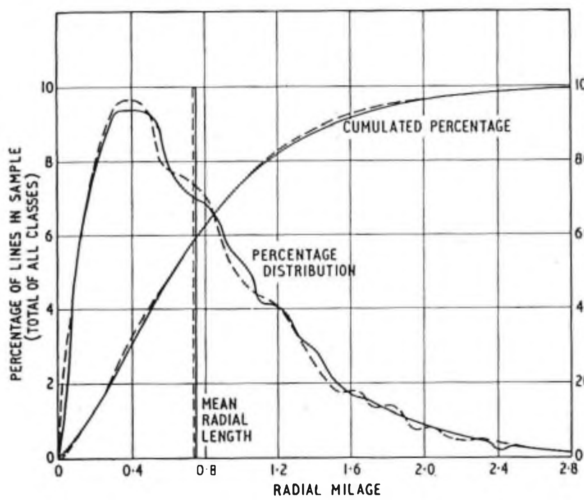
T	
U	
V	
W	
X	
Y	
Z	

FIG. 1—INFORMATION CARD FOR PHASE I

duces the overall work involved, since detailed surveys are only required in the second smaller sample. The first sample is known as Phase I and the second sample as Phase II.

Phase I

A large Phase I random sample of multiple numbers was distributed to Telephone Areas in 1958, and information such as identity, service category and radial milage relating to each sample number was collected; a separate information card was used for each sample number (see Fig. 1). The relevant information was inserted on the cards, which were returned for processing



– – – Phase I first sample
——— Phase I second sample

FIG. 2—DISTRIBUTION OF SAMPLE CONNEXIONS

by punched-card operators so that the results could be analysed automatically by a punched-card machine. A further Phase I study was carried out in 1962, because of a shortage of lines over 1·5 miles in radial length in the original sample. This study served, at the same time, to bring the original sample up-to-date. The results of both the first and second Phase I studies are shown in the table and in Fig. 2.

Phase II

A Phase II sample of exchange connexions, based on a statistical analysis of the Phase I radial-milage distribution, is selected annually from each radial step of half a mile. These connexions are surveyed in detail by local-line planning staff.

A facing sheet, used as a control form, is prepared for each sample line, and on it is inserted the address of the subscriber, the telephone number, type of renter, class of service and radial milage (see Fig. 3). The forms are forwarded to Telephone Areas biannually. On receipt of the forms, the planning staff check the identity particulars of the sample line and, unless the address has changed or the connexion no longer exists, a detailed survey is carried out. Information on the following items is obtained:

(*a*) General
- (*i*) Subscriber's service and lead-in.
- (*ii*) Location of the shared-service teeing point.
- (*iii*) Location of the distribution point.
- (*iv*) Location of the boundary of the subscriber's premises or property.
- (*v*) Location and details of the flexibility units.
- (*vi*) Details of the exchange terminating-cable.

(*b*) Overhead Sections
- (*i*) Type of construction.
- (*ii*) Route length.
- (*iii*) Poles.
- (*iv*) Pole fittings.
- (*v*) Wire.
- (*vi*) Aerial cable.
- (*vii*) Total number of wires, number of working wires and exchange connexions.

EXCHANGE LINE COSTING —— FACING SHEET

FILE No.: 63/46

LAST DATE FOR RETURN TO E.D.: 8·5·63

EXCHANGE AREA: NEWTOWN

TELEPHONE No.: 3456

ADDRESS: 13, HIGH STREET, NEWTOWN, LIVERPOOL.

CIRCULATION

	INITIALS	DATE
ISSUED	H.D.H.	8·12·62
SURVEYING OFFICER		
SCRUTINISED IN E.D.		
SCRUTINISED IN A.G.D.		
PUNCHED IN LEAPS		
VERIFIED IN LEAPS		

A			B		C	
AREA CODE	EXCHANGE CODE	SUBSCRIBER'S NUMBER	TYPE OF RENTER	CLASS OF SERVICE	RADIAL MILAGE MILES	RADIAL MILAGE TENTHS
63	034	3456	RESIDENTIAL	SHARED	0	3

FS1	63	034	3456	2	1	2	3	0	3	BLANKS (MINIMUM 10)

The numerical information in the bottom panel of the form is that used by the operator preparing the punched tape.

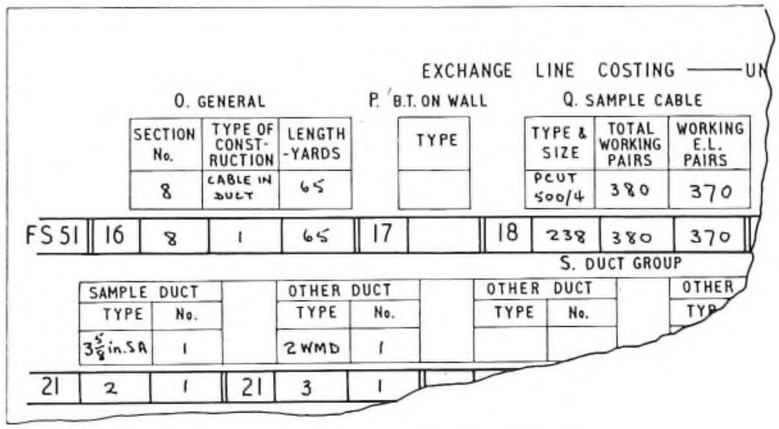
FIG. 3—CONTROL FORM FOR SAMPLE LINE

Distribution of Working Sample Connexions According to Radial Length
(Total for United Kingdom)

Radial Length (Miles) Rounded to Nearest Tenth of a Mile Above	Number of Connexions in Each Radial Length Step													
	Residential				Business				Call Office		Service		Total	
	Exclusive		Shared		Exclusive		Shared							
	Phase I First Sample	Phase I Second Sample	Phase I First Sample	Phase I Second Sample	Phase I First Sample	Phase I Second Sample	Phase I First Sample	Phase I Second Sample	Phase I First Sample	Phase I Second Sample	Phase I First Sample	Phase I Second Sample	Phase I First Sample	Phase I Second Sample
0·1	99	94	30	29	295	243	5	4	16	8	39	75	484	453
0·2	179	206	89	56	406	378	15	12	7	9	18	13	714	674
0·3	270	271	146	121	383	395	9	11	7	6	8	11	823	815
0·4	296	296	142	150	382	350	12	6	14	12	9	5	855	819
0·5	310	363	164	150	304	279	13	8	14	10	4	12	809	822
0·6	302	310	143	139	217	215	8	12	7	4	4	9	681	689
0·7	300	305	148	126	187	180	10	11	6	4	6	3	657	629
0·8	264	290	156	139	165	156	11	12	11	2	6	6	613	605
0·9	199	250	132	124	151	133	10	8	4	3	—	3	496	521
1·0	169	233	125	110	105	110	14	3	7	4	1	3	421	463
1·1	125	157	113	99	101	95	21	4	12	1	3	6	375	362
1·2	147	151	104	98	79	96	11	12	6	3	2	1	349	361
1·3	121	110	88	86	68	82	9	8	1	5	—	1	287	292
1·4	84	108	55	55	62	75	7	7	5	2	3	3	216	250
1·5	60	73	50	49	37	48	8	3	3	6	1	1	159	180
1·6	62	56	47	41	44	39	6	7	2	2	—	1	161	146
1·7	33	48	45	37	29	33	11	7	3	5	—	2	121	132
1·8	40	39	39	25	31	37	10	5	6	—	—	1	126	107
1·9	22	26	28	23	18	29	4	5	2	3	1	2	75	88
2·0	14	24	19	15	29	28	6	9	2	2	—	1	70	79
2·1	17	14	9	19	18	25	1	7	4	—	—	—	49	65
2·2	13	15	10	11	17	16	3	6	2	4	—	—	45	52
2·3	10	11	8	10	17	17	4	4	1	2	—	1	40	45
2·4	6	5	8	4	10	6	6	2	1	1	2	—	33	18
2·5	3	5	4	3	15	14	1	3	1	1	—	—	24	26
2·6	1	1	2	4	9	12	2	2	—	—	2	—	16	19
2·7	2	1	1	1	6	16	3	—	—	—	—	—	12	18
2·8	2	5	1	1	7	3	2	1	—	—	—	—	12	10
2·9	—	2	2	3	7	3	1	2	—	—	—	1	10	11
3·0	4	3	2	1	—	1	1	4	1	—	—	—	8	9
3·1	1	—	2	2	1	5	1	—	1	—	—	—	6	7
3·2	1	3	2	1	1	3	1	1	—	—	—	1	5	9
3·3	2	—	1	1	2	2	—	—	—	—	—	—	5	3
3·4	2	—	—	—	3	1	—	—	—	—	—	—	5	1
3·5	—	—	1	—	2	2	—	—	—	—	—	—	3	2
3·6	—	1	2	—	3	1	—	1	—	—	—	—	5	3
3·7	—	—	—	1	2	—	3	—	—	—	—	—	5	1
3·8	1	—	—	1	—	—	1	—	—	—	—	—	2	1
3·9	—	—	—	—	3	—	1	—	—	—	—	—	4	—
4·0	—	1	—	—	—	1	—	—	—	—	—	—	—	2
4·1	—	—	—	—	—	1	—	—	1	—	—	—	1	1
4·2	—	—	—	—	—	—	1	—	—	—	—	—	1	—
4·3	—	—	—	—	2	—	—	—	—	—	—	1	2	1
4·4	—	—	—	—	2	—	—	—	—	—	—	—	2	—
4·5	—	—	1	—	1	—	1	—	—	—	—	—	3	—
4·6	—	1	—	—	—	—	—	1	—	—	—	—	—	2
4·7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4·8	—	—	1	1	—	—	1	—	—	—	—	—	2	1
4·9	—	—	—	—	—	—	—	—	—	—	1	—	1	—
5·0	—	—	—	—	—	—	—	1	—	—	—	—	—	1
5·1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5·2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5·3	—	—	—	—	1	—	—	—	—	—	—	—	1	—
5·4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5·5	—	—	—	1	—	—	—	—	1	—	—	—	1	1
	3,161	3,478	1,920	1,737	3,222	3,130	234	189	148	99	110	163	8,795	8,796
Mean Radial Length (miles)	0·736	0·751	0·855	0·864	0·636	0·663	1·211	1·229	0·905	0·863	0·460	0·438	0·737	0·748
Standard Error of Mean	0·008	0·008	0·012	0·013	0·010	0·011	0·046	0·063	0·066	0·068	0·066	0·050	0·006	0·006

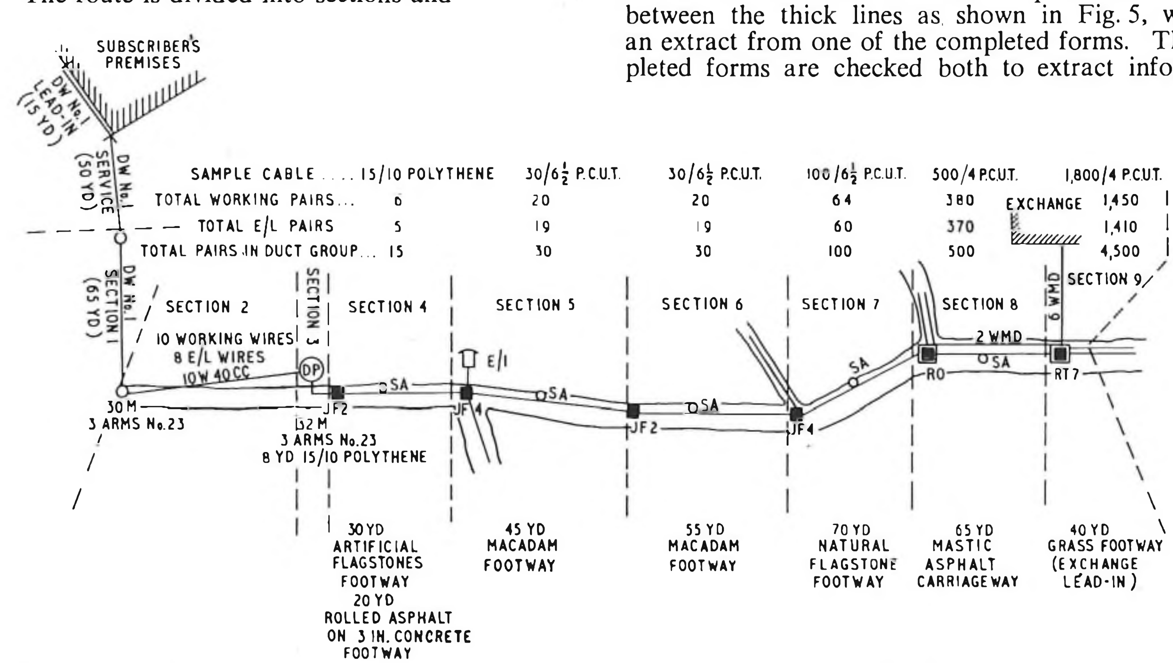
(*c*) Underground Sections
(*i*) Type of construction.
(*ii*) Route length.
(*iii*) Jointing chambers.
(*iv*) Duct length under different surfaces.
(*v*) Cable.
(*vi*) Total number of pairs, number of working pairs and exchange connexions.

A large proportion of the above information is obtained from existing plant records and the remainder from a field survey. The information is inserted on a route plan that the survey officer prepares from a copy of the ordnance-survey record-map or plan, or is recorded in such a manner as is considered most suitable for local circumstances, so that the work can be carried out efficiently and with the minimum of interference with normal duties. The route is divided into sections and each section is numbered from the subscriber's premises to the exchange. A specimen route plan is illustrated in Fig. 4.



E.L. Pairs—Pairs in use for exchange connexions.
FIG. 5—EXTRACT FROM COMPLETED FORM

details are encoded in a standard pattern and entered between the thick lines as shown in Fig. 5, which is an extract from one of the completed forms. The completed forms are checked both to extract information regarding certain non-standard items of plant that need to be manually costed and to ensure that the data are reasonable. Paper tape is then punched with the encoded information and finally fed into the computer, where the data are transferred on to magnetic film for permanent storage under automatic instructions provided by the input program. The program also ensures that further checks are made on the information and that it is recorded and stored in a set pattern for later costing and analysing.



DW—Drop wire. 30M—30 ft medium pole. DP—Distribution pole. JF2—Footway Jointbox No. 2. JF4—Footway Jointbox No. 4. SA—Self-aligning duct. RO—Manhole. RT7—Manhole. 2WMD—2-way multiple duct. 6WMD—6-way multiple duct. 15/10 Polythene—15-pair 10 lb/mile polythene-sheathed cable. 30/6½ P.C.U.T.—30-pair 6½ lb/mile paper-core unit twin cable. E/L—Pairs or wires in use for exchange connexions.
FIG. 4—ROUTE PLAN

In order to present the surveyed information encoded and in a suitable manner for processing by the LEAPS tape-punching staff, four forms were designed and approximately 900 plant-item codes allocated. The forms are headed and used as follows:

(*a*) Exchange-line costing—facing sheet (one per sample connexion).

(*b*) Exchange-line costing—general information (one per sample connexion).

(*c*) Exchange-line costing—overhead section (one for each overhead section of the sample connexion).

(*d*) Exchange-line costing—underground section (one for each underground section of the sample connexion).

Forms (*b*), (*c*) and (*d*) are completed from the information recorded on the prepared route plan. Plant

CALCULATION OF PLANT COSTS

The costing of the study data entails costing an immense variety of plant items and sizes, many of them obsolete. The standard record of average costs covers a relatively small number of standard plant items, and means had to be devised for the costing of any items of plant encountered in the study.

The primary sources of cost information used are as follows:

(*a*) Standard record of average prices for plant, other than contract prices for ductwork.

(*b*) Regional average let prices for contract work (ductwork and buried cable).

(*c*) Rate Book (stores costs).

(*d*) National manhour rate (labour costs).

(*e*) National performance rating (labour costs).

(*f*) Unit construction costs (labour costs).

From this information it has been possible to apply costs to plant items and duct formations, under 29 classified footway and carriage-way surfaces, for the coded items. Obsolete types of jointing chambers are costed as their equivalent, or as a proportion of, current types.

The costing of non-standard items of plant presented a particular problem. It was intended to extract all non-standard items of plant and cost them manually, but this became particularly laborious, especially for wire and non-standard jointing chambers. It was therefore decided to allocate average costs for wire and non-standard jointing chambers, based on ranges of conductor weight and internal volume, respectively, and codes were given to these ranges. This enables the items to be costed and apportioned by the computer and the amount of work is reduced considerably.

Costs of the coded items are fed into the computer and recorded on magnetic film.

PLANT ANALYSIS

The basis of the exchange-line costing study is a plant analysis carried out separately for each connexion in the sample. This analysis has to provide:

(*a*) a measure of the cost of the sample connexion in plant groups, exclusive of the cost of spare plant, i.e. its basic cost,

(*b*) a measure of the cost of the sample connexion in plant groups, including allowance for a due share of spare plant, i.e. its allocated cost,

(*c*) a measure of the element of the cost in plant groups assignable to spare plant, i.e. the allocated cost minus the basic cost, and

(*d*) a measure of the quantity of local plant of any specified type assignable to the sample connexion, including allowance for a due share of spare plant and local plant in use for other than exchange connexions, i.e. its allocated plant.

In any section the sample connexion probably utilizes only a fraction of the total plant provided in that section, and in making quantitative assessments for purposes of apportionment this fraction must be assigned a numerical value.

There are three types of apportionment fractions and, for the purpose of the study, they are called:

(*a*) Basic apportionment coefficient (cost)—B(C)

(*b*) Allocated apportionment coefficient (cost)—A(C)

(*c*) Allocated apportionment coefficient (plant)—A(P)

Basically these coefficients are derived from the total number of pairs of wires or conductors, the number of working pairs of wires or conductors, and the number of exchange connexions for each section of the route, respectively. They are used to calculate the basic cost, allocated cost, and the allocated plant for each section, as follows:

Basic cost. For plant measured in terms of length, the cost chargeable to the sample connexion is given by:

B(C) × length of section × cost per unit length.

For complete items of plant, e.g. a pole, the cost chargeable to the sample connexion is given by:

B(C) × the cost of the item.

Allocated cost. The allocated cost is calculated similarly to the basic cost except that the allocated apportionment coefficient A(C) is used instead of the basic apportionment coefficient B(C).

Allocated plant. The allocated plant is the quantity of plant allocated to the sample connexion, and for plant measured in terms of length is given by:

A(P) × length of section.

For complete items of plant this value is given by:

A(P)

An example of the way in which the apportionment coefficients are used to assess costs and plant quantities is given in the Appendix.

Average values for the above costs and plant quantities are then calculated for different radial-milage steps and overall averages are obtained by applying weighting factors based on the Phase I study. The factors are derived from the ratio of sample connexions in the radial step to the total number of sample connexions.

PROGRESS OF THE STUDY

The study is now in its fourth year and approximately 5,500 sample exchange connexions have been chosen for detailed survey, 500 lines have been rejected due to change of address or cessation, and 3,700 lines have been surveyed. The results of the surveys are in the process of being recorded on magnetic film. It is expected that the first cost results will be available in 1963, but processing of the plant information will take much longer.

The study is planned to continue at the present rate until sufficient information is available to give results within reasonable confidence limits. It is then expected that the study will continue at a reduced rate as a permanent feature for administrative use in the Post Office.

CONCLUSIONS

The study should provide valuable information on both costs and plant quantities. The information derived should assist all levels of administration to formulate financial and engineering policy. It will be particularly useful for (*a*) assessing the profitability of each type of exchange connexion, and ensuring that an adequate financial return is achieved on the capital expended, (*b*) deriving average costs of local-line plant for estimating purposes, (*c*) indicating the effect of changes in engineering methods and procedure in the local-line network, and (*d*) deriving in-situ plant values for use in assessing the average lives of plant groups.

ACKNOWLEDGEMENTS

A study of the magnitude required could not be carried out without the closest co-operation of staff at Headquarters and in the Regions and Areas, and the authors wish to acknowledge the assistance given by all those participating. They also particularly wish to acknowledge the assistance given in the preparation of this article by members of the Accountant General's Department.

APPENDIX

Example of Use of Apportionment Fractions to Determine Costs and Plant Quantities.

Part of the route of the sample connexion is provided by means of a 200-pair $6\frac{1}{2}$ lb/mile cable drawn in a 4-way multiple duct for 176 yards. The 200-pair cable, in which there are 150 working circuits, including 100 exchange connexions, costs £2,000 per mile. Apportionment of costs and plant quantities are assessed as follows:

$$B(C) = \frac{1}{200}$$

$$A(C) = \frac{1}{150}$$

$$A(P) = \frac{1}{100}$$

Basic cost $= £\frac{1}{200} \times \frac{1}{10} \times \frac{2{,}000}{1}$

$= £1$

Allocated cost $= £\frac{1}{150} \times \frac{1}{10} \times \frac{2{,}000}{1}$

$= £1{\cdot}33$

Cost of spare plant $= £1{\cdot}33 - £1$

$= £0{\cdot}33$

Allocated plant $= \frac{1}{100} \times \frac{1}{10}$ miles

$= 0{\cdot}001$ miles of a 200-pair $6\frac{1}{2}$ lb/mile cable.

The duct costs are apportioned in a similar manner, but all cables using the duct formation are taken into account.

A Small Hand-Operated Hydraulic Thrust-Borer

F. L. BEST†

U.D.C. 621.951:621.315.233

A small hand-operated thrust-borer has been developed to facilitate the placing of plastic-sheathed distribution cables under surfaces that it is desirable to disturb as little as possible.

INTRODUCTION

THE post-war large-scale increase of direct underground distribution using plastic-sheathed cables has shown the need for a small thrust-borer to place such cables economically under paved surfaces and ornamental gardens. The small hand-operated borer described here is complementary to the large power-driven machine already in service, and, because of its small size, it requires a pit very little larger than the trench required for the cable.

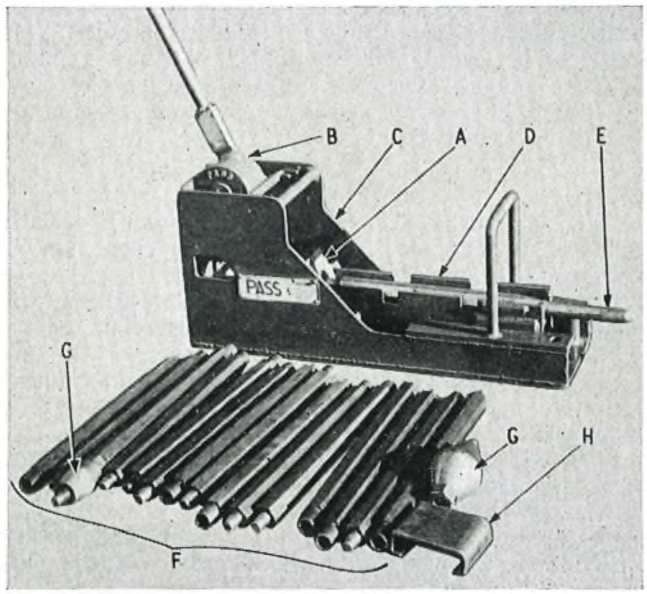
DESCRIPTION

The thrust-borer consists of a self-contained hydraulic hand-pump and oil reservoir connected to an 8-ton proprietary ram fitted with a sliding carriage, all contained within a cast-aluminium box-like chassis. Hexagonal steel rods, 18 in. long, can be screwed together to form a continuous rod that can be thrust through the ground for distances up to 30 ft, although 20 ft is the normal maximum operating distance, the remaining rods provided being retained as spares. The machine, tools, rods and spare oil container are carried in two stout cases of approximately equal weight, each of which can be handled by two men. Normal boring operations can be carried out by one man, but an assistant to connect and tighten additional rods speeds up the work.

The photograph shows a prototype of the new thrust-borer, but the standard machine differs only in minor detail.

The twin-piston hand pump is contained within an aluminium casting which also forms an oil reservoir. This reservoir holds approximately 50 per cent more oil than is required to give full stroke to the ram. The pump is fitted in a raised position at the rear of the frame to reduce the overall length by allowing the carriage and rods to pass underneath.

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



A—Thrust collar. B—Hand pump and oil reservoir. C—Body. D—Sliding carriage. E—Pilot rod. F—Boring rods. G—Enlarging heads. H—Retaining clamp.

HAND-OPERATED HYDRAULIC THRUST-BORER

An internal rocking arm, which operates the two pistons, is connected to an external stirrup to which the handle is attached. The pump delivers oil on each stroke of the handle, which is detachable to allow the carrying case to be kept to a reasonable size. All oil ways within the pump are formed by drilling and only one connexion, a high-pressure rubber hose, is required to take the oil to the ram.

A lever-operated pressure-release valve is provided on the front of the pump body to allow the oil under pressure to be returned to the reservoir when required. A safety valve was incorporated in the prototype machines but was not considered necessary with production machines as it introduced a possible source of leakage and failure.

Oil under pressure is fed to a single 6 in.-stroke ram connected to and mounted on the bottom of the chassis under the sliding carriage. When the pressure is released this ram and carriage are restored to their normal position by one internal and two external springs. The sliding carriage, made of channel-section steel, has the sides notched at three places about 6 in. apart to accommodate a thrust-collar that applies the thrust to the rods. When the ram has pushed the rods forward 6 in. and has been restored to its normal position, the thrust-collar is placed in the next pair of notches and the cycle is repeated with the enlarging head and additional rods until the bore is completed.

A retaining clamp can be engaged with longitudinal projections on the side of the carriage at the front to hold the first two or three rods firmly in place thus ensuring their correct entry into the ground. However, in easy soil conditions it is often possible to push the pilot rod to its full depth by hand before adding the next rod and proceeding in the normal manner.

The rods, 18 in. long, are formed from standard $\frac{5}{8}$ in. Whitworth hexagonal black mild steel with $\frac{3}{4}$ in. Whitworth male and female threads. At the female end approximately 1 in. of the hexagonal is reduced in cross section to form a shoulder that is engaged by the thrust-collar mentioned previously. These rods are held within the transport case in two carrying cradles intended to hold the rods together and clear of dirt both before and after use. A pilot rod approximately 24 in. long is provided.

The chassis is an aluminium-alloy casting of roughly box form, high at the back where the pump is fitted and low at the front. Holes are provided at the front to take stakes designed to prevent lateral movement of the thrust-borer during use, and near these a handle is fitted to facilitate handling and also to hold a guide rod. This guide rod is used in conjunction with the pump handle and a second rod, which serves as the target, to aim the machine and all three need to be lined up for accurate results. The handle and the rods are painted in alternate black and white rings. A spirit level is required to enable the carriage to be set level.

The enlarging head, stakes, and adaptors for drawing-in cables are held on removable shelves within one of the carrying boxes. The adaptors can also be used for withdrawing the rods; the machine is reversed in the pit for this purpose.

OPERATION

The machine is placed in a pit approximately 3 in. deeper than the required bore, with its back firmly against solid ground and the stakes fitted to prevent sideways movement. The stakes are not used to take the full thrust of the machine.

The machine is levelled by packing until the sliding carriage is level. It is important to ensure that the pilot rod and the first ordinary rod are running true and they are corrected if necessary. Thrusting in 6 in. steps then proceeds until the bore is completed. As each additional rod is attached it is essential that the screwed connexions should be tight; one of the main requirements for accurate thrust-boring is that the screwed joints should be sufficiently tightened to be prestressed so that the rods act as a continuous bar.

It is possible to continue the bore beyond the normal 20 ft by moving the machine to the front end of the rods and thrusting forward a further 20 ft. This has been done under paved surfaces for distances up to 100 ft before the rods have gone off course. This method can show a great saving under expensive surfaces, and it can be used to maintain goodwill by causing the minimum disturbance to a surface or garden.

By careful checking of vertical angles it is possible to bore up or down hill; this has particular advantages when passing through raised or sunken gardens. The slope of the required bore is determined and a wedge-shaped cardboard or sheet-metal template made, which, in conjunction with the use of a spirit level, enables the carriage to be set at the correct angle.

ACKNOWLEDGEMENT

The thrust-borer was developed in co-operation with E. Pass and Co.

Book Review

"Handbook of Automation, Computation, and Control: Vol. 3—System and Components." Edited by Eugene M. Grabbe. John Wiley and Sons, Inc., N.Y. 149s.

The first volume of this three-volume handbook has been reviewed in this Journal (Vol. 53, p. 123, July, 1960) The extensive contents will be dealt with by giving a complete list of chapter headings; the pairs of numbers in parenthesis give the number of pages and number of references, respectively.

1. Systems design (27, 14); 2. The human component (16, 28); 3. Automatic machines (29, 5); 4. Automatic inspection and control (13, 9); 5. Materials handling (27, 3); 6. Numerical control of machines (31, 12); 7. Instrumentation systems (81, 19); 8. Designs procedures (20, 6); 9. Process test methods (15, 11); 10. Single and multiple loop controls (42, 27); 11. Non-linearities (29, 24); 12. Sampled-data control (9, 10); 13. Computer control (31, 51); 14. Data processing 23, 28); Industrial control systems: 15 Transmission systems (91, 59); 16. Nuclear reactor control (30, 27); 17. Control of interconnected power systems (126, 40); Components Selection: 18. Basic principles (7.0); 19. Reliability (16, 3); 20. Measuring elements and sensors (28, 43); 21. Amplifiers (49, 12); 22. Actuators (55, 15); 23, Computing elements (15, 8); 24. Continuous end-point analyzers (48, 4); Design of Components: 25. Magnetic amplifiers (39, 12); 26. Semiconductor devices (67, 96); 27. Transistor circuits (112, 171); 28. Gyroscopes (40, 6).

A team of 36 different authors have contributed, mostly from U.S.A., but France, Holland, and the United Kingdom are also represented.

Some of the subjects, perhaps because they are still being developed, are treated rather scantily, for example sampled-data control (nine pages) and component reliability (16 pages). Fig. 3 of the latter chapter (reliability nomograph) must be used with caution: the instructions for finding R mistakenly refer to the R_i scale, and the R_1, R scales are wrongly calibrated at the lower end.

On the whole, however, this book will serve excellently both as a reference for the experienced and an introduction for the novice.

W.E.T.

Ventilation Plant for the Post Office Engineering Department's Main Conference Room

R. S. HUNTER†

U.D.C. 697.92

The mechanical ventilation of the Post Office Engineering Department's main conference room posed problems of noise control and air filtration. The measures taken to obtain quiet operation and air filtration of a standard to remove tobacco smoke are described.

INTRODUCTION

THE Post Office Engineering Department's main conference room is badly situated so far as natural lighting and ventilation are concerned as there is only one window, in the south-east corner. Soon after the building had been taken over by the Engineering Department and meetings were held in the room, complaints arose of poor ventilation, particularly with big meetings of 40–50 people of whom a high proportion were smokers. To improve matters four window-mounted multi-speed fans were fitted. Of these, two were arranged to draw air into the conference room from the main north–south corridor while the other pair extracted, one exhausting to atmosphere via the window and the other into the east–west corridor.

The window-fan installation gave some slight improvement of conditions but was not satisfactory for two main reasons. These were: (*a*) the noise level was too high at other than the lowest fan speed, and (*b*) the air drawn in from the corridor was already partially vitiated.

Up to this time design had been restricted by the desire to avoid alterations involving builder's work. When it became clear that a radical improvement was essential the plant described below was designed, and the opportunity was taken to improve the lighting, heating and decoration of the room and to install an acoustic false ceiling at the same time. Fig. 1 shows the general arrangement and Fig. 2 the completed installation.

†Power Branch, E.-in-C.'s Office.

DESIGN REQUIREMENTS

The requirements for a conference-room ventilation plant differ in a number of important respects from

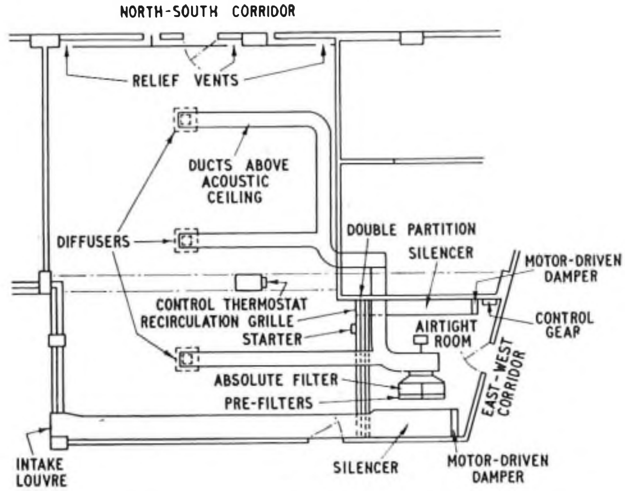


FIG. 1—LAYOUT OF VENTILATING PLANT

normal Post Office practice for, say, apparatus-room ventilation. A high air-change rate (10 air changes/hour) is essential to prevent the accumulation of tobacco smoke, and only an extremely low noise level can be tolerated. With 10 air changes/hour, recirculation of room air, involving special filtration to remove tobacco smoke, is desirable to limit heat loss, and in view of the low finished-ceiling height (8 ft 3 in.) special low-level inlet diffusers were specified to handle large quantities

FIG. 2—COMPLETED INSTALLATION

of air without creating draughts. Arrangements were made to allow the room occupants to start and stop the plant from inside the room and to adjust the dampers.

Sound Control

Builder's Work. For sound-control purposes it is obviously advantageous to locate ventilation plant as far as possible from the accommodation served. In this instance, however, this could not be done and the only space that could be found for the ventilation plant was in a room created by partitioning off an odd corner of the conference room (see Fig. 1). This arrangement made it necessary for the partition to have particularly good sound-insulating properties. In general, the heavier the construction of a wall or partition, the better its sound insulating properties will be. In this instance a 9 in. brick wall would have been ideal but was ruled out by restrictions of floor loading. The most acceptable alternative available was an arrangement of two "Paramount" partitions, each mounted independently and consisting of two layers of plasterboard held together by a honeycomb of pressed card. Another precaution taken was to line the walls and ceiling of the plant room itself with acoustic tiles to reduce the reverberant sound level.

Fan. A slow-running centrifugal fan with forward-curved blades, sleeve bearings, direct drive and a silent motor was selected.

Ductwork, Diffusers and Silencers. With ventilation systems whose plant is remotely situated it is usually sufficient to depend for sound control on the configuration of the ductwork, the fan noise being considerably attenuated by the number of bends that are required on the ductwork run. This installation, however, had very few bends; in fact, on the branch feeding the diffuser nearest to the window only one bend was necessary and the attenuation given by it was inadequate. To improve the attenuation, therefore, it was necessary to line the whole of the ductwork. The material chosen was 1 in. resin-bonded fibreglass, coated with neoprene to avoid air erosion. This precaution could be effectively negatived by regenerated noise arising from high air velocity, particularly at grilles or diffusers. Such regeneration is aggravated if the grilles or diffusers are fitted with volume-control dampers that need a large amount of throttling for balancing purposes. To deal with this difficulty a design duct air velocity of 750 ft/min was adopted for this installation compared with the usual velocity of 1,500 ft/min, the system being designed to need little or no balancing. The sizes of the diffusers, the recirculation grille and the pressure relief vents into the north–south corridor were also chosen to give low air velocities. A feature of the relief vents is that they are acoustically lined to prevent overhearing.

Other critical features affecting sound control are the holes in the double-skinned partition where the recirculation opening and fresh-air inlet duct enter the ventilation-plant room. The major part of the fan noise is at a fundamental frequency of 568 c/s, this being given by the product of the speed and the number of blades on the impeller. To achieve a high degree of attenuation at this frequency, silencers giving a 53 db reduction were fitted to both openings.

Ventilation Design

Air Quantities. As complaints of bad ventilation were, in general, related to smoking, it was decided to apply the standards specified by several authorities for cinemas, etc., namely 30 ft^3 of air per minute per person. Therefore, on the assumption that a large meeting would consist of about 40 people, air would need to be supplied at the rate of 1,250 ft^3/min. With this rate of air change it was necessary to recirculate the air to avoid the large heat loss which would result from the use of a simple supply and exhaust system.

Air Distribution. Air is supplied to the room by means of three large diffusers of a low-level pattern designed to discharge mainly in the horizontal plane to avoid downdraughts. Each diffuser is provided with a volume-control damper for which quiet operation is claimed. The upswept outer edges of the diffusers lower them slightly from the ceiling, thus providing anti-smudge rings which prevent marking of the surrounding ceiling.

Filters. With the decision to employ a large measure of recirculation to conserve heat, it was necessary to consider the removal of tobacco smoke from the air to be recirculated. Tobacco smoke is largely composed of extremely small particles in the range 0·1–0·3 micron, and for the removal of particles of this size only two types of filter are at all effective. These are the electrostatic precipitator and the "absolute" type of filter, which has an element of pleated paper composed of esparto grass and asbestos fibres.

Considerations of first cost, space requirements and simplicity led to the choice of the absolute filter, which has a claimed efficiency of 90 per cent minimum with methylene blue particles, all of which are in the range 0·01–1·3 micron. To prevent the absolute filter from becoming choked by large-particle atmospheric dirt it is preceded by a filter composed of cotton fabric and gauze arranged in pleats and inserted in a fibreboard frame.

Control. As the conference room is not used continuously, START-STOP buttons for remote control of the fan are provided in the conference room to give economy of running. Motor-driven dampers are fitted to the ends of the recirculation and fresh-air intake silencers to control the proportion of fresh and recirculated air. The damper motors are arranged to operate in opposition, i.e. as the fresh-air damper closes the recirculation damper opens and vice versa. The fresh-air damper linkage is arranged so that at least 10 per cent of the air supplied to the room is fresh, even under maximum recirculation conditions.

The dampers are under the control of a room thermostat with a 2½°F range. Outside this range the dampers drive to give 100 per cent fresh air if the temperature is high and maximum recirculation (90 per cent) if the room temperature is low. Within the 2½°F range the dampers assume intermediate positions and adjust the proportion of fresh air within the above limits.

CONCLUSION

The plant has been in use since April this year, and the measures taken for noise control have been found satisfactory, although the use of the diffuser dampers for balancing was found to cause unacceptable noise. This was eliminated by inserting a preset damper in the ductwork at a position where any noise generated is attenuated by the fibreglass lining. First tests of air quantities showed that these exceeded design requirements and a hand-controlled damper was fitted in the main supply duct.

Outline of Transistor Characteristics and Applications

Part 2—Application of Linear Characteristics

J. A. T. FRENCH, B.Sc.(Eng.), A.M.I.E.E., D. J. HARDING, B.Sc.(Eng.), A.M.I.E.E., and J. R. JARVIS, B.Sc.(Eng.), A.M.I.E.E.†

U.D.C. 621.382.3.012.7

Part 1 in this series of three articles defined the types of transistors used and their essential parameters, explained the importance of the correct d.c. operating conditions, and described methods of stabilizing the operating point. Part 2 describes, in more detail, the design of the various types of linear amplifier circuit in relation to the transistor characteristics, and deals briefly with oscillators and voltage-regulator circuits. A practical rather than a mathematical approach has been adopted; mathematical treatments are already available in a number of text books.

INTRODUCTION

A DETAILED mathematical analysis of the operation of transistors is essential for those engaged in the design and production of transistors to enable them to improve and control the quality of their products. Mathematical treatments are available in a number of text books.[1,2] Transistor manufacturers publish data, in the form of tables and graphs, which give the values of typical parameters under practical conditions. Limit values are also given in many cases. The data indicate that there are very large spreads in many parameters, particularly those for common-emitter circuits, e.g. current gain, β, base resistance, r_b, cut-off frequencies, f_α and f_β, and leakage current. These wide variations occur not only between different transistors of the same type but also with the same transistor operated at different currents or different temperatures. Thus, to understand a circuit, or even to design one, it is generally inappropriate to make an accurate analysis. Instead, it is usually adequate to make a simplified analysis, using approximations where these are justified and the appropriate limits of the transistor parameters.

A practical approach is necessary to determine the effects of changes of each parameter, and to determine which of the parameters must be known fairly accurately and which may be ignored.

There are certain similarities between the common-cathode valve amplifier and the common-emitter transistor amplifier as well as other equivalent valve and transistor circuits, so that experience in dealing with valve circuits can be used with advantage. However, there are also certain fundamental differences which it is important to note. The most important difference concerns the relatively low input impedance of the transistor amplifier, which makes it most convenient to regard its output current as a function of the input current and not, basically, of the input voltage as in a valve. It is a fundamental physical property of the transistor that the input current controls the output current. The relationship between these currents is substantially linear and is specified as the "current gain." In Fig. 6, Part 1,* it was shown that the relationship between the input voltage and the input current (i.e. the input impedance) is not a linear one unless the signal is very small compared with the bias current. Fig. 12 shows a typical input-voltage/output-current characteristic and the distorted shape of the output-current waveform that

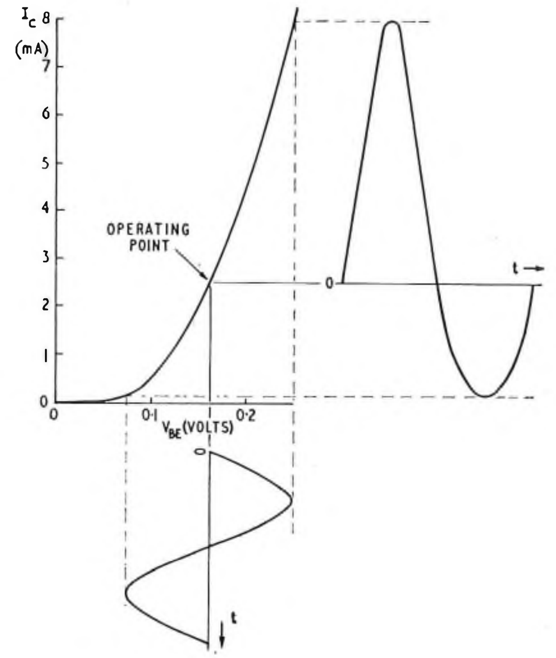


FIG. 12—DISTORTION OF LARGE-SIGNAL SINE WAVE CAUSED BY CURVATURE OF INPUT-VOLTAGE/OUTPUT-CURRENT CHARACTERISTIC OF GERMANIUM TRANSISTOR

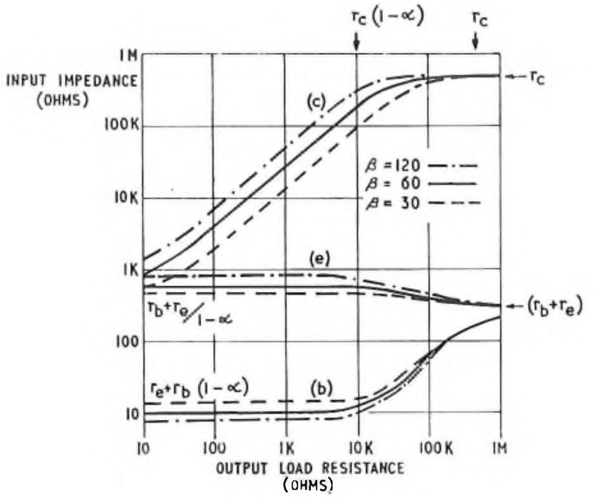
is produced by a large-signal sine-wave input voltage. The input current can be made less dependent on the variable input impedance by adding in series with it a relatively high resistance, which then becomes part of the transistor amplifier thereby increasing the input impedance of the amplifier and improving its linearity.

The relationship between the output load resistance and the input impedance for each of the three possible circuit configurations of a typical transistor, operated at an emitter current of about 5 mA, is shown in Fig. 13. The effects of the input source resistance on the transistor output impedance are shown in Fig. 14. The families of curves given in these two figures apply at low frequencies, i.e. at frequencies below f_α for the common-base stage, and at frequencies below f_β for the other two. The full lines show parameters for $\beta = 60$, and the dotted lines show the effect of $\beta = 30$ and $\beta = 120$. These curves may be derived from the manufacturer's data using the formulae given in Appendix 1.

COMMON-BASE AMPLIFIER

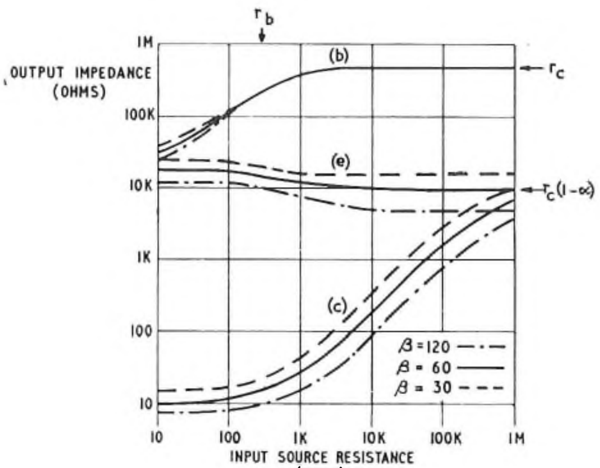
The circuit diagram of a common-base amplifier, using both an input and an output transformer, is given in Fig. 15. A resistor maintains the d.c. bias current in the emitter at 5 mA, and the transformers enable the source

† Post Office Research Station.
* Vol. 56, p. 126, July 1963.



(*b*)—Common-base connexion
(*e*)—Common-emitter connexion
(*c*)—Common-collector connexion

FIG. 13—EFFECT OF LOAD RESISTANCE ON INPUT IMPEDANCE



(*b*)—Common-base connexion
(*e*)—Common-emitter connexion
(*c*)—Common-collector connexion

FIG. 14—EFFECT OF INPUT SOURCE RESISTANCE ON OUTPUT IMPEDANCE

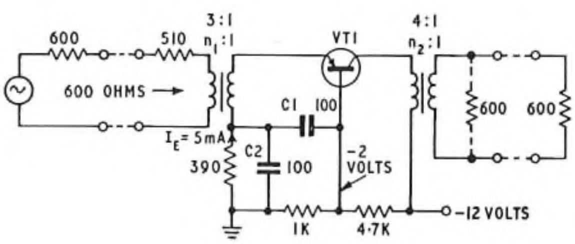


FIG. 15—TRANSFORMER-COUPLED COMMON-BASE AMPLIFIER

and load impedances to be varied without affecting the d.c. condition of operation. Fig. 13 shows that the input impedance of the transistor is very low and is about 10 ohms for collector load resistances below 10,000 ohms; as the collector load is increased above this value, the input impedance gradually rises to a maximum of about 300 ohms. This occurs because the increased signal voltage at the collector, arising from the higher load impedance, is sufficient to produce appreciable internal feedback, within the transistor, from the collector to the emitter circuit. This internal feedback also causes the output impedance at the collector to be affected by the input source resistance, as shown in Fig. 14. This output impedance increases from about 20,000 ohms to 1 megohm as the source resistance at the emitter is increased from 10 to 1,000 ohms. For example, a 4 : 1 ratio output transformer may be used, as shown in Fig. 15, which, with a 600-ohm load and neglecting the resistance of the transformer, will give a 9,600-ohm (i.e. $4^2 \times 600$) collector load impedance. The amplifier output impedance at the collector would be very much higher than this. An output impedance of 600 ohms can be obtained by connecting a 600-ohm resistor across the output transformer, as shown dotted in Fig. 15, and this will result in a collector load of $4^2 \times 300 = 4{,}800$ ohms. The collector load impedance is thus low enough to keep the input impedance down to a value of about 10 ohms. An amplifier input impedance of 600 ohms may then be obtained by connecting a resistor of 510 ohms (less the transformer resistance) in series with a 3 : 1 ratio input transformer, which has an equivalent impedance of $3^2 \times 10 = 90$ ohms. Thus, an effective current gain of 3 is obtained in the input transformer, and a current gain of 4 in the output transformer. The current gain in the transistor of $\alpha = 0{\cdot}98$ represents a slight loss, so that, ignoring transformer losses, there is an overall current gain of $3 \times 4 \times 0{\cdot}98 \simeq 11{\cdot}75$.

Considering the voltages, a loss, which can be expressed as a gain of $0{\cdot}15$ ($= 90/600$) occurs because of the voltage drop across the 510-ohm input resistor, and, similarly, the losses in the two transformers can be expressed as gains of $\frac{1}{3}$ and $\frac{1}{4}$. The voltage gain in the transistor is $(0{\cdot}98 \times 9{,}600)/10 \simeq 940$, and thus the net voltage gain is equal to $0{\cdot}15 \times \frac{1}{3} \times \frac{1}{4} \times 940 \simeq 11{\cdot}75$. The power gain is the product of the voltage and current gains, and these are equal when the input and load impedances have the same value; in the circuit described they are both 600 ohms. The power gain of the amplifier with a high output impedance is, therefore, $11{\cdot}75 \times 11{\cdot}75 \simeq 138$, which is equivalent to a gain of 21·4 db. With the 600-ohm shunt resistor connected to give an output impedance of 600 ohms the current is halved, resulting in an additional loss of 6 db, i.e. giving an overall power gain of 15·4 db. The load line drawn in Fig. 16 shows that the peak signal current in the transistor, at the point where voltage clipping just occurs, is 2 mA for a collector load of 5,000 ohms and a collector voltage of 10 volts.

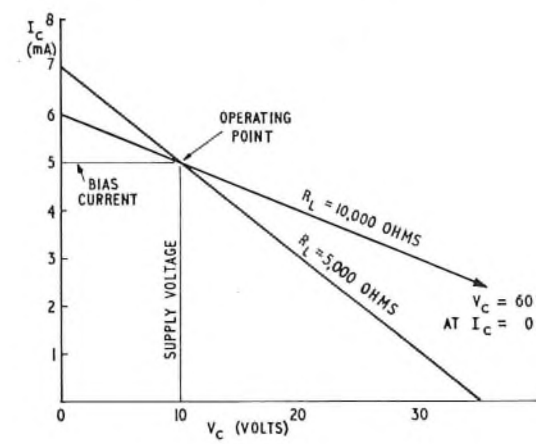


FIG. 16—LOAD LINES FOR TRANSFORMER-COUPLED COMMON-BASE AMPLIFIER

At these values, the output level into 600 ohms will be 4 mW. It would be possible to operate the transistor at an emitter current of less than 5 mA d.c., but this would result in poorer linearity because of the greater ratio of the a.c. signal to d.c. in the emitter circuit, and also because of the resulting increase in the input impedance, which varies inversely to variations in the current.

A considerably larger gain can be obtained by using two transformer-coupled common-base stages in tandem. Then, advantage can be taken of the high output impedance of the first stage in driving the low input impedance of the second stage. This is illustrated in Fig. 17, where the two stages are each similar to the stage shown in Fig. 15 and are operated at the same d.c. emitter bias of 5 mA. The two stages are shown coupled by a 31 : 1 step-down transformer, which raises the 10-ohm input

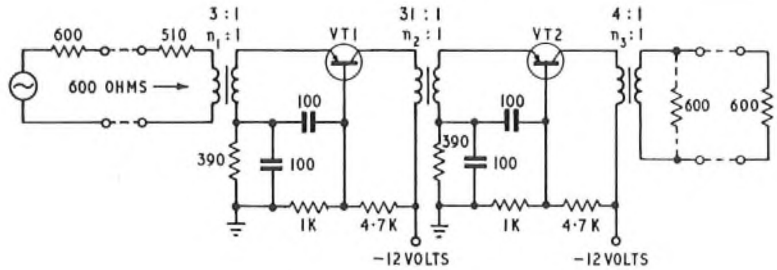


FIG. 17—TRANSFORMER-COUPLED TWO-STAGE COMMON-BASE AMPLIFIER

impedance of the second stage to $10 \times 31^2 \simeq 9{,}600$ ohms, and provides a current gain of 31. The second transistor provides a current gain of 0·98 and a total voltage gain of $0{\cdot}98 \times 960 \simeq 940$ to compensate for the 31 : 1 voltage step down and to match the current gain of $31 \times 0{\cdot}98$ in the transformer and transistor. Thus, by adding the second stage, there is an additional power gain of 30 db giving an overall gain of 51 db (45 db for the 600-ohm output).

No additional gain could be obtained by using two common-base connected transistors in tandem without a coupling transformer. The only possible advantages might be to reduce the input impedance to the first stage, and to increase the output impedance of the second.

The common-base connected amplifier has the advantages of good gain stability and good frequency response. The former is dependent on α and on the input impedance of the transistor being negligible compared with the total input source resistance; good frequency response may be achieved for frequencies almost as high as f_α. It has the possible disadvantage of requiring a transformer for each interstage coupling, and this feature, more than the characteristics of the transistors used, limits the frequency response. There is, however, no difficulty in covering the audio-frequency range (30 c/s–15 kc/s). The capacitance of the decoupling capacitors in the emitter circuit must be large enough to produce, at the lowest frequency, an adequately low impedance compared with the total impedance of the emitter circuit, including the transformer and input source resistances.

One example of an amplifier using the common-base connexion is the negative-impedance 2-wire repeater.[3]

COMMON-EMITTER AMPLIFIER

Fig. 18 shows a common-emitter amplifier designed with both an input and an output transformer. Referring again to Fig. 13, the effect of different collector load resistances on the input impedance of a common-emitter stage is much less than for a common-base stage. The input impedance to the base is about 600 ohms for values

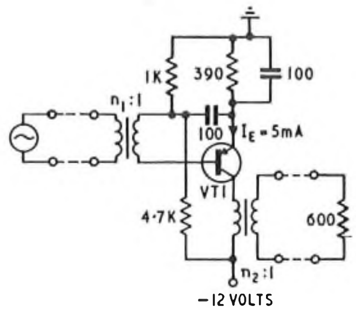


FIG. 18—TRANSFORMER-COUPLED COMMON-EMITTER AMPLIFIER

of collector load below about 10,000 ohms, and above this value the input impedance gradually drops to a minimum value of about 300 ohms. This effect, as for the common-base configuration, is due to internal feed-back from the collector to the base, which occurs when the higher collector load impedance is used. As shown in Fig. 14, the output impedance at the collector drops from about 20,000 ohms for source resistances of a few hundred ohms at the base to about 10,000 ohms as the source resistance rises. These effects are very small compared with those which occur with the common-base-connected stage. The output impedance at the collector is considerably lower than that of the common-base amplifier, it being only about 10,000 ohms if a high-resistance source is used. This means that if a 4 : 1 step-down transformer is used to feed a 600-ohm load, the output impedance of the collector will be approximately matched to the load, and, moreover, the output impedance of the amplifier will be very dependent on the transistor characteristic. The gain of the common-emitter stage is dependent on β which might vary from 30 to 120 for different transistors of the same type.

The input signal voltage that would need to be applied across the base and the emitter to produce a particular collector current is the same value for both the common-base and common-emitter connexions. The voltage gain of the two circuits is, therefore, the same. It follows that because the common-emitter amplifier can also produce a current gain of β, it is possible for it to produce a power gain β times as much as the common-base amplifier. The common-emitter amplifier has the great advantage that it can use resistor-capacitor coupling between stages instead of transformer coupling, the base of one stage being fed from the collector of the previous stage, as shown in Fig. 19. Also, the high output impedance of

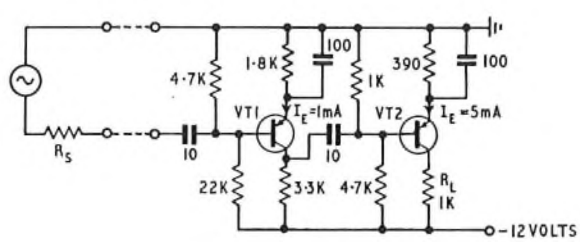


FIG. 19—RESISTANCE-CAPACITANCE-COUPLED TWO-STAGE COMMON-EMITTER AMPLIFIER

the collector provides almost a true current source for the base. If n stages, each with a current gain of β, are connected in cascade in this way, the overall gain is given by $\beta^n R_L/R_S$, where R_S is the input source resistance, and R_L is the final load resistance. This ignores the effect of any biasing resistors that may be connected to each base.

Amplifiers such as these can be used in radio sets, deaf aids, record players, microphone and other small-signal amplifiers, where the precise gain is not of great importance.

For most Post Office applications, the gain needs to be controlled using negative feedback. One way of doing this is to connect a resistor between the collector and the base, as shown in Fig. 20, to provide both a.c. and d.c.

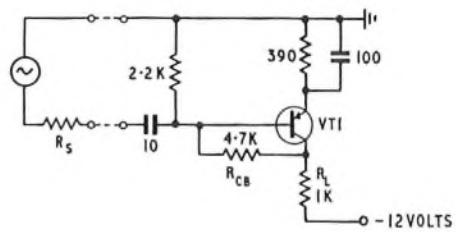


FIG. 20—COMMON-EMITTER AMPLIFIER WITH COLLECTOR–BASE NEGATIVE FEEDBACK BY RESISTOR R_{CB}

negative feedback and so help to stabilize both the gain and the d.c. bias condition. With this arrangement, current proportional to the signal voltage at the collector is fed back to the base in the opposite sense to the input signal. Thus, an increased input signal current is required at the base to produce the same output. Also, the input impedance is reduced to a value that is between the values of the input impedance of the simple common-emitter and common-base stages, and that varies inversely to the collector load impedance. The output impedance is also reduced and varies inversely to both the input source impedance and to β. The dependency of the terminal impedances upon β and upon each other may be serious disadvantages. Thus, by using negative feedback, it is possible to make an amplifier of good gain stability and having comparatively low input and output impedances.

An alternative method of improving the gain stability of the common-emitter stage is to omit the bypass capacitor across the emitter-bias stabilizing resistor (see Fig. 21). Emitter current flowing in this resistor then

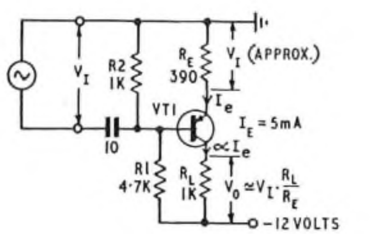


FIG. 21—COMMON-EMITTER AMPLIFIER WITH NEGATIVE FEEDBACK BY UNBYPASSED EMITTER RESISTOR R_E

causes the emitter potential to vary in accordance with the input voltage applied to the base. A larger input signal voltage is, therefore, required to produce the same emitter current and so the input impedance is increased. If a sufficiently large emitter resistance is used, the character of the amplifier is changed from one requiring a current input and having a relatively low input impedance to one having a much higher input impedance and requiring a voltage input. The input impedance is increased as shown by the common-collector curve in Fig. 13. The collector current is then equal to α times the input signal voltage, V_I, applied to the base, divided by the resistance, R_E, in the emitter circuit. The voltage gain is equal to the ratio of the collector load resistance, R_L, to the emitter resistance, R_E. Also, the emitter resistance now increases the output impedance of the amplifier in the same way that the output impedance of the common-base stage is increased, as shown in Fig. 14.

The amplifier input may be driven from a source impedance that is finite but low compared with the amplifier input impedance. If, by connecting a suitable resistor between the collector and the base, additional feedback is applied to halve the voltage gain of the amplifier, it can be shown that both the input and output impedances are reduced so that the amplifier is matched at both its input and its output to the source and to the load, respectively. The impedances are much less dependent on β and the other transistor parameters because of the action of emitter feedback, but there still exists the possible disadvantage of the reaction of the output load upon the input impedance.

The base-bias resistors must be considered as part of the source impedance from which the amplifier is driven. Therefore, when a common-emitter amplifier with emitter feedback is operated as a voltage amplifier driven from a low-impedance source, these bias resistors may be lower in value and so provide for better d.c. stabilization.

COMMON-COLLECTOR AMPLIFIER

The common-collector amplifier is commonly called an emitter follower because the output signal voltage from the emitter closely follows the input signal voltage at the base. The input impedance is high and approximately β times the load impedance over a very large range, as shown in Fig. 13. The output impedance is little more than the source impedance divided by β (see Fig. 14). With germanium transistors, the maximum obtainable input impedance is limited by the transistor leakage current, which determines the highest value of resistance that may be connected in the base circuit for bias purposes. A silicon planar transistor has a much smaller leakage current, so that the input impedance is limited by the collector–base resistance inherent in the device. The input impedance can be increased by using a two-stage emitter follower and decoupling the collector of the first stage to the emitter of the second stage. Fig. 22 shows two n–p–n transistors connected in this manner.

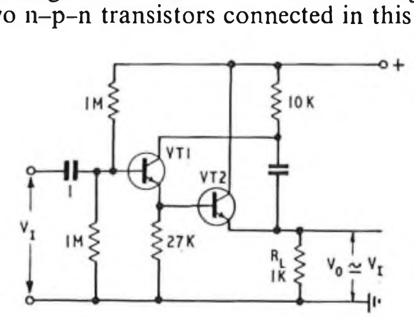


FIG. 22—HIGH-INPUT-IMPEDANCE TWO-STAGE EMITTER-FOLLOWER AMPLIFIER USING N–P–N PLANAR SILICON TRANSISTORS

EFFECTS OF NEGATIVE FEEDBACK

Negative feedback reduces the gain of an amplifier, but can reduce the effect on the gain of variations in the transistor and other circuit parameters. The linearity is improved and the overload point becomes more marked. Also, the frequency response can be improved. In addition, both the input impedance and the output impedance of the amplifier are affected depending upon the manner in which the negative feedback is applied.

If the signal fed back is derived from the current in the output load, the amplifier output impedance is increased. If it is derived from the voltage across the output load, the amplifier output impedance is reduced.

Similarly, if the signal fed back to the input is connected in series with the input source, the voltage required at the input is increased, and, hence, the input impedance is also increased. If, however, it is connected in parallel with the input source, the required input current is increased and the input impedance is reduced.

It is, therefore, possible to use negative feedback to improve the performance of an amplifier and also to modify the input and output impedances in any desired manner. It is also possible to use combinations of the different forms of feedback to achieve particular results.

In principle, a better performance is achieved with a multi-stage amplifier if negative feedback is applied over the whole amplifier rather than to each individual stage. However, if the amplifier consists of low-frequency alloy-type transistors in common-emitter connexion, the amount of overall negative feedback that can be used is limited by phase shifts in the transistors at the higher frequencies. These phase shifts cause the feedback to become positive and so set up oscillations. Phase shifts occur because of the inherent capacitance between collector and base, and may also occur if the operating frequency is too close to f_β. The introduction of the new silicon planar transistors, which have values of f_β higher than 5 Mc/s and collector–base capacitance values as low as 5 pF, has helped to reduce these effects.

EFFECTS OF COLLECTOR–BASE CAPACITANCE

The collector–base capacitance is usually referred to in manufacturers' data as C_{ob} or C_{cb}, and at low frequencies it can be considered as a capacitance between the collector and base terminals. One effect of this capacitance is to shunt the collector load, and so its reactance may have to be taken into account at the higher frequencies, or if the collector has a tuned-circuit load. C_{ob} varies approximately inversely to the square root of the collector–emitter voltage when the emitter–base diode is conducting. Thus, it is possible to calculate its value at any actual collector voltage from the manufacturer's figure, which is given at a specified voltage.

In the grounded-emitter stage, C_{ob} gives rise to unwanted feedback between the collector and base, which, considering the transistor as a current-operated device, requires an increased input current to obtain the same output that would have been obtained if the capacitance had not been present. Because of the current gain in the stage, the effect of the current in C_{ob} on the output current of a grounded-emitter stage is, for most applications, small compared with its effect on the input current. If it is assumed that an input current I_b, additional to the current required by C_{ob}, is applied to the base of the transistor, then the output voltage is I_b multiplied by the current amplification (see Appendix 1) and the collector load impedance, Z_L,

i.e. output voltage $= Z_L\{\alpha/(1 - \alpha + Z_L/r_c)\}\, I_b$.

The current fed back from the collector to the base is equal to this voltage divided by $1/j\omega C_{ob}$, the reactance of C_{ob}. The source must supply this additional current to maintain the same output. The input current is therefore increased by the factor

$$1 + j\omega C_{ob} Z_L\{\alpha/(1 - \alpha + Z_L/r_c)\},$$

the current gain being, therefore, also reduced by the same factor.

For a common-emitter stage with a collector–base capacitance of 10 pF, a collector load impedance of 10,000 ohms and with $\beta = 60$, the current gain begins to be affected at frequencies above about 10 kc/s. This effect can be reduced by using a lower value of collector load impedance or by using negative feedback to reduce the current gain, e.g. by connecting a resistor between the collector and the base. The internal base resistance of the transistor, $r_{bb'}$, limits the improvement which appears to be possible by reducing the input source impedance.

For a common-emitter amplifier having a feedback resistor in its emitter circuit and operated as a voltage amplifier with a high input impedance, it may be more convenient to consider the feedback effect as an increased capacitance across the input. This capacitance is given by $C_{ob}\ (1 + A)$, where A is the voltage amplification of the stage. The effect is the same as the Miller effect, which occurs in triode thermionic valves.

PUSH-PULL AMPLIFIERS

The amplifier stages described so far have been what is known as single-ended class A stages. They are useful for amplifying small signals and for applications where power efficiency is not important. Large-signal operation of common-emitter stages produces considerable even-harmonic distortion, which must be reduced by negative feedback. A balanced push-pull amplifier, as shown in Fig. 23, which uses two matched transistors with inputs 180° out of phase, has the advantage that the curvatures of their characteristics tend to cancel and give a symmetrical combined characteristic that produces very little even harmonic. Also, the design of the output transformer is simplified as the d.c. magnetizing effects produced in the transformer largely cancel out. In class A amplification, the signal currents flowing in the power supply are much reduced so that decoupling is simplified. Another important advantage of push-pull operation is that the improved linearity permits an increased power output with greater efficiency.

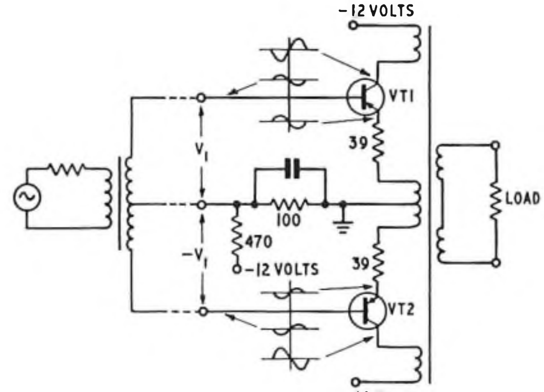


FIG. 23—BALANCED PUSH-PULL AMPLIFIER

An even greater efficiency is possible by using class B operation, which involves reducing the standing-bias current in each transistor to zero with no signal, so tha the signal causes one transistor to conduct whilst the other is cut off. The two transistors amplify alternate halves of the waveform, and current is taken from the supply only whilst the signal is present. Strict class B operation results in distortion at small-signal amplitudes due to non-linearity of the transistor characteristics at low currents. This is known as cross-over distortion. It is reduced by using a bias condition intermediate between that required for class B and that required for class A operation. This is a compromise which gives the best overall advantage with an efficiency at full output of up to 75 per cent, and a low current drain with no signal. The maximum power output can be nearly five times the collector-dissipation rating of a single transistor, compared with a half for a single-ended class A stage and one for a push-pull class A stage.

A push-pull power amplifier most commonly uses the common-emitter connexion because this produces the greatest power gain. Any mismatch of the two transistors causes distortion, particularly in class B operation, but this can be reduced by employing negative feedback. It may be applied partly by using an unbypassed common-emitter resistor, although, by using a separate unbypassed resistor for each transistor better d.c. stabilization will also be achieved. Feedback may also partly be applied from a separate balanced winding on the output transformer to the two emitters; this is called a split-load arrangement because the emitter current helps to drive the load. It gives an increased input impedance and a reduced output impedance which could be designed to match the load. The transistor-type line amplifier for program circuits with the frequency range 30 c/s–20 kc/s (Amplifier No. 135)[4] is an example of a class A amplifier of this type, and for this amplifier overall negative feedback from the output stage to the previous stage is also used.

A single-ended push-pull stage, as shown in Fig. 24, uses the two output transistors connected in series and so

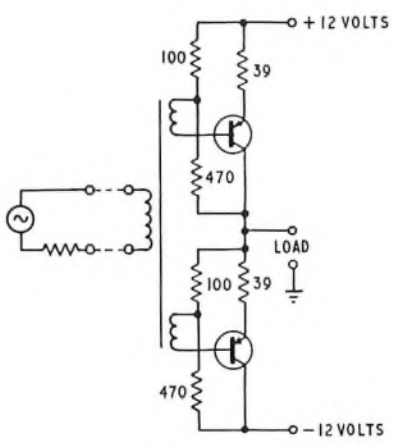


FIG. 24—SINGLE-ENDED PUSH-PULL AMPLIFIER

requires double the supply voltage but no output transformer. Examples of push-pull amplifier design can be found in the literature.[5]

OSCILLATORS

In its simplest form, an oscillator is a tuned amplifier which uses positive feedback to provide an input that is more than sufficient to sustain the output. Although the amplifier is an essential part of the oscillator, means for determining the frequency of oscillation and for limiting the amplitude are equally essential. The oscillation is started by noise inherent in the circuit, or by the disturbance caused by switching on, and its amplitude builds up until the overall loop gain of the circuit is reduced to unity by the non-linear characteristics of the amplifier; if this were not so the amplitude would continue to increase indefinitely. To allow the oscillations to build up, the signal fed back to the input of the amplifier must be exactly in phase with the input signal required to produce it and have a greater amplitude. Phase shift in the amplifier will therefore affect the frequency of oscillation and its stability.

The frequency of oscillation, f_0, is usually determined by a parallel LC tuned circuit, as shown in Fig. 25(*a*), in

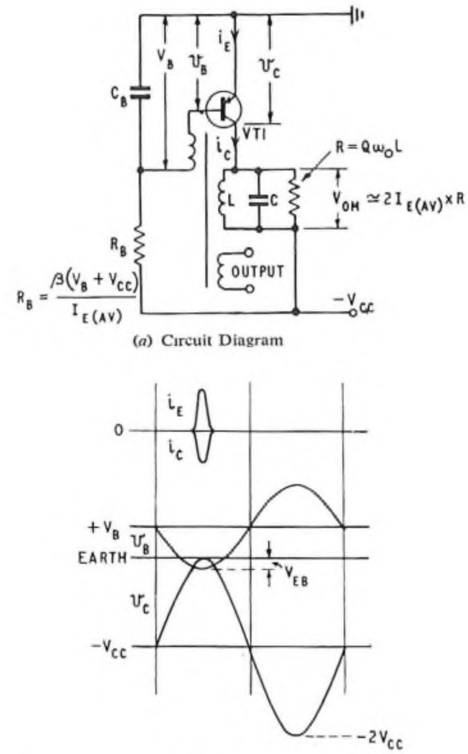


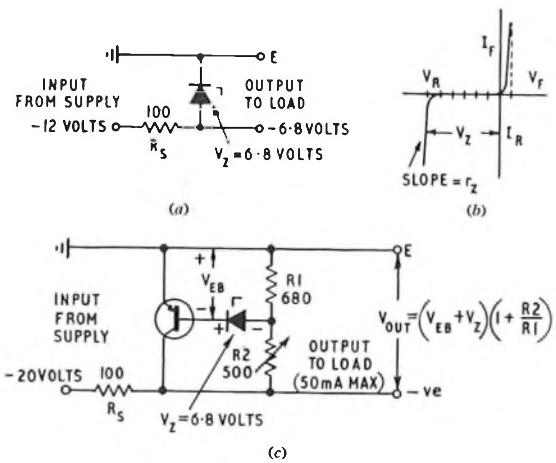
FIG. 25—COMMON-EMITTER CLASS C SINE-WAVE OSCILLATOR

which $f_0 \simeq 1/2\pi\sqrt{LC}$. The figure shows a common-emitter oscillator in which positive feedback is provided from a secondary winding that is coupled to L and connected so as to reverse the phase because of the phase reversal in the amplifier. The non-linearity in the amplifier not only limits the amplitude but also produces harmonics of the fundamental frequency in the output current flowing in the tuned circuit. The output of the oscillator must be taken from across the tuned circuit, or from a third winding coupled to L, if a good sinusoidal waveform is required. Waveform distortion is reduced by using low-loss components for L and C to produce a high-Q tuned circuit, and by making C as large as possible. Waveform distortion will be increased if the amplitude of the oscillation is limited by the transistor bottoming for more than a small part of a half cycle of the oscillation, because this will cause flattening of the peaks.

Similar considerations apply to oscillator amplifiers as to other amplifiers regarding gain variations with β, input and output impedances, and frequency of operation. However, the oscillator amplifier has to be non-linear in some respect to limit the oscillation amplitude. The method of operation chosen for each application will depend on the particular requirements. Stable frequency, a sinusoidal waveform and constant amplitude are generally required to a certain degree. Class C operation, in which the operating point is biased beyond cut-off, is suitable for many purposes. The best control of amplitude is achieved with a loop gain well above unity and the emitter current adjusted so that the transistor just bottoms on the peaks but is cut off completely for most of the cycle. The appropriate waveforms of collector voltage, base voltage and collector current are shown in Fig. 25(*b*). When switched on, the transistor conducts and oscillations build up until the transistor just bottoms. At the same time, a reverse base-bias is built up across capacitor C_B. The mean base-current is controlled by resistor R_B, and the mean collector-current will depend upon β. The degree of bottoming will, therefore, depend upon the characteristics of the transistor used, so that when a circuit is designed, components are chosen just to bottom a transistor having the minimum value of β. Further information about oscillators can be found in the literature.[1, 5]

VOLTAGE REGULATORS

Transistor circuits require low-voltage, high-current, low-impedance power supply units that have fairly accurately-controlled output voltages free of mains ripple. The functions of smoothing, providing a low output impedance at low frequencies, and controlling the output voltage can be solved simultaneously by using an electronic voltage regulator; power supply units incorporating these are available. The simplest shunt regulator, or stabilizer, for a fixed voltage, shown in Fig. 26(*a*),



(*a*) Simple Circuit Using Zener Diode for Fixed Voltage
(*b*) Zener-Diode Characteristic
(*c*) Variable Voltage Circuit
FIG. 26—SHUNT VOLTAGE REGULATORS

consists of a silicon Zener reference-diode connected in series with a resistor, R_S, to limit the input current. A Zener diode has a forward characteristic similar to that of an ordinary diode, but its reverse characteristic, shown in Fig. 26(*b*), has a very sharp turn-over at a critical voltage. This corresponds to the avalanche mode mentioned in Part 1. The resistance, r_Z, of the Zener diode to a small change in current is typically 1 ohm for a 6·8-volt device run at 50 mA. If the value of resistor R_S is 100 ohms for a regulator connected to a 12-volt supply, the ripple on the supply and the variations are reduced by a factor of 1/100, i.e. $r_Z/(R + r_Z)$, and the output impedance of the device is only 1 ohm, i.e. r_Z. The maximum load current is limited by the minimum current in resistor R_S. The Zener voltage, V_Z, varies very little with temperature.

In a variable shunt regulator, shown in Fig. 26(*c*), a power transistor is used as the shunt by connecting its base in series with a Zener diode to the junction of two resistors, R1 and R2, that are connected in series across the output terminals. When the transistor is conducting, the voltage across resistor R1 is equal to $V_Z + V_{EB}$. The output voltage is, therefore, equal to $(V_Z + V_{EB})(1 + R_2/R_1) + I_B R_2$, and this can be varied down to a minimum of $(V_Z + V_{EB})$ by adjusting the value of resistor R2. The output impedance is approximately equal to R_2/β. If $R_2 = 500$ ohms and $\beta = 50$, $R_2/\beta = 10$ ohms. If $R_S =$ 100 ohms, variations of supply voltage are reduced by a factor of

$$\frac{10}{100 + 10} = \frac{1}{11}.$$

A shunt-type voltage regulator draws from the supply an input current that is practically unaffected by the load current, but the input current changes considerably with input voltage. On the other hand, series-type voltage regulators, which are more generally used in power supplies, have the property that their input currents vary in sympathy with the load currents but are very little affected by the input voltage. All good voltage regulators operate by comparing the output voltage with an internal reference voltage (usually derived from a Zener diode), amplifying the difference and using this as a control signal to regulate the output voltage.

Fig. 27 shows a simple series regulator in which the

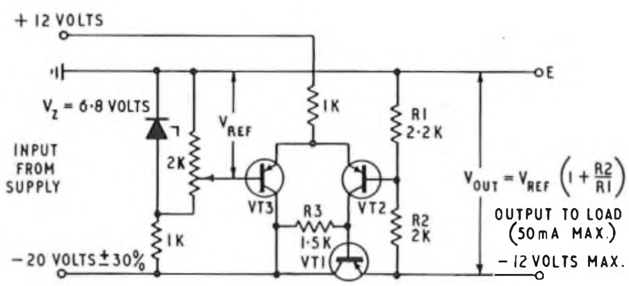


FIG. 27—SERIES VOLTAGE REGULATOR

full-load current is carried by transistor VT1. The transistor operates as a common-collector amplifier, and must be capable of dissipating about 1·3 watt. Part of the output voltage is developed across resistor R1 and is compared with a reference potential, V_R, obtained from a potentiometer connected across the Zener diode. The voltage difference is applied between the bases of the two transistors, VT2 and VT3, which form a difference amplifier (known as a long-tailed pair). The variations of V_{EB} of these two transistors with temperature tend to cancel one another. Base current for transistor VT1 is supplied via resistor R3 but is reduced by the collector current of transistor VT2. As the output voltage rises, the collector current of transistor VT2 increases and further reduces the base current of transistor VT1; this, in turn, reduces the output voltage. The output voltage is equal to $V_R(1 + R_2/R_1)$ and can be adjusted to any value from zero to $V_Z(1 + R_2/R_1)$ by the potentiometer which is connected across the Zener diode. The output impedance of this regulator is approximately equal to $R_2/\beta_1\beta_2$, where β_1 and β_2 are the current gains of transistors VT1 and VT2, respectively, but it can be considerably reduced by inserting a further common-collector stage between transistors VT2 and VT1. Variations of the input voltage are reduced by the factor $R_3\beta_2/R_2$, which is 1/30 for the values chosen. Thus, a $\pm$ 30 per cent variation on the 20-volt input (i.e. the voltage varying from + 14 to + 26 volts) would be reduced at the output to $\pm$ 1 per cent, i.e. $\pm$ 0·2 volt.

If a short-circuit fault occurs in transistor VT1, the output voltage can rise to a value equal to the maximum input voltage. The power rating of transistor VT1 must be at least equal to the maximum input voltage multiplied by the maximum load current.

(*To be continued*)

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APPENDIX 1

Formulae for Small-Signal Low-Frequency Performance

The following formulae are based on the small-signal low-frequency equivalent T-network parameters shown in Fig. 28.

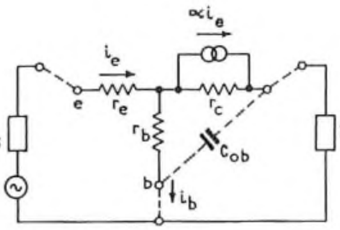


FIG. 28—SMALL-SIGNAL LOW-FREQUENCY EQUIVALENT T-NETWORK FOR JUNCTION TRANSISTOR

They are accurate provided that $r_e \ll r_c(1-\alpha)$ and $r_b \ll r_c$, where r_b, r_c and r_e are the internal resistances of the base, collector and emitter, respectively. These inequalities are normally true for modern transistors. Some further approximations are also given together with the conditions for which the error is less than 10 per cent.

The value of r_e may be calculated from the following expression, which is valid at room temperatures, and in which I_E is the d.c. value of the emitter current in mA:

$$r_e = \frac{25}{I_E} \text{ ohms,}$$

i.e. r_e is inversely proportional to the emitter current.

Both r_c and r_b vary inversely with the current, but not quite proportionately.

This information is sufficient to construct the curves of Fig. 13 and 14 from transistor manufacturer's data, and to determine the performance of simple circuits at frequencies that are low compared with f_α for common-base stages and with f_β for the other two methods of connexion, e.g. for frequencies up to $f_\alpha/3$ or $f_\beta/3$.

For the common-emitter stage it may be necessary to take account of the collector–base capacitance, C_{ob}, at frequencies above about 10 kc/s. This capacitance will increase the input current for a given output by the factor

$$1 + j\omega C_{ob} Z_L \left(\frac{\alpha}{1 - \alpha + \frac{Z_L}{r_c}} \right),$$

and so the current amplification will be reduced by this same factor. The quantity in parenthesis is the low-frequency current amplification.

The reduced current amplification is equal to

$$\frac{\{\alpha/(1-\alpha+Z_L/r_c)\}}{1 + j\omega C_{ob} Z_L \{\alpha/(1-\alpha+Z_L/r_c)\}}$$

$$\simeq \frac{\beta}{1 + j\omega C_{ob} Z_L \beta}, \text{ if } Z_L < 0{\cdot}1\, r_c(1-\alpha).$$

Common-Base Amplifier

Input impedance

$$= r_e + r_b \frac{r_c(1-\alpha) + Z_L}{r_c + Z_L}$$

$$\simeq r_e + r_b(1-\alpha), \text{ if } Z_L < 0{\cdot}1\, r_c(1-\alpha).$$

Output impedance

$$= r_c \frac{r_e + r_b(1-\alpha) + Z_s}{r_e + r_b + Z_s}$$

$$\simeq r_c, \text{ if } Z_s > 10\, r_b.$$

Current amplification

$$= \frac{\alpha}{1 + Z_L/r_c}$$

$$\simeq \alpha, \text{ if } Z_L < 0{\cdot}1\, r_c.$$

Common-Emitter Amplifier

Input impedance

$$= r_b + r_e \frac{r_c + Z_L}{r_c(1-\alpha) + Z_L}$$

$$\simeq r_b + \frac{r_e}{1-\alpha}, \text{ if } Z_L < 0{\cdot}1\, r_c(1-\alpha).$$

Output impedance

$$= r_c(1-\alpha) + r_c \frac{\alpha r_e}{r_e + r_b + Z_s}$$

$$\simeq r_c(1-\alpha), \text{ if } Z_s > 10 \frac{r_e}{1-\alpha}$$

Current amplification

$$= \frac{\alpha}{1 - \alpha + Z_L/r_c}$$

$$\simeq \frac{\alpha}{1-\alpha} = \beta, \text{ if } Z_L < 0{\cdot}1\, r_c(1-\alpha).$$

Common-Collector Amplifier

Input impedance

$$= r_b + r_c \frac{r_e + Z_L}{r_c(1-\alpha) + Z_L}$$

$$\simeq r_b + \frac{Z_L}{1-\alpha}, \text{ if } 10 r_e < Z_L < 0{\cdot}1\, r_c(1-\alpha).$$

Output impedance

$$= r_e + r_c(1-\alpha) \frac{r_b + Z_s}{r_c + Z_s}$$

$$\simeq r_e + (r_b + Z_s)(1-\alpha), \text{ if } Z_s < 0{\cdot}1\, r_c.$$

Current amplification

$$= \frac{1}{1 - \alpha + Z_L/r_c}$$

$$\simeq \frac{1}{1-\alpha} = \beta + 1, \text{ if } Z_L < 0{\cdot}1\, r_c(1-\alpha).$$

Voltage amplification

$$= \frac{Z_L}{r_e + r_b(1-\alpha) + Z_L}$$

$$\simeq 1, \text{ if } Z_L > 10\{r_e + r_b(1-\alpha)\}.$$

Notes and Comments

H. Leigh, B.Sc.(Eng.), M.I.E.E.

Mr. Leigh has been appointed Deputy Director, Operations, in the External Telecommunications Executive (E.T.E.). He started his career in the Post Office as an Assistant Traffic Superintendent in 1927, following 3 years as a Student Engineer with Siemens Bros. and Co., Ltd., Woolwich, and joined the Engineering Department through the open competition for Assistant

Engineer (old style) in 1929 after having gained his B.Sc.(Eng.) with Honours. For the 17 years he was in the Engineering Department he covered a variety of duties mainly connected with exchange and transmission equipment; this experience was of the greatest value to him as Secretary of the Precedence Panel, a position which he occupied so effectively during the war years and after. In 1947 he was promoted to Regional Engineer of the Home Counties Region, where he grappled with the technical problems and practical difficulties of internal construction work, and he was chosen in 1952 to be the Assistant Staff Engineer on planning when the E.T.E. was set up. On this duty he was concerned with the great variety of engineering problems connected with overseas telecommunications, and travelled extensively in the service of the Department and the Foreign Office. He continued this work when he was promoted to Staff Engineer in the E.T.E. in 1958. It can truly be said that he has a world-wide reputation and is respected for his deep knowledge and a forthright manner in which he expresses his views.

Apart from the many demands of his official activities he has found time to add lustre to the post of Assistant Editor, and later that of Managing Editor, of this Journal and to indulge in his favourite sports of rock climbing and Rugby football.

His technical knowledge will be a great assistance to him in his new appointment; so too will be his vigour, enthusiasm and friendliness. All who know him will wish him every success in this new sphere.

E.F.H.G.

Retirement of Mr. L. L. Tolley, O.B.E., B.Sc.(Eng.), M.I.E.E.

Mr. Tolley, who retired on 21 September 1963, commenced his Post Office career as a Probationary Assistant Engineer (old style) in 1924 after studying electrical engineering at University College, Southampton.

During the first few years of his service he was engaged on properties of materials in the Materials and Measurements Group in the Research Station at Dollis Hill. In 1932 he was transferred to the Research Services Group, where he was in charge of workshops and the drawing office. Shortly afterwards he was promoted to Executive Engineer (old style) and took charge of all services. Amongst the large variety of jobs undertaken was the construction of the original speaking clock and its installation at Holborn telephone exchange. He was closely concerned with the installation of services when the main research block was built at Dollis Hill.

In 1938 Mr. Tolley was appointed Assistant Superintending Engineer, Eastern District, and became Regional Engineer, stationed at Cambridge, when the Home Counties Region was set up. He was responsible for maintenance and training, and was actively concerned with communications for the many aerodromes and other defence establishments in the Region. During the war he was, in addition, Post Office Liaison Officer to the Regional Commissioner at Cambridge. He commanded the 6th (P.O.) Battalion of the Cambridgeshire Home Guard from 1940 to 1943 and became Regional Home Guard Commander, Home Counties Region, in 1944. He was promoted to Deputy Chief Regional Engineer, Home Counties Region, in 1944, retaining his responsibilities for maintenance and training.

Appointed Chief Regional Engineer, Midland Region, in 1947, Mr. Tolley was faced with the formidable task of tackling an order list which grew to 70,000 at a time when the annual provision of exchange connexions in the Region was less than 30,000. During his term of office the total engineering and motor-transport staff in the Region grew from 5,700 to 10,000 and the telephone system grew from 274,000 to 594,000 exchange connexions. He has, of course, been concerned with a very wide field of activities, ranging from the provision of radio and line links for the original Sutton Coldfield television transmitter to the large-scale introduction of trunk mechanization and S.T.D., as well as the special problems of post-war developments in the industrial Midlands.

For a number of years Mr. Tolley was a member of Engineering Department Promotion Boards for major engineering grades, and in 1952 was a member of the Study Group appointed to review the work of Senior Executive Engineer and Executive Engineer grades in the Post Office.

He has always been an active staff association member, and was at one time Chairman of the Society of Post Office Engineers and later a council member of the Association of Staff and Regional Engineers.

Always keenly interested in professional activities, Mr. Tolley was Chairman of the South Midland Centre of the Institution of Electrical Engineers in 1957–58.

Mr. Tolley was awarded the O.B.E. in the New Year Honours List, 1962.

In his younger days Mr. Tolley was a keen Rugby player and was a member of the Civil Service team. He is a vice-president of the Civil Service Rugby Football Club.

Throughout his career, Mr. Tolley's work has been characterized by his enthusiasm and abounding energy, by his remarkable flair for analysing all aspects of a problem, whether technical or administrative, and by his cheerful and understanding attitude to his staff and colleagues. He is very well liked throughout the Post Office and by a large number of people outside the Post Office with whom he has been associated during his career. His many friends will wish him well in his retirement.

W.L.A.C.

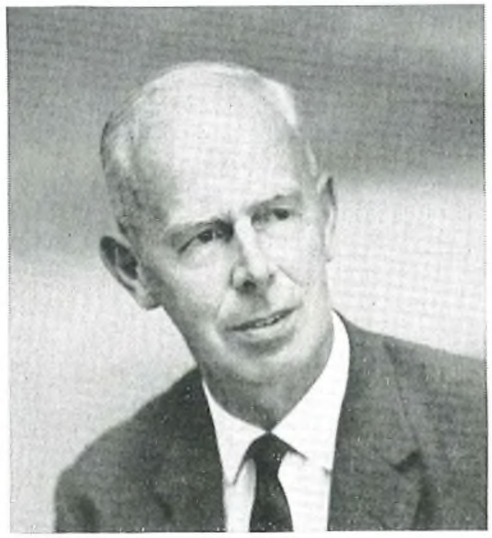
W. L. A. Coleman, B.Sc.(Eng.), M.I.E.E.

Mr. Coleman, who has been appointed Chief Regional Engineer, Midland Region, to follow Mr. L. L. Tolley, entered the Post Office Engineering Department as a Probationary Inspector in 1927. He did his early training in the Test Section, Fordrough Lane, Birmingham, and in the Bristol Section. He was appointed Inspector in the West External Section of the London Engineering District and covered the full range of external work, including the setting up of the first Installation Control in the country at Shepherds Bush in 1931.

During this period he continued his technical education at Battersea Polytechnic and gained his B.Sc.(Eng.) in 1931. In 1934 he headed the list in the limited competition for Probationary Assistant Engineer and returned to the West Country, being employed in the Bristol area mainly on external work. In January 1939 he was transferred to Exeter as Assistant Engineer (old style), where he was concerned with all classes of work, including defence needs, and later with restoration work after the Exeter "blitz."

In 1942 he was promoted to Executive Engineer (old style) in the Engineering Department, Transmission and Lines Branch, and was concerned with repeater station maintenance, circuit provision and transmission training arrangements.

In November 1944 he transferred to Plymouth as Area Engineer, Planning and Works, and was concerned with the replanning work following the war devastation there.



He renounced the attractions of the West Country in 1951 and transferred to the Central Training School, Stone, as Deputy Principal, where he turned his energies to training, with special interest in organization and supervision training.

In April 1953 he was promoted Regional Engineer, Midland Region, and has since been mainly concerned with the staff, organization, promotion and training problems in the thriving industrial Midlands. During this period the engineering workmen staff in the Region has grown by 3,000.

In 1961 he was seconded to the Commonwealth Relations Office for a short assignment in Ghana to report on the need for technical assistance in the staffing of the telecommunications organization and in the training of engineering staff.

His wide experience, coupled with his unrivalled knowledge of the staff in the Midland Region, makes him eminently suited to his new post. He has the confidence and good wishes of all his colleagues.

G.A.P.

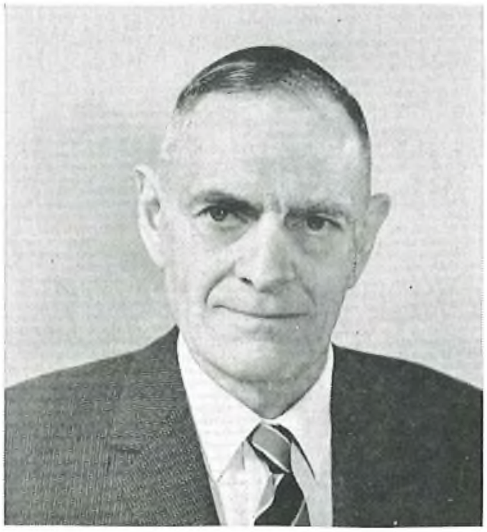
Retirement of Mr. F. C. Carter, O.B.E., B.Sc.(Eng.), M.I.E.E.

When Mr. Carter was promoted to Executive Engineer in 1934 he commenced the responsibility for subscribers' apparatus and, in his own characteristic phrase, "this and that," which has remained with him in increasing degree until his retirement as Staff Engineer in charge of the Subscribers' Apparatus and Miscellaneous Services Branch on 31 July 1963. During that period he has successfully steered many changes in subscribers' apparatus through to completion.

The first 10 years of his career after he entered the Engineering Department in 1922 by the open examination for Assistant Engineers (old style) were spent in the Wireless Section. There he spent a short time on the design and installation of coupled circuits for arc transmitters, but was transferred to the group responsible for the development and testing of antennae arrays for long-distance commercial radio links when the merits of higher frequencies for long-distance communications to the Commonwealth and the United States were recognized.

The development of the thermionic valve had proceeded rapidly and by 1932 it was becoming more economical to use light-gauge underground cables with amplifiers in place of large heavy-gauge overhead routes. At this time Mr. Carter was transferred to the Designs Section where he was responsible for the physical design of the toll amplifier and v.f. telegraph converter.

During the war years, he had the difficult and important task of finding alternative materials to replace those which were in short supply, and ensuring that components and materials were directed appropriately



to meet conflicting demands arising from the war effort. He was the Post Office member of the Inter-Services Radio Components Standardization Committee. He visited America and Canada with a Ministry of Aircraft Production mission in 1945.

In 1946 he was promoted to be Staff Engineer in charge of the Branch he joined in 1932. The efforts he made to lessen the effect of the post-war shortage of materials on the supply position for internal telephone apparatus and to improve the supply of apparatus needed to meet demands for shared telephone service were of considerable value to the Department.

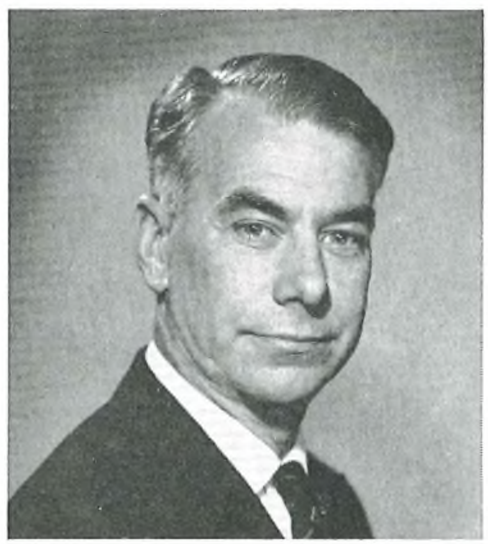
In 1948 the Post Office assumed responsibility for the development and production of a new type of hearing aid, which was urgently required to meet the needs arising from the National Health Act. His organizing ability and determination coupled with tactful handling of many difficult situations ensured that a satisfactory output of hearing aids was achieved. For this and other work he was awarded the O.B.E. in the New Year Honours List in 1952.

In the early 1950s, it became apparent that the whole range of subscribers' apparatus would have to be redesigned to take account of both technical developments and subscribers' requirements. In preparation for this extensive redevelopment, Mr. Carter was the engineering representative on a joint visit to America to study the American Telegraph and Telephone Company methods of providing and designing subscribers' apparatus and services. He was, therefore, in an excellent position to steer the Branch through what was undoubtedly its most busy and exciting years. He quickly realized that, to the customer, an attractive appearance of Post Office apparatus was equally as important as a satisfactory design to the engineer. His personal efforts in establishing and stabilizing an excellent working relationship with the Council of Industrial Design has greatly facilitated the use of industrial designers and consultants in our development work. The very favourable comments on the appearance of our current models of telephones, switchboards and coin-boxes must be a pleasing and lasting reward to him for his efforts. His many friends in the Post Office and in the manufacturing organizations will miss him. They would all wish him and Mrs. Carter a long and happy retirement. In the coming winter they will think rather enviously of them relaxing in the warm Spanish sunshine near Torremolinos.

C.E.C.

W. H. Maddison, T.D., B.Sc., M.I.E.E.

Mr. Maddison, who was appointed Staff Engineer of the Subscribers' Apparatus and Miscellaneous Services Branch of the Engineering Department on 1 August, has had a long and varied career in telecommunications. After leaving school, and following brief periods in the factories of Standard Telephones and Cables, Ltd., and British Thomson-Houston, Ltd., he entered the Post Office as a Youth-in-Training in 1928 and spent two years on automatic exchange maintenance in the L.T.R. He was then transferred to Research Branch, where he was employed as a research assistant on corrosion and allied problems. Success in the open competition for Probationary Inspectors in 1931 led to his return to the L.T.R., where he spent some 3 years on local-line-plant development and, during this period, obtained B.Sc. in physics at London University.



Success in the limited competition for Assistant Engineer (old style) led to his appointment to the Subscribers' Apparatus and Miscellaneous Services Branch of the Engineering Department in 1934, where he remained for 5 years employed on a number of duties including the development of the 300-type telephone.

As a Territorial Army officer he was mobilized in 1939 as a Second Lieutenant on A.A. defence, and was soon specializing in radar; he subsequently became an Instructor and attained the rank of Major. This led to 7 months in the U.S.A. as a member of a mission to advise the U.S. Army on A.A. defences and methods of training technical personnel. Secondment to the Ministry of Supply for direction of radar and predictor development followed, and by 1946 when he was demobilized he had attained the rank of Lieutenant-Colonel.

On demobilization he was posted to Telephone Branch [having been promoted Executive Engineer (old style) *in absentia* in 1944]. In this Branch for the next 5 years he had charge successively of groups dealing with maintenance procedure, operational facilities, and telephone power-plant development and maintenance.

In 1951 he was selected to become Chief Factories Engineer, and for the next 6 years was largely preoccupied with modernization of production methods and the design and introduction of "flow line" methods for the repair of telecommunications apparatus—mainly subscribers' apparatus.

Returning to Telephone Branch in 1957, he took charge of a Section dealing fundamentally with local exchange switching, and this period has largely been concerned with the many modifications and additions to local exchanges that have been rendered necessary by the introduction of S.T.D. He has also been the Branch representative on the Post Office Terms and Symbols Committee, and the Engineering Department representative on one or two British Standards Institution Committees.

In spite of all the pressures of his official duties, Mr. Maddison has, like all wise men, his hobbies. He is no mean performer as an artist and has received several commendations in the P.O. Art Club exhibitions. He is also a very keen sailor, and the inevitable in this pursuit has not damped his ardour although it has his camera—which is the subject of another hobby.

Maddison has always interested himself in his staff and endeavoured to assist those requiring encouragement, and has been a friendly and helpful colleague. There is no doubt that all who have known him during his career in the Post Office and elsewhere welcome his promotion and wish him all success in his new post.

W.J.E.T.

Retirement of Mr. C. E. Moffatt, A.C.G.I., Wh.Ex., M.I.E.E.

On 18 July Mr. C. E. Moffatt, Chief Regional Engineer, South Western Region, retired after nearly 40 years service in the Post Office.

Mr. Moffatt entered H.M. Dockyard, Devonport, as an apprentice in 1917 and, after completing the course, gained a Whitworth Exhibition and spent 3 years at the City and Guilds Engineering College, London.

He entered the Post Office as a Probationary Assistant Engineer in 1925, and after a short period in the Testing Branch he was posted to Southampton, where he remained for 6 years. In 1932 he was transferred to the Technical Section of the former South Midland District at Reading, and two years later was appointed Sectional Engineer, Reading.

In 1938 he moved to Bristol on his appointment as Assistant Superintending Engineer, later Regional Engineer. He spent the war years in Bristol and fully played his part in the restoration of services following

bombing attacks on the major cities in the Region and also in the provision of communications leading up to D-day operations.

In 1946 he was transferred to London as Deputy Chief Regional Engineer, and was concerned with the arrangements for the reorganization of the engineering staff of the London Telecommunications Region. Four years later he became Staff Engineer in charge of the External Plant and Protection Branch of the Engineering Department, but within 12 months he transferred to Cardiff as C.R.E., Wales and Border Counties.

During the whole of the time since 1938 he had retained his home in Bristol and it was no surprise therefore when in 1957 he returned to the South Western Region as Chief Regional Engineer.

Mr. Moffat's long experience of Regional activities gained as a Regional Engineer, and later as a Chief Regional Engineer, made him a valued member of many Headquarters' committees and promotion boards. To mention one in particular, he was a member of the committee, set up in 1952 to review the appraisements and promotion procedure for Post Office engineering staff.

His 6 years as Chief Regional Engineer, South Western Region, saw two major developments take place in the Region. The first was the introduction of S.T.D. at Bristol and the other was the construction of the satellite ground communication station at Goonhilly Downs.

Charles Moffat has always been keenly interested in sport and was chairman of sports associations both in the London Telecommunications Region and the South Western Region. He maintains his membership of the Cardiff Athletic Club and does not miss many international matches at Cardiff Arms Park. His friendly nature and generous disposition will be greatly missed by all his former colleagues, and everyone who has been associated with him will wish him long life, health and happiness in his retirement.

C.A.L.N.

C. A. L. Nicholls, O.B.E., M.I.E.E.

The appointment of Mr. C. A. L. Nicholls as Chief Regional Engineer, South Western Region, provides an excellent example to engineering staff, and will no doubt give encouragement to many junior officers who are at the beginning of their careers in the Post Office.

On leaving Colston School at Bristol in 1925, Mr. Nicholls joined the Post Office as a Youth-in-Training at Bath, and after his initial training he spent the next few years on equipment maintenance in Bath automatic telephone exchange.

In 1931 he was successful in passing the limited competition for Probationary Inspector, and spent a relatively short period in the South Western District Technical Section at Bristol, dealing mainly with the design of local-line plant.

In 1934 he was successful in the Assistant Engineer (old style) Competition, and as a result was transferred to the Post Office Research Station at Dollis Hill, where he was occupied for several years on research into the behaviour of automatic switches.

One of the major problems he tackled during this period was that of bank noise on 2,000-type selectors, and his studies influenced the subsequent bank-cleaning techniques adopted in the Post Office.

Mr. Nicholls joined the Post Office War Group at the outbreak of the Second World War to assist with

the many circuit provision problems which then arose, and spent the major part of the war dealing with the provision and rearrangement of communications for the fighting services.

In 1945 he joined the staff of the Control Commission in Germany, and after some 10 years with the Commission he eventually became Controller of the Posts and Telecommunications Group.

The Commission was responsible both for the rehabilitation of the German civil communications system and for the provision of communications required by the occupying Forces, and Mr. Nicholls gained valuable experience in discussion and negotiation with foreign personnel.

He attended many meetings of the Quadripartite Committees, the International Telecommunication Union and the Universal Postal Union, and he represented the British Zone of Germany at NATO Conferences.

Mr. Nicholls was awarded the O.B.E. in 1951.

In 1955 he returned to the United Kingdom and spent two years in the Liverpool Area as Area Engineer before returning to Bristol in 1957 on his appointment as Regional Engineer on external planning and works.

His many friends confidently wish him every success in his wider field of activities.

A.J.C.

Retirement of Mr. J. Stratton, A.C.G.F.C., M.I.E.E.

John Stratton retired on 31 July 1963 after a varied and successful career in the Post Office Engineering Department, during which he made very many friends, not only in the Engineering Department but in the Administrative Departments, in the Regions and in the communications industry.

After completing his studies at City and Guilds Technical College at Finsbury, he spent 4 years in the electrical industry before joining the Post Office in 1927 as an old-style Probationary Assistant Engineer. After a short period of training in the old London Engineering District he was posted to the Lines Section of the Engineer-in-Chief's Office where he was engaged on planning and provision work on trunk-line circuits. He likes to recount that when he was first concerned with this work there were still 800lb/mile copper open wires working between London and Glasgow, and one of his early tasks was the clearing of the heavy open-wire trunk routes by the diversion of their circuits to cable. In the early 1930s there was considerable pressure on trunk-circuit provision when the cheap evening call and trunk demand working were introduced, and Mr. Stratton was responsible for the lines side of both these projects. He reached the rank of Assistant Staff Engineer in 1939.

In 1943 he was transferred to the Midland Region where he was responsible for external plant, power services and radio. He was in charge of this work during the difficult post-war years, and one of his principal tasks was to reorganize local-line provision to give the maximum service from the restricted amount of plant available. Moving again in 1950, he became

Deputy Chief Regional Engineer in the London Telecommunications Region.

1951 brought promotion to Staff Engineer in charge of the Local Lines Branch and it was during his time as the head of this Branch that the 1,000-ohm local line was first introduced. This was followed in 1954 by a transfer to the Engineering Organization and Efficiency Branch where he had close contacts with the staff associations and the P.O.E.U.

In 1958 Mr. Stratton was given charge of the newly-formed Main Lines Planning and Provision Branch, and he thus returned to the work which had occupied the first 16 years of his service and in which he has always found his greatest interest. He remained in charge of this Branch until his retirement. In late 1958, trunk traffic started to increase rapidly, and has continued to do so up to the present time. The demand for trunk circuits has been greater than ever before: over a 6-year period starting in 1958 the size of the trunk network will be approximately doubled. The problems of planning and installing new plant and setting up new circuits to achieve such a rate of growth, and at the same time to keep expenditure within bounds, have been very considerable, and the Branch has been fortunate in having someone with the experience of Mr. Stratton at its head during these years.

He is a genial and friendly man with a great interest in sport. In his younger days he played cricket and football for the Old Bromleians, and he has been for some time Chairman of the Engineer-in-Chief's Cricket Club and a member of the Surrey County Cricket Club. He has a very great number of friends in the Post Office, all of whom will miss his cheerful company.

H.B.

H. Barker, B.Sc.(Eng.), A.M.I.E.E.

His many friends both inside and outside the Engineering Department will be pleased to hear of the well-earned promotion of Mr. H. Barker to Staff Engineer of the Main Lines Planning and Provision Branch. He brings to the job a wealth of experience in a number of fields and this, coupled with a capacity for quickly reaching the root of a problem and drawing sound conclusions, will ensure his success and that of the Branch.

Entry into the Department in 1928 was followed in 1934 by transfer to the Lines Section of that day, where early forms of carrier working were then being tried out. Carrier Systems No. 1 and No. 3 were simple forms of system providing two and four channels on open wires where only one existed before, but the commissioning of such systems as a first step in a career in main lines could hardly have been bettered and the new Staff Engineer of Main Lines Planning and Provision Branch will always look back on those days with some pride and no little sense of achievement.

Since those early days Mr. Barker has been involved in one way or another with every major development of line engineering, from multi-pair carrier to the latest 174-type coaxial cables. In recent years has come the need to integrate microwave radio systems into the trunk-line network. This is being done with a smoothness of change-over which could not have been envisaged before the event, and is largely due to the detailed planning carried out by Mr. Barker at the inception of the scheme.

Large developments in the television network occurred while Mr. Barker was the planning engineer for main lines. The ease with which these were carried

out gives promise that the plans which he also laid down for the further developments of television, B.B.C. second program, etc., will work as smoothly, when the time comes to put them into effect.

The period from 1938 to 1954 was spent away from main lines. In 1938 the Royal Air Force was expanding rapidly against the threat of war and a completely new communication system was needed for administrative and operational control. Mr. Barker was seconded in that year to assist in planning it. The outbreak of war saw him mobilized with the Royal Air Force Volunteer Reserve, and after a variety of duties in the Air Ministry, he was appointed in 1943 to the post of Deputy Chief Signals Officer, Second Tactical Air Force, with which he served in France and Germany until late in 1945.

Following demobilization he was posted to the Subscribers' Apparatus and Miscellaneous Services Branch, but in 1951 was seconded to Royal Air Force Fighter Command on special duties. His return in 1954 to main lines coincided with the expansion of the television network on the introduction of the Independent Television Authority, to be followed later by an unprecedented upsurge of requirements for trunk lines which has continued to the present day.

Until the outbreak of war he was a keen player of Rugby football and still retains his interest in the game.

J.S.

D. E. Watt-Carter, M.I.E.E.

On 1 August 1963, Mr. D. E. Watt-Carter was appointed Staff Engineer of the Overseas Radio Planning and Provision (WO) Branch, a post for which his long experience in the radio field makes him exceptionally well qualified.

He entered the Post Office as a Probationary Inspector in 1933 and was appointed to the West Area of the London Telecommunications Region, where he spent some 5 years on external planning and construction. In 1938 he was successful in the limited competition for Assistant Engineer (old style) and spent a short period in the Centre and North West Areas on automatic-exchange maintenance. This, however, held little attraction for him, for, in 1940, a cleverly-worded

advertisement for engineers with external-construction experience persuaded him to apply for a post in the Radio Branch of the Engineer-in-Chief's Office, and for the next 7 years he was engaged in the design and construction of external radio plant. Although he may have had some misgivings during his first few days in this new job, he now regards it as perhaps the most rewarding period of his official career. His ability for this kind of work led to his promotion to Executive Engineer (old style)—later Senior Executive Engineer—of the External Construction Group of the Radio Branch, being in charge of this group for some 4 years. During this whole period of some 11 years he was engaged in a variety of work, calling for a wide knowledge of civil, structural and mechanical, as well as electrical, engineering. He was very much concerned with the design of the external plant at Criggion Radio Station, in particular the v.l.f. aerial system, and later with the planning and provision of the aerial system and aerial-switching arrangements of the Rugby "B" Radio Station. About this time, rhombic aerials were being brought into general use at h.f. transmitting and receiving stations and he played a large part in their design and construction. As a diversion from "steam radio," he concerned himself with the specification and provision of towers and other external plant for the London–Birmingham and Manchester–Kirk O'Shotts television links.

In 1952 he moved over to take charge of the group in Radio Branch responsible for the planning and development of the main radio stations, and his wider interests now embraced internal as well as external radio plant and the study of radio-telephone and telegraph systems. In 1956, however, he was promoted to Assistant Staff Engineer in the Radio Experimental (WE) Branch at Dollis Hill, where he was in charge of the groups concerned with frequency standards and network design. Although he found these new fields pleasant he was not allowed to linger in them for too long, and in 1959 returned to WO Branch. Until his recent promotion to Staff Engineer, he has been in charge of the Provision and Installation Section of that Branch, being responsible for the provision and installation of all plant at main and coast radio stations. One of the major jobs with which he has been concerned has been the complete reconstruction of Leafield Radio Station. He is the National Chairman of C.C.I.R. Study Group I (Transmitters), and led the United Kingdom Delegation to the Interim Meeting of C.C.I.R. Study Groups I and III in 1962, and was a member of the United Kingdom Delegation to C.C.I.R. Plenary Assembly in 1963.

Mr. Watt-Carter's extra-mural activities cover a wide field and include a taste for good music, good architecture and good wine and, more recently, foreign travel, none of which he will claim he can indulge in as much as he would like. He takes over WO Branch just at the time when the depredations of its younger associated branches, the Inland Radio Planning and Provision Branch (WI) and the Space Communication Systems Branch (WS), have somewhat depleted its staff. However, his cheerful enthusiasm for work and his flair for organization will go some way at least to compensate for this. His friends and colleagues in the Engineering Department and in the External Telecommunications Executive wish him every success in his new post.

C.W.S.

Retirement of Mr. P. L. Barker, B.Sc., M.I.E.E.

Mr. P. L. Barker, Chief Regional Engineer of the Wales and Border Counties Directorate, retired on 2 June 1963.

After taking his degree in engineering at Birmingham University, he began 38 years of Post Office service in 1925 with appointment as an open competition Probationary Assistant Engineer. Ten years of work in the Wireless Experimental Section of the Radio Branch in the Engineer-in-Chief's Office, where he was engaged on the development of short-wave radio telephony and on propagation measurements, were followed by service in the Sectional Engineer's Office at Cambridge. With promotion, Mr. Barker moved back to the Engineer-in-Chief's Office, this time in charge of development work

on equipment for audio and carrier transmission over local lines, in the newly formed Wire-Broadcasting Branch.

Mr. Barker's 18 years of Regional work began in 1945 when, after service with the Royal Electrical and Mechanical Engineers during the war, at home, and overseas with the British Army Staff in Washington, he became Area Engineer at Chester, a move very quickly followed by another to the Northern Ireland Directorate. Here he held the combined post of Regional Engineer and Telecommunications Controller, and so had a valuable opportunity to study two important sections of the headquarter's work of a Region—experience which was to stand him in good stead when, in 1957, he moved to his final position in the Post Office Headquarters in Wales.

During his period of office as Chief Regional Engineer, the growth of telecommunication plant went ahead steadily with encouragement from him to use newly available equipment and methods. Rapid growth of trunk mechanization and S.T.D. was accompanied by the modernizing of engineering depots and motor-transport workshops.

Experience and study of the art of speaking and a firm sense of order made him a welcomed committee man whether as a chairman or as a member; for either duty he was careful to prepare himself to contribute usefully and accurately. He served as a member and a Chairman of the Local Centre Committee of the I.E.E. in Northern Ireland and as a member of the Western Centre Committee; in Northern Ireland and in Wales he was Chairman of the local centres of the I.P.O.E.E.

By nature a kindly man, he took pains to make as sure as he could that he held the balance between the official and the staff aspects of his dealings with his men honestly and fairly. He was readily available to his staff to listen and to advise; that their interests were much in his mind was shown by his work on the Regional Engineering Whitley Committee.

A conscientious chief, always to be found early at work, who believed in keeping his colleagues informed of his policies and actions as much as he could, he will be greatly missed by his staff in the Wales and Border Counties Directorate, who all wish him a long and happy retirement.

F.W.

D. C. Blair, A.M.I.E.E.

Mr. D. C. Blair, recently appointed Chief Regional Engineer, Wales and Border Counties, received his early training as an apprentice in H.M. Dockyard, Chatham. In 1929 he joined the Post Office as a Probationary Inspector and served in the Radio Branch. In 1933 he was successful in the limited competition for Probationary Assistant Engineers (old style), and after general training was appointed to the Construction Branch, where he was chiefly concerned with problems of induction between power lines and Post Office plant. As a Territorial Officer he was called up with the Royal Corps of Signals at the outbreak of war, and had six years of active service, chiefly in the Middle East and later in Italy, being mentioned in despatches during the Allied advance in Cyrenaica.

He was promoted to Executive Engineer (old style) *in absentia* in 1941, and on demobilization took up

appointment as Area Engineer at Brighton in charge of maintenance and installation. His first concern, as always, was for the morale of his staff, many of whom, like himself, were returning ex-service men. By his understanding of their problems, and his determined efforts to provide them with the guidance and training they needed, he gained their ready co-operation in the tasks which faced the Area in the difficult post-war years. An outstanding improvement in the fault rate in the Brighton Area, to a figure as good as probably any in the country, was in no small measure due to his enthusiasm and leadership. A keen sportsman in his youth, he played a big part in fostering sporting and social activities in the Brighton Area.

In 1957 he was promoted to Assistant Staff Engineer in the Engineering Organization and Efficiency Branch, where his wide knowledge of practical conditions in the field and his understanding of the human factors in management have been applied to the problems involved in achieving greater productivity. He has played a major part in the introduction of work study in the field of Post Office engineering.

His many friends wish him every success in his new appointment.

J.B.

Institution of Post Office Electrical Engineers

Essay Competition 1963–64

To further interest in the performance of engineering duties and to encourage the expression of thought given to day-to-day departmental activities, the Council of the Institution of Post Office Electrical Engineers offers five prizes, a first prize of six guineas and four prizes of three guineas, for the five most meritorious essays submitted by members of the Post Office Engineering Department *below the rank of Inspector.* In addition to the five prizes, the Council awards five certificates of merit. Awards of prizes and certificates made by the I.P.O.E.E. are recorded on the staff dockets of the recipients.

An essay submitted for consideration of an award in the essay competition and also submitted in connexion with the Associate Section I.P.O.E.E. prizes will not be eligible to receive both awards.

In judging the merits of an essay, consideration will be given to clearness of expression, correct use of words, neatness and arrangement, and, although technical accuracy is essential, a high technical standard is not absolutely necessary to qualify for an award. The Council hopes that this assurance will encourage a larger number to enter. Marks will be awarded for originality of essays submitted.

Copies of previous prize-winning essays have been bound and placed in the Institution Central Library. Members of the Associate Section can borrow these copies from the Librarian, I.P.O.E.E., G.P.O., 2–12 Gresham Street, London, E.C.2.

Competitors may choose any subject relevant to current telephone, telegraph or radio practice. Foolscap or quarto-size paper should be used, and the essay should be between 2,000 and 5,000 words. An inch margin is to be left on each page. A certificate is required to be given by each competitor, at the end of the essay, in the following terms:

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

Name (in block capitals) ....

Signature ....

Rank ....

Departmental Address ....

....

Date ....

The essays must reach
The Secretary,
The Institution of Post Office Electrical Engineers,
G.P.O.,
2–12 Gresham Street,
London, E.C.2.
by 31 December 1963.

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

Essay Competition 1962–63

The Council of the Institution is indebted to Mr. R. O. Boocock, Chairman of the Judging Committee, for the following report on the 1962–63 Essay Competition, the results of which were published in the July 1963 issue of the Journal:

The subjects selected covered a very wide field of activity, a diversity which did not make the task of the judges an easy one.

Marks were awarded on the basis of:
(*a*) originality of ideas,
(*b*) method of treatment,
(*c*) accuracy of fact, and
(*d*) suitability of length of essay to the subject.

Marks awarded on accuracy of fact and length of essay were fairly even throughout, leaving originality of ideas and method of treatment as the predominant factors in arriving at the final decision.

Many essays with high technical content lost marks due to faults in the method of treatment. It is not easy to produce a readable essay in which technical formulae frequently appear, and where symbols are used the reader should not be forced back too much on to his own knowledge for their interpretation.

Some competitors produced compendiums of facts which, whilst being most interesting and obviously the result of much research and study of the subject, lost heavily on the method of treatment: they were not essays.

Five essays were selected as being in the prize class and, after much deliberation, the judges awarded the "Palm" to the essay "Brief Encounter with a Nuclear Explosion" submitted by Mr. W. Mercer, Technical Officer, of Portpatrick; this essay, well written, describes in some detail means by which voltages induced in submarine cables by the tides are measured. It describes the circumstances of the time, a prevailing radio fade-out and an "unsatisfied curiosity which remained." Over and above all the variations in voltage caused by the tidal variations due to the moon and the influence of the wind, there was a sharp voltage surge which coincided with the detonation of the first American high-altitude nuclear device.

The author discusses the physical effects of a nuclear explosion in terms of gamma radiation and neutrons, both prompt and delayed visible light, X-rays and the electromagnetic effects, and argues that the voltage observed could have been caused by such an explosion although he "would hesitate to draw a firm conclusion" from the limited results available.

The second prize was awarded to Mr. J. C. Hines, Technical Officer, Inverness, for his essay "Some Aspects of Human Relationship in the Engineering Department." This was an excellent essay on human nature, its frailty, its hopes and aspirations, and its reaction to different treatments. The author deals with the difficulties with which large organizations are faced in maintaining contact between the head and the tail, and of the difficulty in selecting the right man for a particular job. The human characteristics necessary for some of the duties in the Post Office are mentioned, with particular reference to the desirability of balancing the requirements of the job against the man's intellect.

The third prize was awarded to Mr. D. J. G. Corin, Technical Officer, Portscatho, for his essay "A Non-Director Man Goes Out"—a descriptive essay on the change in life from that as maintenance man at a non-director exchange to that on dual maintenance. Thrown in at the deep end, as it were, the author starts his external duties on the day after a night in which 9 in. of snow had fallen in Cornwall. The variety of equipment maintained and the characters he meets as a detached linesman are described; add to this a description of what a rural community expects from its own Post Office technical representative and you have an interesting essay.

The fourth prize was awarded to Mr. A. G. Hickson, Technical Officer, Northampton, for his essay "Training of Maintenance Staff (Microwave Radio Equipment)." Touching on the transmission techniques from single-pair audio to microwave radio, the author quickly covers the many varieties of carrier telephony via four wires and co-axial cable, and criticizes the fault-locating techniques on the complex microwave equipment. He suggests that a more practical approach to the subject, would, in his opinion, lead to speedy fault location with efficient and economic maintenance. His proposal is to temper the highly theoretical approach to training with a greater use of the block schematic diagram which could serve as a basis for most systems. The suggestion is, of course, not novel but the essay is well written and interesting.

The fifth prize was awarded to Mr. H. R. Merry, Technical Officer, Reading, for his essay "Housing Estates and the Telephone Service." Beginning with the social history of the past 80 years and the "emancipation of the working classes from their humble standards of living to their present day affluence," the author presents his subject in an extremely interesting manner. He covers the procedures adopted for ensuring co-operation with estate developers, describes in considerable detail the methods of dealing with specific cases, and, supported by plans and cabling schemes, a mundane subject is turned into an interesting essay.

S. Welch,
General Secretary.

Additions to the Library

Library requisition forms are available from Honorary Local Secretaries, from Associate Section Centre Secretaries and representatives, and from the Librarian, I.P.O.E.E., G.P.O.,2–12 Gresham Street, London, E.C.2.

2704 *Motor Manuals, Vol. V—Modern Transmission Systems.* A. W. Judge (Brit. 1962).
For the car owner, mechanic and student requiring fuller information on motor engineering than is given in books covering the whole field in a single volume. Gives special emphasis to the semi-automatic and fully-automatic systems.

2705 *Symbols, Signals, and Noise—The Nature and Process of Communication.* J. R. Pierce (Brit. 1962).
A book on the up-to-date theories about communication, using the minimum of essential mathematics.

2706 *Systematic Slide-Rule Technique.* R. K. Allen (Brit. 1962).
Aims at presenting a comprehensive and clearly reasoned description of both the theory and practice of all important aspects of the logarithmic slide rule.

2707 *Executive Skills.* R. Bellows, T. Q. Gilson and G. S. Odiorne (Amer.1962).
A study of the modern approach to the training, qualifications and functions of executives.

2708 *The Construction of Buildings—Vol. 2.* R. Barry (Brit.1960).
Deals with the masonry, windows, sills, doors, partitions, fireplaces and flues, stairs, internal finishes and external renderings; includes notes on the properties and uses of materials, and explanations are given of the advantages of various details of construction in common use.

2709 *The Home Electrician.* F. J. Camm (Brit.1962).
A complete guide to the installation, upkeep, overhaul and repair of all electrical apparatus in the home.

2710 *Radio and Television Test Instruments.* C. J. King (Brit.1962).
A guide to the use of modern test gear in servicing radio, television, and audio equipment.

2711 *Introduction to Electronics.* R. J. Hughes and P. Pipe (Brit.1962).
Presents the principles of electronics in terms of radio communication using the "Tutor Text" method of self-instruction.

2712 *Television Simplified.* M. S. Kiver. (Amer.1962).
A comprehensive presentation.

2713 *The Release and Use of Atomic Energy.* T. E. Allibone (Brit.1961).
The historical approach to atomic and nuclear theory is given, followed by a statement of the present position.

2714 *The Construction of Buildings—Vol. I.* R. Barry (Brit.1962).
This volume covers foundations, walls, floors and roofs.

2715 *Principles of Colour Television.* G. H. Patchett (Brit. 1962).
Deals with the basic principles of colour, basic colour television systems, and apparatus in the studio and in the receiver, with particular reference to the NTSC system.

2716 *Einstein's Theory of Relativity.* M. Born (Brit. 1962).
Presents Einstein's theory, using only simple algebra, but attempting to give a fuller understanding than the "popular" treatments.

2717 *Hi-Fi Pocket Book.* W. E. Pannett (Brit. 1962).
Gives comprehensive and concise information on all aspects of high-fidelity sound reproduction.

2718 *The General Properties of Matter.* F. H. Nemman and V. H. L. Searle (Brit. 1957).
Intended primarily for the physicists; presents a fairly complete survey of the fundamental properties of matter.

2719 *Ultrasonic Physics.* E. G. Richardson (Dutch 1962).
The emphasis is on laboratory-applied ultrasonics.

2721 *Motor Manuals, Vol. VI—Modern Electrical Equipment.* A. W. Judge (Brit. 1962).
The sixth in the author's Motor Manual Series; covers particularly the recent developments.

2722 *Laplace Transformation.* W. T. Thomson (Amer. 1960).
Discusses the theory of the Laplace transformation and demonstrates its varied applications to electrical, dynamical, structural, and servo-mechanical engineering.

2723 *Nuclear Power Today and Tomorrow.* K. Jay (Brit. 1961).
Intended to give the layman a better understanding of the nature of nuclear power and to explain some of the major problems which have to be overcome in making practical use of it.

2724 *Gevaert Manual of Photography.* A. H. S. Craeybeck (Belgium 1962).
A practical guide for professionals and advanced amateurs.

2725 *Living With The Atom.* R. Calder (Amer. 1962).
The author presents the reality of nuclear development, its dangers, and the dilemma of the scientist who fears distortion of the facts, and outlines the progress being made in controlling the new force.

W. D. Florence,
Librarian.

Regional Notes

North Western Region

UNUSUAL DAMAGE TO COAXIAL CABLE

Unusual damage, caused by frost and the subsequent thaw, occurred on Sunday, 3 March 1963 to the Carlisle–Lancaster No. 1 coaxial cable at the point where it crosses Borrow Beck over Hucks Bridge on Shap Fell. Upon investigation, three of the six coaxial tubes were found to be short-circuited, and the fault was cleared by inserting a short length of cable by unidiameter-jointing methods to replace the damaged portion.

The cable runs through steel pipe at shallow depth, with approximately 15 in. of cover, over Hucks Bridge. Also, the affected steel pipe is situated at the bottom of a valley with steep gradients on either side. On recovery of the damaged cable it was found that, over a section of 16 yd, coaxial tubes Nos. 1, 2 and 3 had been severely flattened to the extent of crushing the polythene disks. Opinion differs as to the precise reason for the damage, but it does appear that changes in temperature, which was about freezing-point at the time of the thaw, resulted in a sudden expansion of the water and ice trapped in the steel pipe.

The cable concerned has six coaxial tubes each having an external diameter of 0·375 in., and, having only 32 20 lb/mile interstice pairs, possesses very little strength to withstand compressive forces. Another 6-tube coaxial cable, with 344 20 lb/mile layer pairs, running alongside under exactly the same conditions in another steel pipe, was undamaged.

G.F.S.

Midland Region

PROVISION OF TELEPHONE SERVICE AT THE ROYAL AGRICULTURAL SHOW 1963

Two years ago, The Royal Agricultural Society of England (R.A.S.E.) obtained from Lord Leigh a 7-year lease, with a renewal option for 99 years, of 364 acres of Stoneleigh Park near Kenilworth. The Annual Show was held there for the first time from 2 to 5 July this year During the two years, about four miles of roads have been laid, a show ring, grandstand, and covered accommodation for exhibitors constructed, and a Royal Pavilion, and administrative, police, press and Post Office buildings erected.

By courtesy of The Coventry Evening Telegraph.

AERIAL VIEW OF THE ROYAL AGRICULTURAL SHOW 1963

The actual exhibition area, shown in the aerial photograph, is approximately a rectangle 800 yd by 1,200 yd. The remainder of the site is used as car parks. The larger exhibitors erect their own semi-permanent buildings, and the smaller ones either rent accommodation in 100 yd-long open-sided sheds provided by the Society, or bring their own tents or caravans.

As it is possible that this will be the permanent show site, it was decided to plan the telephone service using standard distribution without any temporary wiring.

Preliminary plans of the new site, and statistics of telephone demand at previous shows, were obtained early in 1962. From these, a fundamental plan was prepared and stores were ordered in the knowledge that final requirements for telephone service could not be given until the beginning of 1963. This plan included a 600-line cabinet, three 200-line and one 100-line pillars, 2,500 yd of single-way duct, 4,000 yd of cable in duct, 3,500 yd of buried polythene cable and 50 distribution points (D.P.s). It was decided to serve the site from Coventry telephone exchange, and about a mile of 2-way duct was laid to connect the site to existing underground routes. Then, five miles of 542 pr., 20 lb/mile cable were drawn in between the exchange and Stoneleigh Park. A short length of 300-pair cable was run to connect the main cable to the cabinet on the show site. The cable was pressurized up to the cabinet.

In January 1963, the Sales Division, Coventry Area, canvassed all exhibitors, and the service requirements of the majority were known by the end of February, but not the exact positions of their stands.

It had been intended that duct and cable laying should start in January 1963, but this was delayed until March due to bad weather. A Post Office excavator was used for trenching at 24–30 in. of cover. These depths avoided damage to the plant when just before the show the ground was reduced to a quagmire due to bad weather and to heavy lorries delivering exhibitors' equipment. Also, it is hoped that the plant will not have to be moved if the roads are later widened or extended.

In May 1963, an empty mobile U.A.X. trailer was moved to the site for use as a planning and advice note control office. Planning and laying of distribution cables by the excavator and a mole drainer were carried out as details of the stand positions were given by the R.A.S.E.s resident clerk of works, and about this time a final layout plan of the show ground was supplied. The completed distribution included, in addition to the fundamental plan, 2,000 yd of buried polythene cable and 21 D.P.s. Of the total of 71 D.P.s, 32 were "drop wire" and the remainder block wiring. A block terminal was fitted at one end of each of the 100 yd-long open-sided sheds, and drop wire run through spiral screw-eyes to each subscriber. Wherever drop wire was used it was never cut to a length of less than 60 yd, and any surplus was neatly coiled. This ensured that the wire could be reused after recovery.

Most of the exhibitors arrived during the three days before the show and their telephones were fitted as they moved into, or as they erected, their stands. A sales representative was in attendance and took orders for any additions or alterations, which were carried out as they were received. Exhibitors rented a total of 183 exchange lines, one coin-box, one telex installation, and eight P.B.X.s; five permanent lines were rented by contractors and one P.B.X. and five coin-boxes by the R.A.S.E.; 14 private-circuit pairs were provided for B.B.C. and I.T.V. circuits, and eight service lines for the Post Office control caravan and liaison circuits for the outside broadcast services. In addition, 37 public telephone kiosks were erected.

During the show, a maintenance team was in attendance and quickly rectified the few minor faults that were reported. As it was known that the exhibitors would leave as soon as possible after the show closed, a sales representative visited each subscriber and enquired when service should cease.

From this information a recovery program was compiled, and two days after the show had ended the majority of the telephones had been recovered and most of the stands had gone.

P.E.S.

Home Counties Region

WOKING MOBILE NON-DIRECTOR RELIEF EXCHANGE

Woking is a rapidly-growing town on the borders of the London Telecommunications Region and the existing manual exchange, which is a C.B. 10 extended by C.B.1 suite to a multiple capacity of over 6,000 lines, is incapable of further extension and has been virtually a "closed" exchange for some months. A new automatic telephone exchange is now being built, but it was decided that the very large waiting list which would build up by January 1965, the anticipated opening date, could not be tolerated. The only practicable means of relief available was to use the new mobile non-director (N.D.) units then being produced, and three of these were earmarked for Woking.

The new mobile exchange, which was named "Mayford" after a district in Woking, was brought into use on 5 June 1963. The capacity of the exchange is 800 lines, and it is the largest mobile automatic telephone exchange yet provided by the British Post Office. It is contained in three trailer caravans, which weigh about seven tons each; two of the trailers are identical and contain the calling equipment, 1st selectors and final selectors, together with common equipment for 400 lines each, and the third trailer contains incoming 1st selectors, group selectors and junction relay-sets. Each trailer has its own self-contained power plant.

The trunking arrangements are flexible, and for Mayford exchange the available equipment in the tandem unit has been arranged to give a 5-digit numbering scheme so that the lines transferred or connected to the mobile exchange can be transferred to the new N.D. exchange later without a change of number. The scheme was originally designed for the ultimate use of a fourth trailer to give a total capacity of 1,200 lines, and the external cabling arrangements were based upon this assumption and also upon the need to provide the greatest flexibility in the use of the equipment. In order to relieve the manual exchange of some of its increasing traffic load, it was proposed to transfer some 300 existing subscribers to the new mobile exchange, and use the remaining capacity of 500 lines for growth.

A 600-pair cable serving the Mayford district of Woking was intercepted and additional relief cables were provided to selected cabinets. Since more than one mobile unit was involved, it was necessary to provide a hut in which all the cable terminations could be housed on a main distribution frame (M.D.F.). P.V.C. switchboard cable run in duct has been used for cabling between the M.D.F.s in the hut and the units, and where necessary, between the units themselves. Care has been taken to prevent the entry or collection of water in the duct.

Since the trailers are fitted with the new type of fuse mountings and no protectors are provided, pole-top protection has had to be provided in those cabinet areas transferred to the mobile exchange, and will have to be provided to individual subscribers in other parts of Woking connected to the new exchange via the M.D.F. of the old C.B. 10 exchange.

Coin-boxes could not be connected to the mobile exchange since there is no provision for a separate coin-box group, but it is understood that this is being provided in future mobile units.

E.J.M.

South Western Region

THE LANDING OF THE SHORE-END OF TAT-3 SUBMARINE CABLE AT WIDEMOUTH BAY

Early on the morning of Sunday, 26 May 1963, H.M.T.S. *Alert* of 6,413 tons, commanded by Captain J. P. Ruddock, slipped quietly to anchor half a mile off shore at Widemouth Bay, Cornwall, and preparations were begun for the laying of the shore-end of the new submarine telephone cable, TAT-3, which is being laid between this country and America.

The weather had not been exactly ideal over the previous few days, but the day broke fine with the prospect of a warm sunny day and calm sea, and with no visible portent of the usual westerly gales that make this coast notorious and dangerous for any seafarer caught on a lee shore. The promise of fine weather materialized and fortunately was maintained, but with it came the holiday makers and sightseers attracted by the sight of the *Alert* shining in the morning sun and the miscellany of Post Office lorries, excavators and gear drawn up on the Downs.

On the previous day, the local staff had streamed a buoy 100 yards out from the low-water mark and had anchored it with a 56 lb weight borrowed from a local shopkeeper. Low tide was at 2.30 p.m., but by 12.30 p.m. operations were well under way and a line attached to this buoy had been picked up by the ship's launch, and a heavier line attached, hauled in, and connected to a 4-ton heavy-duty winch located on the Downs adjacent to the beach manhole. The launch then returned to the *Alert,* and soon afterwards the cable could be seen running over the bow sheaves, with inflated balloons attached at 3-fathom intervals.

The heavy hawser was now made fast to the cable-end, which was pulled to the beach and there supported on pole bogies and cable rollers. Then, with the added assistance of a Fordson Major tractor, the cable was hauled up to the winch, a distance of some 460 yd from the low-water mark. A total of 30 pole bogies and 60 cable rollers were used to support the cable at regular intervals. The photograph shows the activity on the beach at this stage of the

By courtesy of Dempster's Studios, Bude.

HAULING ASHORE THE TAT-3 SUBMARINE CABLE AT WIDEMOUTH BAY, CORNWALL.

operation. During this period, two excavators were hard at work on the first 100 yards of beach from the Downs, and by 6.30 p.m. the cable was safely drawn-in to the beach manhole, the slack cut away and testing in progress to the far end coiled in the ship's tanks. During the following day, and subsequently when the tide and weather permitted, the remainder of the route across the beach was excavated and the cable buried.

Telephone communications during laying consisted of a ship-to-shore v.h.f. radio, a walkie-talkie for local operation on the beach, and a further link, via the local telephone network and the repeater station, to Ilfracombe radio station and the ship.

May 26, the day the shore-end was laid, will be long remembered as a most interesting and exciting job of work, which was successfully completed and which amply rewarded the 30 or so Area engineering staff and supervisors taking part, of whom quite a few had been drafted from Exeter at short notice. To the holiday makers this was an unexpected thrill and the local police coped bravely with the traffic congestion; as to the 56 lb weight, it was picked up and given a free return passage to America.

J.E.M.

HISTORIC ISLAND HAS TELEPHONE RESTORED

Brownsea Island in the confines of Poole Harbour, Dorset, has a chequered history. Known in the Doomsday Book as Bruno's Island, it has been owned by nobles, kings, abbots and private persons. These owners have used it for various purposes; for example, King Henry VIII used it for the defence of Poole town, its trade and its shipping, and in the mid-nineteenth century an attempt was made to establish a ceramics industry. Its population in 1881 was 270, and it was complete with its own church, castle, school, inn and railway. During the last war, it acted as an effective enemy aircraft decoy, and was also used to house Dutch refugees.

It is perhaps best remembered for its use by Lord Baden Powell who held the very first Boy Scout camp there in 1907.

Its monetary value increased from £2 11s. 11d. in 1293, and £13,000 in 1852, to £125,000 in 1927.

Its last single owner was Mrs. Bonham Christie who was a recluse and animal lover; she used the island as an animal and bird sanctuary, and had no telephone communications. She, however, died in 1961 at the age of 96, and the island is now National Trust property. The need to re-establish communications was fulfilled on 5 April 1963 when an officer of the Submarine Branch, Engineering Department, with the assistance of Area staff, laid a new 16-core submarine cable in under half an hour over the 0·328 nautical miles across the main shipping fairway. The photograph shows this operation being carried out. Service to the several telephones was established the same day.

LAYING THE SUBMARINE CABLE TO BROWNSEA ISLAND IN POOLE HARBOUR

The island was, appropriately enough, officially opened to the public by Lady Baden Powell on 16 May 1963.

O.P.M.

Associate Section Notes

Dundee Centre

At the annual general meeting of the Dundee Centre, held in April 1963, the following officers were elected: *Chairman:* Mr. R. L. Topping; *Vice-Chairman:* Mr. D. L. Miller; *Secretary:* Mr. R. T. Lumsden; *Treasurer:* Mr. R. B. Duncan; *Committee:* Messrs. G. Deuchars, B. D. Mackie, R. C. Smith, R. Fraser and A. S. Beattie.

The 1963–64 session begins on 21 September 1963 with a visit to Grampion Television in Aberdeen and the Girdleness Lighthouse.

Our membership continues to increase, and we hope this indicates that a greater interest is being taken in the activities of the Centre.

R.T.L.

Aberdeen Centre

On 27 April 1963, 45 of our members visited the Forth Road Bridge and were shown over the workings at North Queensferry. The party had lunch in Edinburgh, and, after touring the southern-approach road works to the new bridge, assembled at Dalmeny Railway Station to start the long walk across the railway bridge. This was a wonderful experience for all the members of the party and will be long remembered. The trip was filmed by Mr. J. Yule, one of our members, and the film will be shown at one of our meetings next session.

The thirtieth anniversary of the founding of our Centre occurred this year and a dinner was held in the Imperial Hotel to mark the occasion. Mr. R. C. Birnie, Telephone Manager, proposed a toast to the "Aberdeen Associate Centre," and Mr. Jas. McLeod, Area Engineer—a founder member of the Centre—replied to the toast of "The Guests."

30 June saw the members again on the road, when a trip to Pitt Street exchange, Glasgow, took place. The Glasgow Associate Centre very kindly provided guides and gave our party a comprehensive tour of this large building.

D.W.

Edinburgh Centre

The annual general meeting of the Edinburgh Centre was held at the Adelphi Hotel on Wednesday, 10 April 1963.

The Assistant Secretary reported that increases in attendances, though small, had been maintained throughout the session. All visits had been very well attended and the average attendance at meetings had been 22 members. The improvement in attendance figures was thought to be due to the fact that meetings were now held at the Cockburn Hotel, and also because of the introduction of a system whereby each member was given individual notification of the meetings.

The Treasurer's report stated that the financial situation was sound, and in closing called for an expression of appreciation for our ex-secretary, Mr. D. S. Henderson, who had recently been promoted to Assistant Engineer, for the excellent work carried out by him, and wished him well in his new post.

The following office bearers were then elected: *Chairman:* Mr. R. P. Donaldson; *Secretary:* Mr. J. M. Dixon; *Assistant Secretary:* Mr. T. W. Henderson; *Treasurer:* Mr. A. G. Gilmour; *Librarian:* Mr. H. Allan; *Committee:* Messrs. H. Philips, I. Barclay, I. Coghill, J. Duncan, D. Stenhouse and J. H. King.

Plans are well advanced for the new session ahead, and it is hoped that the varied program will be of interest to our members.

J.M.D.

London Centre

The March lecture was given by Mr. F. C. G. Greening, Main Lines Planning and Provision Branch, Engineering Department, who spoke on "The Inland Trunk Network." His schematic diagrams and easy method of describing the transit network and the types of system used made the evening an interesting one, and evoked many questions at the end.

A visit took place in March to the British Railways Electrical Control Room and Port Installations, Dover. About 30 members participated, and in their opinion it was one of the best visits ever organized.

The early death of Mr. H. A. M. Clark, of E.M.I., prevented members from meeting one of the foremost authorities in stereophonic sound reproduction. He was to have given the April talk and recital entitled "A Concert of Stereophonic Recordings." The program was given by Mr. R. Passerieux, an assistant to the late Mr. Clark, and was enjoyed by a large audience of members and friends in the Fleet Building Assembly Hall, where the acoustics gave a remarkably lifelike quality to the recordings.

Also in April, a visit took place to the Standard-Triumph motor-car factory at Coventry. It was marred by the coach bursting a tyre whilst travelling at speed along the A45, causing a delay. Nevertheless, we were able to make a complete tour of the Herald assembly line, and saw many interesting aspects of car production.

The session ended in May 1963 with a talk given by Mr. R. W. Palmer, the Principal of the Central Training School, Engineering Department. In his talk, entitled "The Future Post Office Technical Staff. What Does the Future Hold?," Mr. Palmer looked back over the 40 years of his service with the Department and compared techniques and qualifications with present-day conditions. He also speculated on the corresponding conditions which might be expected in the future, when the work of the new generation of telephone engineers is certain to change more rapidly in their lifetime than it had changed during the careers of those about to retire. Such changes arising from technical developments were discussed in relation to organization, technical qualifications and training of staff. Mr. Palmer also described the Post Office Engineering Training College that is to be built at Harlow and illustrated this part of his talk with a scale model.

The annual general meeting followed, when the officers of the London Centre Central Committee were re-elected *en bloc,* as follows: *Chairman:* Mr. A. G. Welling; *Vice-Chairman:* Mr. H. A. Horwood; *Secretary:* Mr. A. J. Dow; *Treasurer:* Mr. W. C. Peck; *Editor "London Centre Review":* Mr. E. S. Glynn; *Librarian and Technical Quiz Organizer:* Mr. G. S. Milne; *Assistant Secretary:* Mr. W. H. Upton; *Visits Secretary:* Mr. B. C. Hatch. Mr. F. C. G. Greening continues as the London Centre Liaison Officer.

The C. W. Brown Award for the 1962–63 session was presented to Mr. T. R. Richardson, the Watford Group Organizer of the North-West Area.

The 1963–64 session began on 4 September 1963 with a talk on "Communication Satellites" by Mr. V. C. Meller, Space Communication Systems Branch, Engineering Department.

Our program for the remainder of the Session will include talks on "Bank Contact Wear," "Harmstorf Flush Jet Bedding System for Cables," "Developments in Tape-Recording Techniques," "Highgate Wood Developments," "Telecommunications in Other Countries," "Colour Television Techniques" and "Aspects of Amateur Radio," and will end, in conjunction with the B.B.C., with a closed-circuit demonstration of colour television.

E.S.G.

Middlesbrough Centre

At the annual general meeting of the Middlesbrough Centre the following officers were elected: *Chairman:* Mr. N. Williams; *Secretary:* Mr. D. Campbell; *Treasurer:* Mr. K. Ashworth; *Librarian:* Mr. M. A. Landers; *Committee:* Messrs. H. Daggett, E. E. Sparkes, D. A. Pratt, J. Whittington and J. O'Connon.

The Centre is steadily increasing in membership and it is hoped to increase the facilities available to our members. A full program of visits and talks is being arranged for the coming session and an interesting and enjoyable session is anticipated.

D.C.

Bournemouth Centre

During this quarter, our membership has reached the record figure of 88.

On 4 June 1963, 28 of our members visited the Control Tower and the Southern Air Traffic Control Centre at London Airport. This was a very well conducted and highly interesting visit.

Our future program includes visits to a police driving school, the B.B.C. television centre and the Ford motor works at Dagenham.

A.E.A.B.

Bath Centre

During the winter, two meetings were held. At one of them, held in January 1963, the speaker was Mr. Moorland, a personnel officer of the South Western Gas Board (S.W.G.B.). His subject, "The Interview," dealt with methods used by the S.W.G.B. when selecting candidates for employment. This meeting was well attended considering the bad weather conditions prevailing at that time.

The first joint meeting of the Bristol and Bath Centres was held in February 1963. Members of the Bath Centre travelled to Bristol to attend a demonstration of hi-fi equipment. This provided an opportunity for members to enjoy the quality of first-class stereophonic sound reproduction and to renew contact with friends and colleagues of the Bristol Centre. It was a successful meeting, approximately 80 people being present, and will, no doubt, pave the way for further joint meetings of the Centres.

The annual general meeting was held on 24 March 1963 and the following officers were elected: *President:* Mr. C. L. Burgess, Area Engineer; *Chairman:* Mr. L. W. F. Vranch; *Vice-Chairman:* Mr. A. Arlett; *Treasurer:* Mr. R. P. Bowers; *Secretary:* Mr. R. R. Darke; *Assistant Secretary:* Mr. W. J. Rossiter; *Librarian:* Mr. R. D. Cowley; *Committee Members:* Messrs. Faulkner, Roberts, Jennings, Martin, P. Moxham, Silcox, R. K. Walk, and D. G. Rossiter; *Auditors:* Messrs. Steer and Willis.

It was with regret that the committee accepted the resignation of Mr. D. G. Rossiter from the secretaryship. He did much to maintain and improve the standard of activities at the Centre. We congratulate him on his promotion to Assistant Engineer.

The 1963–64 session opened in April 1963 with a very informative, introductory lecture on "Relativity." This was given by Mr. Smith, a member of the staff of the University of Bristol, who, over the years, has been a frequent visiting lecturer to the Centre. This lecture was extremely interesting and much enjoyed by members.

During May, a party of members visited the Esso Research Establishment at Abingdon. Since the visit to Abingdon was scheduled for the afternoon only, the morning was spent at Oxford, where members enjoyed a conducted tour of the colleges. At the Research Establishment, members were given a lecture on the part played by research in the petroleum industry, after which the party was conducted over the laboratories and the test section.

R.R.D.

Bristol Centre

The annual general meeting was held in May 1963 at the end of the Bristol Centre's first year of existence.

During the year, visits have been made to the St. Hilary Transmitter of I.T.A., The Pontcanna studios of T.W.W., Hinkley Point nuclear power station, British Railways diesel depot, and the Western Daily Press. One film show has been held, and, in conjunction with the Bath Centre, we had a very entertaining evening's demonstration of hi-fi equipment by the Bristol House of Sound. Unfortunately, one meeting, which promised to include a most unusual demonstration of glass-blowing, had to be cancelled owing to the bad weather. A few of our members attended a meeting given by Mullard, Ltd., in conjunction with the Radio Society of Great Britain and the Television Society, on modern problems of television and ultrasonics.

The circulating library of magazines is well under way, but a new method of distribution is to be introduced to speed up circulation.

Membership of the Centre is now 140—members leaving through promotion, transfer or resignation are requested to inform the Secretary to enable the records to be kept up to date.

The officers elected at the annual general meeting were as follows: *Chairman:* Mr. D. Berry; *Vice-Chairman:* Mr. A. Manley; *Secretary:* Mr. H. Punchard; *Treasurer:* Mr. C. Sage; *Committee Members:* Messrs. J. Trott, R. Crespin, R. Rundel, B. Body, D. Elkins and E. Ewers.

H.F.N.P.

Bishop's Stortford Centre

During the past few months, members have had the opportunity of visiting Vauxhall Motors at Luton, the P.O. Railway at Mount Pleasant, J. Lyons at Cadby Hall, Bowater's pulp and paper mill at Gravesend, and the Shell refinery at Shellhaven.

Our evening meetings suffered at the hands of the elements, but Mr. R. C. T. Warboys gave us a very interesting lecture entitled "The Solar System."

The annual dinner and dance was held on 9 March 1963. This was organized once again by our Chairman, Mr. R. C. Dayley, and proved to be a great success.

Our present membership stands at 75, but we are pleased to report a steady stream of applications to join.

D.J.S. and A.J.W.

Canterbury Centre

The annual general meeting and annual dinner of the Canterbury Centre was held on Friday, 10 May 1963 at the Abbots Barton Hotel. The following officers and members of the Committee were elected: *Chairman:* Mr. M. S. J. Green; *Vice-Chairman:* Mr. C. P. Cox; *Treasurer:* Mr. H. Shugrue; *Secretary:* Mr. H. J. Fulcher; *Assistant Secretary:* Mr. B. Clapson; *Canterbury Representatives:* Messrs. D. W. Wainwright and P. A. Croucher; *Thanet:* Messrs. B. Fletcher and P. L. Johnson; *Dover:* Mr. W. Gretton; *Ashford:* Mr. H. E. Pittock; *Tolsford:* Mr. J. Read.

The dinner was attended by approximately 80 members, senior members and guests. The speeches, as always, were brief and humorous. The guest speaker was Mr. F. C. G. Greening, Main Lines Planning and Provision Branch, Engineering Department, his subject being "The Developing Trunk Network." Guests present included Mr. R. V. Sanders, Regional Liaison Officer, and Messrs. S. T. E. Kent and G. F. Arnold, Area Engineers. Mr. C. W. A. Kent, Telephone Manager, presided.

B.C.

Bletchley Centre

Towards the end of March 1963, a few of our members, together with others from the Ipswich and Tunbridge Wells Centres, visited colleagues of the P.T.T. engineering staff at Dusseldorf. The party, headed by Senior Section members Mr. S. L. Freeman and Mr. Palin, travelled by air from Luton and, on arrival at Dusseldorf, were met by Herr Peetz, the Regional Engineer, and some of his staff who then conducted our party to the hotel. During the brief few days' visit, the party visited Telephone House, where the Chief Regional Director, Herr Wosnik, was presented with a scroll commemorating the occasion of the visit; the Town Hall, to meet the Bürgermaster; Duisburg harbour, followed by a cruise along the Rhine—with dinner aboard; a training school, planning group, repeater station and the continental exchange. The ladies of the party were taken on a tour of Cologne Cathedral. A coloured cine film has been taken of the visit and we hope to show this to members in the near future.

Our winter program finished with a talk by Mr. E. J. J. Hitchin, Engineering Branch, Home Counties Region, on S.T.D. development; this topical subject produced a barrage of questions. Afterwards, Mr. Sanders presented Mr. D. W. J. Smith with an Institution Certificate of Merit won in the 1962–63 essay competition.

In June, a visit was made to the Associated Television Studios at Boreham Wood. The party was conducted around the studios by the Deputy Technical Controller, Mr. Bernard Marsden, and the Senior Engineer, Mr. Robinson. The tour covered the rehearsal rooms, the control rooms, studios, and the carpenters' workshops, where scenery in various stages of construction was viewed with interest. The props store caused us to realize the vast problems of storing scenery for all types of studio settings. Outside-broadcast equipment, particularly the type used for the Palladium Sunday Night shows, was inspected in the motor-transport section. This was followed by a tour of the metal workshops where minor construction work for studio equipment is performed. The visit ended with lunch in the staff restaurant before the party proceeded to the Museum switching centre, where members were able to see the important part that the Post Office plays in providing the link between the private companies and the viewer. Although the Post Office Radio Tower is only half completed, our party was able to obtain a close view of it from the rooftop of Museum exchange.

We also had our second annual general meeting in June at the Swan Hotel, Fenny Stratford. The officers and committee for 1963–64 are as follows: *Chairman:* Mr. W. J. Allen; *Secretary:* Mr. A. J. Hudson; *Assistant Secretary:* Mr. C. Tooth; *Treasurer:* Mr. D. R. Castle; *Committee:* Messrs. P. B. King, A. F. Coates, D. W. J. Smith, R. H. Stanesby, J. Vickers, M. Walduck and G. J. Brown; *Auditors:* Messrs. F. H. Daniels and D. G. Atkins. The meeting was supported by films, on winter sport and autumn cruising, for which we are greatly indebted to Mr. Flintham of Gateway Tours, Aylesbury.

Our winter program has now been prepared. On 16 September 1963 there was a technical film show, and on 6 April 1964 there will be a talk on the new speaking clock by Mr. J. H. Gee and Mr. R. K. Walker of the Telephone Exchange Standards and Maintenance Branch, and Research Branch, Engineering Department, respectively.

A.J.H.

Staff Changes

Promotions

Name	Region, etc.	Date
Staff Engineer to Deputy Director		
Leigh, H.	E.T.E.	23.5.63
Assistant Staff Engineer to Staff Engineer		
Maddison, W. H.	E.-in-C.O.	1.8.63
Barker, H.	E.-in-C.O.	1.8.63
Watt-Carter, D. E.	E.-in-C.O.	1.8.63
Assistant Staff Engineer to Chief Regional Engineer		
Blair, D. C.	E.-in-C.O. to W.B.C.	5.6.63
Regional Engineer to Chief Regional Engineer		
Nicholls, C. A. L.	S.W.Reg.	19.7.63
Coleman, W. L. A.	Mid. Reg.	22.9.63
Power Engineer to Assistant Staff Engineer		
Harris, D. J.	H.C. Reg. to Joint P.O./M.P.B.W. R. & D.G.	4.6.63
Senior Executive Engineer to Assistant Staff Engineer		
Clinch, C. E. E.	E.-in-C.O.	6.5.63
Frost, A. C.	E.-in-C.O.	13.5.63
May, C. A. M.	E.-in-C.O.	13.5.63
Nicholson. T.	E.-in-C.O.	25.6.63
Senior Executive Engineer to Chief Factory Engineer		
Croisdale, A. C.	E.-in-C.O. to Factories Dept.	1.4.63
Area Engineer to Telephone Manager		
Gandon, N.	W.B.C. to Mid. Reg.	4.6.63
Senior Executive Engineer to Telephone Manager		
Warnock, W. T.	E.-in-C.O. to H.C. Reg.	20.5.63
Executive Engineer to Area Engineer		
Burgess, C. L.	S.W. Reg.	9.5.63
Executive Engineer to Senior Executive Engineer		
Cridlan, D. E.	E.-in-C.O.	16.4.63
Phillips, B.	E.-in-C.O.	4.4.63
Spratt, C. J.	E.-in-C.O.	4.4.63
Munday, S.	E.-in-C.O.	4.4.63
Crank, G. J.	E.-in-C.O.	16.4.63
Rae, J. D.	E.-in-C.O. to L.T. Reg.	22.4.63
Ellis, W. A.	E.-in-C.O.	27.5.63
Andrews, J. D.	E.-in-C.O.	28.5.63
Northall, B. V.	E.-in-C.O.	28.5.63
Tridgell, R. H.	E.-in-C.O.	10.6.63
Kirtland, J. P.	E.-in-C.O.	14.6.63
Executive Engineer (Open Competition)		
East, D. W.	E.-in-C.O.	21.2.63
Morris, W. A.	E.-in-C.O.	2.4.63
Vinter, N. G.	E.-in-C.O.	27.5.63
Executive Engineer (Limited Competition)		
Tavener, A.	E.-in-C.O.	29.4.63
Charmer, F. W.	N.W. Reg.	29.4.63
Foster, S.	E.-in-C.O.	29.4.63
Fenning, J. C.	E.-in-C.O.	29.4.63
Robb, J. W.	E.-in-C.O. to Scot.	29.4.63
Elliott, B. A.	E.-in-C.O.	13.5.63
Larrett, A. D.	H.C. Reg. to L.T. Reg.	6.5.63
Soar, A.	E.-in-C.O.	29.4.63
Davies, G. T.	E.-in-C.O.	29.4.63
McKay, N. P.	E.-in-C.O.	29.4.63
Orbell, A. G.	E.-in-C.O.	29.4.63
Kerr, A. S. H.	Scot. to E.-in-C.O.	29.4.63
Rogers, J. D.	E.-in-C.O.	29.4.63
Executive Engineer (Limited Competition)—continued		
Richardson, F. S.	E.-in-C.O.	29.4.63
Sharp, J. E.	N.E. Reg.	29.4.63
Pinnock, D. C.	E.-in-C.O.	29.4.63
Nightingale, C. R.	E.-in-C.O.	29.4.63
Hudson, H.	E.-in-C.O.	29.4.63
Duffy, P. S. J.	E.-in-C.O.	6.5.63
Hubble, R. A.	E.-in-C.O.	29.4.63
Murray, J. I.	Scot. to E.-in-C.O.	29.4.63
Trumper, J. W.	E.-in-C.O.	29.4.63
Hughes, A. D.	E.T.E. to E.-in-C.O.	29.4.63
Longbottom, R.	E.-in-C.O.	29.4.63
Harcourt, E. N.	H.C. Reg. to E.-in-C.O.	29.4.63
Walkden, M. R.	E.-in-C.O.	13.5.63
Wilkinson, K.	E.-in-C.O.	29.4.63
Crossley, M. D.	E.-in-C.O.	29.4.63
Burton, W.	N.I. to E.-in-C.O.	29.4.63
Thomas, F. D.	N.W. Reg.	1.5.63
Assistant Engineer to Executive Engineer		
Gee, J. A.	E.-in-C.O.	22.4.63
Tait, J. M.	Scot.	4.3.63
Batchelor, H. R.	L.T. Reg.	29.3.63
Lawrence, J. P.	E.-in-C.O.	1.4.63
Murrey, W. J.	E.-in-C.O.	9.4.63
Smith, P. W.	E.-in-C.O.	25.4.63
Austin, D. N.	E.-in-C.O.	25.4.63
Embling, F. D. W.	S.W. Reg. to Scot.	20.5.63
Hustler, R. H.	E.T.E.	1.5.63
Jackson, B. D.	E.T.E.	1.5.63
Smith, H. V.	W.B.C. to E.-in-C.O.	24.5.63
Bell, J.	N.E. Reg.	12.6.63
Chamberlain, H.	N.W. Reg.	17.6.63
Wiltshire, P. L. R.	S.W. Reg.	18.6.63
Inspector to Assistant Engineer		
Rees, T. H.	Mid. Reg.	15.2.63
Robertson, W.	Scot.	18.3.63
Warren, D. C.	H.C. Reg.	8.4.63
Cockburn, W. J.	S.W. Reg.	25.3.63
Lassey, S.	N.E. Reg.	25.4.63
Chappell, B. W.	W.B.C.	1.5.63
Rigglesford, N. W. A.	Mid. Reg.	16.5.63
Moorhouse, J.	N.W. Reg.	24.5.63
Illingworth, J. D.	N.E. Reg.	27.5.63
Pasco, M. J.	S.W. Reg.	3.5.63
Kennedy, F. B.	N.W. Reg.	10.6.63
Teague, T. L.	S.W. Reg.	5.6.63
Morgan, H. J.	L.T. Reg.	21.6.63
Technical Officer to Assistant Engineer		
Wright, N. L.	Mid. Reg.	12.2.63
Thorpe, W. N.	Mid. Reg.	12.2.63
Hunt, F. G.	Mid. Reg.	12.2.63
Wright, E.	Mid. Reg.	12.2.63
Duerden, R.	N.W. Reg.	3.4.63
Martin, C. E.	S.W. Reg.	3.4.63
Renaud, J. D.	Mid. Reg.	8.2.63
Towers, K. A.	Mid. Reg.	8.2.63
Wilkins, D. A.	Mid. Reg.	8.2.63
Hall, E. R.	Mid. Reg.	8.2.63
Coleman, D.	Mid. Reg.	15.3.63
Davis, A. D.	Mid. Reg.	8.2.63
Pritchard, G. E.	Mid. Reg.	8.2.63
Morrey, W. G.	Mid. Reg.	15.3.63
Brooks, G.	Mid. Reg.	8.2.63
Colbourne, D. H.	Mid. Reg.	8.2.63
Tuck, D. G.	Mid. Reg.	8.2.63
Bickley, S. J.	Mid. Reg.	8.2.63
Pearce, H. N.	Mid. Reg.	8.2.63
Cadle, G. E.	H.C. Reg.	1.4.63
Frew, J. D.	H.C. Reg.	1.4.63
Cripps, N. J.	H.C. Reg.	25.3.63
Marsh, J.	L.T. Reg.	8.4.63

Technical Officer to Assistant Engineer—continued

Name	Region, etc.	Date
Sneddon, T. T.	Scot.	18.3.63
Pope, D. A.	Mid. Reg.	15.3.63
Watley, I. C.	Mid. Reg.	15.3.63
Henderson, D. S.	Scot.	18.3.63
Speed, D. J.	Mid. Reg.	15.3.63
Parsons, J. N.	S.W. Reg.	16.4.63
Francis, M. J.	H.C. Reg.	8.4.63
Hatton, N. F.	S.W. Reg.	25.3.63
Roberts, B. E.	H.C. Reg.	8.4.63
Dewhurst, J.	N.W. Reg.	1.4.63
Perowne, B. G.	H.C. Reg.	9.4.63
Mitchell, J. S. D.	Scot.	10.4.63
Pye, R. J.	E.-in-C.O.	16.4.63
Walker, A.	Mid. Reg.	23.4.63
Lynch, E.	N.W. Reg.	25.4.63
Smart, P. C.	Mid. Reg.	23.4.63
Willetts, N. T.	Mid. Reg.	23.4.63
Chilton, K. W.	Mid. Reg.	23.4.63
Retallack, L. A.	S.W. Reg.	19.4.63
Berry, W. C.	W.B.C.	24.4.63
Henderson, T. G.	N.E. Reg.	25.4.63
Newton, F.	N.E. Reg.	25.4.63
Kirkby, W.	N.E. Reg.	25.4.63
Fuller, J. H.	Scot.	11.4.63
Thorpe, H.	Mid. Reg.	17.5.63
Davies, J. C.	W.B.C.	30.4.63
Hendy, M. W.	L.T. Reg.	29.4.63
Henley, K. J.	L.T. Reg.	15.5.63
Briggs, J.	H.C. Reg.	15.5.63
Trawford, V. H.	Mid. Reg.	16.5.63
Finch, P. R.	H.C. Reg.	8.5.63
Hey, G. P.	N.E. Reg.	27.5.63
Price, J. C.	W.B.C.	20.5.63
Sullivan, S. R.	E.-in-C.O.	17.5.63
Pickering, E.	N.W. Reg.	24.5.63
Robinson, J. A.	N.W. Reg.	6.5.63
Bedworth, L. A.	N.W. Reg.	17.6.63
Boffey, J. A.	Mid. Reg.	31.5.63
Edington, D. G. B.	Scot.	17.6.63
Wilson, E.	Mid. Reg.	24.6.63
Young, J.	Scot.	4.6.63
Mercer, W.	Scot.	17.6.63
Walker, T.	Scot.	4.6.63
Withers, R. S.	Scot.	4.6.63
Smith, W. L.	Scot.	10.6.63
Smith, A. R.	Scot.	4.6.63
Wicks, M. S. P.	H.C. Reg.	7.6.63
Barnard, J. R.	H.C. Reg.	7.6.63
Liptrot, R. A.	N.W. Reg.	10.6.63
Smith, S. P.	E.-in-C.O.	20.6.63
Austin, C. J.	L.T. Reg. to E.-in-C.O.	28.6.63
Adams, D. C. R.	Mid. Reg.	24.6.63
Akehurst, G. A.	S.W. Reg.	21.6.63
Piper, W. A. C.	L.T. Reg.	21.6.63
Crossfield, H. C.	L.T. Reg.	21.6.63
Driver, J. R.	L.T. Reg.	21.6.63
Burchell, K. M.	L.T. Reg.	21.6.63
Rainford, L. J.	L.T. Reg.	21.6.63
Ashford, C.	L.T. Reg.	21.6.63
Smyth, D. R.	L.T. Reg.	21.6.63

Draughtsman to Assistant Engineer

Name	Region, etc.	Date
Barton, D. S.	E.-in-C.O.	13.5.63

Technical Officer to Inspector

Name	Region, etc.	Date
Koughan, E. D.	H.C. Reg.	8.4.63
Burrows, R.	H.C. Reg.	8.4.63
Snow, W. E.	H.C. Reg.	9.4.63
Rowland, D. D.	H.C. Reg.	13.5.63
Gibb, A. C.	Scot.	6.5.63
Rutherford, A. C.	Scot.	6.5.63
Christie, W.	N.W. Reg.	29.5.63
Mizen, A. E.	S.W. Reg.	24.5.63
Giles, S. C.	S.W. Reg.	24.5.63
Burton, J. F.	S.W. Reg.	24.5.63

Technical Officer to Inspector—continued

Name	Region, etc.	Date
Carter, R. A.	H.C. Reg.	30.5.63
Wills, R. H.	H.C. Reg.	8.5.63
Vickery, M. E.	H.C. Reg.	4.6.63
Clarke, T. A. D.	H.C. Reg.	7.6.63
Price, F. J.	L.T. Reg.	21.6.63
Robinson, W. C.	N.I.	26.6.63

Technician I to Inspector

Name	Region, etc.	Date
Elliott, A. L.	Mid. Reg.	1.4.63
Burton, J. R.	Mid. Reg.	2.4.63
Rolf, B.	N.W. Reg.	24.4.63
Murphy, F.	N.W. Reg.	1.4.63
Murphy, J. F.	N.W. Reg.	24.4.63
Albins, J. N.	H.C. Reg.	9.4.63
Taylor, G. W.	H.C. Reg.	9.4.63
Moody, T. A.	N.W. Reg.	25.4.63
King, I. L.	Mid. Reg.	7.5.63
Halpin, T.	N.W. Reg.	22.5.63
Jones, H.	N.W. Reg.	23.5.63
Pickford, B. B.	N.W. Reg.	9.5.63
Browne, J. L.	Mid. Reg.	16.5.63
Hurst, E. J.	N.E. Reg.	27.5.63
Newhall, J. F.	N.W. Reg.	5.6.63
Wyrill, J. J.	N.E. Reg.	10.6.63
Robinson, H. M.	N.E. Reg.	10.6.63
Henaghan, M.	Mid. Reg.	17.6.63
Price, C.	Mid. Reg.	30.5.63
Ross, W. M.	Scot.	17.6.63
Edwards, R. G.	L.T. Reg.	21.6.63

Senior Scientific Officer to Principal Scientific Officer

Name	Region, etc.	Date
Faktor, M. M.	E.-in-C.O.	6.5.63

Senior Scientific Officer (Open Competition)

Name	Region, etc.	Date
Bingham, J. A. C.	E.-in-C.O.	29.4.63
Young, M. A.	E.-in-C.O.	6.5.63

Senior Assistant (Scientific) to Experimental Officer

Name	Region, etc.	Date
Batey, H.	E.-in-C.O.	31.5.63

Assistant Experimental Officer to Experimental Officer

Name	Region, etc.	Date
Levett, A. L.	E.-in-C.O.	20.3.63
Cross, A. C.	E.-in-C.O.	20.3.63

Assistant Experimental Officer (Open Competition)

Name	Region, etc.	Date
Penge, O. C.	E.-in-C.O.	10.4.63

Assistant (Scientific) (Open Competition)

Name	Region, etc.	Date
Upton, C. P. (Miss)	E.-in-C.O.	16.4.63

Technical Assistant to Assistant Regional Motor Transport Officer

Name	Region, etc.	Date
Pickles, A.	London Reg.	31.5.63
Hare, L. V.	H.C. Reg. to N.I.	31.5.63

Technical Assistant to Motor Transport Officer III

Name	Region, etc.	Date
Kirby, J. W.	London Reg. to E.-in-C.O.	31.5.63

Leading Draughtsman to Senior Draughtsman

Name	Region, etc.	Date
Cradduck, F.	H.C. Reg.	17.4.63

Draughtsman to Leading Draughtsman

Name	Region, etc.	Date
Evans, C. I.	W.B.C.	25.4.63
Davenport, J. A.	L.T. Reg.	25.4.63
Barnet, G.	Scot.	25.4.63
Hill, J. F. B.	E.-in-C.O.	25.4.63
Edwards, D. T.	W.B.C. to H.C. Reg.	25.4.63
Gilbert, T. P.	E.-in-C.O.	25.4.63
Martin, J. W.	E.-in-C.O.	25.4.63
Beddoe, V.	E.-in-C.O.	25.4.63
Clarke, D. E.	L.T. Reg.	25.4.63
Sillick, S. J.	E.-in-C.O.	25.4.63

Promotions—*continued*

Name	Region, etc.	Date
Draughtsman to Leading Draughtsman—continued		
Jones, E. E.	W.B.C. to N.W. Reg.	9.4.63
Metcalf, B.	N.W. Reg.	9.4.63
Carne, A. D.	N.I. to N.W. Reg.	9.4.63
Higher Executive Officer to Senior Executive Officer		
Merrony, A. E.	E.-in-C.O.	25.6.63
Executive Officer to Higher Executive Officer		
Farr, B.	E.-in-C.O.	20.5.63
Samuels, R. V.	E.-in-C.O.	25.6.63
Clerical Officer to Executive Officer		
Short, J. E.	E.-in-C.O.	1.4.63
Grimmett, B.	E.-in-C.O.	21.6.63
Markwell, T. E.	E.-in-C.O.	24.6.63

Retirements and Resignations

Name	Region, etc.	Date
Chief Regional Engineer		
Barker, P. L.	W.B.C.	3.6.63
Moffatt, C. E.	S.W. Reg.	18.7.63
Tolley, L. L.	Mid. Reg.	20.9.63
Staff Engineer		
Carter, F. C.	E.-in-C.O.	31.7.63
Stratton, J.	E.-in-C.O.	31.7.63
Regional Engineer		
Ackerman, H. M. W.	L.T. Reg.	31.5.63
Senior Executive Engineer		
Beck, E. H. A.	E.-in-C.O.	7.4.63
Lash, A. R.	E.T.E.	12.5.63
Executive Engineer		
Powell, J. E. H.	L.T. Reg.	9.3.63
King, A.	Scot.	17.3.63
Gill, E. S. A.	E.-in-C.O.	25.4.63
Woolford, S. W.	E.T.E.	30.4.63
McLean, J. C.	L.P. Reg.	8.3.63
Shepherd, C.	Mid. Reg.	31.5.63
Coldrick, E. A. (*Resigned*)	E.-in-C.O.	31.5.63
Knight, R. A. (*Resigned*)	E.-in-C.O.	31.5.63
Armistead, N. C.	E.-in-C.O.	11.6.63
Carter, R. E.	E.-in-C.O.	15.6.63
Abel, G. P.	W.B.C.	8.6.63
Moore, H. C.	N.W. Reg.	29.6.63
Assistant Engineer		
Hay, M.	E.-in-C.O.	3.4.63
Whalley, J.	N.W. Reg.	7.4.63
North, J. W.	E.-in-C.O.	8.4.63
Butterley, C. J.	N.W. Reg.	8.4.63
Henderson, V. R.	E.-in-C.O.	23.4.63
Hoff, R. F. (*Resigned*)	H.C. Reg.	19.4.63
Curron, D. A. (*Resigned*)	E.-in-C.O.	30.4.63
Harding, W. G.	S.W. Reg.	6.3.63
Keast, N. C.	S.W. Reg.	1.5.63
Coton, W.	Mid. Reg.	8.5.63
Ogle, T.	N.I.	18.5.63
Evans, E. G. P.	Mid. Reg.	21.5.63
Erratt, R. S.	Mid. Reg.	1.6.63
McWhirter, R. W.	N.I.	4.6.63
Assistant Engineer—continued		
Yates, J. J.	N.W. Reg.	8.6.63
Hartup, R. F.	Mid. Reg.	11.6.63
Pritchard, G.	N.W. Reg.	16.6.63
Mercer, A. E.	L.T. Reg.	19.6.63
McLean, K. B.	Scot.	21.6.63
Stenton, H.	L.T. Reg.	22.6.63
Eason, F. E.	L.T. Reg.	27.6.63
Hiscocks, W. I.	N.I.	30.6.63
Buick, R. P. (*Resigned*)	E.-in-C.O.	14.6.63
Medland, J. R. B. (*Resigned*)	Mid. Reg.	17.6.63
Inspector		
Biles, A. H.	N.W. Reg.	1.4.63
Heaton, L.	N.W. Reg.	23.4.63
Ashcroft, J.	N.W. Reg.	23.4.63
Kennedy, W.	N.E. Reg.	28.4.63
Ashton, J.	N.W. Reg.	30.4.63
Geary, E. W.	L.T. Reg.	11.5.63
Hendry, A. K.	Scot.	27.5.63
Rayner, D. A. (*Resigned*)	L.T. Reg.	10.5.63
Warne, G. R. (*Resigned*)	Mid. Reg.	30.5.63
Lindsey, E. W.	S.W. Reg.	31.5.63
Holliday, F.	L.T. Reg.	21.6.63
Jones, J. O.	W.B.C.	28.6.63
Dunne, L. H. D.	L.T. Reg.	28.6.63
Annesley, R.	L.T. Reg.	30.6.63
Hampton, J. H. (*Resigned*)	Mid. Reg.	3.6.63
Experimental Officer		
Jackson, C. A. (*Resigned*)	E.-in-C.O.	7.5.63
Assistant Experimental Officer		
Dack, R. N. (*Resigned*)	E.-in-C.O.	3.5.63
Senior Draughtsman		
Cooke, F. O.	H.C. Reg.	31.3.63
Senior Executive Officer		
Wilkinson, F. W.	E.-in-C.O.	9.4.63
Duncan, W. B.	E.-in-C.O.	22.5.63
Executive Officer		
Watling, L. F.	E.-in-C.O.	31.3.63

Transfers

Name	Region, etc.	Date
Assistant Staff Engineer		
Laver, F. J. M.	E.-in-C.O. to Treasury	17.4.63
Rees, T. J.	E.-in-C.O. to L.T. Reg.	10.6.63
Senior Executive Engineer		
Forster, A. E. T.	E.-in-C.O. to S.H.A.P.E.	11.6.63
Executive Engineer		
Hambrook, L. G.	E.-in-C.O. to Ministry of Power	10.6.63
Bishop, G.	E.-in-C.O. to Malaya	10.6.63
Beckley, D. J.	Scot. to S.H.A.P.E.	24.6.63

Transfers—*continued*

Name	Region, etc.	Date
Assistant Engineer		
Lovering, R. T.	E.-in-C.O. to Gambia	21.4.63
Hince, E. W.	E.-in-C.O. to N.W. Reg.	6.5.63
Favre, R. A.	E.-in-C.O. to Ministry of Aviation	5.6.63
Assistant Engineer—continued		
Snell, B. F. P.	E.-in-C.O. to S.W. Reg.	27.5.63
Assistant Regional Motor Transport Officer		
Fossey, G. H.	London Reg. to H.C. Reg.	27.5.63

Deaths

Name	Region, etc.	Date
Executive Engineer		
Hawkins, N. V.	Mid. Reg.	10.6.63
Dorn, F. C.	E.T.E.	30.5.63
Cadman, P. T.	W.B.C.	23.6.63
Assistant Engineer		
Willson, A. H.	E.-in-C.O.	25.4.63
Cotterell, F. W.	E.-in-C.O.	29.4.63
Sell, L. S.	L.T. Reg.	18.5.63
Kirtlan, J.	N.W. Reg.	16.6.63
Inspector		
Staples, E.	Mid. Reg.	18.4.63
Davis, L. V.	S.W. Reg.	31.5.63
Ellis, F.	N.W. Reg.	5.6.63
Senior Draughtsman		
Harding, J. F.	E.-in-C.O.	7.5.63
Executive Officer		
Fisher, M. E. (Mrs.)	E.-in-C.O.	11.6.63

Book Received

"Systematic Slide Rule Technique." R. K. Allan, A.M.I.Mech.E., M.I.P.E. Sir Isaac Pitman & Sons, Ltd. viii + 126 pp. 66 ill. 27s. 6d.

In his preface to the book the author writes that "this book has its origin in the belief that prospective users prefer to know the reasons why the slide rule is so effective in performing complicated calculations, rather than to learn by rote how to achieve these results." With this objective the author has given a description of the theory and practice of all the important aspects of the logarithmic slide rule, with the salient features classified and grouped in a manner designed to assist the student to grasp the underlying principles.

The book, which includes a very brief historical note, covers nomenclature, definitions, basic equations, and the description and derivation of over 50 different scales, from the basic decade scale to the log-log and hyperbolic scales. The treatment is such that it applies to all kinds of slide rule, logarithmic or otherwise, including those designed to suit particular formula.

Subscriptions and Back Numbers

The Journal is published quarterly, in April, July, October and January, price 2s. 6d. (3s. 6d. post paid) per copy or 14s. per year post paid (2 dollars 25 cents, Canada and U.S.A.). Back numbers will be supplied, if available, price 2s. 6d. (3s. 6d. post paid) per copy. With the exception of April and July 1961 Journals, copies of the January 1963 and all earlier Journals are no longer available. Orders should be sent to *The Post Office Electrical Engineers' Journal*, G.P.O., 2–12 Gresham Street, London, E.C.2.

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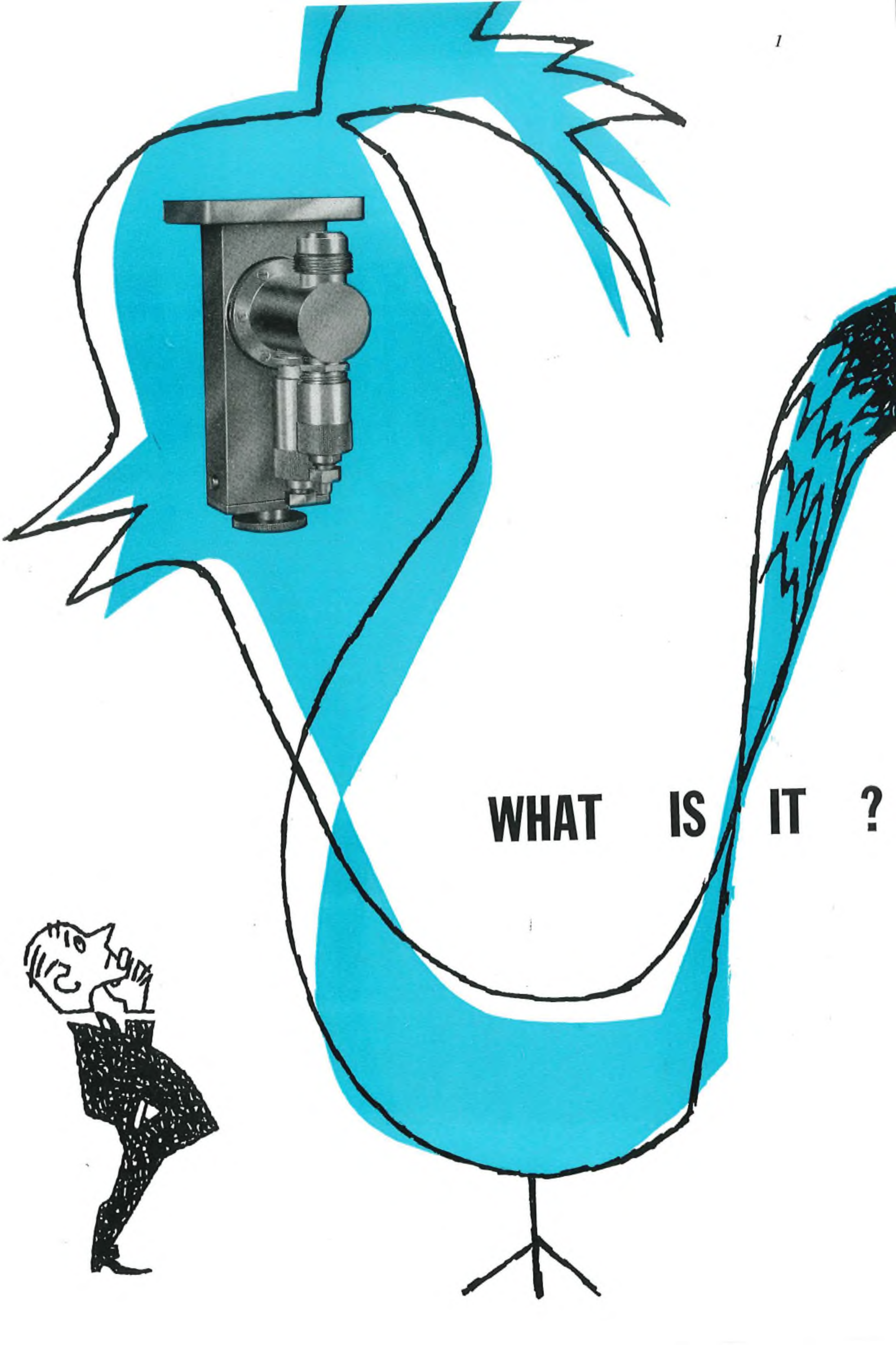
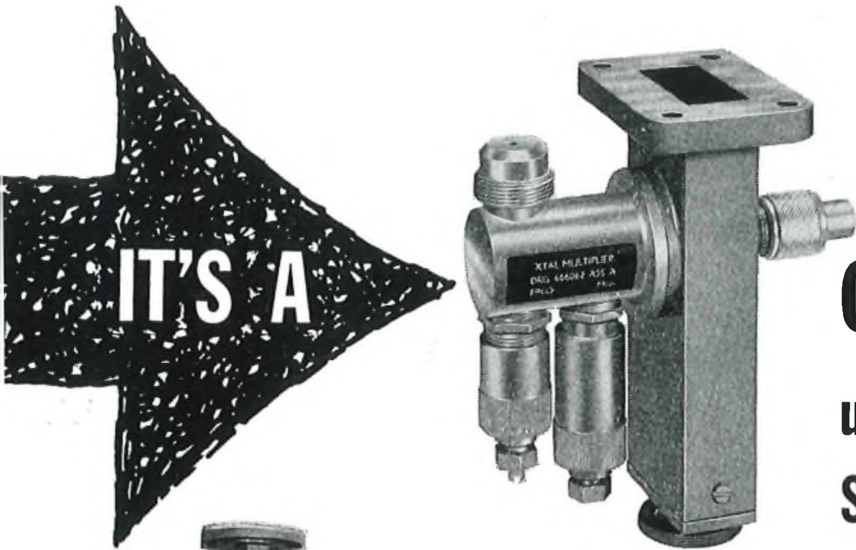
Model Answer Books

Books of model answers to certain of the City and Guilds of London Institute examinations in telecommunications are published by the Board of Editors. Details of the books available are given at the end of the Supplement to the Journal.


WHAT IS IT ?



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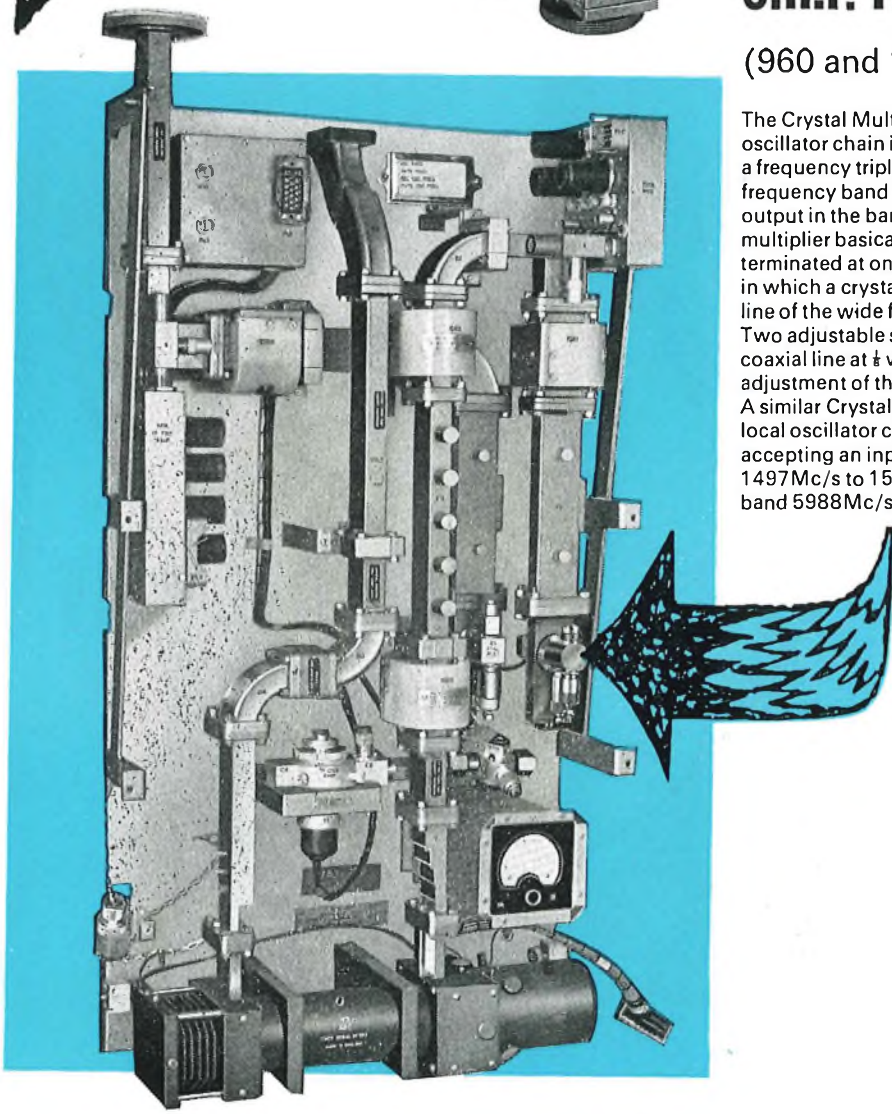
used in the G.E.C. S.H.F. Transmitter/Receiver

(960 and 1800 channel versions)



The Crystal Multiplier is part of the local oscillator chain in the S.H.F. transmitter. It operates as a frequency tripler, accepting an input in the frequency band 1996Mc/s to 2121Mc/s and providing an output in the band 5988Mc/s to 6363Mc/s. The multiplier basically consists of a short length of waveguide, terminated at one end by a variable short circuit, in which a crystal diode is coaxially mounted on the centre line of the wide faces of the waveguide.
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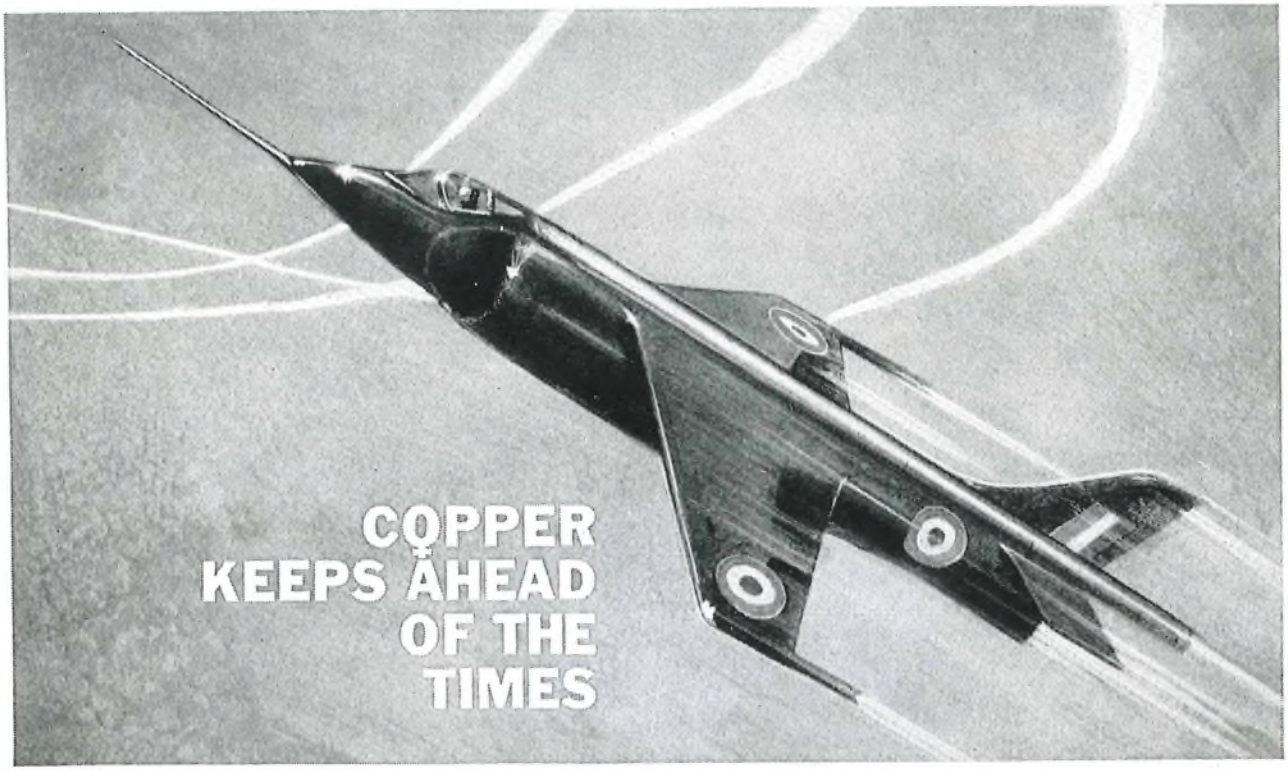

Whenever an idea is born technology calls more and more for improved materials. Copper and its alloys are playing an increasingly large part in bringing these ideas to fruition. In supersonic aircraft for instance, the commutators at the heart of their electrical systems get hotter as conditions become more exacting. Here Zirconium copper (0.12% zirconium) gives efficient electrical conductivity at temperatures that would break down other conductors. Back on the ground Chromium copper (1% chromium) is used in resistance welding electrodes and for electrical switchgear. Electric trains, too, have power supplied through cadmium copper (1% cadmium) catenary and contact rails.

Why can copper alloys be used so effectively? Because copper itself is still the most efficient and economical conductor of electricity. Alloyed with minute quantities of other metals, copper gains additional properties. Zirconium, for instance, raises the safe operating temperature of copper. Tellurium copper (1% tellurium) and sulphur copper (0.3% sulphur) both improve copper's machinability.

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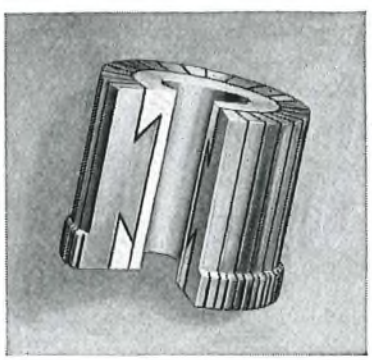
Zirconium copper is used in the construction of commutators in the latest electrical generators.



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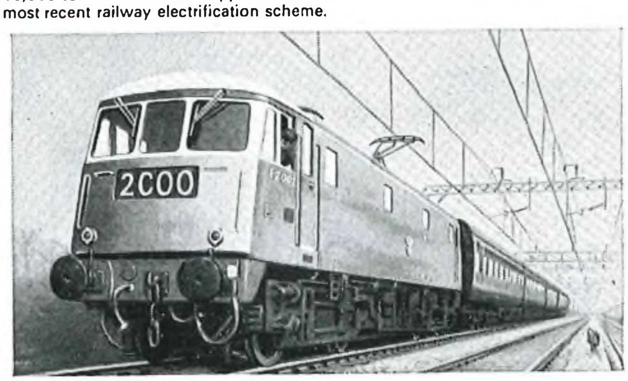

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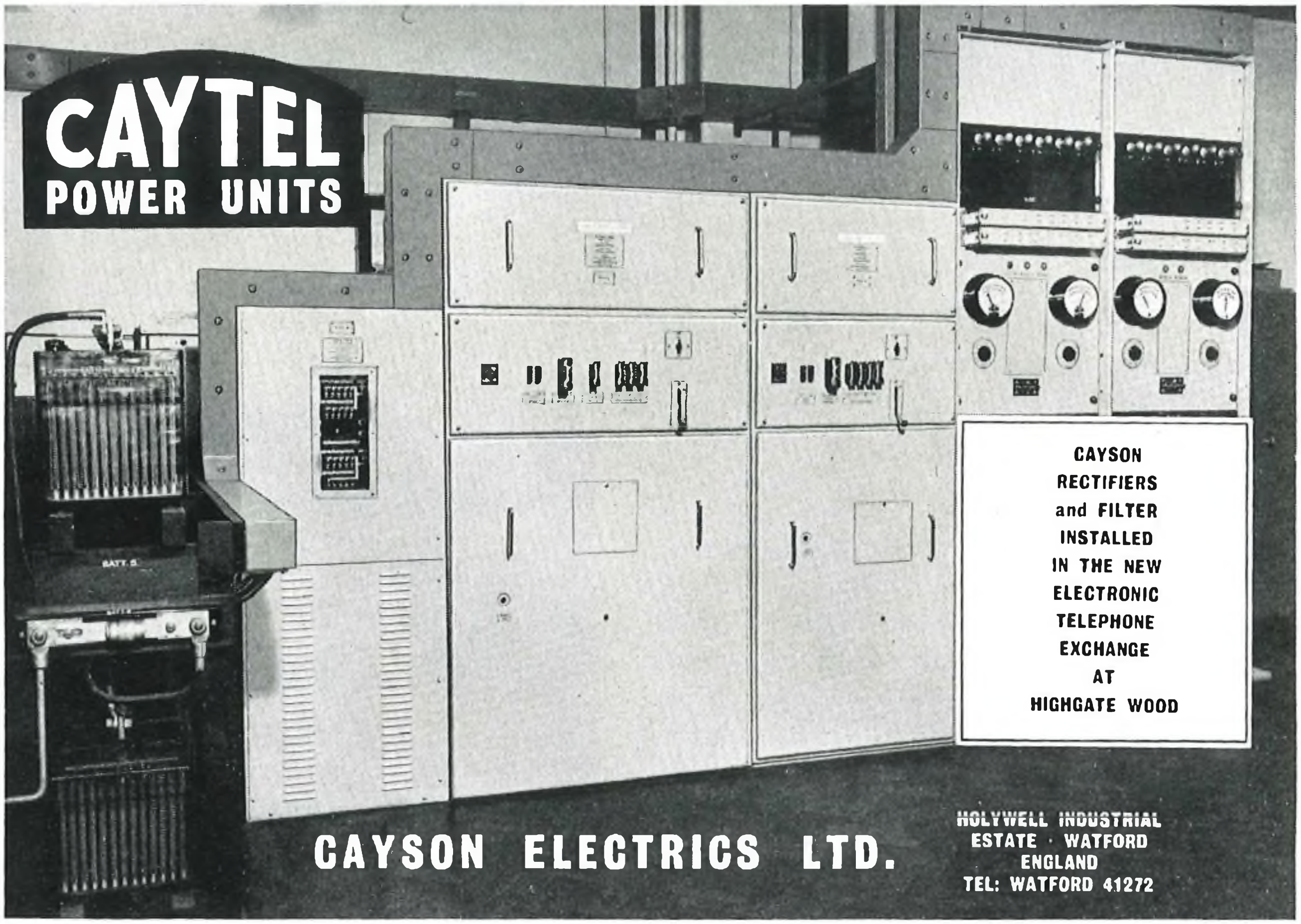
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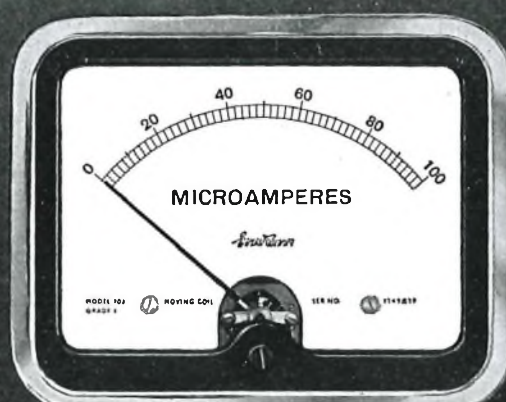
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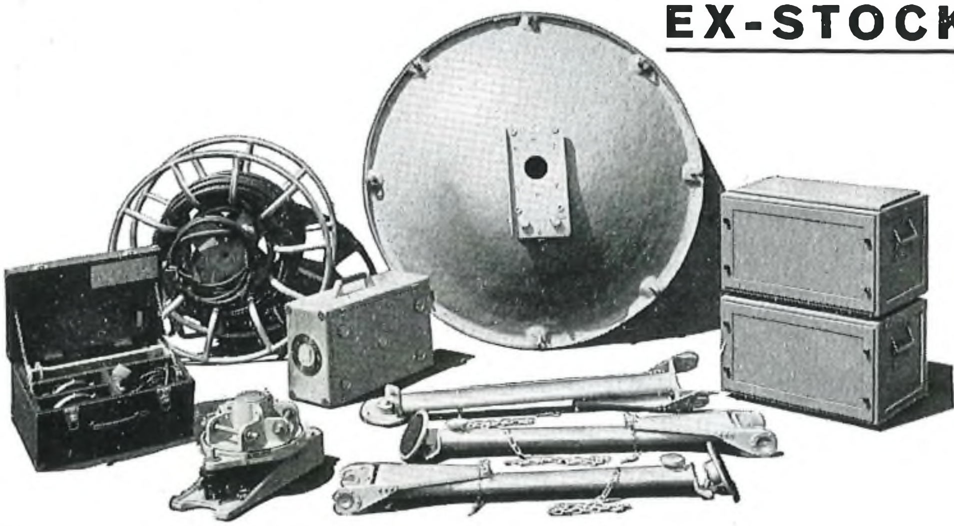

Receive terminal disassembled into its component parts for transport.

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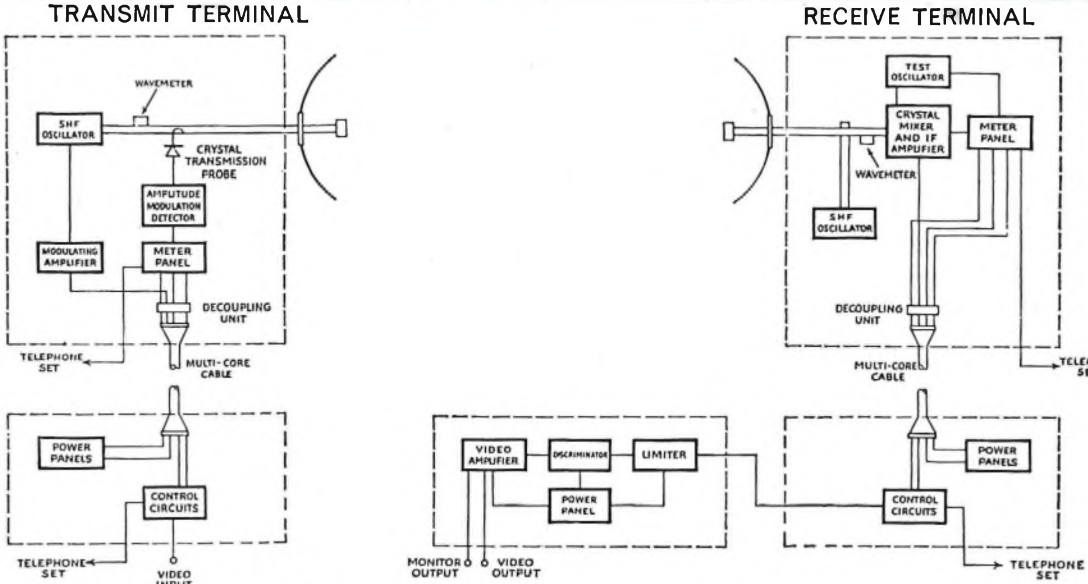

Block schematic of transmit and receive terminals.

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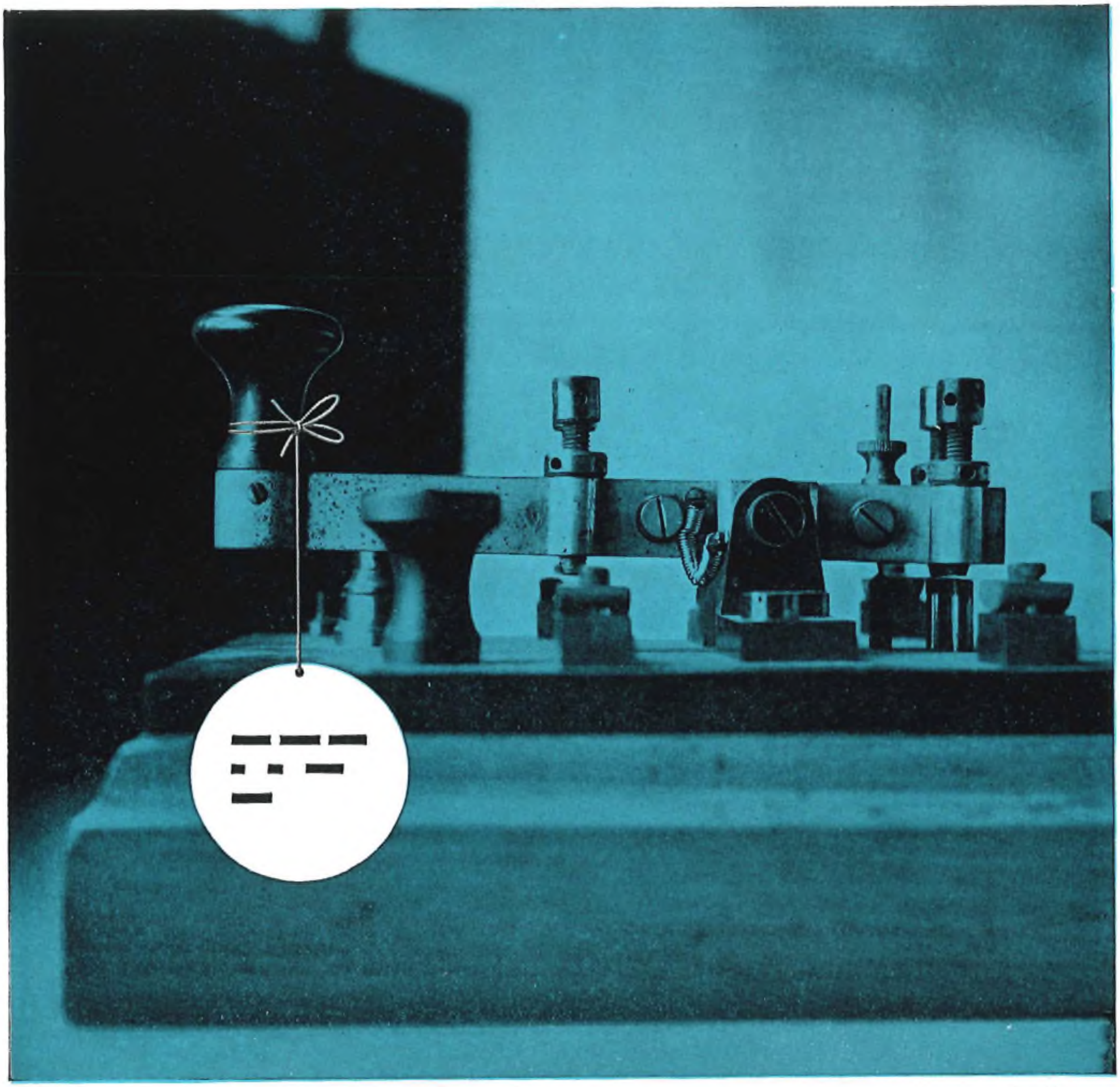

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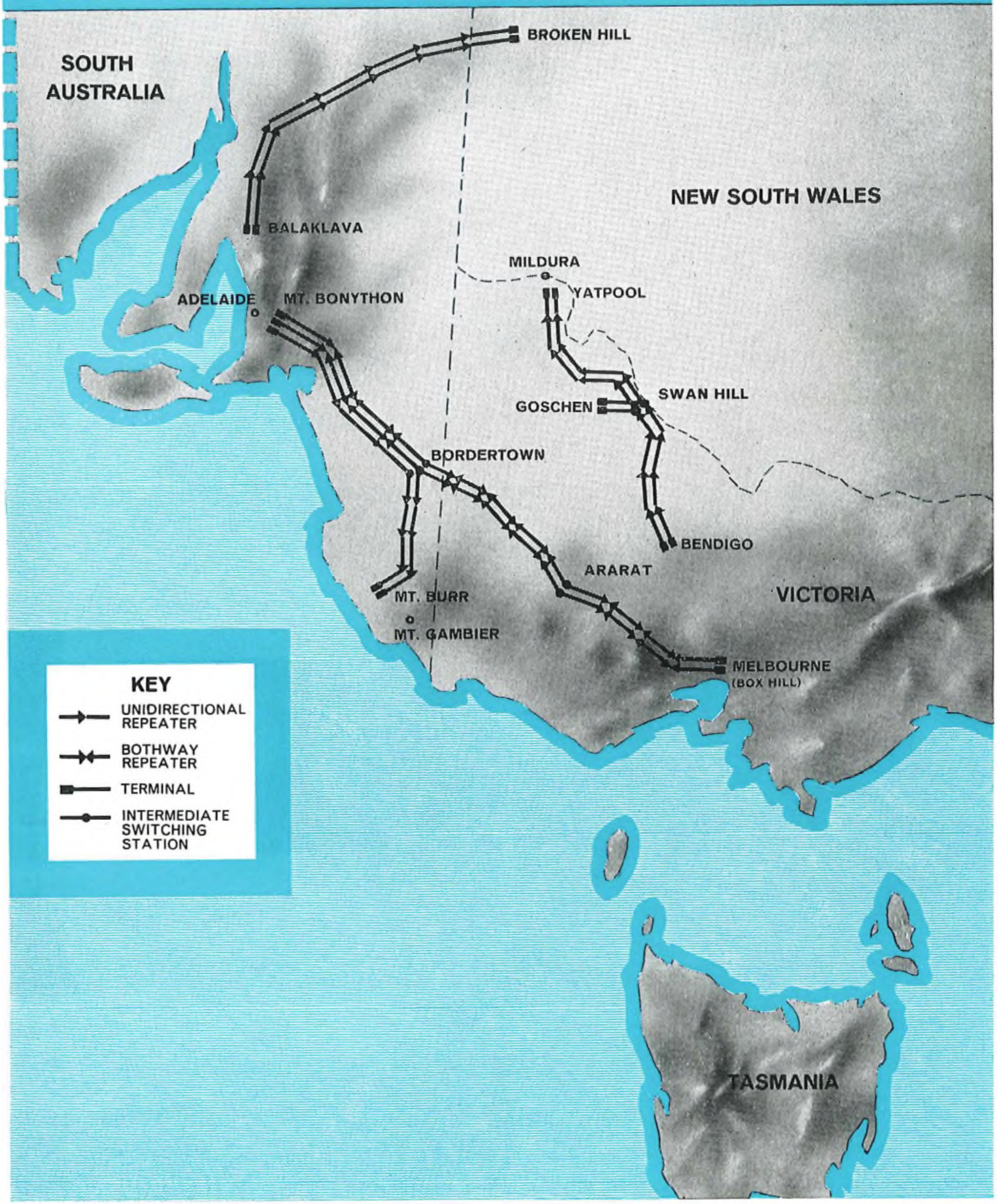

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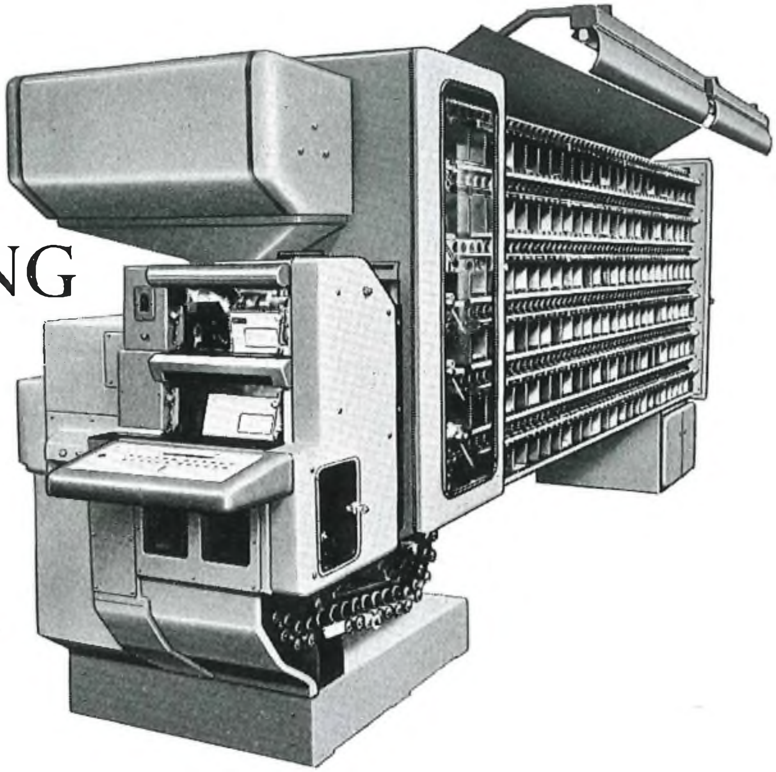

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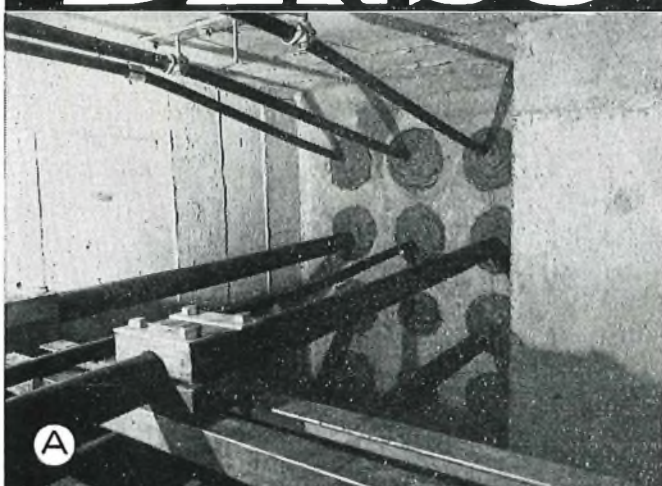
DENSO PROTECTION



FOR CABLES AND PIPES

A Inside an inspection chamber — the cables are supported by steelwork and the ends of the duct sealed with Denso Mastic. Denso Mastic is the all-purpose cold applied sealing medium, and can be used for plugging, sealing and caulking duties below ground, above ground or underwater.

B Underground cables in ducts. Denso Tape is used to protect the cables where they pass over lead linings at the edge of the pipe in case the cable sinks onto the hard edges.

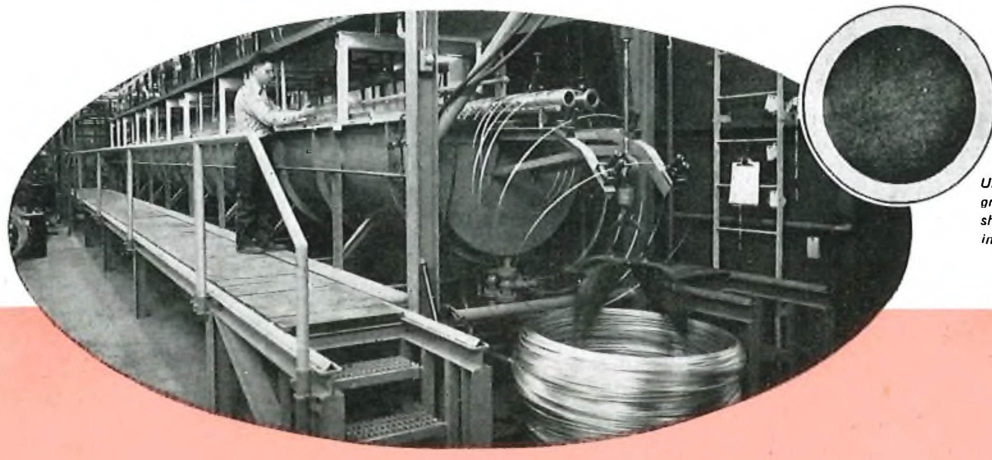
DENSO MASTIC and DENSO TAPE are used by the Central Electricity Generating Board, who also supplied the photographs.

WINN & COALES LTD

Denso House, Chapel Road, London, S.E.27.
Tel: GIPsy Hill 7511.
Also at Manchester, Belfast and Dublin.
Agents throughout the Commonwealth.

COPPERPLY

is produced in England



Un-retouched photomicrograph of COPPERPLY shows precise concentricity in finished size.

The exclusive electro-plating process by which "Copperply" is made produces precisely concentric wire with a maximum copper thickness variation of only about 1% of the wire diameter.

This means that on ALL standard sizes the minimum copper thicknesses on "Copperply" are considerably greater than the minimum thicknesses laid down in ASTM Specification B 227-57. (Viz. Chart 1)

In many cases our guaranteed minimum copper thicknesses for 30% conductivity wires are equal to the minimum copper thicknesses laid down in ASTM Specification B 227 for 40% wires.

CHART 1

MINIMUM COPPER THICKNESSES			
SIZE	ASTM SPECIFICATION 40% Conductivity	"COPPERPLY" 40% Conductivity	"COPPERPLY" 30% Conductivity
·1443"	·008"	·013"	·0083"
·1285"	·007"	·0116"	·0074"
·104"	·006"	·0096"	·0059"
·080"	·005"	·0072"	·0046"

CHART 2

SINGLE UNINSULATED WIRE			FLAT TWIN INSULATED PAIR	
SIZE	CONDUCTIVITY	LBS./MILE	BREAKING LOAD OF PAIR WITH 90 TON p.s.i. STEEL	AVERAGE D.C. RESISTANCE PER LOOP/MILE AT 68°F
·0403"	30%	23·80	426 lbs.	206 ohms
·0359"	30%	18·87	320 lbs.	260 ohms
·032"	30%	14·97	272 lbs.	328 ohms
·0253"	30%	9·41	168 lbs.	522 ohms

The National Standard Group, with platers in U.S.A., Canada and England, has supplied "Copperply" for open wire lines to Telecommunication Authorities in many parts of the world. Increasing interest is now being shown in the use of smaller and less obtrusive insulated "Copperply" drop wires.
Cheaper and *stronger* "Copperply" drop wire possesses resistance characteristics which many Authorities find perfectly adequate. (Viz. Chart 2)

Other applications include:

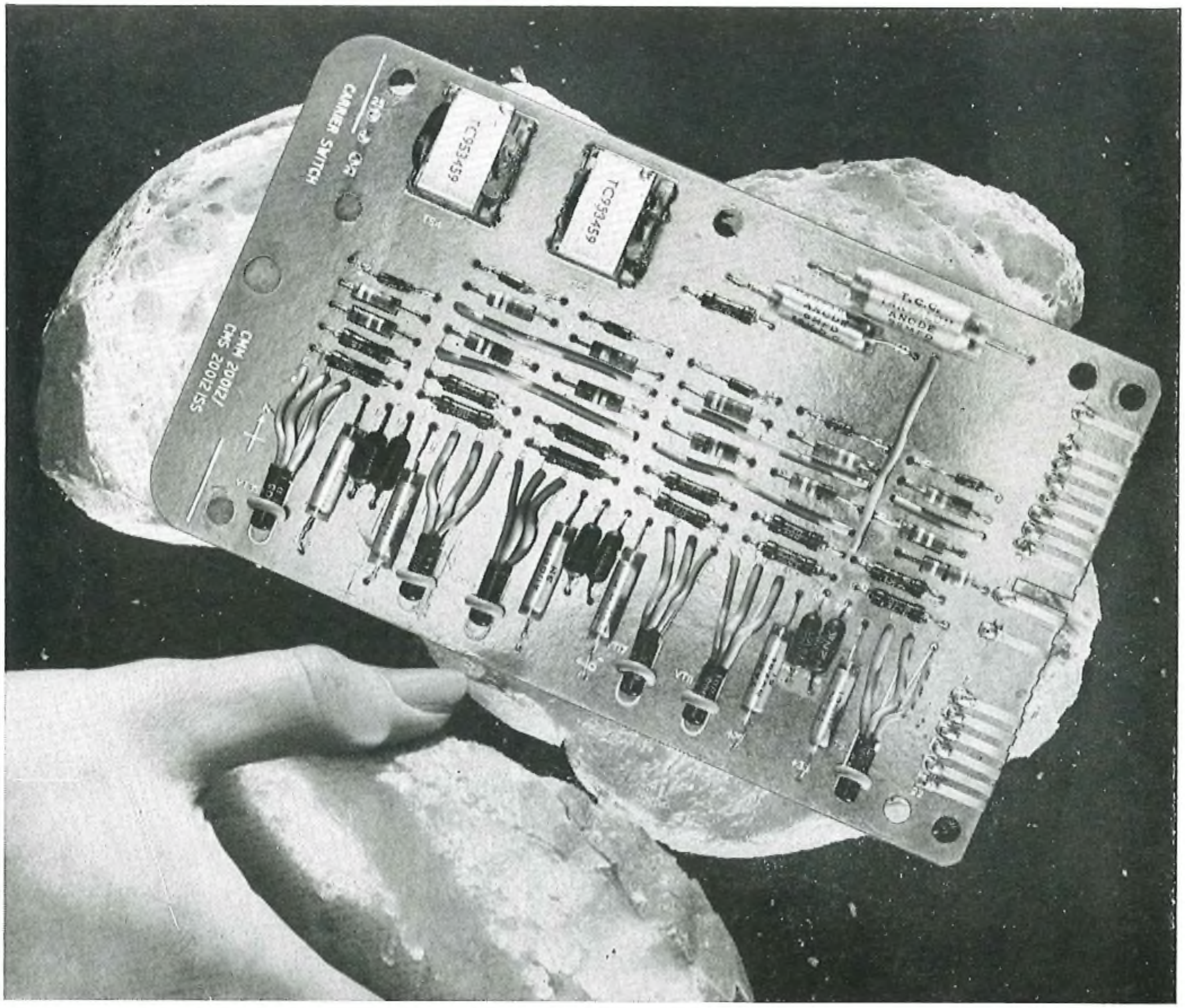
LOW-LOAD POWER TRANSMISSION, EARTH & COUNTERPOISE WIRE,
CABLE SCREENING, INDOOR TELEPHONE WIRE,
CAPACITOR LEAD WIRE, STAY WIRE, ETC.

NATIONAL STANDARD (OVERSEAS) LTD

19 GROSVENOR PLACE, LONDON, S.W.1

THE NATIONAL STANDARD CO. LTD. KIDDERMINSTER, ENGLAND

it's the filling that matters . . .



TYPE
CM
CARRIER

. . . and in A.T.E. type CM Transmission Equipment, the filling is the best — card-mounted printed circuits which take full advantage of the small size and proven reliability of modern components and provide in the equipment substantial savings in prime and operating costs. The result is a compact, reliable system with up to 90% power saving over equivalent valve equipment. A.T.E. type CM Transmission Equipment has already been chosen by many organisations, for microwave, open-wire and cable carrier communications.

* Fully transistorized * Plug-in printed circuit cards * Mains or battery operation * Optional in-built out-band 3825c/s low or high level signalling for ringdown or dialling * Suitable for extension to existing valve equipment * Up to 96 channels per rackside * Easy accessibility * A third of the size of equivalent valve equipment.

AUTOMATIC TELEPHONE & ELECTRIC COMPANY LIMITED
8 Arundel Street · London WC2 · Telephone: TEMPLE BAR 9262
Edge Lane · Liverpool 7

ATE(E 4

Chosen for underwater communications systems all over the world

Submarine telephone cable on order or already manufactured at the STC Southampton factories:

UK — USA (TAT3)	*3 600*	*UK — Germany No 2*	*253*
Commonwealth Pacific Cable	*2 800*	*UK — Germany No 1*	*250*
USA — Bermuda	*820*	*Bournemouth — Channel Islands*	*140*
Scotland — Faeroes — Iceland	*750*	*UK — Holland*	*115*
Puerto Rico — Florida	*715*	*Wales — Isle of Man*	*66*
UK — Sweden	*536*	*UK — Belgium*	*61*
UK — Denmark	*315*	*(all distances in nautical miles)*	

STC engineer and manufacture all types of submarine telephone and telegraph cable

Standard Telephones and Cables Limited
SUBMARINE CABLE DIVISION:
NEW DOCKS · SOUTHAMPTON · HANTS

63/8T

LOW BUDGET
ERROR PROOF TELEGRAPHY

with the **NEW**
MARCONI

AUTOSPEC

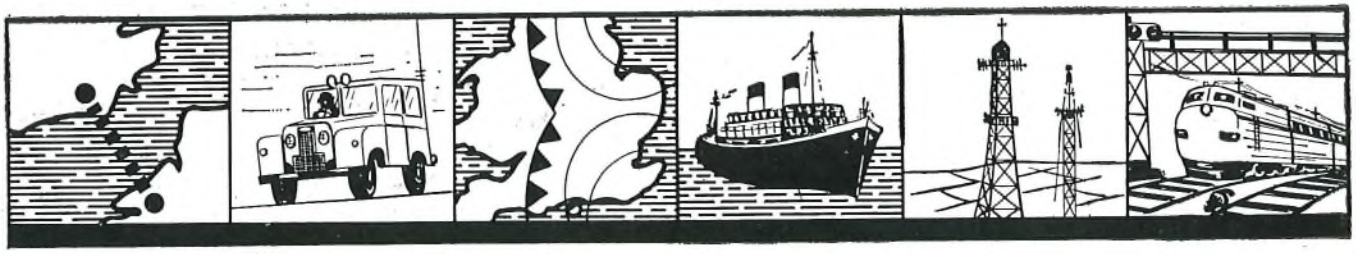
AUTOMATIC **S**INGLE **P**ATH **E**RROR **C**ORRECTION

- **RUGGED**
- **UNATTENDED OPERATION**
- **SOLID STATE** • **LOW COST**
- **COMPACT** • **SIMPLE**
- **NO MODIFICATION TO EXISTING INSTALLATIONS**

AUTOSPEC provides error proof telegraph working on services where no return path is required or on low capacity point-to-point circuits

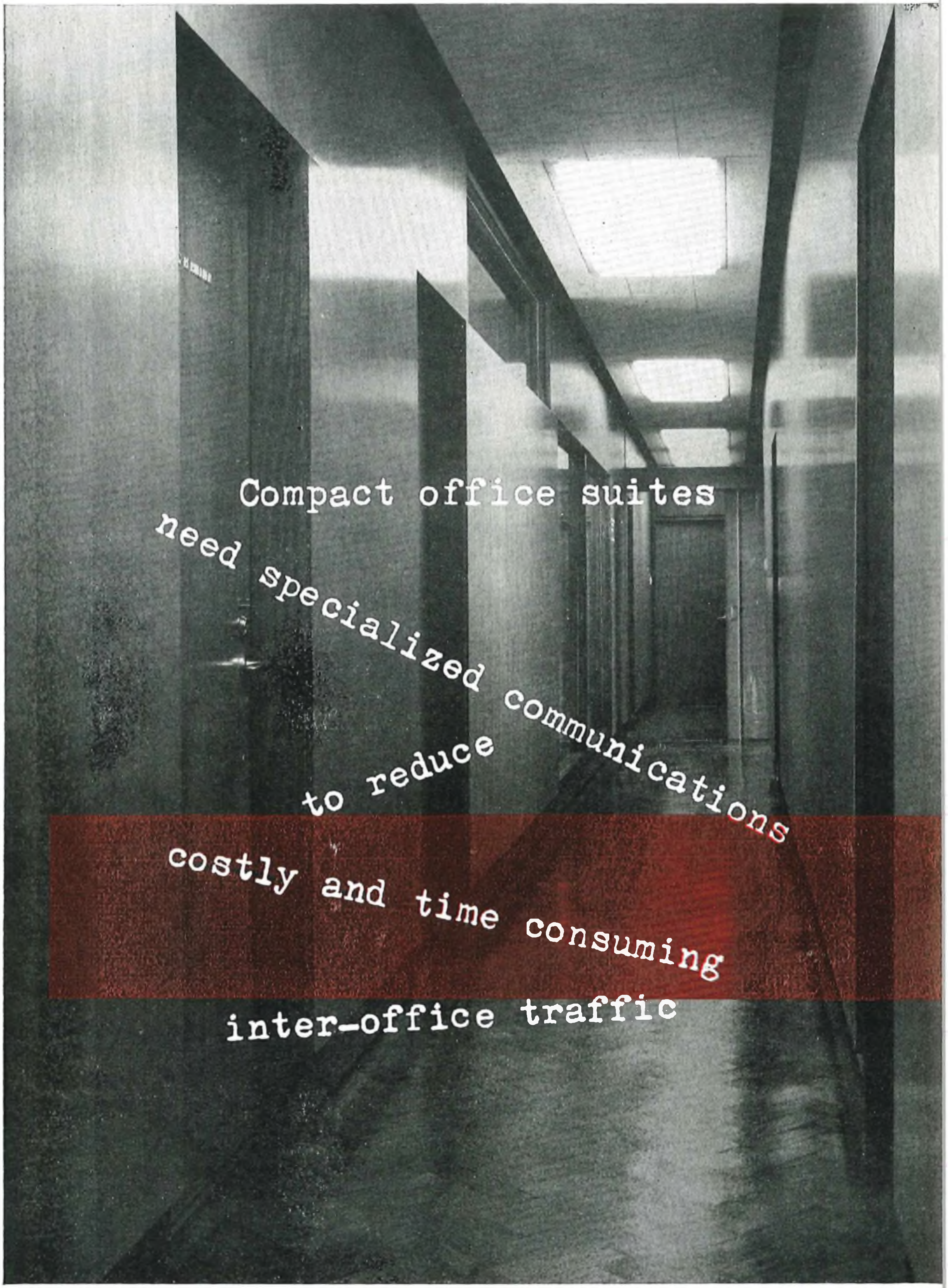
AUTOSPEC is the first single path error corrector to include automatic correction without the need for repetition

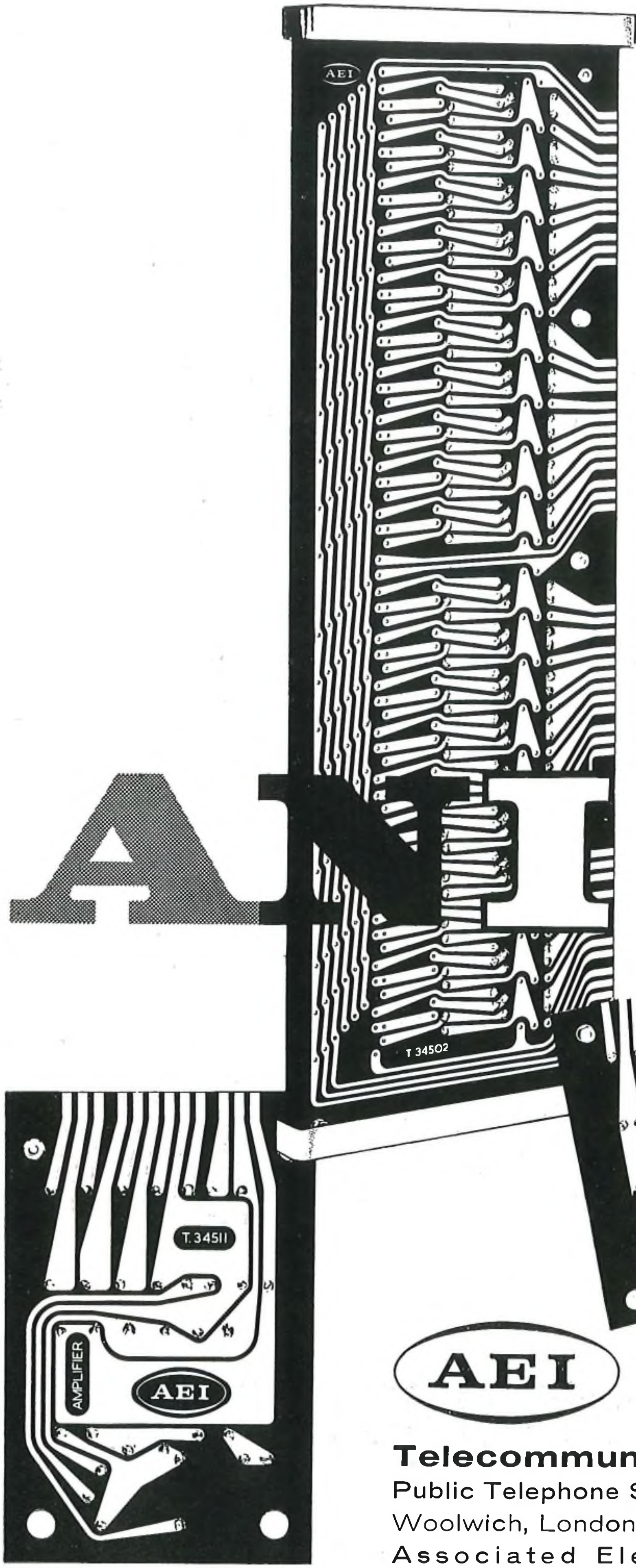
AUTOSPEC is a product of the same design team responsible for the production of the world famous AUTOPLEX



THE MARCONI COMPANY LIMITED · CHELMSFORD · ESSEX · ENGLAND

H9


Compact office suites
need specialized communications
to reduce
costly and time consuming
inter-office traffic



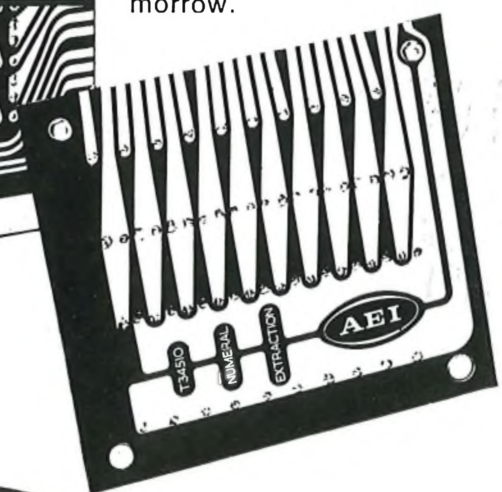
a tradition of progress...

Long before the 'automation' era, the telephone engineer was quietly supplanting manually performed tasks with automatic machines of considerable refinement.

The progressive approach of AEI designers has become traditional by their participation at every stage in the steady development of the electro-mechanical telephone switching systems of today.

Typical of their latest developments is a system of Automatic Number Identification which swiftly and surely locates a calling line and conveys the number to automatic trunk ticketing equipment at a distant centre.

Adaptable for several purposes, this equipment takes every advantage of electronic components and compact construction, and provides a foretaste of the suitability of these techniques for the needs of tomorrow.



AEI

Telecommunications Division

Public Telephone Systems Department

Woolwich, London, S.E.18

Associated Electrical Industries Limited

G.E.C.

manufactures telephones for all applications

G.E.C. 711 telephone
a general purpose wall instrument.

G.E.C. 710 telephone
for plan and extension systems and special facilities.

G.E.C. switching telephone
for plan 105 and plan 107 operation.

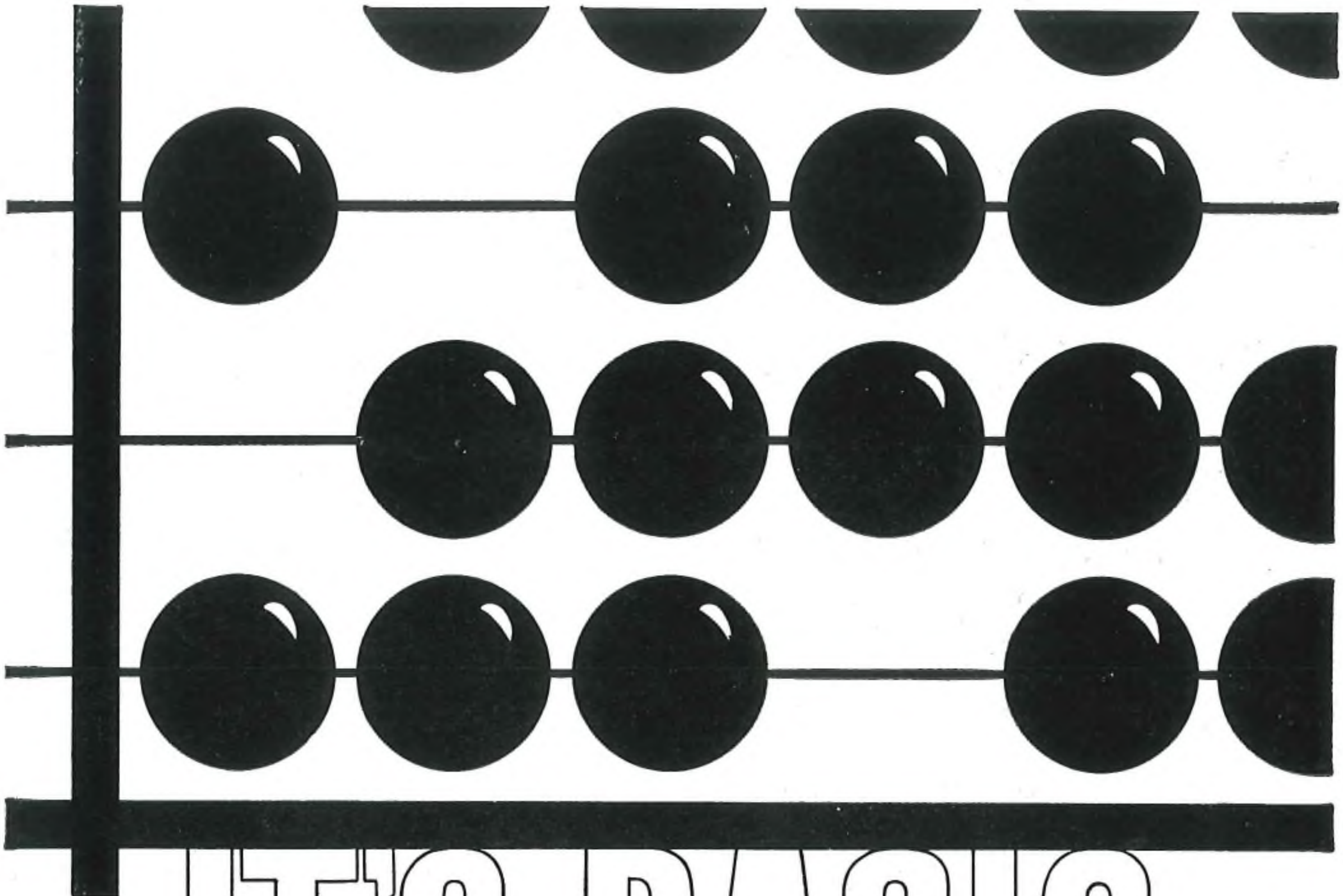
G.E.C. 706 telephone
a general purpose table instrument.

G.E.C. also produces intercommunication sets, loudspeaking telephones and telephones for special applications for ships, railways, mines etc.

Telephone Division

G.E.C. (TELECOMMUNICATIONS) LTD · TELEPHONE WORKS · COVENTRY · ENGLAND

Works at Coventry and Middlesbrough



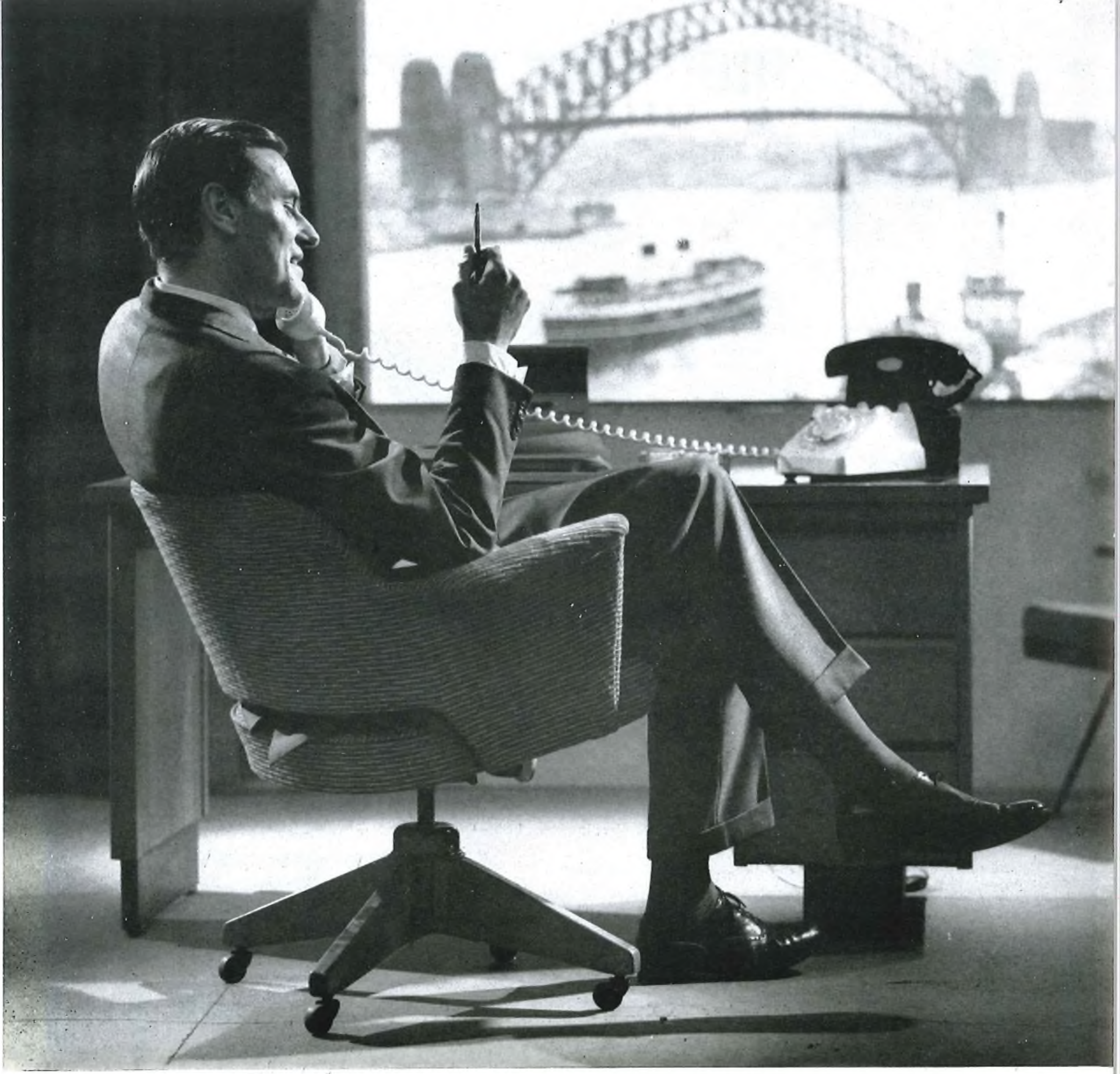
IT'S BASIC

. . . tomorrow's communications transmitter already in use today.
Seeing far beyond immediate operational requirements, the basic Redifon G.420 series allows for the addition of a wide variety of extra facilities *whilst still in service.* You should know more about the Redifon G.420. Write to our London headquarters for a full specification — or to any of our agents throughout the world.

1 Basic transmitter–A linear amplifier with manual tuning.
2 Add Low-level exciter to provide A1, A2, A3 operation.
3 Or add SSB Generator to provide A1, A2, A3, A3A, A3H, A3J operation.
4 Then add ISB Generator to provide A3B operation.
5 Add Servo system to provide rapid push-button frequency changing.
6 Add DC Remote Control units for extended local control.
7 Add Tone Translator units to provide full remote control over a single-pair line or radio link.

Redifon G.420

REDIFON LIMITED Communications Sales Division,
Broomhill Road, London, S.W.18 Tel: VANdyke 7281.
A Manufacturing Company in the Rediffusion Group.



across the world

disposal whilst, overseas, there are associated factories in Australia, New Zealand, South Africa, Portugal and Brazil.

The whole of the Company's research and development programme is centrally co-ordinated and the resultant cross-fertilisation of ideas and information is one of the main reasons why A.T.E. telecommunications equipment is the most advanced in the world.

ATE 8 ARUNDEL STREET · LONDON WC2 · *A Principal Operating Company of the Plessey Group*

ATE(T)2

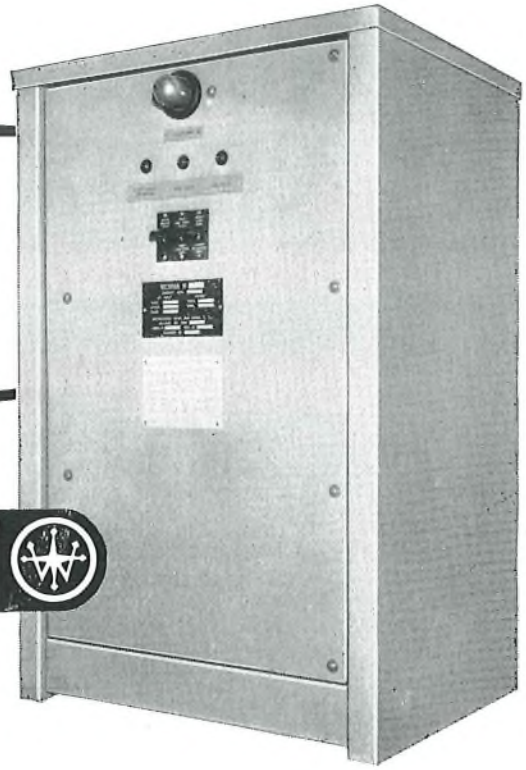
TELECOMMUNICATIONS CABLES

Pirelli General are in a position to advise on complete Telecommunications schemes and are organised to manufacture and install cables for distribution and trunk services; also carrier and all types of coaxial cables.

Pirelli General also manufacture cables to meet special requirements of Public Utilities or of industry.

PIRELLI GENERAL CABLE WORKS LIMITED SOUTHAMPTON TELEPHONE SOUTHAMPTON 20381

P9315



Typical constant voltage float charger type PO.91B incorporating the TRINISTAT circuit. Output 15 amperes at 27 volts smoothed to 1mV weighted to 800 cycles when operating with a battery.

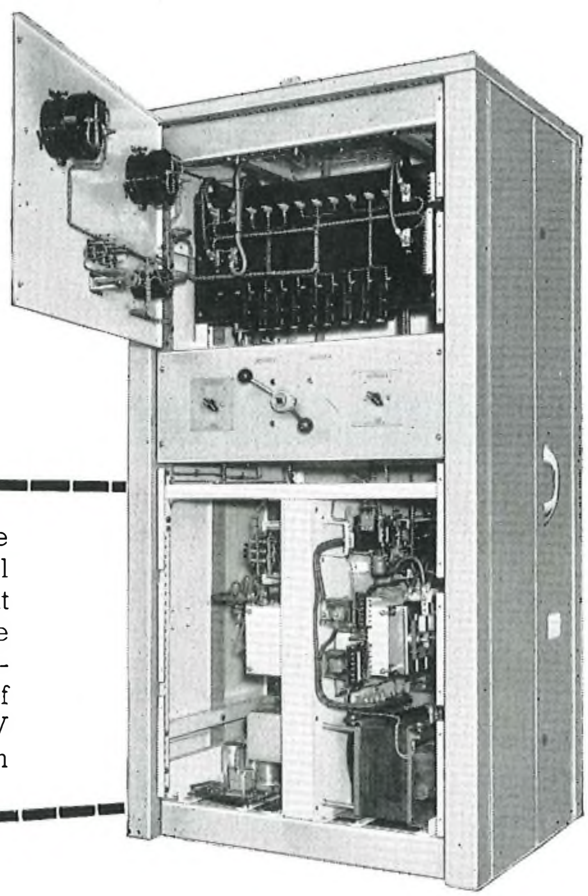
WESTINGHOUSE

TRINISTAT

CONSTANT VOLTAGE RECTIFIER SETS

Salient features of the new Westinghouse TRINISTAT silicon controlled rectifier regulated circuit are:—

- CLOSE LIMITS of voltage regulation irrespective of wide input VOLTAGE and FREQUENCY changes.
- Regulation achieved over ENTIRE LOAD RANGE without use of heavy bleed resistances.
- LOW WEIGHT and REDUCED DIMENSIONS.



TRINISTAT constant voltage equipment type 6113 designed to achieve a similar technical performance to the PO.91 range of sets but having a greater output. Contained within the lower half of the cubicle only are two independent circuits each having an output of 75 amperes at 50 volts, smoothed to 2mV weighted to 800 cycles when operating with a battery.

For further information please write to Dept. POEEJ 10/63 Rectifier Division (Equipments).

WESTINGHOUSE BRAKE AND SIGNAL CO. LTD · 82 YORK WAY · KING'S CROSS · LONDON N1

Tel: TERminus 6432

CONTINUOUSLY VARIABLE MEASUREMENTS UP TO 20 Mc/s

with the 74194-A Selective Level Measuring and the 74195-A Oscillator Equipments.

- **10 kc/s to 20 Mc/s continuously variable**
- **Scale length effectively 900 ft.**
- **Frequency accuracy ± (1 part in 10^5 + 400 c/s)**
- **Short term stability ± 5%**
- **Automatic tracking between Oscillator and S.L.M.S.**

Each equipment includes a power supply unit which operates from 90-264V 45-66 c/s a.c. mains

74195-A Oscillator:

Harmonic margin	50db
Output Level	0 to −80 dbm continuously variable
Impedance	75 ohms

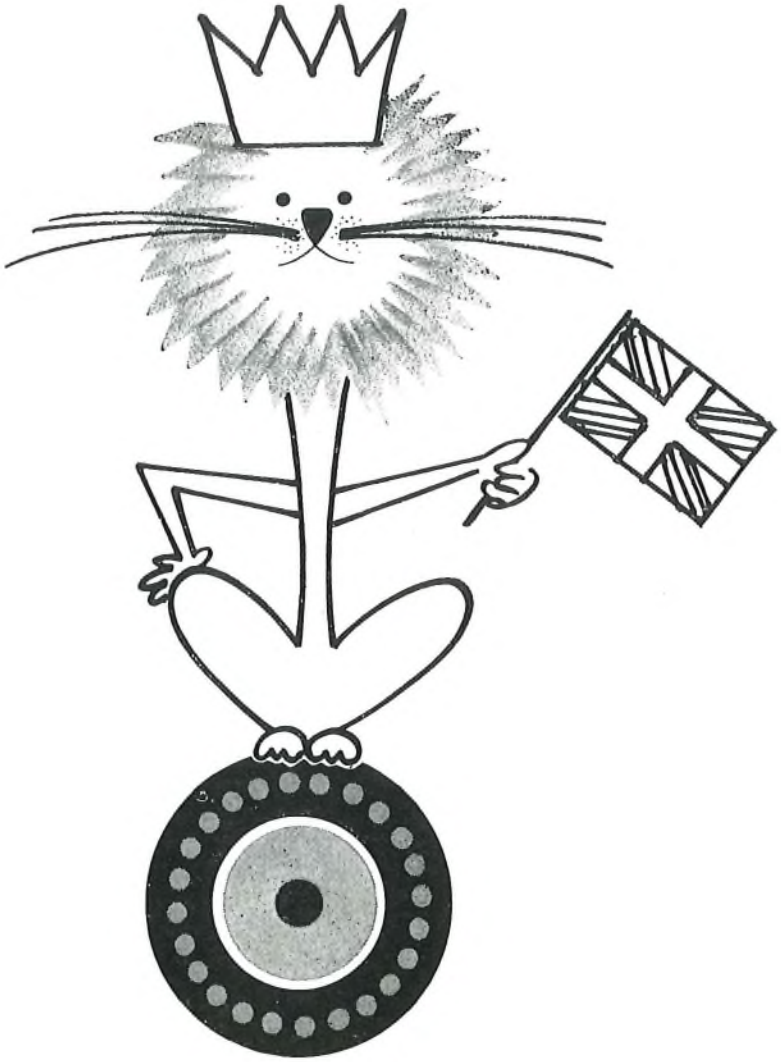
74194-A S.L.M.S.:

Bandwidths	4 kc/s and 100 c/s
Measuring range	+ 11 to −100dbm
Input Impedance	75 ohms

63/2CT

Write, 'phone or Telex for leaflet

Standard Telephones and Cables Limited
TRANSMISSION SYSTEMS GROUP (Marketing Department)
NORTH WOOLWICH · LONDON, E.16 · Telephone ALBert Dock 1401 · Telex 21645



THE LION'S SHARE

Submarine Cables Ltd., England, and its predecessors have pioneered and supplied far the largest proportion of the world's submarine telecommunication cable—90% of the telegraph cable between 1850 and 1950 and the largest share of telephone cable since 1950—also the main cable-laying gear for Cable Ships, MONARCH, ALERT, MARCEL BAYARD, MERCURY, INGUL and JANA. For submarine telecommunication cable, repeaters and—through AEI—terminal equipment; for cable handling gear and also for deck auxiliaries, consult:

HERE ARE SOME OF THE COMPANY'S MILESTONES:

1850 *First ever submarine telegraph cable—from England to France.*

1866 *First successful transatlantic telegraph cable.*

1939 *First polythene-insulated submarine cable.*

1955/6 *First transatlantic telephone cable—95% supplied by the Company.*

1961 *First armourless telephone cable—2000 miles from Newfoundland to England.*

1961 *Longest repeatered 120-circuit telephone cable—400 miles from Newfoundland to Canada.*

1961/3 *Supply over 5000 miles of armourless cable and 90 repeaters for the 8000-mile Commonwealth Pacific system.*

1962 *Contract for 420-circuit transistorised repeaters.*

SUBMARINE CABLES LIMITED

(OWNED JOINTLY BY AEI AND BICC) · **MERCURY HOUSE · THEOBALD'S RD · LONDON WC1 · ENGLAND**

Economical Cross-Country Communications with the Seven Channel ATE Type 900.

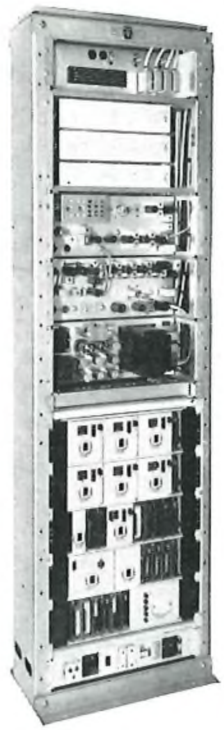
The ATE Multi-Channel VHF/UHF Equipment has been specially designed for applications where a number of short or medium distance circuits are required between two or more locations. The equipment provides telephone operating companies with all the normal dialing, supervisory and metering facilities associated with manual and automatic public or private telephone networks, and can be integrated with line or larger radio multiplex networks.

The terminal consists of aerial filters, transmitter unit, receiver unit, power supply unit, multiplex equipment, and mains supply panel. The Multiplex apparatus conforms strictly to CCITT recommendations and provides six high grade carrier-derived speech circuits with out-of-band signalling, and an audio channel for use as an engineering control circuit. An automatic and/or manual changeover is also incorporated to give either local or remote indication of signal or equipment failure and switch the transmission through to a standby link.

The transmitter is frequency modulated and occupies a nominal band-width of 250 kc/s per system with an effective modulation baseband of from 300 c/s to 36 kc/s. The equipment is available for operation in the 156-184, 220-260, and 430-500 Mc/s bands and the nominal output power ranges from 5 watts to 150 watts as required.

The Type 900 Equipment is just one of a wide range of communication equipment built by AT&E, who also offer a comprehensive planning, surveying and installation service. If you would like more details, please write to:

AT&E (Bridgnorth) Ltd · Bridgnorth · Shropshire · England



ATE(B)2

Typical radio cubicle

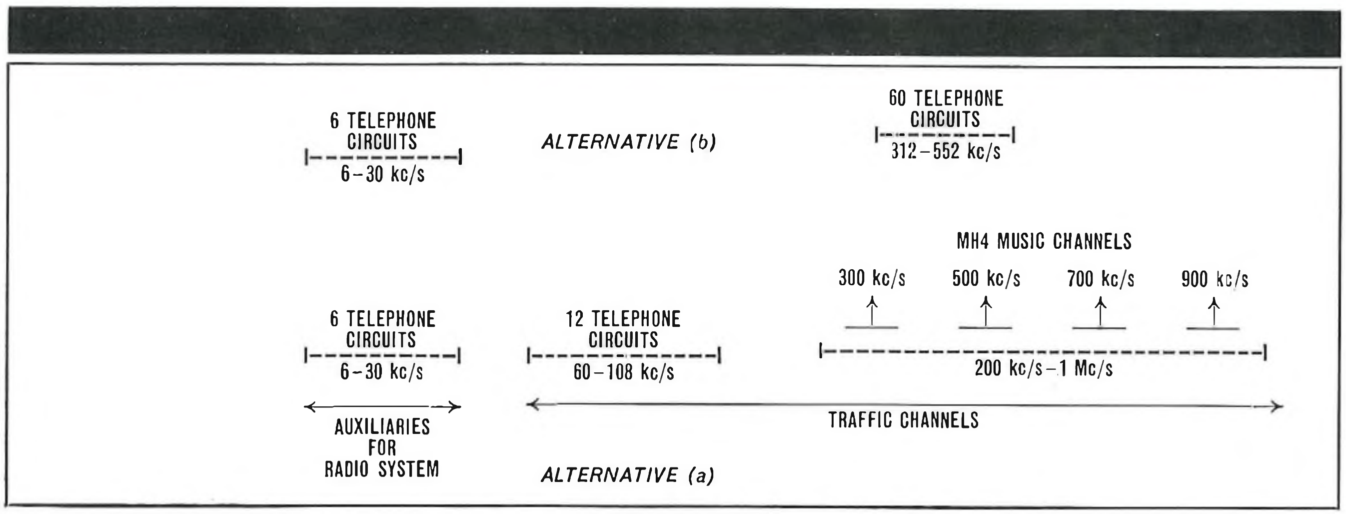
STC NEW Auxiliary 4 Gc/s Link Type RA4

This medium bandwidth microwave system will carry not only the supervision control signals for a main-line high-capacity microwave system, but also high-quality music circuits and medium-haul telephone circuits.

No v.h.f. radio or land lines are required when the RA4 link is installed because it uses the main-line aerial system. The RA4 link is otherwise independent and there is no reduction in the traffic capacity of the main-line system.

One radio cubicle mounts the transmit and receive apparatus for a terminal or for one direction of transmission of a repeater. The multiplexing equipment is mounted in a 6ft 6in (1,98 m) high STC rackside.

Typical multiplex channelling rackside



6 to 30 kc/s vehicle channel for:
Low speed tone signals
High speed tone signals for channel switching
Omnibus speaker circuit
Express speaker circuit
plus two spare circuits

60 kc/s to 1 Mc/s:
4 music channels and
12 short-haul telephone circuits
or
60 short-haul telephone circuits

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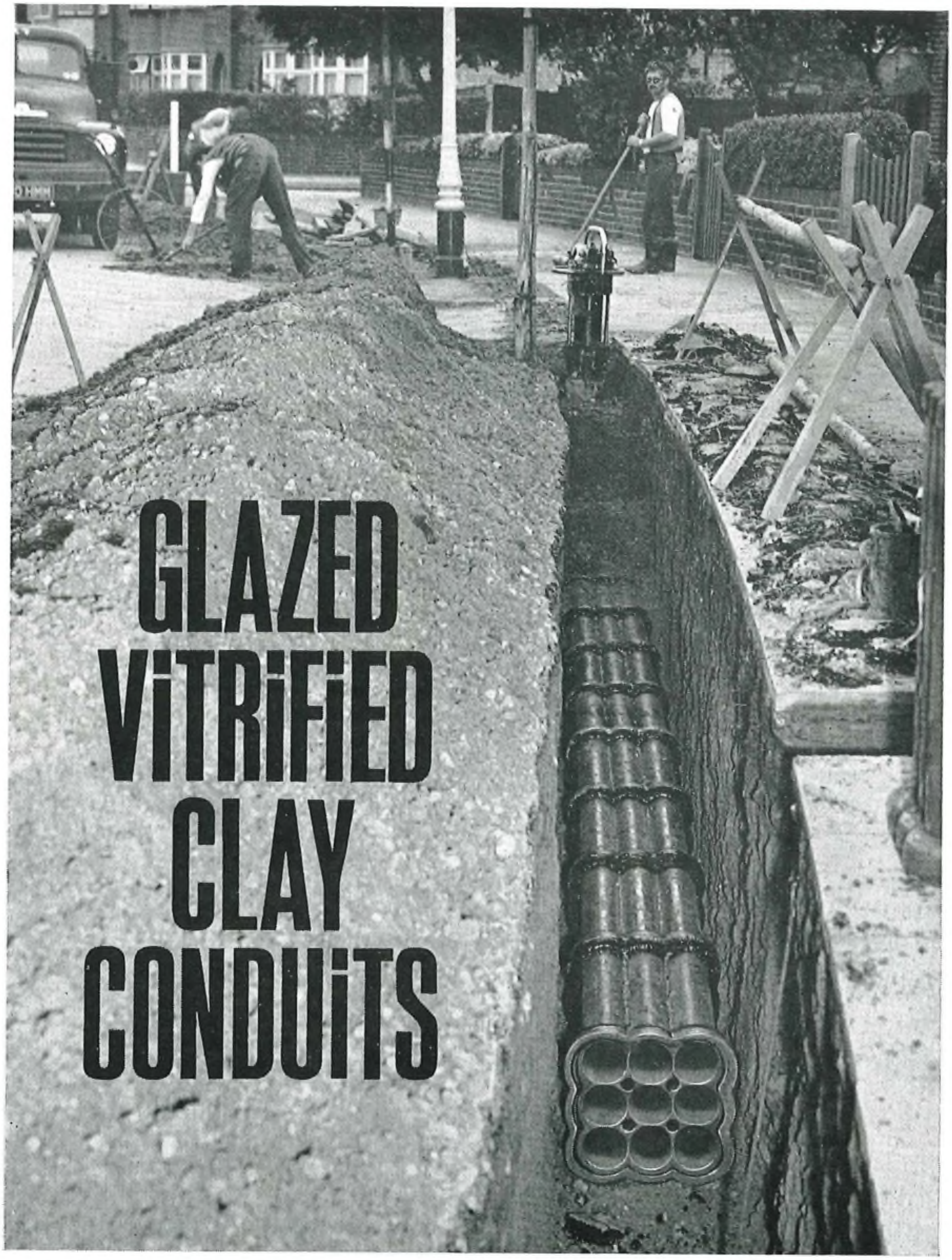
63/15C



Photograph by courtesy of H.M. Postmaster General.

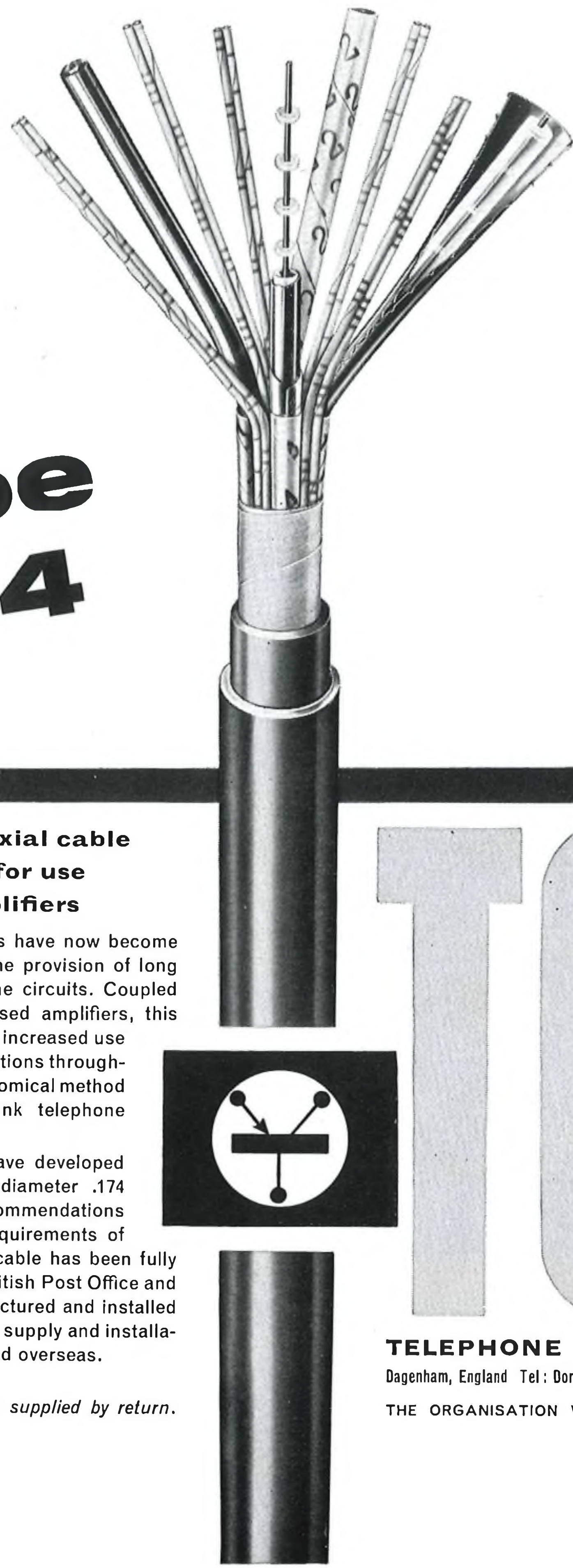
. . . for underground security

Our telecommunications, lighting systems and power lines are vital.
For permanence, how right to use **glazed vitrified clay conduits**
. . . there is no adequate substitute.

write for further information to the Engineer

NATIONAL SALT GLAZED PIPE MANUFACTURERS' ASSOCIATION
Hanover Court, Hanover Square, London W.1
Telephone: Mayfair 0364

GLAZED VITRIFIED CONDUITS



type 174

small diameter coaxial cable specially designed for use with transistor amplifiers

Small diameter coaxial cables have now become an established medium for the provision of long distance high grade telephone circuits. Coupled with underground transistorised amplifiers, this type of cable is rapidly finding increased use amongst telephone administrations throughout the world as the most economical method of providing groups of trunk telephone circuits.

Telephone Cables Limited have developed their own design of small diameter .174 Coaxial Tube to meet the recommendations of the C.C.I.T.T. and the requirements of the British Post Office. The cable has been fully tested and approved by the British Post Office and cables of this design, manufactured and installed by T.C.L., are now in hand for supply and installation in the United Kingdom and overseas.

Fullest technical details of Type 174 Coaxial Cable gladly supplied by return.

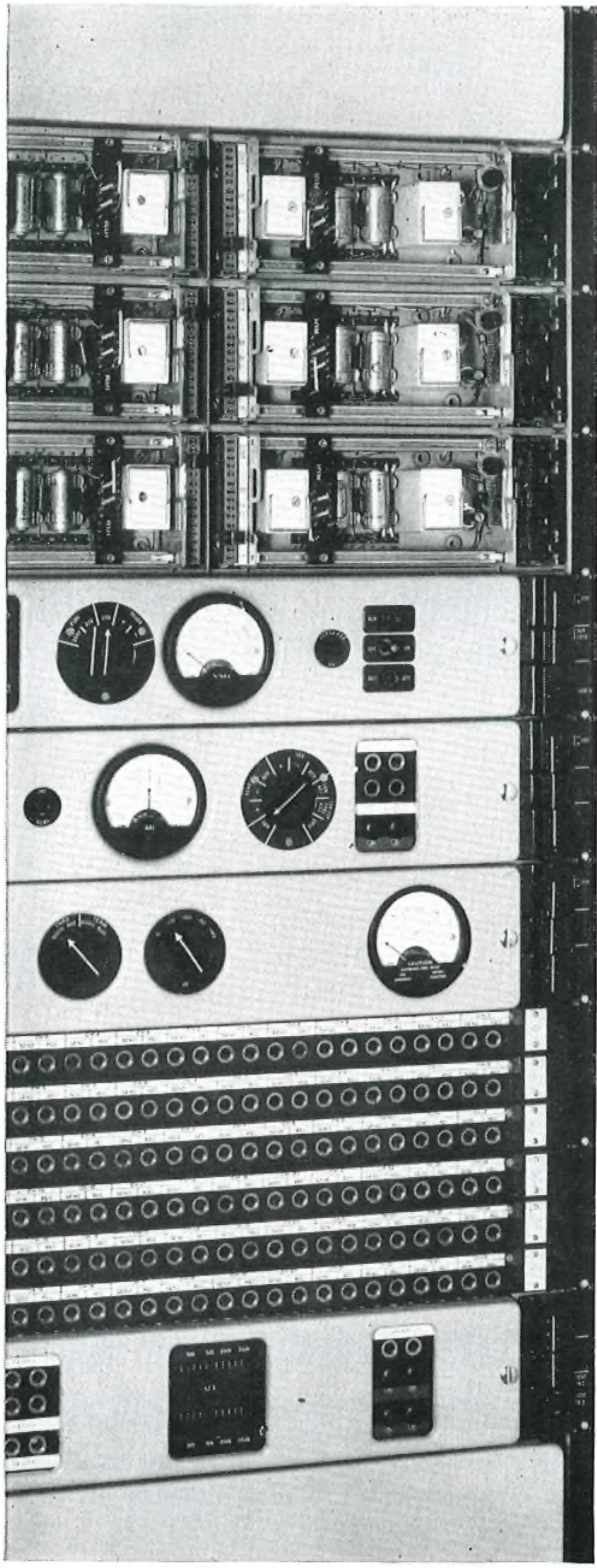
TCL

TELEPHONE CABLES LIMITED

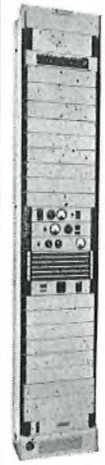
Dagenham, England Tel: Dominion 6611 Cables: Drycore Dagenham

THE ORGANISATION WITH 125 YEARS' EXPERIENCE

TA(S)9021



24-CHANNEL V.F. TELEGRAPH SYSTEM TYPE TF8



The TF.8 is a new all-transistor system, using frequency-shift modulation. It will provide up to 24 full duplex telegraph channels meeting C.C.I.T.T. recommendations for national and international teleprinter and TELEX networks and is designed to operate over long-distance land-line systems and stable s.h.f. and v.h.f. radio links. A special feature is pilot control to correct the incoming frequencies for up to 15 c/s of frequency shift arising in the bearer channels used.

Telegraph speed: 50-75 bauds
Channel spacing: 120 c/s in audio band 300-3 400 c/s
Characteristic distortion:
50 bauds: 5% maximum
75 bauds: 8% maximum

The use of plug-in panels and one type of transistor throughout the transmission circuits simplifies maintenance requirements. Equipment for one complete terminal for 24 channels can be accommodated on a 9 ft (2,74 m) rackside.

Write, 'phone or Telex

Standard Telephones and Cables Limited
TRANSMISSION SYSTEMS GROUP
NORTH WOOLWICH · LONDON, E.16
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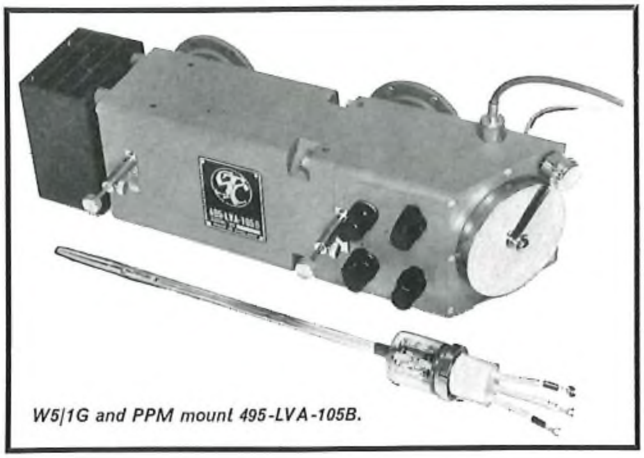
63/8C

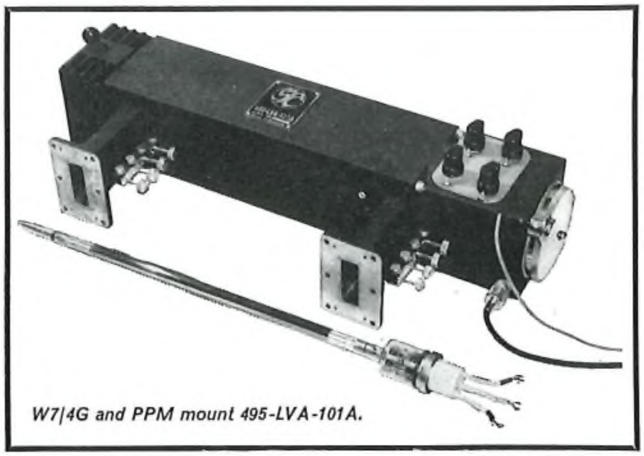
WORLD-WIDE ACCEPTANCE of STC MICROWAVE TUBES

New tube development continues

STC have been leaders in the design and production of microwave communications for many years. Microwave tube development and production programmes have resulted in: improved gain, lower noise factor, higher synchronous saturated output level and phase modulation distortion, together with a high degree of reliability and simplicity of operation.



W5/1G and PPM mount 495-LVA-105B.



W7/4G and PPM mount 495-LVA-101A.

C-band

Travelling wave tube type W5/1G has an established reputation in microwave link repeaters operating at about 5.0W output level in the 6.0 Gc/s band. A modified tube type W4/1G can be used in the *same* periodic permanent magnet mount as the W5/1G to cover the upper frequencies of this band (7.0 to 7.8 Gc/s). Type W5/2G has been especially designed for 1 800 channel link systems and is intended for operation with a 10 to 15W output.

ABRIDGED DATA

Tube Type	Mount Type	RF Connexion (W.G. Flange)	Frequency Range (Gc/s)	Sync. Sat. Output (W)	Gain (db)	Noise Factor (db)
W4/1G	As for W5/1G	As for W5/1G	7.0 to 7.8	8 to 11	37 to 40	26
W5/1G	495-LVA-105B 495-LVA-105C 495-LVA-105D	UG344/U CMR137 UG344/U	5.85 to 7.2	8 to 11	35 to 39	26
W5/2G	495-LVA-107B	UG344/U	5.925 to 6.425	16	37 to 41	27
LS985	WM108	UG51/U	7.0 to 8.5	8 to 11	36	26

S-band

For the communication frequencies of this band (3.6 to 4.2 Gc/s) there are two STC travelling wave tubes:

Type W7/3G performance has been proved in national and international microwave systems in fourteen countries.

Type W7/4G is a higher gain version of the W7/3G. It is provided with a periodic permanent magnet mount which incorporates simple mechanical adjustments for obtaining the very best performance from any tube of this type.

ABRIDGED DATA

Tube Type	Mount Type	RF Connexion (W.G. Flange)	Frequency Range (Gc/s)	Sync. Sat. Output (W)	Gain (db)	Noise Factor (db)
W7/3G	495-LVA-104	12A*	3.6 to 4.2	8 to 10	28	27
W7/4G	495-LVA-101A	12A*	3.6 to 4.2	10	42	27

*Transition pieces to WR 229 available.

Write, 'phone or Telex for leaflet

COMPONENTS GROUP
VALVE DIVISION

Standard Telephones and Cables Limited
FOOTSCRAY SIDCUP KENT
Telephone FOOtscray 3333 Telex 21836

63/13MS

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TELECOMMUNICATION PRINCIPLES A

TELECOMMUNICATION PRINCIPLES B

ELEMENTARY TELECOMMUNICATION PRACTICE

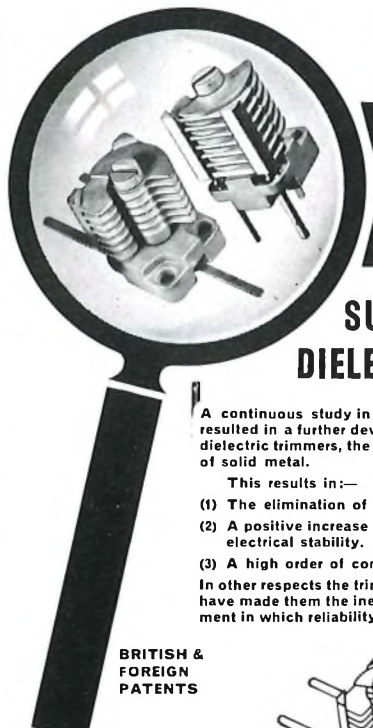
Price 7s. 6d. each. Post Paid 8s.

The following model answer book, although published for the old Telecommunications Engineering Course, is still useful and is offered at a considerably reduced price.

TELEPHONE EXCHANGE SYSTEMS I
(Telephony and Telegraphy A, Telephony B)
Price 2s. each. Post Paid 2s. 6d.

Orders to
The Post Office Electrical Engineers' Journal
G.P.O., 2–12 Gresham Street, London, E.C.2

OXLEY DEVELOPMENTS CO. LTD.



XLEY

SUBMINIATURE AIR DIELECTRIC TRIMMERS

A continuous study in the laboratory and in the field has resulted in a further development in Oxley subminiature air dielectric trimmers, the rotor and the stator both being made of solid metal.

This results in:—

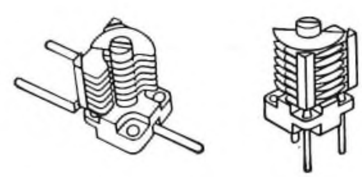
(1) The elimination of practically all soldered joints.

(2) A positive increase in mechanical rigidity and improved electrical stability.

(3) A high order of consistency in capacity.

In other respects the trimmers retain all those facilities which have made them the inevitable choice of professional equipment in which reliability is the dominant requirement.

BRITISH & FOREIGN PATENTS



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Write for technical details of these and other Oxley products.

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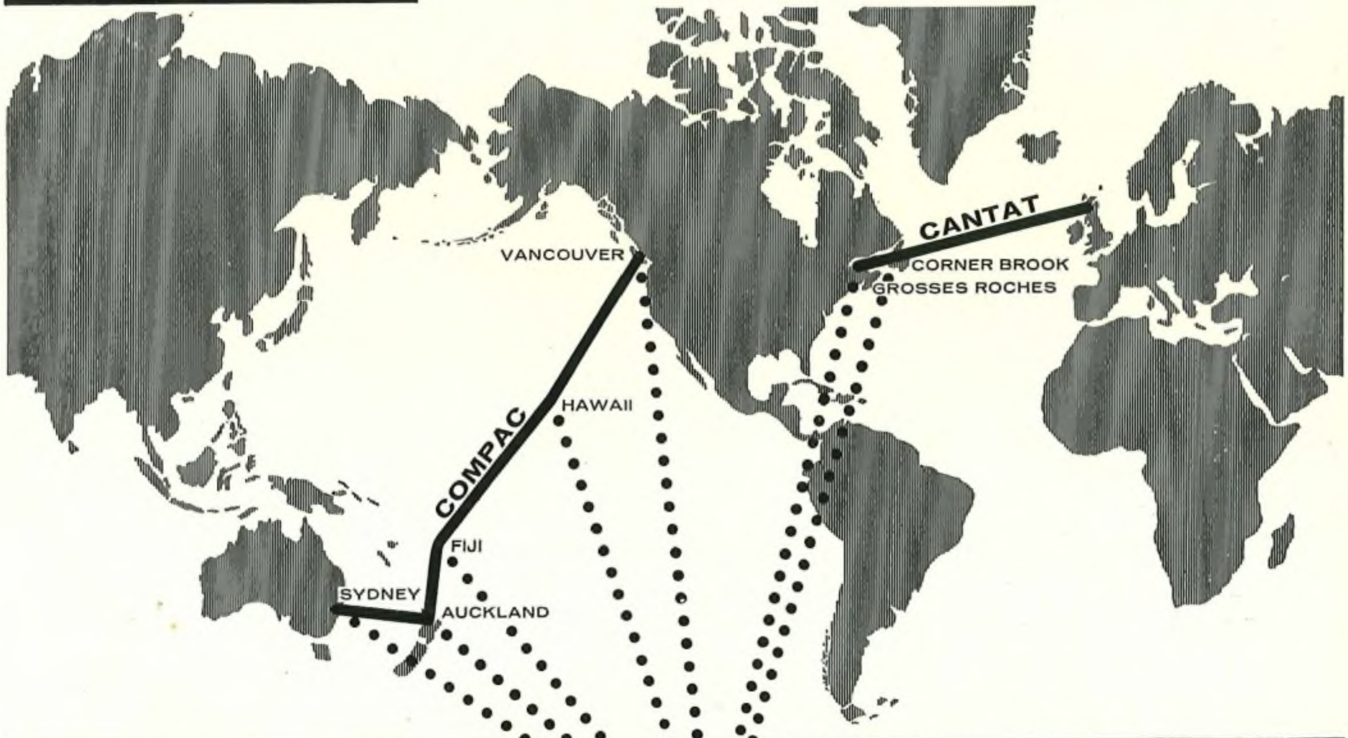

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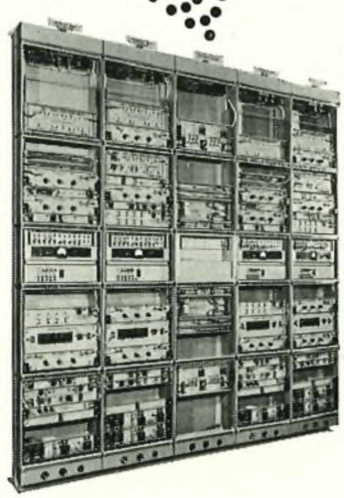

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