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External Practices at Post Office Radio Stations

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U.D.C. 614.8:621.396.7

Recent legislation has brought within the scope of the Factories Acts the work of constructing and maintaining radio masts, and it has been necessary to review current practices to ensure that they afford the necessary safety to the men concerned and comply with the Regulations. Some of the major changes proposed are outlined in this article.

INTRODUCTION

OVER the years many different types and sizes of radio tower and mast have come into use to meet a variety of needs. These structures range from the largest, the 820 ft high masts supporting the very-low-frequency (v.l.f.) aerial at Rugby, the 600 ft towers performing a similar duty at Criggion, and the somewhat smaller but still massive square-sided masts used to support the Franklin beam aerials for so long a feature of the overseas short-wave stations, to the relatively slender multi-stayed galvanized masts 100–300 ft in height that are coming into use in large numbers for modern high-frequency aerial systems. The work of constructing and maintaining these masts is necessarily hazardous, and it says much for the skill of the men concerned and the practices which have been prescribed for carrying out the work that serious accidents have been so few.

However, as a result of an unfortunate fatal accident at Portishead Radio Station in 1960, it was decided that the whole of the external work at Post Office radio stations should be reviewed by an independent expert knowledgeable in this field, and Sir William Halcrow and Partners, a well-known firm of civil-engineering consultants, were asked to undertake this work. About this time draft regulations were introduced by the Ministry of Labour, extending the provision of the Factories Act to works of engineering construction, and in making their investigation and framing recommendations the consultants paid due regard to these new regulations.

STATUTORY REQUIREMENTS

The welfare of employees is safeguarded by Statutory Law and by Common Law. The former, mainly through the Factories Act and its Regulations, lays down the requirements for the safety, health, and welfare of employed persons; infringement of these requirements is a criminal offence, whilst Common Law gives right of redress to persons injured through the negligence of others.

Although there were, prior to 1937, a number of Acts affecting conditions in factories (including workshops) the Factories Act of 1937 was a significant advance in safeguarding the welfare of employees, and it has enabled the courts to adopt an increasingly high standard as regards the duty expected of employers in the interests and safety of their employees. It gave the Minister power to make subsequent regulations having the binding powers of the Act itself.

The Regulations so prescribed which mainly concern Post Office duties are the Building (Safety Health and Welfare) Regulations 1948, the Engineering Construction (Extension of Definition) Regulations 1960, the Construction (General Provision) Regulation 1961, and the Construction (Lifting Operations) Regulations 1961.

The Building Regulations 1948 applied to the construction, structural alteration, repair or maintenance of a building, and to machinery or plant used in such operations. They prescribed requirements in respect of such matters as scaffolding and means of access, lifting appliances, chains, ropes and lifting gear, hoists, excavations, health and welfare. Their effect on Post Office operations has usually been limited to the use of scaffolding for providing services in buildings, and the use of lifting gear.

The Engineering Construction (Extension of Definition) Regulations 1960 extended the existing definition of the term "works of engineering construction" (given in Section 162 of the 1937 Act) to cover any steel or reinforced-concrete structure other than a building, and hence it is deemed that it covers any work in connexion with steel masts or poles.

The Construction (General Provision) Regulations 1961 and the Construction (Lifting Operation) Regulations 1961 revoked certain of the 1948 Building Regulations and replaced them by others applicable both to building operations and to works of engineering construction. The old regulations have been considerably expanded and, in many instances, given more precise definition; they have also become more exacting. They cover such matters as the appointment of safety supervisors, the safety of working places and means of access, excavations, tunnels, lifting appliances, lifting gear, and the keeping of records. The regulations apply to works undertaken by or on behalf of the Crown or any public

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

authority as well as to industrial and commercial undertakings.

These regulations together with a host of others were consolidated in the recent Factories Act of 1961.

SAFETY OFFICERS

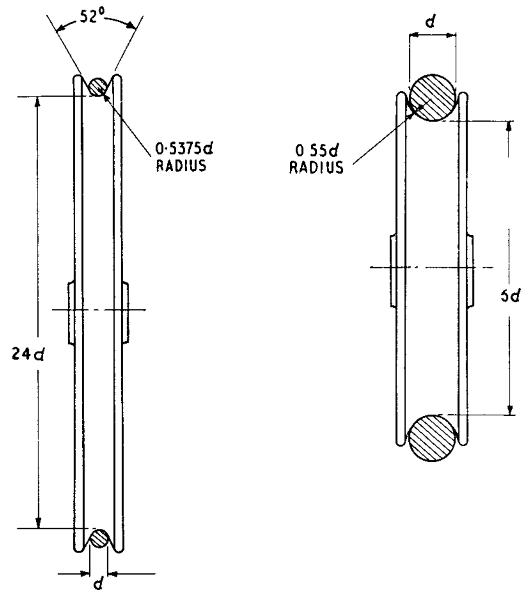
An important feature of the new Regulations is the recognition that the exercise of normal management and control is not sufficient to achieve the standards of safe conduct required. It is now obligatory for every employer undertaking works to which the regulations apply, and who normally employs more than 20 persons (not necessarily at the same site or all at work at the same time), to appoint one or more safety supervisors. These are to be persons, experienced in the operations or works and suitably qualified, who will advise the employer as to the observance of the requirements for the safety and protection of persons employed and exercise a general supervision of these requirements as well as promote the safe conduct of the work generally. These need not be full-time appointments, but, if not, such persons must be given sufficient time and opportunity to discharge their duties under the regulations with reasonable efficiency.

In the Post Office, safety officer posts have now been created in the External Plant and Protection Branch of the Engineering Department to generally co-ordinate and supervise safety matters among engineering personnel throughout the country, in the External Telecommunications Executive with a specific responsibility for safety and welfare at their radio stations, and in the Radio Branches of the Engineering Department. In addition to exercising general supervision in safety matters and advising on safety requirements, the safety officers will investigate accidents, obtain the relevant statistics and make recommendations regarding safe practices, improved methods of working, and training requirements.

WIRE ROPES

One of the main recommendations of the Halcrow report was designed to ensure that ropes received proper treatment to give a reasonably long life consistent with safety. Ropes appear to be ordinary everyday commodities and tend to be treated accordingly. However, if maltreated, they can become extremely dangerous in use.

Wire ropes had largely replaced fibre ropes for aerial and rigging work, but the fibre-rope pulley blocks had been retained. One of the main causes of deterioration of wire ropes is due to flattening under tension, and this is unavoidable if a fibre-rope pulley block, or even a wire-rope pulley block of the wrong size, is used. The difference between the two types of pulley is shown in Fig. 1. Whereas with fibre ropes the width of the pulley groove is slightly greater than the diameter of the rope being used, and the groove is suitably radiused to provide efficient seating for the rope, with wire ropes the radius of the groove should be approximately 7½ per cent larger than the nominal radius of the rope, the bottom of the groove should be a circular arc over an angle not less than 120°, and the angle of flare of the sides should be 52°. Also, the diameter of a pulley used for wire rope should be at least 12 times the diameter of the rope, or 24 times if the rope is to be used to lift men. With fibre ropes the pulley diameter need only be six times that of the rope.



(a) Pulley for Wire Rope (b) Pulley for Fibre Rope

FIG. 1—TYPES OF PULLEY USED FOR WIRE ROPES AND FIBRE ROPES

All ropes, both wire and fibre, and all pulley blocks have now been thoroughly examined and tested and any that were suspect or sub-standard have been scrapped. All pulley blocks, shackles and other auxiliary equipment used with wire ropes will in future be distinctly marked with their safe working loads and, where necessary, certified by the manufacturers. All lifting gear, including slings, hooks, shackles, swivels and eye-bolts, will also be tested and periodically examined in accordance with the Regulations.

Wire ropes are lubricated during manufacture to exclude moisture, retard corrosion and reduce internal abrasion, and it is important to apply fresh lubricants at regular intervals. The use of paraffin or petrol for cleaning wire ropes is prohibited, as it would penetrate into the rope and destroy the internal lubrication. Galvanizing is being adopted for all wire ropes used for lifting personnel, because it greatly reduces the risk of undetected deterioration.

The splicing of wire ropes is a very skilled operation and can result in damage to the galvanizing. Although the statutory requirements do not ban splicing, it has been decided to prohibit the in-line splicing of all wire ropes used at radio stations. To avoid the need for splicing, terminal fittings such as thimble eye-pieces will be secured to wire ropes by swaged ferrules.

When handling wire ropes the aim should be to keep some tension in them at all times. A slack rope, particularly if lying on the ground, is very easily kinked and damaged. Two reels are required: a "store" reel, which should be a permanent fixture in the store, and a "field" reel used for transporting the rope when it is to be used. The store reel should be clearly marked to show the size and length of the rope, and the particular field duty for which it is to be used. The field reel and the rope should also be marked so that they and the associated store reel are clearly identifiable.

Until now hand-operated pawl-and-ratchet type crab winches of 2–2½ tons safe working load have been used at radio stations. They do not, however, comply with the new Construction (Lifting Operation) Regulations 1961, which require that "every crane, crab, or winch shall be provided with an efficient brake or brakes or other safety device which will prevent the fall of the load when suspended and by which the load can be effectively controlled whilst being lowered." It is also required that "where a hoist is operated by means of a winch, the winch shall be so constructed that the brake is applied when the control lever handle or switch is not held in the operating position, and the winch shall not be a winch with a pawl-and-ratchet gear on which the pawl has to be disengaged before the platform or cage can be lowered."

The regulations do not specifically prohibit the use of hand winches, but it has been decided to replace all crab winches by mobile 2-ton diesel-engine power winches rated at 5 h.p. and mounted on trailers (Fig. 2). Replacement will not be on a one-for-one basis, however, as at many of the stations the hand winches were permanent fixtures at the base of each of the larger masts and were used at infrequent intervals. The number of power winches to be provided will depend on the program of work necessary throughout the year; suitable additional units will be provided for emergency purposes.

FIG. 2—MOBILE 2-TON DIESEL-ENGINE POWER WINCH

The use of power winches should lead to considerable economies in working. Whereas a hand-driven crab winch requires a crew of three men, a power winch only requires one man, but he needs to concentrate his attention on the machines and cannot be expected to pay attention to what is happening aloft. A "banksman" will therefore be necessary to relay signals from the rigger aloft to the winch operator, and a suitable code of signals has been designed for this purpose.

A power winch also gives a substantial saving in the time needed to carry out maintenance or repair operations, as it is some four to five times faster than hand operation and can raise a cage or hoist to the top of a 300 ft mast in some 5 minutes compared with 20–25 minutes using a hand winch.

Large Square-Section Parallel-Sided Masts

Large square-section parallel-sided masts (Fig. 3) are of lattice-steel construction and are some 300 ft high, having sides some 5 ft or more in width. Maintenance operations have in the past been carried out from cradles raised and lowered on the outside of the mast by hand winches. The insides of the masts were dealt with from scaffold boards pushed through the mast and supported on cradles on opposite sides of the masts. These methods of working are quite unacceptable under the new statutory regulations.

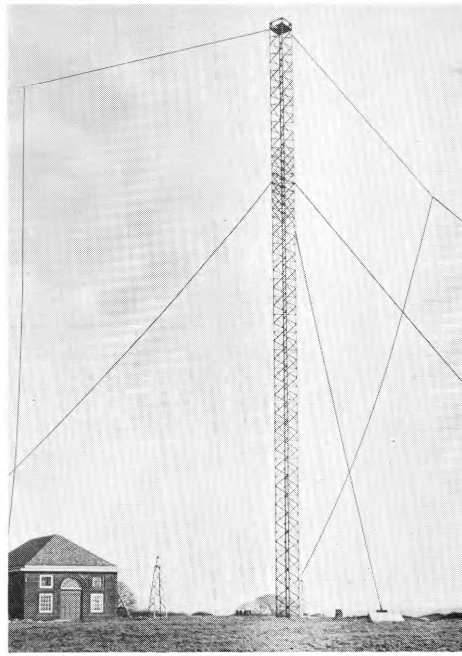


FIG. 3—LARGE SQUARE-SECTION PARALLEL-SIDED MAST

The methods now under consideration are based on the use of two cradles each controlled by a separate winch, as shown in Fig. 4. Light steel frames are erected at the head of the mast to support the head pulleys. The cradles run in guide wires and are suspended from two $\frac{7}{16}$ in. diameter steel ropes which pass over the head pulleys and are shackled to the top of a triangular yoke plate in the fall. A downhaul steel rope is shackled to the bottom of the yoke plate and led through a pulley block at the base of the mast to the drum of a winch.

For operations on tall open-type structures such as lattice masts, a cradle must run in guides throughout the whole height of lift. Guides also prevent the cradle from swaying outwards when the men lean over the guard rail to work on the mast structure and guard against movement which might be caused by sudden squalls of

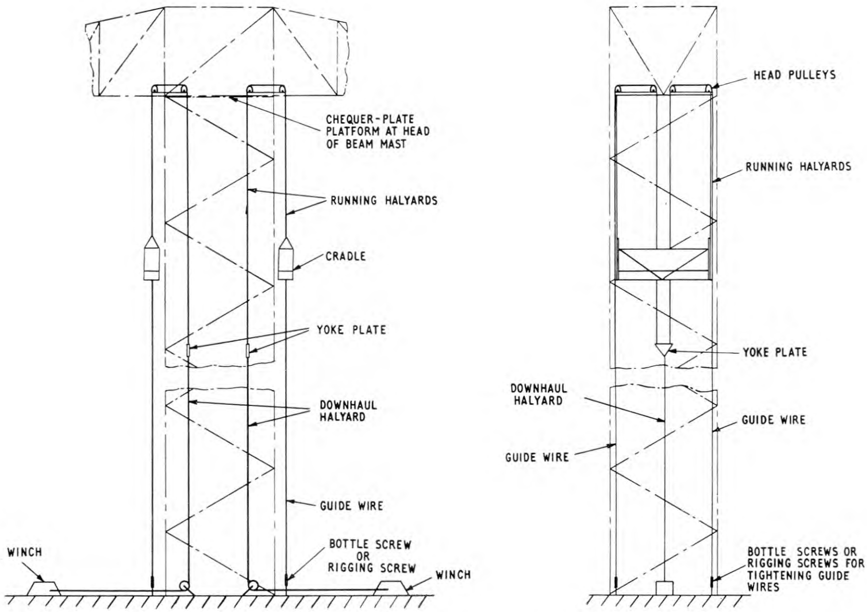


FIG. 4—HOISTING ARRANGEMENTS FOR CRADLES ON LARGE SQUARE-SECTION PARALLEL-SIDED MASTS

wind. These guides are small-diameter wire ropes threaded through eyes at each end of the cradle and fixed the correct distance apart between the head and base of the mast. Their tautness can be adjusted by rigging screws at the base of the mast.

The cradle is a safe means of transporting men up the mast to their working position, and with the use of power winches a fully-loaded cradle can be raised in very much less time than it took with the old hand-operated crab winches.

Where work is necessary on the inside of a mast in a position which cannot be reached from the cradles, a suspended safety chair is employed. Under the new regulations the conventional bos'n's chair is no longer acceptable, and wherever chair work is required in civil-engineering operations, structural or building work, the bos'n's chair has been replaced by a safety chair (Fig. 5). The basic requirements for these chairs are laid down in B.S. 2830.* No safety belt is necessary, the occupant has both hands free for work at all times, and a fair supply of tools and materials can be carried, the chair being designed to be self-contained for several hours continuous work aloft. It is suspended at the apex of a 4-part yoke which is well above the occupant's head, and the halyard is taken from the chair to a pulley block at the centre of the head of the mast, across to a pulley block on the inside face of the mast, down the mast and through a pulley block at the base to the winch.

The regulations call for the provision of effective ways of preventing a suspended chair from spinning, and this

FIG. 5—SAFETY CHAIR

*British Standard 2830:1957. Suspended Safety Chairs. British Standards Institution, 1957.

is done by threading the fall of the halyard down the inside face of the mast and through a light ring to which is attached a length of sash cord, the other end of which is hitched to the chair.

Self-Supporting Towers

There are two main types of self-supporting tower: one type (Fig. 6) has concave faces (Eiffelized) and

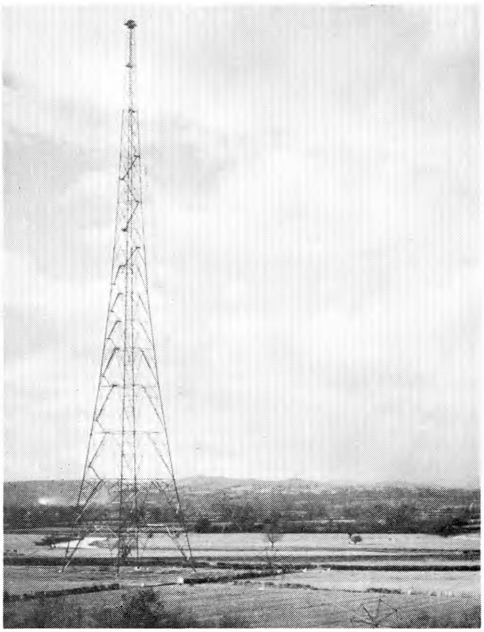


FIG. 6—SELF-SUPPORTING 600 FT EIFFELIZED TOWER

ranges from about 130–600 ft in height; the other has straight faces and corners forming a truncated pyramid, and the masts are between 70 ft and 300 ft in height. In the past, maintenance has been carried out by means of the bos'n's chair or by the use of scaffold boards placed across horizontal members.

The methods adopted in future will be similar to those used for parallel-sided masts, using light-weight metal-framed skips large enough to carry two men. These skips are suspended by means of running halyards passing over head pulleys, supported on light frames at the head of the mast, to a common yoke plate to which is attached the downhaul (Fig. 7). This leads through a pulley block at the base of the mast to a winch. Skips on opposite faces of the masts are raised and lowered together. Guide ropes are fixed on either side of the head beam, passing through eyes in the skip to mobile attachments at the base, so that the skip can be moved across the face of the mast. Rigging screws at the lower end of the guide ropes enable the clearance between the skip and the face of the mast to be adjusted as required. Before being raised or lowered, the skips are brought to the central position on the face of the mast by the use of the guide ropes down the middle of the face.

Long-Wave Aerial Masts at Rugby Radio Station

There are twelve masts supporting the long-wave aerial at Rugby. The masts are 820 ft high, triangular in section with sides 10 ft wide, and are stayed at 150 ft intervals. A hoist travels up the inside of each mast.

The method that is being adopted to paint these masts is to use three skips, one on each side of the mast. Each skip is suspended on the outside of the mast on two steel ropes by means of "Tirfor" pulling machines. These machines can be operated by the men in the skips, and by this means the skips can be gradually lowered or, if necessary, raised. The two steel ropes per skip act both as guide ropes and lifting ropes; each is 200 ft in length and fixed at the top and bottom to outriggers temporarily rigged on the mast.

The skips, one of which is shown in Fig. 8, are made of aluminium alloy and covered on the back and sides by wire mesh which, when earthed to the mast, forms an electrostatic screen to protect the men from the powerful radiation field. Three skips are operated together, one on each face of the mast, and each skip has earthing clamps fitted so that it can at all times be earthed to the mast.

The mast is painted in 180 ft stints starting from the top. The skips are first hoisted to the required height and fastened to the face of the mast by hinged support brackets and adjustable hooks. The outriggers are fixed 200 ft apart, and the wire ropes are rigged by being passed through the top and bottom of each skip, through the Tirfors, which are inside the skips, and attached to the upper and lower outriggers. When rigging is complete the skips are unclamped from the mast and are then supported by the Tirfors. By the operation of these machines, movement of the skips down the ropes is then under the complete control of the two occupants. On completion of the first stint of 180 ft the skips are anchored to the mast and the ropes lowered to allow work to proceed on the next length. Landing platforms will be provided to allow men to enter and leave the skips at the anchorage points, and additional platforms will give access to the outriggers for handling the ropes.

A skip is shown on the mast face in Fig. 9.

Small-Section Stayed Masts

Small-section stayed masts at Post Office radio stations are of the "Marconi" type or the Post Office No. 1 type. The Marconi mast is square in section with 12 in. sides, and the No. 1 type mast is triangular in section with 10 in. sides. The masts are erected up to some 200 ft in height, and are stayed at approximately 40 ft intervals.

Part of the new safety policy is to provide vertical ladders, with landing places at 30 ft intervals, as required on building works. These landing plates should be of adequate dimensions and provided with guard rails. This is clearly impracticable for masts of such small section, and portable light-weight metal seats have been provided which can be carried by riggers and clipped to the mast when they need to take a rest while climbing. Similar seats will be used when climbing tubular steel masts, which are only some $5\frac{1}{2}$–$7\frac{1}{2}$ in. in diameter and 150 ft in height. For climbing purposes step-irons have been permanently bolted to the outside of the mast.

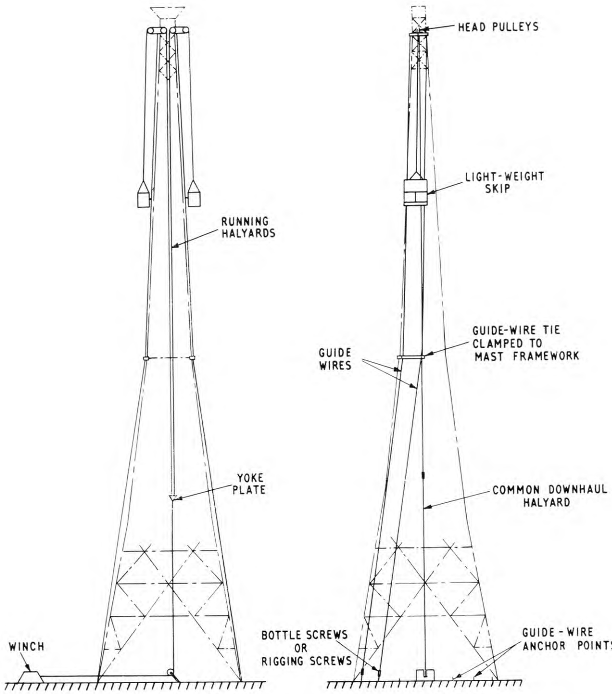
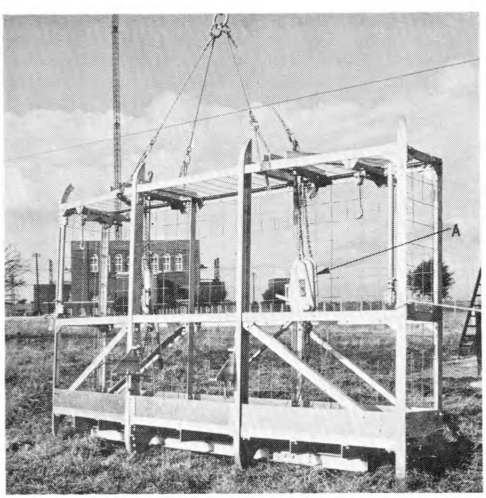


FIG. 7—HOISTING ARRANGEMENTS FOR SKIPS ON SELF-SUPPORTING TOWERS



A—Tirfor Pulling Machine
FIG. 8—SKIP USED ON LONG-WAVE AERIAL MASTS AT RUGBY RADIO STATION

To give additional safety while climbing or carrying out maintenance work on these masts it is proposed to use the "Everest" mobile safety anchor threaded through a wire rope secured to the top and bottom of the mast. The rigger will be secured to the safety anchor by a strap and safety harness. The safety anchor slides freely on the wire rope and allows a man to climb up or down, but grips the wire rope firmly in the event of a fall.

The device is illustrated in Fig. 10; it contains a weight freely supported on six stainless-steel springs. At the top of the weight are three steel balls held in a cage. If a man attached to the outer casing should fall the weight will move up relative to the casing and in doing so will force the balls between a conical wedge, attached to the outer casing, and the wire rope. The balls become progressively wedged, and the rope is thus firmly gripped and the fall arrested. By design, the amount of compression by the balls on the cable is such that the anchor will slide down the cable a foot or so before stopping, thus reducing the shock of the fall.

It is necessary after a fall that the wire rope be scrapped and replaced. The safety anchor, however, is not damaged and can be used again.

Parabolic and Horn Aerials on Towers used in the Inland Microwave Network

Parabolic Reflectors. On the inland microwave network dish-shaped solid reflectors up to 12 ft in diameter and 3 ft deep, supported by a lattice-steel framework, are attached to a face of the aerial-tower structure. Access to the inside of the reflector is necessary from time to time to inspect, adjust and maintain the fittings. In the past the work has been carried out by using a metal ladder with hooks at the head of the stiles; the hooks enabled the ladder to be suspended from the rim of the reflector, and the top of the ladder was lashed to prevent it slipping. The rigger clambered through the mast on to the top of the reflector, manoeuvred himself on to the ladder and descended until he could reach the central fittings.

Arrangements are now being made for this work to be carried out from a safety chair suspended from a jib. The chair will be hoisted to the reflector from the ground by means of a winch and running halyard, spinning being prevented by means of a ring passing over the downhaul and attached to the chair by a short chain. The head pulley can be moved along the jib by means of a small carriage so that the chair can be brought close to the reflector.

Horn Reflectors. Horn-reflector aerials have only recently come into service and are attached to a face of the aerial-tower structure, the larger type being 26 ft high and 12 ft deep. The horns are in the form of an inverted pyramid of square section, tapering from a width of 15 ft at the top to a 3 in. circular waveguide

FIG. 9—SKIP IN POSITION ON FACE OF MAST

at the base. The upper portion is capped by a section of parabolic reflector which directs energy horizontally through an opening at the front of the horn some 14 ft wide and 12 ft high. The opening is covered by a radiation-transparent membrane bolted to the horn, and maintenance is mainly concerned with the repair and renewal of this membrane; for this two men are necessary. The means to be adopted to permit these men to work safely aloft have not yet been finally decided, but will probably be similar to the method being adopted for obtaining access to parabolic reflectors.

MAINTENANCE OF MAST STAYS

Stays consisting of multiple-wire strands or wire ropes are widely used to support radio masts. The heights of these stayed masts are in the range 100–820 ft (the height of the Rugby long-wave-aerial masts). It is the practice for the stays to receive periodic maintenance in the form of cleaning-off old grease and re-greasing. This has been carried out in the past by several methods including the use of a bos'n's chair or skip supported from the stay and drawn along its length by a halyard passing through pulleys at the head and foot of the mast and secured to a winch.

To conform with statutory requirements, specially-designed skips would be necessary for travelling along the stays. Such skips could not, however, be used on

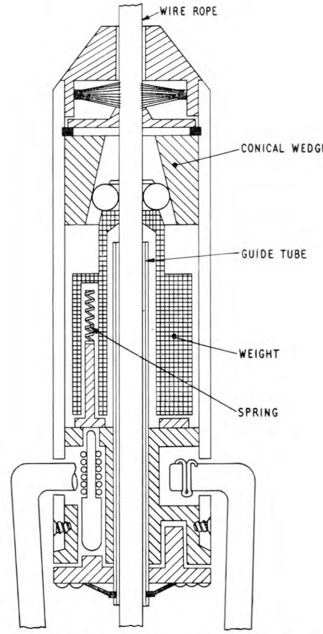


FIG. 10—CROSS-SECTION OF EVEREST SAFETY ANCHOR

the stays of the long-wave aerial masts at Rugby while the aerials are in use unless special measures were taken to screen the occupants from the intense field. The development of a mechanical device that would both clean and grease a stay while being drawn along it is therefore being considered.

CONCLUSIONS

The design and manufacture of the safety rigs outlined will necessarily take some time, and to expedite this work the design and preparation of the necessary drawings and contract documents have been placed in the hands of consulting engineers, Sir William Halcrow and Partners. It is aimed to complete the more urgent work, to enable access to be obtained to aerials, by mid-1965 and the remainder of the work a year later. In the meantime all maintenance work has been stopped, except where essential services would otherwise be affected, until the necessary safety arrangements are available.

ACKNOWLEDGEMENT

Thanks are due to Sir William Halcrow and Partners for permission to use the information contained in their reports in the preparation of this article.

A Combined Linefinder and Final-Selector Rack

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U.D.C. 621.395.722:621.395.34

A combined linefinder and final-selector rack is described that can be used to provide increased capacity quickly in exchanges whose equipment would otherwise be insufficient to cater for unforeseen growth.

INTRODUCTION

ONE of the objectives of the Five-Year Plan described in the White Paper, "The Inland Telephone Service in an Expanding Economy," is to abolish the telephone waiting list as quickly as possible. It was realized that, in many instances, special measures would have to be adopted for providing the additional exchange equipment necessary to accomplish this objective. One of these measures has been the introduction of a combined linefinder and final-selector rack for installation in director and non-director exchanges equipped with 2,000-type or 4,000-type apparatus and having uniselector calling equipments.

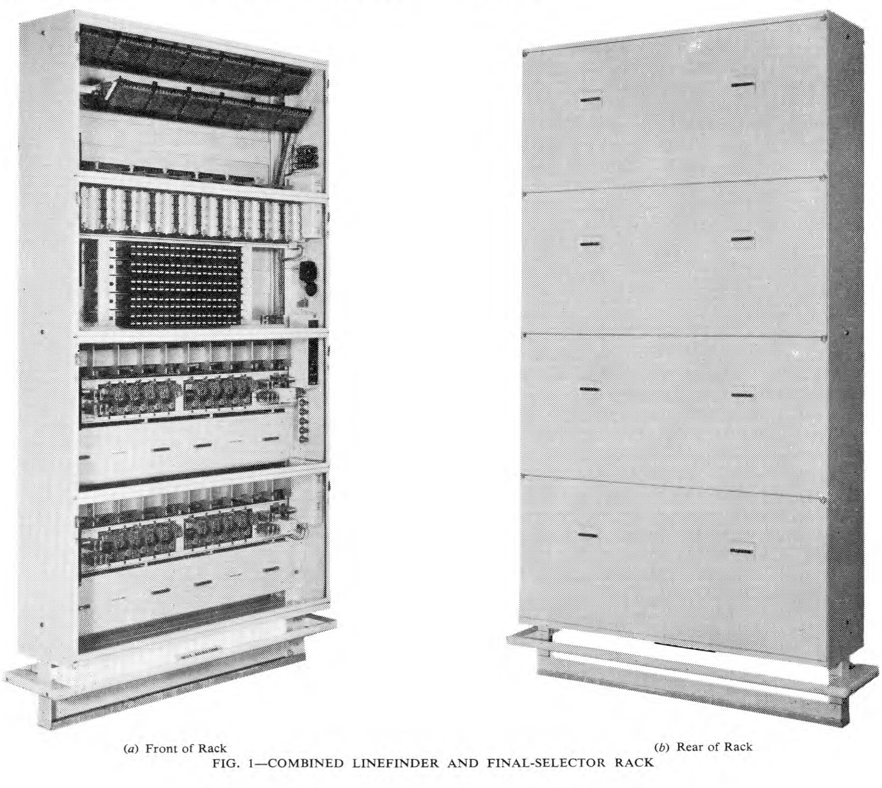
GENERAL DESCRIPTION

Fig. 1 shows front and rear views of the combined linefinder and final-selector rack. A standard open-type equipment rack, 8 ft 6½ in. high by 4 ft 6 in. wide, accommodates the various items of equipment required to serve up to 200 exchange connexions. The main items on the rack comprise four groups of subscribers' 50-point linefinders* catering for 196 exclusive connexions, one shelf of 10 banks of 200-outlet final-selector multiple equipped with eight 2–10-line private branch exchange (P.B.X.) final selectors, one test final selector and one trunk-offering final selector, and 200 subscribers' meters.

The line side of the calling equipments and the final-selector multiple are terminated on connexion strips at the top of the rack to form an intermediate distribution frame (I.D.F.) for the purpose of giving a measure of flexibility in the loading of the linefinder groups and to enable the appropriate connexions to be made to spare numbers in the multiple. The linefinder relay-sets and the final selectors are also terminated on

†Exchange Equipment and Accommodation Branch, E.-in-C.'s Office.

*Fox, W. H., Ashwell, J. L. K., and Weaver, A. L. Subscribers' 50-point Linefinder System. *P.O.E.E.J.*, Vol. 51, p. 81, July 1958.



(*a*) Front of Rack (*b*) Rear of Rack

FIG. 1—COMBINED LINEFINDER AND FINAL-SELECTOR RACK

these connexion strips in order to facilitate inter-rack cabling.

The rack is completely enclosed by the fitting of removable panels to both the front and the rear of the rack, and this feature, together with the rack height of 8 ft 6½ in., makes the equipment suitable for installation, where necessary, in rooms other than the apparatus room of the telephone exchange. The selectors and linefinder relay-sets are not provided with individual covers; the panels on the front of the rack are transparent so that it is possible to observe the operation of relays and mechanisms.

METHOD OF USE

The method by which the equipment on the composite rack is integrated with the exchange equipment is shown in the trunking diagram, Fig. 2. It will be seen that, for

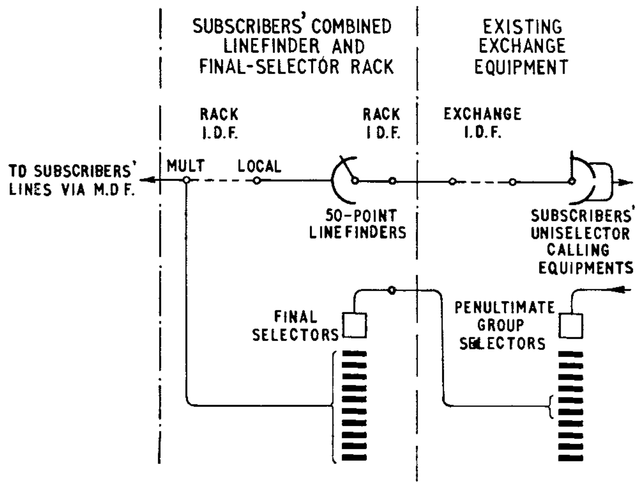


FIG. 2—TYPICAL TRUNKING DIAGRAM SHOWING METHOD OF INCORPORATING COMBINED LINEFINDER AND FINAL-SELECTOR RACK IN EXISTING EXCHANGE

a fully loaded combined rack, connexion is made to 20 subscribers' uniselector-type calling equipments and to two spare levels on penultimate group selectors in the relieved exchange. Wherever possible the existing equipment will be supplemented in the various switching stages concerned in order to maintain the grade of service, but where this is not practicable a lower grade of service will be tolerated until relief measures can be implemented.

SPECIAL FEATURES

An important feature of the combined rack is that it can be used in different types of exchange without the necessity of having to change any major items of equipment. Some minor changes to the subscribers' 50-point linefinder circuit were made to enable the meter connexions to be readily altered so that one type of rack can be used for all existing types of metering employed in director and non-director exchanges, except those using booster-battery metering. Booster-battery-metering exchanges can, however, be catered for by changing the 500-ohm type subscribers' meters on the combined rack for 2,300-ohm meters and by fitting linefinder relay-sets that incorporate an additional resistor. Exchange connexions with shared service can be connected to the composite rack, and, in order to avoid the use of tie-circuits to the existing exchange, the sharing subscribers should preferably have multiple numbers from the range catered for by the combined rack. Some spare tags have been left on the connexion strips on the rack I.D.F., and these can be used for tie-circuits to the exchange I.D.F., thereby making limited provision for interconnexion with calling equipments and final-selector numbers on the existing exchange.

CONCLUSION

The composite rack will enable relief to be given quickly in exchanges where unforeseen growth has accelerated the exhaustion date. Approximately 250 of these racks have been ordered from the manufacturers, and the first deliveries were made to the Home Counties Region where the equipment is now in service.

Books Received

"Control System Design." S. M. Shinner, B.E.E., M.S.E.E., S.M.I.E.E. John Wiley & Sons, Ltd. xiv + 523 pp. 289 ill. £4 9s.

The author, Mr. Stanley M. Shinner, is head of a research section in the Advanced Studies Department of the Sperry Company's Radiation Division as well as a lecturer in electrical engineering at the Polytechnic Institute of Brooklyn, N.Y. His industrial experience coupled with his teaching experience has influenced the style, presentation and content of this book, which should, therefore, prove useful to both the student and practising engineer: the theory developed is punctuated by numerous practical examples in order to illustrate important concepts.

The author has omitted the usual introductory mathematical information found in books on control-system design, considering the space normally thus devoted to be better used on a wider and more detailed treatment of the subject at hand. The book covers basic feedback concepts, linear, non-linear and sampled-data systems, statistical design, and optimal and adaptive control systems, as well as a review of the advanced mathematical concepts required to understand the presentation. Further, as a natural development attendant upon the inclusion of much of this material, emphasis has been given to the use of analog and digital computers as aids in solving control-system problems.

"A Guide to Advanced Electrical Engineering." Ruth M. Buckley, B.Sc., Ph.D., A.M.I.E.E. The English Universities Press, Ltd. viii + 168 pp. 100 ill. 12s. 6d.

This paper-back book has been prepared for students studying advanced electrical engineering, in particular, those students preparing in this subject for the Institution of Electrical Engineers Part III examination. It consists of 10 chapters, each one giving a brief theoretical introduction to a particular topic, followed by worked examples and other examples unworked but with numerical answers provided: altogether there are 67 worked and 102 unworked examples. The unworked examples have all been taken from the Institution of Electrical Engineers Part III examination papers from 1956 onwards. As the theoretical coverage is only brief, a useful but short list of books has been included for the assistance of students.

Baldock Radio-Control Station

F. M. BILLINGHURST, B.Sc., A.M.I.E.E., and H. W. EVANS†

U.D.C. 621.396.722:621.391.81:621.317.361

Baldock radio-control station is maintained by the Post Office to assist the day-to-day operation of its radio services. The station, its equipment, and the type of work performed, are briefly described.

INTRODUCTION

THE Post Office, as the government department responsible for licensing British radio stations, and itself a large-scale operator, has maintained a radio-monitoring station at Baldock since 1938. This station has been largely concerned with clearing interference, finding frequencies for new services, and routine monitoring of United Kingdom radio transmissions. In 1959 it incorporated the functions of the Brentwood monitoring station which, up to 1950, had been operated by Cable & Wireless, Ltd.

During the last 15 years, the number of radio circuits in use internationally has increased to the point where there is now no longer sufficient space in the h.f. communication bands for all the potential users. As a result the operational limitations on radio circuits are now frequently set by interference from neighbouring channels, and the importance and magnitude of the work done by the monitoring stations has increased accordingly. The Baldock radio-control station was enlarged and extensively re-equipped in 1960 to enable it to carry out its increasingly complex tasks more effectively.

The Post Office also maintains a radio-measuring station at Banbury[1] to collect engineering information for the national and international planning of radio services.

THE FUNCTIONS OF A RADIO-CONTROL STATION

The primary function of a radio-control station is to assist the day-to-day operation of an administration's radio services. In the United Kingdom this function is performed by the Post Office station at Baldock (Baldock Radcontrol), by the British Broadcasting Corporation (B.B.C.) station at Tatsfield and by the Ministry of Aviation station at Pailton.

The duties of Radcontrol may be summarized as follows.

(*i*) To make routine frequency measurements of the transmissions of all radio stations under the control of the Administration, in the range 15–30,000 kc/s.

(*ii*) To make, on request, frequency measurements of transmissions of radio stations under the control of the Administration, in the range 30–300 Mc/s or higher.

(*iii*) To investigate and assist in the removal of interference with, or by, radio stations, including amateur stations, under the Administration's control.

(*iv*) To measure the frequencies of incoming overseas radio-telegraphy and radio-telephony services, and, on request, the transmission frequencies of stations located in various parts of the world.

(*v*) To carry out observations in connexion with the selection of suitable frequencies for new communication channels.

(*vi*) To perform special interception work as required.

These duties may involve the interception and identification of radio signals and the measurement of their frequency, bandwidth and spectrum, field strength and direction of transmission.

To assist it to carry out these tasks with the speed and efficiency demanded by present-day conditions, Radcontrol has been extensively re-equipped with a variety of devices for making measurements of the necessary precision, some of which are described in the sections that follow.

FACILITIES AND EQUIPMENT

Site

The station occupies part of the Baldock main receiving-station site about 40 miles north of London. The accommodation consists of the single-storey building shown in Fig. 1, which houses the receiving room, staff offices, a dark room and a small test room. In addition a separate small building is used as a workshop.

FIG. 1—BALDOCK RADIO-CONTROL STATION

Aerials

The main aerial system consists of 12 wires extending radially at 30° intervals from a central 150 ft mast and sloping down to a height of 60 ft at a distance of 500 ft from the mast, where they are each terminated to earth through a 400-ohm resistor. At the centre of the system each wire is terminated in a 300/75-ohm transformer and connected by underground coaxial cable into the building. Switching facilities have been arranged so that the aerials can be used either as single sloping wires or in a combination of any two wires to form a sloping Vee

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aerial.[2] Both systems provide appreciable directivity, although, in practice, a single-wire aerial gives satisfactory results and the Vee arrangement is seldom used.

A v.h.f. wideband steerable array, shown in Fig. 2, is used to receive both vertically-polarized and horizontally-

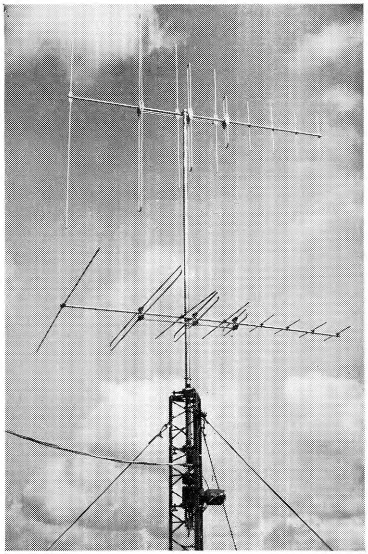


FIG. 2—V.H.F. WIDEBAND STEERABLE ARRAY

polarized signals in the frequency range from about 40 Mc/s to about 250 Mc/s. The array is mounted on top of the 150 ft mast and may be rotated by a remotely-controlled motor.

A wideband inverted-cone monopole aerial with a vertex angle of 50° and a height of 25 ft, erected on a clear site about a $\frac{1}{4}$ mile from the building, enables field strengths in the frequency band 15 kc/s–30 Mc/s to be measured. In the band 3–30 Mc/s the impedance throughout the band is sufficiently close to the cable impedance to dispense with matching devices; below 3 Mc/s the reactive impedance of the aerial increases but the resultant mismatch is allowed for in the calibration of the system.

Both m.f. and h.f. direction-finding aerials also need to be erected well clear of any buildings, aerials, power and telephone lines, and other obstructions. A set of Adcock h.f. aerials is erected on a clear prominence about $\frac{1}{2}$ mile from the monitoring station, with the goniometer in a hut at the centre of the aerial system. The search coil, range and sense switching associated with the goniometer are remotely operated over telephone-cable pairs from a dummy goniometer at the monitoring station; the radio-frequency signals from the goniometer search coil are fed over a coaxial cable to the control position at the monitoring station.

Receivers

Four different types of receiver have been provided to cover the various tasks and classes of service below 30 Mc/s. This is often helpful, when investigating interference, in determining whether the interference is in any way dependent upon the type of receiver used. The four types are described below.

(*i*) Two Post Office Receivers, Radio, No. 22, originally designed for i.s.b. telephony reception from 4–30 Mc/s, have been modified to receive both telephone and telegraph signals and to measure the characteristic frequencies of these signals.

(*ii*) A conventional marine communications receiver (Marconi NS702) was chosen as representative of its type, and covers the range 14 kc/s–28 Mc/s. It is used in connexion with frequency measurement and direction finding.

(*iii*) Two Racal Receivers type RA17 are available which, with adaptors, will cover the frequency range 10 kc/s–30 Mc/s. These receivers are particularly suitable for measuring frequency, as the first beating oscillator may be driven from a standard source and the frequency of the free-running second oscillator may be counted.

(*iv*) Marconi CR150 receivers having a range of 2–60 Mc/s are used when a second receiver is required to check intermodulation or spurious radiations on an emission.

Two Eddystone receivers are used for signals in the range 30–580 Mc/s.

Identification Equipment

The identification of radio signals is one of the most difficult tasks laid upon a radio-monitoring station. The difficulty is due partly to the infrequent emission of call signs by many stations and partly to the use of abbreviated or unregistered call signs, and, in large measure, to the difficulty of decoding signals because of the growing use of complex telegraph systems, e.g. frequency-shift modulation and time-division or frequency-division multiplex emissions. In addition, there are single and independent sideband systems, emissions using privacy equipment, facsimile emissions and machine-telegraph systems using a variety of codes other than morse. Broadcasting identification may be complicated by the wide use of languages not indigenous to the country originating the emission.

Probably the most effective single piece of equipment for identification purposes is a pair of headphones. Low-speed morse and telephony stations, both broadcast and point-to-point, may often be identified by listening. In addition, other types of emission may be identified by listening to the characteristics of the signal. For comparing signals, provision has been made for energizing each of the two headphone earpieces separately.

For telegraphy signals up to 200 words/min, undulators are used, and double-pen models are used for comparing signals. To identify 5-unit start-stop telegraph signals, variable-speed tape teleprinters have been provided; these may be adjusted to any speed between 42 and 55 bauds during operation. Prototype equipment has been developed to monitor and print synchronous 7-unit radio-teleprinter signals. A Marconi HU14 receiver adaptor unit enables channels of 4-frequency diplex emissions to be separated for printing.

A Mufax recorder is used to identify facsimile emissions in which the station code is included in the chart. An oscilloscope with a camera and a magnetic-tape recorder enable any signal to be stored for later breakdown and identification.

Frequency-Measuring Equipment

The C.C.I.R.* recommends that frequency-measuring equipments should be able to determine frequency to about an order better than the permitted tolerance of the emissions they are required to measure. For the h.f. fixed service this tolerance is 30 parts in 10^6 at present; it will be reduced to 15 parts in 10^6 after 1 January 1966. The corresponding measuring equipment, therefore, needs to determine frequency to an accuracy of at least 1·5 parts in 10^6.

The basis of any frequency measurement is a frequency standard from which reference frequencies can be derived. The standard at Baldock comprises three 100 kc/s oscillators utilizing GT-cut crystals, with beat counters for comparing the three frequencies. To achieve the necessary environmental stability the whole equipment is housed in an underground tank. The standard can be relied on to be within ± 2 parts in 10^8 per day, and the minute-to-minute stability to be within a few parts in 10^9, when the equipment is left undisturbed. Entering the tank for maintenance purposes causes a change of about 5 parts in 10^8. The accuracy is checked daily by comparison with the 60 kc/s standard-frequency signal emitted from Rugby. The received signal is frequency-multiplied 50 times and the resulting beat at 3 Mc/s is observed for 100 seconds. Frequencies derived from the standard are distributed around the receiving room to the measuring positions.

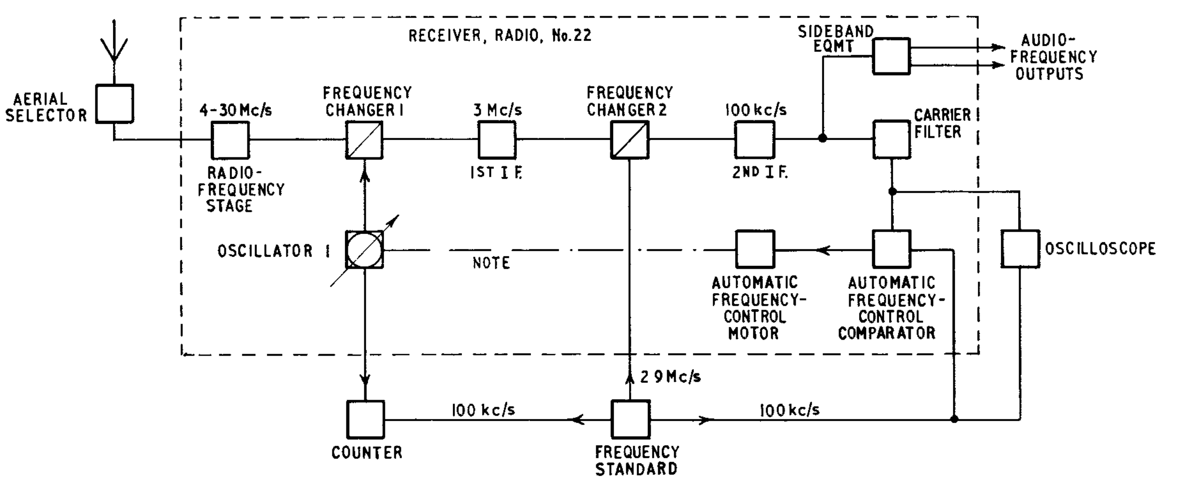
When measuring the frequency of a radio signal it is usual to select an identifiable component of this signal to beat against a local source and to measure the frequency of this source. In this way the effects of noise and the ambiguity associated with intermodulation components are removed, and a clear steady signal is available for measuring purposes.

Three methods of frequency measurement are used at Radcontrol at the present time. The first method is shown diagrammatically in Fig. 3. A Receiver No. 22 is used which has a free-running first beating oscillator and a first i.f. of 3 Mc/s. The second i.f. stage is reached through a second mixer stage supplied with a frequency of 2·9 Mc/s derived from the station standard. Comparison between the resultant 100 kc/s signal and a 100 kc/s reference causes the automatic frequency-control (a.f.c.) system to adjust the first oscillator to give an accurate first i.f. of 3 Mc/s. The receiver is thus held in tune, and the frequency of the first oscillator, which is now accurately related to the signal frequency, is measured on a counter. Provision is made for accurate comparison at 100 kc/s without a.f.c.

The second method makes use of a Racal Receiver Type RA17 and an electronic counter. The first circuit arrangements are such that any band 1 Mc/s wide in the range 1–30 Mc/s may be selected and converted to the 2–3 Mc/s i.f. band with the accuracy of the station frequency standard. The required signal is selected from this band by tuning the i.f. and ganged second oscillator so that the signal is converted to 100 kc/s. Accurate tuning is achieved by using an oscilloscope to compare this 100 kc/s with the station standard. The frequency of the wanted signal is then obtained from the receiver dial setting and the counter which measures the second-oscillator frequency.

The third method requires the use of a synthesizer giving an output at signal frequency. The method of operation is to tune the receiver to the wanted signal, then to inject the synthesizer output into the second r.f. stage and adjust for audio beat in the headphones. This note may be made exactly 1 kc/s by comparison with the 1 kc/s reference frequency on an oscilloscope. The signal frequency is then that of the synthesizer setting together with the allowance for the 1 kc/s offset. A harmonic amplifier enables the frequency range of measurement to be extended up to 600 Mc/s when used with a suitable receiver.

Comparing the three methods, the first is fast, accurate, enables the signal to be monitored during measurement, and permits continuous recording under favourable conditions. The second method is neither as fast nor as accurate as the first under normal conditions; it allows the signal to be monitored during measurement but is not suitable for continuous recording. The third method is accurate but slow, and may give rise to error if care is not taken to allow for and resolve the sense of the 1 kc/s offset; it does not lend itself to continuous monitoring nor is it suitable for monitoring the signal during measurements. It is, however, capable of application to a wide range of frequencies, and it is the most suitable for comparing the frequency standard at 3 Mc/s, for



Note: Mechanical connexion

FIG. 3—SCHEMATIC DIAGRAM OF FREQUENCY-MEASURING EQUIPMENT USING RECEIVER No. 22 AND 100 kc/s REFERENCE STANDARD

*C.C.I.R.—International Radio Consultative Committee.

which an observation for a period of 100 seconds is necessary.

Spectrum Analysis

For examination of the spectral characteristics of emissions in the range 10 kc/s–30 Mc/s a spectrum analyser of Post Office design is used. The band under examination can be swept once every 0·5–30 seconds by a narrow-band filter, a choice of a 6, 30 or 150 c/s bandwidth being available. The sweep may be stopped or varied to cover any band up to 30 kc/s. The various parameters are chosen according to the bandwidth of the emission and the degree of resolution required.

The analyser is put to a variety of uses such as the identification of the class of emissions, the measurement of occupied bandwidths, the identification of spurious radiation, and the investigation of faults and other irregularities in emissions. A photographic record of the oscilloscope display is available; a typical example is shown in Fig. 4.

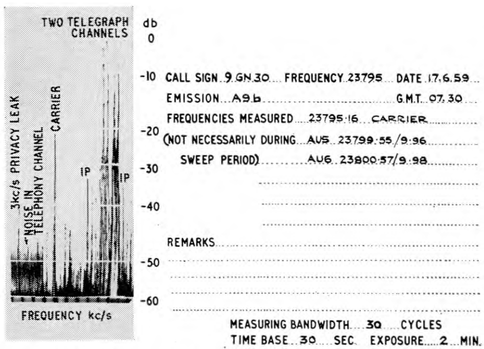


FIG. 4—EXAMPLE OF PHOTOGRAPHIC RECORD OF SPECTRUM-ANALYSER DISPLAY

Field-Strength Measuring Equipment

Equipment for both individual measurements and continuous recording of field-strengths is installed at Radcontrol to cover the frequency range 15 kc/s–30 Mc/s. A schematic diagram of the arrangement is shown in Fig. 5. The equipment enables the amplitude of the received signal to be compared with a local signal of the same frequency and known amplitude. Operation of relay S switches the receiver from the aerial to a signal generator. The signal-generator frequency and output level are adjusted to give the same reading on the receiver output meter as that obtained from the received signals. Attenuators are provided to bring the levels at different points within the working range and to minimize impedance irregularities. The aerial attenuator also provides a static leak and prevents switching surges.

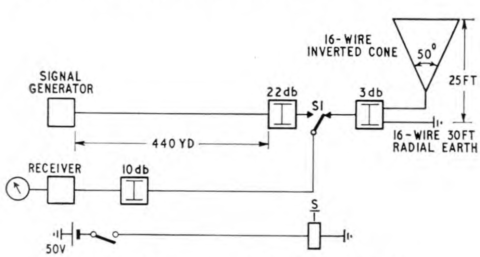


FIG. 5—FIELD-STRENGTH MEASURING EQUIPMENT

The field strength (db relative to 1 μV/m) is determined by applying a correction to the signal-generator output-attenuator reading; the correction curve was obtained by calibrating the system on distant signals. In the range 15 kc/s–1·6 Mc/s the calibration was carried out using a loop-aerial receiving equipment, which, in turn, was accurately calibrated using a loop standard-field generator of Post Office design. From 1·6–30 Mc/s calibration was effected using a Post Office field-strength measuring set (Measuring Set, R.I., No. 1).

With this arrangement the maximum field-strength level that can be measured is + 98 db relative to 1 μV/m over the whole frequency range, the minimum levels being + 15 db at 15 kc/s and — 25 db at 30 Mc/s.

Direction Finding

Direction-finding facilities are useful as an aid to signal identification, and remotely-controlled equipment has been provided to cover the range 1·5–20 Mc/s. The equipment is housed in a hut in the centre of the aerial system. Range and sense switching, and the search coil, are remotely controlled from a panel on a console in the receiving room. The receiver used is a Marconi NS702, which can also be used with the 12 sloping-wire aerials. These normally give sufficient discrimination for sense purposes.

Band-Occupancy Studies

In the past the search for spaces in the frequency spectrum for new services has been carried out by manual monitoring of the band in which it is required to operate the new service. This work is slow, tedious and expensive. An automatic scanning receiver,[3] developed by the Post Office, is used at Radcontrol to produce a record on paper of all the signals present above a pre-determined field-strength in a chosen band. In this equipment, shown in block schematic form in Fig. 6, a sensitive

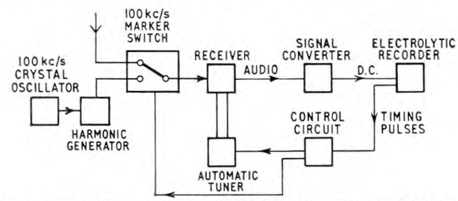


FIG 6.—SCHEMATIC DIAGRAM OF AUTOMATIC SCANNING RECEIVER

communication-type receiver, with positive non-slip slow-motion drive, is swept over a pre-determined frequency band once every 2 minutes by a drive unit mechanically coupled to the tuning spindle of the receiver. A recording device moves steadily over a chart of electrolytic paper in synchronism with the receiver tuning control, recording a mark whenever a signal is picked up by the receiver at a strength higher than the preset threshold level.

The swept band is represented by the width of the printed chart and can be adjusted as required by changing the gear wheels that drive the receiver tuning spindle; the smaller the frequency sweep the larger the spacing between the traces of adjacent emissions. A normal operating condition gives a swept band of approximately 1 Mc/s for the 8 in. width of the chart. The normal chart speed is ½ in./hour. At 2-hourly intervals the input of the radio receiver is automatically disconnected from the aerial and is switched to receive frequency-calibration signals from a 100 kc/s harmonic generator. The minimum receiver input level for reliable recording is between 1 and 5 microvolts. A typical record is shown in Fig. 7.

Layout of Equipment

It has been found convenient, particularly for monitoring work involving routine measurements and the clearance of interference cases, to accommodate all the required equipment on console units. There are five such consoles at Radcontrol, three of which may be seen in Fig. 8. The equipment is so arranged that the operator can generally reach, from a sitting position, any item at his disposal. Aerial-selection and telephone facilities are provided at each console, together with such equipment as electronic frequency-counters, which may be shared between console positions. The first console is used to deal with interference in the 4–30 Mc/s frequency range, and comprises frequency-measuring equipment of the first type described earlier with associated electronic counter, variable-speed teleprinter, double-pen undulator, Hellschrieber printer, and an auxiliary receiver for general search purposes; it also has access to a spectrum analyser. The second console has facilities for interference investigations on frequencies not covered by the first console, routine frequency measurements (h.f. and u.h.f.) using the third method, and direction finding. It is equipped with an undulator and a variable-speed teleprinter. The third console is fitted with field-strength measuring equipment, frequency-measuring equipments of both the first and second types, and an undulator. The fourth and fifth consoles are similar and are equipped with Racal receivers and frequency-measuring equipment of the second type.

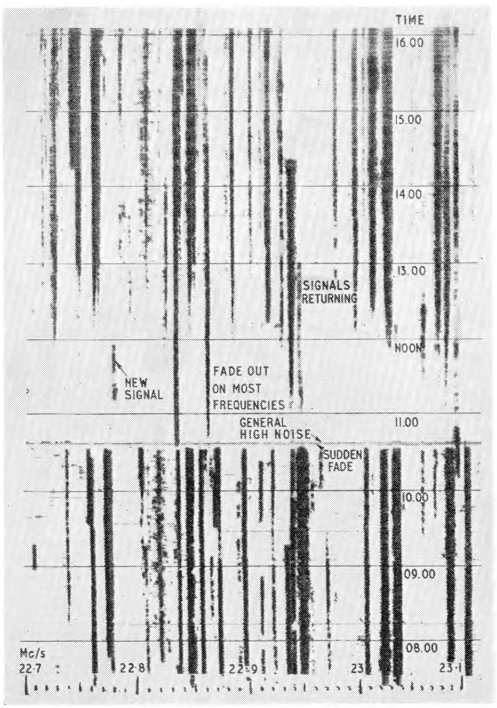


FIG. 7.—TYPICAL SCANNING RECORD

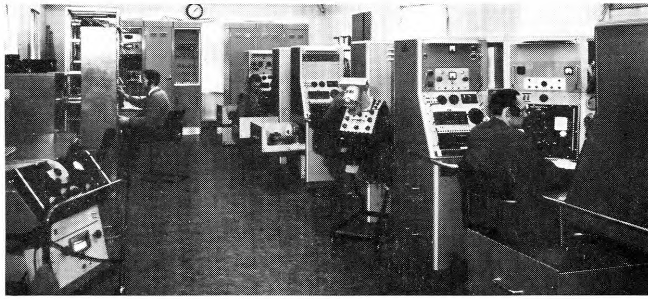


FIG. 8—LAYOUT OF EQUIPMENT AT RADCONTROL

Miscellaneous equipment which is not continuously used, but which may be required at short notice, is mounted on racks. Such equipment includes the tape recorder, scanning receiver, audio equipment, filters and the telegraph distortion-measuring set.

OPERATIONAL PROCEDURE

The name RADCONTROL LONDON is registered as a telegraphic address, and messages so designated are received from the overseas telegraph terminal at Electra House, London, on one of two teleprinters at Baldock radio-control station.

The telephone system is multipled on each console position in such a way that an incoming call can be answered from any position and the call then taken by the appropriate position. Only rarely are all positions engaged at the same time, so that any call is sure of prompt attention. For verification or identification purposes provision is made either for listening to line and receiver signals simultaneously or for extending the received signals to line.

Article 13 of the Radio Regulations, Geneva, 1959, deals with international monitoring, and the procedure to be followed in the event of harmful interference is given in Article 15 of these Regulations. The procedure used over many years at Radcontrol for dealing with interference consists in communicating with identifiable offenders by service messages and inviting their co-operation. The messages, couched in discreet, courteous terms, quote the measured frequencies of the stations concerned, describe the nature of the interference, and seek assistance in removing the cause. If the offending transmitter is located in a country possessing a monitoring station the message is addressed to that station; the latter then verifies the complaint and communicates with the transmitting station. Despite the informal nature of this procedure and the absence of any form of pressure, it has proved satisfactory in practice because of the friendly collaboration which has developed between the various monitoring and transmitting stations in a common endeavour to clear mutual interference. As a result, the number of instances of interference requiring administrative action is only a very small percentage of the total.

The number of investigations referred to Radcontrol has increased from 5,000 during 1960–61 to 6,283 in 1963–64. The most significant change shown by an analysis of the returns for these years is an increase from 12·5 per cent to 19 per cent in requests for assistance from foreign administrations. The nature of the work may be summarized approximately as follows: interference investigations, 93 per cent; emission assessment, 3 per cent; other circuit observations, including identification assistance, 4 per cent.

Although the B.B.C. monitoring station at Tatsfield is concerned with measurements relating to the broadcasting service, the clearance of broadcast interference on an international basis is referred to, and is dealt with by, Baldock Radcontrol.

ACKNOWLEDGEMENT

The authors wish to thank the staff of Radcontrol for their assistance in preparing this article.

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A New Approach to the Duct-Rodding Problem—Ductmotor No. 1

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U.D.C. 621.315.232

A pneumatic duct-rodding motor is being introduced to enable specialist duct-rodding parties of two men to rod in advance of a cabling gang. This will not only ease the duct-rodding situation but will also allow cabling to be done in a more logical sequence than has previously been possible.

INTRODUCTION

DUCT rodding has always presented difficulties to telecommunication engineers, and any possible advance in design or technique has always been carefully investigated. Today, however, with mechanical aids available for almost every other arduous task, duct rodding remains as one task requiring much physical effort and often producing a good deal of frustration. Because of this, the development by the British Post Office of duct-rodding devices has been high on the priority list for many years.

Rodding devices, or "moles" as they are sometimes called, are being used in several countries, and many of the devices have been considered by the British Post Office for modification or adoption. German and Swiss devices for duct rodding, and numerous devices from the U.S.A. for duct and conduit rodding, are all very good from one point of view or another, but none is capable of being modified to meet all British Post Office requirements.

A duct-rodding device should be capable of rodding both empty and partly occupied ducts. It must pass through ducts of a variety of materials, although salt-glazed earthenware[1] is the most common. It should be able to pass through water, mud and silt, round small-radius bends, and up or down steep inclines. In addition, it should be capable of operating over any distance up to about 600 yards and it must be able to pass over a coaxial cable without damaging it.

At present no device has been produced that will meet all these requirements, but a new Post Office device, the Ductmotor No. 1,[2] is the best powered machine available, while the device described in a recent article[3] is the most satisfactory hand-operated device. The ductmotor meets the essential requirements, and combines a reasonably high speed of operation, and the ability to be handled by a 2-man party, with a fairly reliable design that requires little maintenance in the field. The reasonably high speed of operation and the reduction in manpower from a 6-man cabling gang to a 2-man rodding party reduces the effective time of duct rodding from 0·07 to 0·017 man-hours per yard, i.e. a reduction of about 75 per cent.

SOME EARLY DUCT-RODDING DEVICES

The means of propulsion that have been tried for duct-rodding devices make an almost exhaustive list. Electric and air-turbine motors have been used in conjunction with rotating wheels touching the duct wall, but compressed air has proved to be the best means of transferring power from the duct mouth to the duct-rodding device. Early devices used a pneumatic motor and gripped the duct wall by means of longitudinal springs covered with corrugated rubber.

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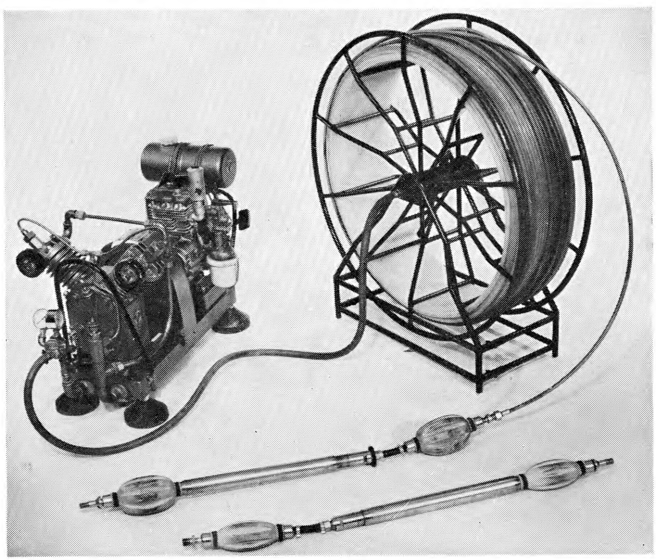
In a later development, the disk-grip machine, the body of the machine is in two coaxial pieces having a reciprocating action given by the valve arrangement inside the machine and the compressed air supplied at the rear end. The duct is gripped by disks consisting of three laminations of rubber and one lamination of tough plastic sheet, the plastic sheet being in front of the rubber to prevent it bending forwards. Further progress towards the present design was made by the use of nylon-bristle grips, inclined towards the rear of the mole, coupled with a percussion motor. In this device a heavy piston, inside the machine barrel, moves quickly in the forward direction and slowly in the reverse direction supplying energy by impact momentum to move the device forward. These devices have met with various degrees of success, and the better points of them all have been incorporated in the new Post Office ductmotor.

POST OFFICE DUCTMOTOR NO. 1

The photograph shows two Post Office Ductmotors No. 1, one using the large-size air bags and the other the small air bags, together with associated hose, reel and air compressor. The Ductmotor No. 1 is supplied with compressed air at 80–100 lb/in^2 by a petrol-engine driven single-stage compressor. The air is fed to the centre of the hose reel, passes through an annular space in the spindle and along 200 yd of $\frac{3}{8}$ in. diameter nylon hose on the reel to the ductmotor. The compressed air fills the rear air bag until the pressure in the bag is about 6 lb/in^2, and the body, which is in two concentric pieces, then extends by the action of the full air pressure on a piston. When the body is fully extended a change-over valve-gear operates, and the rear air bag is allowed to deflate while the front air bag is inflated to about 6 lb/in^2; the full air pressure on the opposite face of the piston causes the body to contract. The process is automatically repeated, and the ductmotor moves along the ductline, drawing a small Courlene rope behind it. When the motor reaches the far end of the ductline it is disconnected from the nylon hose and the hose is recoiled on the reel.

The two ductmotors shown in the illustration are identical except for the air-bag sizes—large air bags are used for unoccupied ducts or for those containing only one or two very small cables, and small air bags are used for ducts containing more cables. Air bags are easily replaced and either size of air bag may be fitted to any machine. In order to reduce damage to the outer tube of the extendable body it is made of stainless steel, while most of the rest of the motor is made of brass.



DUCTMOTOR No. 1 WITH HOSE, REEL AND AIR COMPRESSOR

CONCLUSIONS

The possiblity of ductmotors completely superseding cane and continuous rods cannot yet be envisaged. However, field trials indicate that the Ductmotor No. 1, which is the result of many years of effort by a large number of Post Office engineers in conjunction with some engineering firms, will be able to tackle successfully 80 per cent of all duct rodding required. Some difficult jobs will still require the use of canes and, possibly, of continuous rods.

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New North Sea 120-Circuit Submarine-Cable Systems

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The four 120-circuit submerged-repeater systems ordered following the North Sea Cable Conference in 1961 have now been laid. A brief report on the first system to Germany has already been given in this Journal, but a more detailed report on the operation, design and performance of the systems can now be made.

INTRODUCTION

THE 1961 North Sea Cable Conference, which was attended by representatives from eight European countries, considered the probable growth of traffic between the United Kingdom and Europe and the types of systems by which the additional circuits could be made available. The Conference concluded that microwave radio systems were ideally suited to telephone traffic to France, but the microwave path length would be too great for systems to other countries. Although tropospheric-scatter systems were considered, it was finally decided to lay a series of repeatered submarine cables. The four cables referred to in this article were all required by 1964, and the development of wideband systems was not then sufficiently advanced to permit ordering systems of more than 120-circuit capacity. The provision of cables to Norway and Holland in 1966 and the provision of extra capacity on the St. Margaret's Bay to La Panne (Belgium) cable were also recommended by the 1961 Conference, and these systems will be of greater bandwidth.

The four 120-circuit submerged-repeater systems ordered as a result of the Conference have now been laid. A brief report on the first system to Germany has already appeared in this Journal,[1] but a more detailed account of the operation, design and performance of the systems can now be given.

GENERAL

Existing repeater stations in East Anglia did not offer the facilities required for the terminal stations of these new cables. New sites were acquired at Winterton, Norfolk, and Covehithe, Suffolk, and new repeater stations have been built to accommodate both the equipment associated with these projects and the terminals of the inland coaxial systems by which the circuits are extended to London.

Specifications were prepared and tenders invited for the following 120-circuit systems.

(*a*) Two systems from Winterton to Leer (Germany).

(*b*) One system from Winterton to Esbjerg (Denmark).

(*c*) One system from Covehithe to Katwijk (Holland).

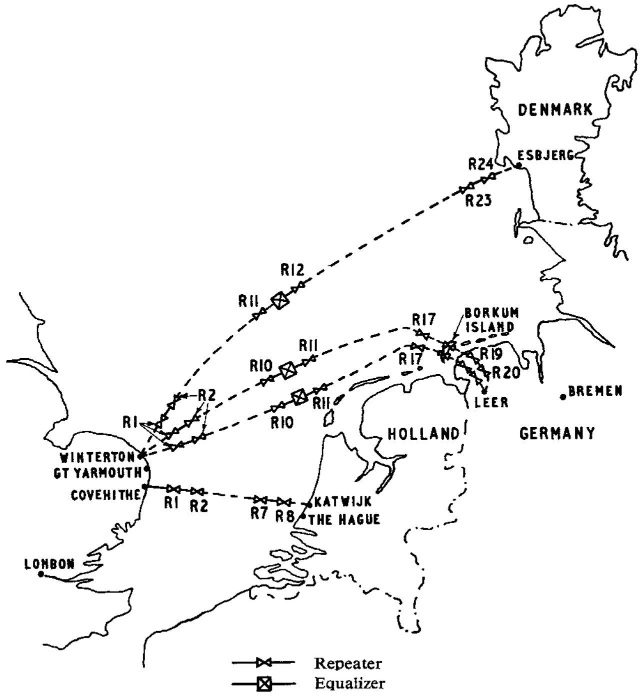
The approximate routes are shown in Fig. 1 and the system lengths, etc, are given in the table.

The tenders were invited to a specification detailing only the performance requirements—a radical departure from the practice for ocean-cable projects, but justified by a belief that (*a*) an adequate degree of reliability for shallow-water repeaters could be maintained with some relaxation of the standards imposed for ocean systems, and (*b*) manufacturers of submerged-repeater systems had gained sufficient experience of this work to ensure satisfactory designs suited to their own manufacturing processes.

It was hoped that this method of purchasing would materially reduce the cost of the systems, and so it proved—all tenders received were substantially lower than system prices hitherto, and in the event the four contracts were awarded to Standard Telephones and Cables, Ltd. (S.T.C.).

Frequency Spectrum

The preferred line-frequency spectrum was given in the specification, but the type of repeater supervisory system



All cables are 0·62 in. diameter throughout except for 0 935 in. section between Borkum and the German mainland

FIG. 1—NORTH SEA 120-CIRCUIT SUBMARINE-CABLE SYSTEMS

North Sea 120-Circuit Submarine-Cable Schemes

System	Overall Route Length (n.m.)	Total Number of Repeaters	Number of Equalizers	Land-Based Repeaters
United Kingdom –Denmark	298·5	24	1	0
United Kingdom –Germany No. 1	251·1	20	1	3
United Kingdom –Germany No. 2	249·7	20	1	3
United Kingdom –Holland	107·9	8	0	0

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

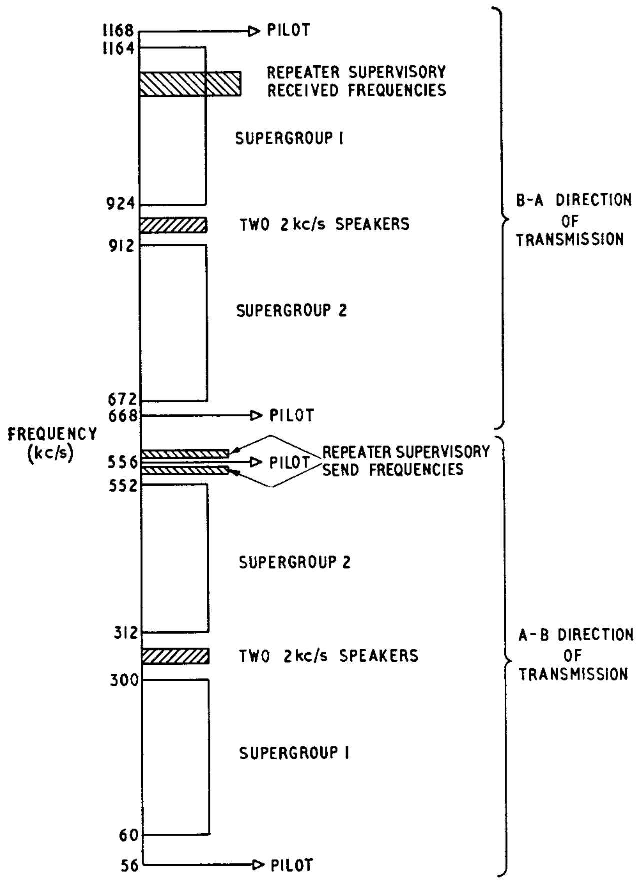


FIG. 2—LINE FREQUENCY SPECTRUM FOR 120-CIRCUIT SYSTEM

was left to the contractor. S.T.C. chose the frequency-doubling method, using a separate test frequency for each repeater; the line spectrum used is shown in Fig. 2.

Cable Type

Conventional armoured sea-cable is generally made in two sizes: 0·62 in. and 0·935 in. diameter, the respective attenuations per nautical mile (n.m.) at 1 Mc/s being about 3·9 db and 2·6 db. Although either type was acceptable, use of the larger cable results in fewer repeaters, and the choice of size therefore depended on relative costs of cables and repeaters. The 0·62 in. cable proved the cheaper solution for these schemes and has been used throughout, except for a short section of 0·935 in. cable used in German shoal waters to increase the repeater spacing at a difficult location. The main sea sections are protected with a single layer of armour wires, but the more vulnerable shore-end lengths are protected with double armouring. A typical depth of the laid cable is about 20 fathoms.

SYSTEM DESIGN

The basic principles of wideband line-transmission-system design are well established and have been discussed before.[2] However, it may be timely to briefly restate these principles, particularly as, for submarine-cable systems, there are some special factors which have to be taken into account and which merit explanation. As on all other types of transmission system, the design has to meet a minimum requirement for channel signal-to-noise ratio, and to achieve this the designer is limited on one hand by the level of inherent resistance noise plus valve noise at the input of the amplifier and on the other hand by the overload level at the amplifier output.

The designer of the inland transmission system, having fixed the nominal minimum signal input level relative to the basic-noise level and having determined the nominal output signal level according to the valve and output stage chosen, then takes steps to see that the nominal conditions are reasonably maintained in the practical case. This can be done, for example, by automatically controlling the amplifier gain to match changes in cable attenuation with temperature and also, if necessary, to match changes due to valve aging, etc., and by ensuring that equalization errors do not exceed a certain value by providing residual equalization at every, or at frequent, intermediate-amplification points.

To avoid unnecessary complexity in the submerged repeater such methods are not open to the submarine-system designer, and the design has therefore to include allowances for variations and misalignments, of which the most serious is that due to the change in cable attenuation with the sea-bottom temperature variation. This particular problem is of a lower magnitude for deep-water ocean schemes, where the sea-bottom temperature is substantially constant (about 3°C); but for shallow waters such as the North Sea and the English Channel the cyclic temperature variation each year is very considerable, and the allowances which have to be made for the resulting attenuation changes are discussed below.

Effects of Sea Temperature on Attenuation

The range of sea-bottom temperatures in the region of the cable is published in the relevant route specification from information supplied principally by the Ministry of Agriculture and Fisheries and also gained from operating experience of systems already in service in the same area. As examples, the temperature of the Danish cable was quoted as 10 $\pm$ 5°C, and that of the German cable as 11 $\pm$ 6·6°C. The mean loss per nautical mile at 1,164 kc/s (the highest channel frequency on this design) for 0·62 in. cable is 4·16 db at 11°C. The overall loss of the German cable (250 n.m.) at 1,164 kc/s is therefore 1,040 db at the mean sea temperature, and, taking the temperature coefficient of attenuation to be 0·16 per cent per °C, the attenuation at this frequency will change $\pm$ 11 db for temperature changes of $\pm$ 6·6°C.

Any change in output level of the submerged repeaters must be accommodated without overloading the output valve, and hence the nominal working level must be set accordingly.

The effect of cable-temperature change on the repeater signal levels can be conveniently accommodated by providing equal values of temperature equalization at the transmit and receive terminals. For example, at the minimum point of the sea-temperature cycle, when the cable attenuation at 1,164 kc/s (for the example quoted) is approximately 11 db below nominal, the transmit level would be reduced by 5·5 db and the corresponding received level at the distant terminal would be 5·5 db higher than the nominal. The temperature equalizer is, of course, designed to match the attenuation/frequency change of the cable, which follows, approximately, a $\sqrt{f}$ law, where f is the frequency, and lower frequencies are therefore correspondingly less affected. This is shown diagramatically in Fig. 3.

The foregoing technique tends to stabilize the system noise performance because, as Fig. 3 shows, to a first approximation the noise increase of the repeaters in one half of the route is offset by the noise reduction of the repeaters in the other half. In practice, complete cancellation does not occur, and a small noise misali nment penalty must be allowed for in the design in accordance with the following approximate formula (attributed to the American Telegraph & Telephone Co.).

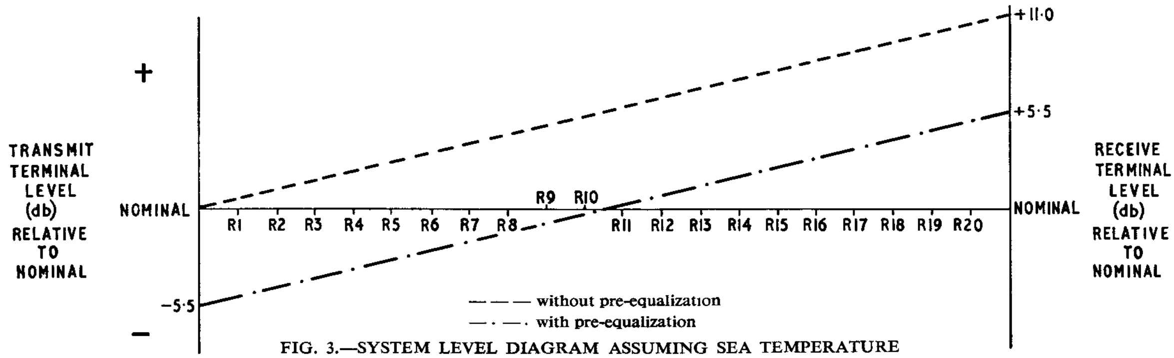


FIG. 3.—SYSTEM LEVEL DIAGRAM ASSUMING SEA TEMPERATURE AT MINIMUM

$$\text{Penalty (db)} = 10\log_{10}\left[\frac{1}{M}\left(\text{antilog}\frac{M}{20} - \frac{1}{\text{antilog}\frac{M}{20}}\right)\right] + 6{\cdot}4\text{ db},$$

where M = total system misalignment, i.e. the maximum attenuation change from nominal.

The resulting penalty for the German and Danish systems is about 1·25 db.

While discussing cable temperature effects it is worth considering the effect of cable repairs, which may increase a cable-section length by a small amount. The effect on the system performance is proportional to $\sqrt{f}$ and similar to the temperature effect; its magnitude is, therefore, offset by inserting equal values of "cable-repair" equalization in both the transmit and receive terminals. Hence, an appropriate allowance has to be made in the system design for the consequential increase in output level and a small margin provided for the resulting misalignment.

DETERMINATION OF THE NUMBER AND THE GAIN OF THE SUBMERGED REPEATERS

Individual designers may determine their repeater parameters and allocate the allowances and margins in a different manner from the method used below, but as all the designs for these systems were required to use a particular type of valve (the Post Office 10 P type) the solutions arrived at were similar. Each designer must solve the system noise equation:

$$N_p = N_{ip} + 10\log_{10} n + G - O_l$$

where N_p = total noise power limit for the system,

N_{ip} = amplifier input noise, including generated noise referred to the input,

n = number of repeaters in the system,

G = gain of repeater (amplifier gain minus filter losses), and

O_l = repeater output level.

By way of example, this equation will be solved for a typical 250 n.m. route using 0·62 in. cable (e.g. the systems to Germany), and the components of the equation are therefore examined below.

Amplifier Noise

Assuming that, on a well-designed coaxial system, induced noise is negligible, then three sources contribute noise to an amplifier: (*a*) resistance noise, (*b*) valve noise, and (*c*) intermodulation noise.

(*a*) Resistance noise is developed across the cable resistance, and the resulting noise power is kTB watts,

where k = Boltzmann's constant

$= 1{\cdot}38 \times 10^{-23}$ Joule/°K,

T = temperature in degrees Kelvin, and

B = bandwidth of circuit in cycles/second.

For a weighting factor of 2·5 db, appropriate to a 3·1 kc/s bandwidth channel, the weighted noise power for ambient temperatures of 280–300°K is −141·6 dbm, and if, as is normally the case, the amplifier input impedance is designed to match the cable, an equal value of noise power is generated in the amplifier termination. The total weighted input noise due to resistance is then −138·6 dbm.

(*b*) The effect of valve noise is usually minimized by using an input transformer having a high voltage-gain, but there are practical limits to the turns ratio that can be used for wideband transformers, and a typical value for valve noise "referred to the input" is 2 db. This value is sometimes referred to as the amplifier "noise criterion."

(*c*) Intermodulation noise is dependent upon the amplifier design, and the designer must decide the proportion, if any, of the permitted noise allowance that can be allocated to intermodulation effects, and design accordingly. In general, the intermodulation noise proportion is lower for submerged-repeater designs than for normal inland transmission systems, because the amplifier feedback is higher for reasons of gain stability, and this further improves the intermodulation performance. Assuming that 25 per cent of the total noise allowance is allocated to intermodulation noise, then the equivalent allowance referred to the input will be 1·25 db (it would be 3 db if equal powers were allocated to random and intermodulation noise, as is more generally the case on inland transmission systems[2]).

Typical values of the allowances to be added to the input noise are therefore:

2·0 db noise criterion,

1·25 db intermodulation noise,

1·25 db temperature misalignment penalty, and

0·5 db misalignment penalty for equalization errors and cable repairs.

The maximum amplifier input noise is therefore

$$-138{\cdot}6 + 5{\cdot}0 = -133{\cdot}6 \text{ dbm.}$$

Repeater Gain

The repeater gain remains to be established. However, as it should equal the cable loss at mean sea temperature, then G = cable loss/n.

Taking the loss per nautical mile of 0·62 in. cable at 1,164 kc/s to be 4·16 db at 11°C, then the total loss equals 1,040 db, and $G = 1{,}040/n$.

Repeater Output Level

The overload level of the 10P type valve can be taken to be +22 dbm when used in a parallel-amplifier configuration. To determine the nominal channel output level it is necessary to make allowances for the following various factors to ensure that the total multi-channel signal power does not overload the output stage:

(*a*) *Multi-Channel Loading*. Obviously, circuits will not all contribute equal levels of speech power at any instant, as speech is random. The classic work on loading of multi-channel systems was done by Holbrook and Dixon;[3] based on their results the C.C.I.T.T.* now quote the r.m.s. power of a sine-wave whose amplitude is equivalent to the peak voltage of a multiplex signal arising from 120 and 240 channels as +21·2 and +22·2 dbm0, respectively.[4] The equivalent power resulting from common path amplification of both directions of transmission of 120 circuits is not specified, but an allowance of 22 db is regarded as conservative, particularly as the mean low-band loading is normally set at least 3 db below the mean high-band loading.

(*b*) *Temperature Allowance*. The temperature allowance has already been considered above: for this example 5·5 db swings will occur and must be allowed for.

(*c*) *Equalization-Error Allowance*. Although every effort is made to match the amplifier gain to cable loss, it is neither practicable nor economic to ensure that the ideal response is obtained, and small residual errors have to be corrected in submerged equalizers fitted, say, after every 10–12 repeaters. The designer must therefore estimate by how much the repeater output levels may increase over the nominal value and allow accordingly; 2·5 db will be allowed for in this example.

(*d*) *Cable-Repair Allowance*. The system specification (for systems up to 350 n.m. in length) requires the design to accommodate up to 1·5 n.m. of extra cable in steps of 0·1 n.m. per cable section; this implies an additional cable attenuation of 6 db. If the probability of cable faults, for shallow waters, is proportional to system length, then an allowance of 4 db should be adequate for a 250 n.m. route. By dividing the compensating equalizers between each terminal the increase in repeater output level should not exceed 2 db.

(*e*) *Directional-Filter Loss*. As the total directional-filter loss per repeater is about 2 db, the repeater gain will be 2 db lower than the amplifier gain; for purposes of completing the noise equation it is convenient to allow this 2 db on amplifier output level, although in fact the loss is divided equally between output and input level.

The maximum nominal repeater output level per channel will therefore be:

$$+22 - (22 + 5{\cdot}5 + 2{\cdot}5 + 2 + 2) \text{ dbm} = -12 \text{ dbm.}$$

Total System Noise Power Limit

The C.C.I.T.T. weighted line noise limit per 3·1 kc/s channel is 3 pW/km (or 5·56 pW/n.m.).[4] Hence the noise limit = 250 × 5·56 = 1,400 pW, or −58·5 dbm.

Solution of System Line-Noise Limit

The system line-noise equation can, therefore, now be solved as follows:

$$-133{\cdot}6 + 10 \log_{10} n + 1{,}040/n - (-12) = -58{\cdot}5$$

$$\therefore \quad 1{,}040/n + 10 \log_{10} n = 63{\cdot}1$$

and $n = 21$, i.e. 20 submerged repeaters plus terminal receive amplifier.

Therefore, repeater gain $G = 1{,}040/21 = 49{\cdot}7$ db and the repeater spacing will be 11·9 n.m. Nominal operating levels at 1,164 kc/s are −60·7 dbm and −11 dbm for the input and output levels, respectively.

Assuming that, in fact, all allowances add arithmetically, then this solution offers no margin. However, the multi-channel loading factor (+22 dbm0) presumes equal mean loading per channel, but the designer generally applies a measure of pre-emphasis to the transmitted signal (i.e. the level of the lower line frequencies is reduced relative to the higher frequencies) and the 22 db allowance then relates approximately to the average level of the transmitted bandwidth. A 6–10 db pre-emphasis therefore permits the output level (and consequently the input level) of the upper-frequency channels to be increased by, say, 2–4 db. An improved noise performance is thereby obtained in the channels most likely to be marginal at the expense of those channels at the lower frequencies, which normally have large margins. The degree of emphasis is usually left to the final system tests and suitably adjusted on the evidence of white-noise test results to obtain optimum conditions.

TWO-TONE INTERMODULATION EFFECTS

Sum $(p + q)$ and difference $(p - q)$ 2-tone intermodulation is a problem in any wideband amplifier, and the use of emphasis to improve the noise performance of the upper frequency channels, although minimizing the effect of $p + q$ intermodulation, considerably magnifies the effect of $p - q$ products. Amplifying two directions of transmission in one amplifier gives added significance to this effect, as $p - q$ products caused by two signals at relatively high-level at the upper-frequency end of the high band (e.g. 1,161 kc/s and 1,100 kc/s) will fall into a relatively low-level channel at the bottom end of the low-band (e.g. 61 kc/s). Due to the very regular repeater spacing on submarine systems, discrete frequency products from each repeater can add in-phase at regular frequency intervals, and the resulting sum of intermodulation products can be undesirably high. Fortunately the submerged equalizer tends to break up the phase-pattern, and the more equalizers in the system the more random the interference becomes.

At present there is no C.C.I.T.T. recommendation for 2-tone effects. Hence, emphasis is applied to the high-band to obtain optimum high-band noise performance,

*C.C.I.T.T.—International Telegraph and Telephone Consultative Committee.

but reduction in the low-band repeater levels is kept to a minimum so that the $p - q$ intermodulation products are maintained within reasonably low limits.

SUBMERGED REPEATERS

The submerged repeaters are of conventional design, employing a common-path amplifier and separating each direction of transmission by means of filters, as shown in Fig. 4. The actual amplifier comprises two 3-stage

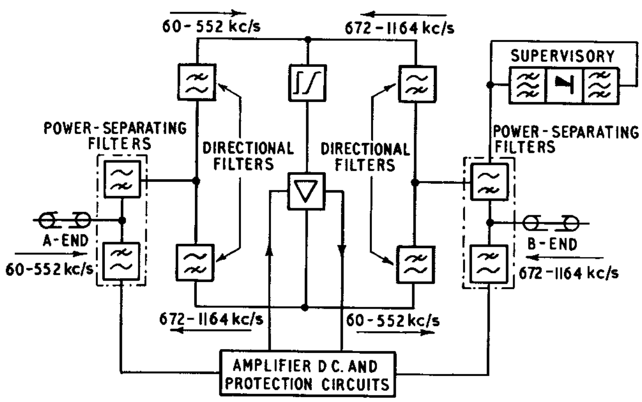


FIG. 4—BLOCK SCHEMATIC DIAGRAM OF SUBMERGED REPEATER

amplifiers parallel-connected at the input-valve grids and output-valve anodes. Common feedback is used, and the failure of either amplifier only marginally affects the system performance. The amplifiers are energized by a direct current of 430 mA fed over the centre conductor through all repeaters in series, the return path being via the sea-earth system.[5] The cable power is connected through the six valve-heaters in series, and the resulting voltage drop (about 85 volts) is used as the h.t. supply for the valves. In the event of a heater failure, the d.c. path is maintained by the operation of a short-circuiting fuse[6] which connects a combination of resistors across the failed amplifier heaters to restore correct potentials on the remaining working amplifier. To protect the amplifier from damage by surge voltages which may result from a cable break, quick-operating gas-discharge tubes are connected across both the h.t. supply path and the power-separating filter inductors.

The gain of the repeater is monitored by means of a frequency-doubler circuit at the B-end of the repeater. Each repeater has a very-narrow-band pick-off filter at the power-separating filter point, and a separate frequency is allocated to each repeater in the system. The output of this filter is connected via a frequency-doubler back to the repeater input terminals. If an appropriate test frequency is injected into the transmitted (low) band at the A-terminal then the frequency is doubled in one particular repeater and becomes a frequency in the high-band (B–A) spectrum and therefore returns to the A-terminal. Comparison of the received test-signal level with previous measurements provides an indication of gain variation of the repeater (and of all other repeaters, by suitable choice of frequency). The input-level/output-level characteristic of this type of device is not linear and, as the output levels vary with the sea-temperature cycles, the level of received loop-gain signal has to be very carefully interpreted.

The repeater is only required to operate in water depths down to 350 fathoms; hence, the costly high-pressure housings required on deep-sea repeaters are not necessary, and S.T.C. have encased their repeaters in mild-steel housings. The bulkheads use a novel arrangement of O-ring water seals which permits the efficacy of the seal to be quickly checked by verifying that petroleum jelly injected into the sealing chamber at 1 ton/in^2 (twice the maximum sea pressure) does not lose pressure.

SUBMERGED EQUALIZERS

System misalignment cannot be eliminated, and errors must be corrected in a submerged equalizer. Only one equalizer was required for each of the German and Danish systems, and none was necessary on the shorter system to Holland. The equalizer is located at a point approximately midway between the two repeaters in the centre of the route, and is fitted in a pressure housing similar to that used for the repeaters. Power-separating filters are mounted in the equalizer to permit the equalizer units to operate at earth potential. In addition, directional filters are employed to permit the attenuation/frequency distortion of each direction of transmission to be equalized separately. The arrangement is therefore as shown in Fig. 5.

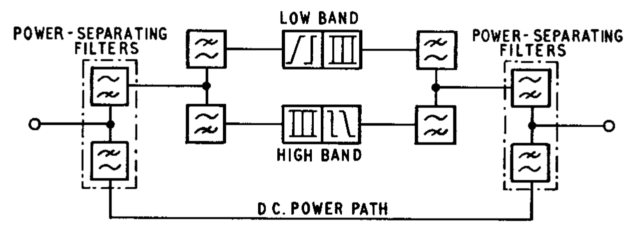


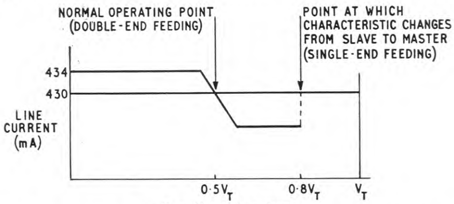
FIG. 5—BLOCK SCHEMATIC DIAGRAM OF SUBMERGED EQUALIZER

Following current British Post Office practice, the equalizer sections for each direction of transmission were designed and wired-up on board ship, based on the results of ship-to-shore transmission measurements during the lay. Constant-impedance 4-terminal networks were used, the components being mounted in factory-sealed units and the required values obtained by strapping external tags. By a suitable choice of these units, which are mounted on circular panels of correct diameter for fixing within the internal structure, a reasonable range of component values can be obtained. All strapping within the equalizer is done with sleeved gold-plated wire. The equalizer is also a convenient point to insert cable-simulation networks if, for any reason, it is necessary to alter the geographical position in which succeeding repeaters will be laid. This expedient was used on both German cables to ensure that the final repeater was an adequate distance from the Winterton shore. After re-assembly of the equalizer the bulkhead seals were pressure tested with petroleum jelly to 1 ton/in^2 before the equalizer was laid.

TERMINAL EQUIPMENT

Power-Feeding Equipment

The power-feeding equipment has been designed to supply a constant direct current of 430 mA ± 1 per cent to the cable at voltages up to 5 kV. However, the voltage drop per repeater section (cable section plus repeater) is of the order of 100 volts, and the voltage gradient on the longest of these systems (United Kingdom–Denmark with 24 repeaters) is about 2,350 volts. The cables are normally energized from both ends, the terminal power equipments being connected in series aiding and each supplying about half the system voltage—the A-terminal feeding positive to earth and the B-terminal negative to earth. Although the equipments at both ends are identical, only one feeds constant current at one time, the other operating to the voltage/current characteristic shown in Fig. 6. The equipments are then said to be working as



V_T = Total line voltage

FIG. 6—MASTER/SLAVE CHARACTERISTIC OF POWER-FEEDING EQUIPMENT

master and slave, respectively; this technique ensures good voltage-sharing and avoids the problem of operating constant-current generators in series. Either end can feed the entire system load automatically and without any interruption of the traffic circuits should power at the other terminal fail.

The current control is effected by transductors, and, in order to maintain a fast response time and to keep their physical size reasonably small, the equipment has been designed to operate at 400 c/s. The power supply for these equipments has been derived from 400 c/s 3-phase generators driven either by a 3-phase 50 c/s mains supply or by direct current from a floating battery, depending upon the type of no-break power provided for the station.

A typical installation is shown in Fig. 7: it comprises the cable-terminating cubicle, the common unit (line voltage and current monitoring, and alarms, etc.) and working and stand-by power units (high-voltage rectifiers, current-control devices, etc.). Mechanical interlocks between all the frameworks comprising the equipment prevent access to any part of the circuit until the equipment has been rendered safe from dangerous voltages.

Line Equipment

The line terminal equipment is similar in general layout to that of land systems and does not merit detailed description. Fig. 8 shows a complete terminal suite including the supergroup combining equipment, 2 kc/s speaker rack and the loop-gain monitoring equipment.

Separation of the two directions of transmission is effected by translating signals in the B–A direction into the spectrum 668–1,168 kc/s by means of a 1,224 kc/s carrier frequency. The 1,224 kc/s carrier frequency is obtained by frequency doubling the 612 kc/s station carrier supply.

Unlike inland systems, in which differences in repeater spacing are corrected by cable-simulation networks at the input of intermediate amplifiers, the transmit level/frequency characteristic of a submarine system has to be adjusted at the transmit terminal so that the correct submerged-repeater output levels are obtained, and, consequently, a variety of networks has to be provided to cater for various "end-section" lengths, which are only known accurately at the completion of a lay. It is obviously desirable to avoid the necessity of providing an additional submerged repeater if the end-section length is marginally greater than the nominal repeater spacing. Excess length cannot be permitted at the A-end of the system, as the high-frequency band input level at the A-terminal would be too low to provide an acceptable signal-to-noise ratio, but at the B-end of the system a special transmit amplifier having a single-tone overload of + 36 dbm is provided to permit the high band to be transmitted over an end-section up to $1\frac{1}{3}$ times the nominal spacing and still maintain the correct submerged-repeater output levels. The extra cable length is no problem in the low-band receive side, where the attenuation is relatively small. The special amplifier is bypassed when not required.

Pilot frequencies are transmitted (at —15 dbm0) 4 kc/s above and below the traffic spectrum for each direction of transmission, and their levels are continuously recorded at the receive terminals to provide an indication of the insertion-gain performance of the system. The pilot-frequency level variations that result from cable-temperature changes are used to determine the points at which temperature equalization changes are made.

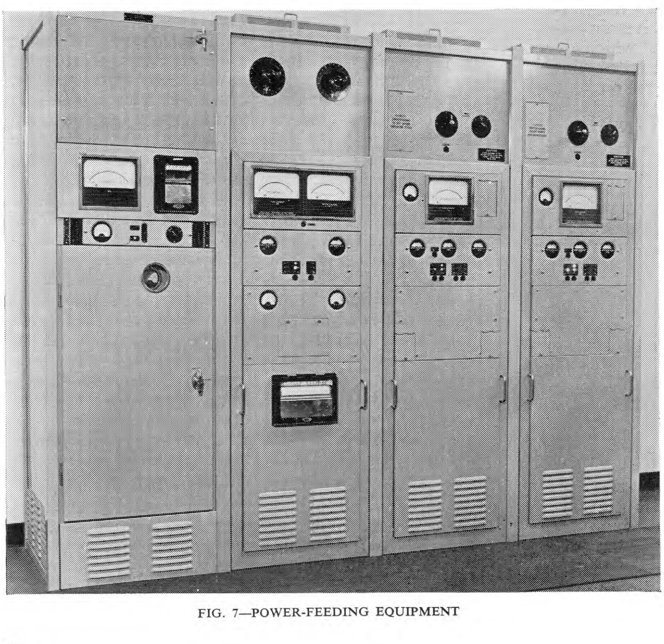


FIG. 7—POWER-FEEDING EQUIPMENT

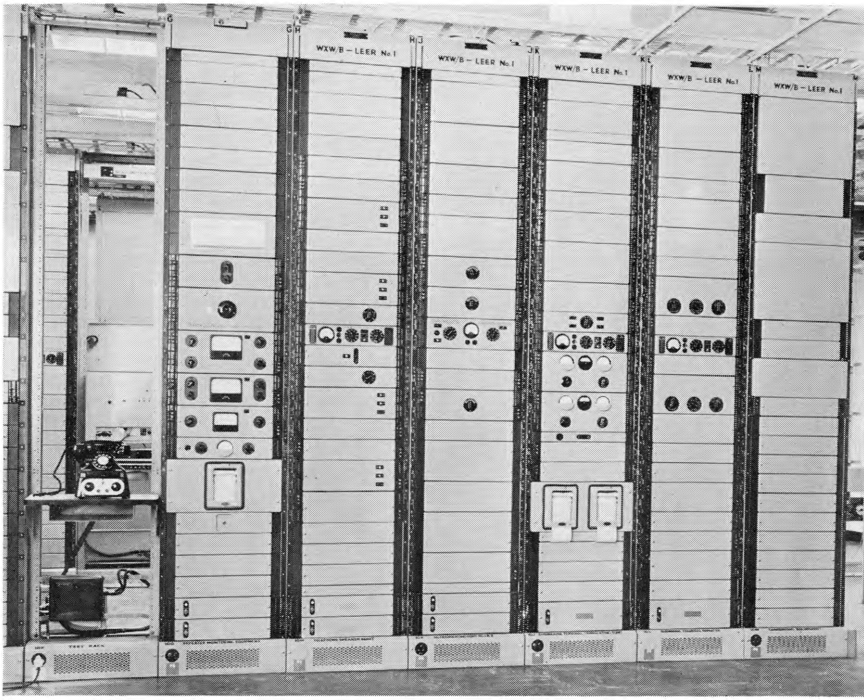


FIG. 8—COMPLETE TERMINAL SUITE

Monitoring the Submerged Repeaters

To permit the performance of individual submerged repeaters to be checked, two forms of monitoring are employed.

(*i*) The repeater loop-gains are checked by sending a continuous tone at the frequency appropriate to the supervisory-circuit frequency doubler of each of the repeaters in turn, and measuring the level of the returned signal. The actual frequencies used are from 552·375 kc/s to 563·375 kc/s in 250 c/s intervals. The returned frequencies (about 1,100 kc/s) are in-band, and affected channels have to be withdrawn from service while this test is made. This method can obviously be used only from the A-terminal.

(*ii*) The repeater harmonic (or intermodulation) performance is checked by sending a pulse of frequency at relatively high level to line and measuring the amplitude of each of the returned pulses in the train that results from harmonic production in the repeater amplifier. There will be one pulse received from each repeater and, due to the time delay of each cable section, these pulses will all arrive spaced in a regular time sequence. The harmonic (or intermodulation) performance of each individual repeater (indicated by the height of the returned pulse) can, therefore, be readily identified and measured.

The test equipments (Submerged-Repeater Monitoring Equipments Type 15) have been designed and supplied by the British Post Office. The technique is not new, but the record of the returned pulses is now displayed by a pen-recorder instead of on a cathode-ray tube, as on many earlier models. An equipment is fitted at both terminals of the system—that at the A-end sending a pulse of frequency in the low-frequency band so that the resulting second and third harmonic-frequency pulses are returned in the high-band, whereas at the B-terminal a continuous tone (1,128 kc/s) is applied to the high-frequency band together with the pulsed frequency, e.g. 784 kc/s. Two sets of receive pulses whose amplitude is determined by the second-order and third-order intermodulation performance of each repeater, are produced in the low-band, e.g. 344 kc/s and 440 kc/s, and thus returned to the B-terminal. A photograph of a Submerged-Repeater Monitoring Equipment Type 15 is reproduced in Fig. 9.

No facility for measuring the noise performance of individual repeaters has been provided.

LOADING AND LAYING

The advent of very long ocean systems employing a large number of repeaters necessitated considerable planning of the order and method in which cable and repeaters should be stowed to ensure that laying could proceed smoothly. The methods of loading, tanking, testing and laying used for the North Sea schemes were decided by the contractor in consultation with the cable

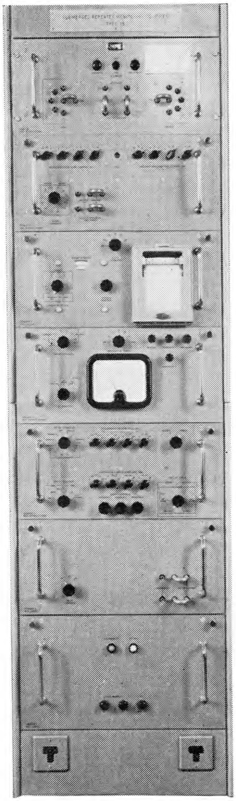


FIG. 9—SUBMERGED-REPEATER MONITORING EQUIPMENT TYPE 15

ship's officers, and followed closely the pattern established for CANTAT and already described.[8,9]

The first German cable was laid by H.M.T.S. *Monarch* in November 1963, but the remaining three cables were laid by H.M.T.S. *Alert* during 1964: United Kingdom–Denmark in May; United Kingdom–Germany No. 2 in June; and United Kingdom–Holland in September. Both the German No. 1 lay and the Holland cable lay were unfortunate in being considerably delayed by gales that developed during passage to pick up the shore-end cable, but in all other respects the cable lays were completed without incident.

Due to the tidal currents and high shipping-density in the North Sea, both the German cables and the Holland cable had to be bow-laid completely because, when laying over the stern, the heavy armoured cable tends to steer the ship, and accurate navigation becomes difficult. Repeaters cannot negotiate the bow-laying cable drum, and to lay a repeater it is necessary to stop the ship while the repeater is manhandled past the cable machinery and bow sheaves. While this is done the strain of the laid cable is temporarily transferred to a rope controlled by a second cable-engine. The resulting manhandling of the very heavy and dirty (bitumen-coated) cable at approximately 3-hourly intervals is very fatiguing to the crew. Fortunately, it proved possible to lay a substantial part of the Danish cable over the stern, which is a much less tiring operation.

SYSTEM PERFORMANCE

The overall commissioning tests were the responsibility of the contractor, but were carried out as a joint operation with the British Post Office and its European partners.

The C.C.I.T.T. quote the conventional loading for this type of system as $-0{\cdot}1 + 5 \log_{10} N$ dbm0, where N is the number of circuits.[4] This gives a loading of +10·3 dbm0 for 120 circuits. However, to cater for the use of multi-channel voice-frequency telegraphy on one channel of each of the 10 groups, the conventional load was specified as +11 dbm0. The white-noise performance[10] of the systems was therefore measured at loadings applied simultaneously at each end from 0 dbm0 to +20 dbm0, and the performance margin recorded at +8 dbm0 (i.e. +11 dbm0 on the repeaters). Fig. 10

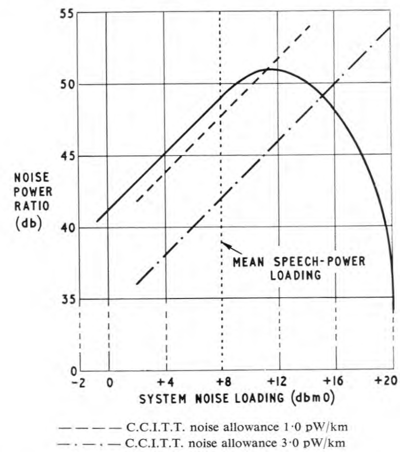


FIG. 10—WHITE-NOISE RESPONSE IN HIGH-BAND DIRECTION OF UNITED KINGDOM–GERMANY NO. 2 SYSTEM

shows the white-noise response obtained in the high-band direction (line frequency 1,154 kc/s) of the Germany No. 2 system. This is representative of the other systems, and, although the specified noise limit was 3 pW/km, it can be seen that a value better than 1 pW/km has been attained. The noise power ratio (n.p.r.)* at all other measured frequencies was greater, as would be expected at lower frequencies, due to the correspondingly lower repeater gain.

The n.p.r. values measured include all $p - q$ intermodulation products affecting the measured channel, and, due to the random nature of the white noise (or speech), these products are not particularly significant.

*Noise power ratio—the ratio of the level of noise power in a narrow arbitrarily selected frequency band at the output of a transmission system to which a particular level of noise test signal is applied, to the noise in that band when the corresponding part of the test signal is stopped by a filter at the input to the system.

However, intermodulation peaks at about -45 dbm0 were recorded at the low-frequency end of the spectrum due to two test tones applied at discrete frequencies to channels at the high-frequency end of the spectrum. Provided that test tones (or any other tones of relatively long duration) are always applied to channels at one specified channel frequency then the $p-q$ interference product will occur at 4 kc/s multiples and fall between channels. If, however, test tones of different frequencies are applied simultaneously, e.g. at 800 c/s and 1,600 c/s, then the product will fall within a channel, and should its frequency coincide with a frequency at which products from successive repeaters add in-phase, then the interference may be appreciable. This is not likely to occur on the North Sea systems described as, fortuitously, with 12-mile spaced repeaters, the frequencies of voltage (in-phase) addition occur at almost 4 kc/s multiples. Nevertheless, unless the level of test and signalling tones can be reduced to, say, -10 dbm0 or less, the use of various continuous frequencies could present an increasing problem to designers of the new higher-bandwidth systems of a similar type.

CONCLUSIONS

The systems described are now all operating satisfactorily in service and are confidently expected to provide a reliable high-grade service to Europe. For the future, the trends are towards systems of wider bandwidth, and recent advances in transistor technology, particularly as regards reliability, have resulted in successful designs for systems to the Continent which will use transistor-operated repeaters of 5 Mc/s bandwidth. Two 420-circuit transistor-operated repeaters were inserted in a United Kingdom–Belgium cable during 1964 and are working satisfactorily. One project, a new United Kingdom–Norway cable, will utilize 52 transistor-operated repeaters spaced at 7·5 n.m. intervals on 0·935 in. diameter cable to provide 480 circuits, each of 4 kc/s bandwidth.

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Book Reviews

"Principles of Telegraphy." N. N. Biswas, Ph.D. (Eng.). Asia Publishing House. x + 185 pp. 97 ill. 30s.

Chapters are devoted to telegraph codes, instruments and relays, circuits, teleprinters and telex, facsimile and picture telegraphy, submarine-cable telegraphy and voice-frequency telegraphy. In a modern book of limited size, one may question the justification for giving space to such obsolescent methods as differential and bridge duplex, gulstad and baudot, or even d.c. submarine telegraphy.

The scanty treatment of telegraph distortion is misleading, confused, and self-contradictory. The diagram illustrating relay operation is incorrect. The brief treatment of telex is restricted to one particular network which cannot be regarded as typical.

The book is by no means free of typographical errors. Many incorrect statements are made: for example "morse code is universally used for signalling by human operators over landline telegraph circuits"; or "teleprinters however will always have the disadvantage that a punched tape is to be prepared by an operator"; and "Problem: In the 24-channel f.m.v.f.t., in some channels the on-line mark frequency is higher than the on-line space frequency, whereas reverse is the case in some other channels. Explain. Calculate the on-line mark and space frequencies for channel Nos. 4, 8, 12, 16, 20 and 24"—a problem, certainly.

R.N.R.

I.P.O.E.E. Library No. 2813.

"Physical Electronics." G. F. Alfrey. D. Van Nostrand Co., Ltd. 220 pp. 48 ill. 27s. 6d. (paper bound). 50s. (cloth bound).

According to its preface, this book is "an attempt to provide a concise and coherent introduction to the physical principles governing the operation of electronic devices. It is written for electrical engineers and physicists . . . " The book contains 15 chapters, of 5 to 18 pages each, with the following main titles: the discovery of the electron; electrons in atoms; forces between atoms; emission of electrons from solids; electron optics; control of electron current in a vacuum; electrical conduction in gases; some gaseous plasma applications; electronic conduction in solids; semiconductors; the p–n junction and the transistor; magnetic properties of matter; dielectric materials; electrical noise; and molecular amplification. So much has been attempted in so limited a volume that the treatment is in many places no more than a rudimentary introduction. Ideas are disconcertingly telescoped, and a number of errors have crept into the text in the process: thus on p. 72, in discussing cathode-ray tubes it is said that "electrostatic deflection is to be preferred, on account of the intrinsically low-impedance nature of deflecting coils, and the difficulty of matching to them an amplifier of high-impedance input." On p. 162 a so-called diffusion law includes n with clearly different dimensions on the two sides of the equation.

Most chapters conclude with a number of quite useful exercises, but more extensive references would in many cases be desirable to strengthen the student's basic reading.

F.F.R.

A New Carbon Transmitter—Transmitter Inset No. 16

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A new transmitter has been developed to supersede the Transmitter Inset No. 13 which has been in service for nearly 30 years. The new transmitter has a slightly improved sensitivity, better frequency response, lower amplitude/amplitude distortion, and freedom from positional effects. Its introduction will complete the development of the 706-type telephone.

INTRODUCTION

THE development of the 700-type telephone circuit envisaged the use of both a new receiver and a new transmitter.[1] New developments in magnetic materials and the replacement of the single magnetic diaphragm by a balanced magnetic armature and separate aluminium diaphragm enabled the new receiver (Receiver Inset No. 4T)[2] to have a considerably greater sensitivity and improved frequency response compared with its predecessor—Receiver Inset No. 2P. Unfortunately, no corresponding basic improvements which could lead to higher sensitivity had taken place in the carbon transmitter. Nevertheless, the low cost, robustness, and high sensitivity of the carbon transmitter had lead to its almost universal use in telephony, and development was mainly directed towards improving its quality of reproduction and its stability.

It was possible, therefore, when the new receiver became available to incorporate it in a new circuit using the Transmitter Inset No. 13, with the knowledge that a new transmitter could be used later without any modification of the circuit. With the introduction of the Telephone No. 706,[3] it was also possible to incorporate a new handset (Handset No. 3) designed to work in conjunction with both the existing transmitter and the new transmitter as soon as it became available. This new transmitter, known as the Transmitter Inset No. 16 and illustrated in Fig. 1, is now being fitted on all new telephone instruments.

FIG. 1—TRANSMITTER INSET NO. 16 MARK 1

DESIGN OBJECTIVES

Although many of the performance characteristics required of the new transmitter can be specified in absolute terms, it is simpler to consider the design objectives in relation to the known achievements and limitations of the Transmitter Inset No. 13. The latter, which has been in almost universal use during the post-war period both in the United Kingdom and many Commonwealth countries, has on the whole an excellent record of service, and the basic design has not been changed since its introduction about 30 years ago. The main performance characteristics of this transmitter and the improvements required to be achieved by redesign are as follows.

Sensitivity

Increased sensitivity is generally desirable to give improved performance on long lines, but any marked improvement would require adjustment to the transmission or regulator circuit to avoid excessive output on short lines. For the reasons stated in the introduction, and the fact that, on the most commonly used cables, the 706-type telephone set using the No. 13 transmitter has a transmission limit at or above its signalling limit, only a marginal improvement in sensitivity was required.

Frequency Response

To obtain an overall talker–listener response as similar as possible to that obtained under direct conversation, it was desirable to achieve a slightly rising frequency response over the range 300–3,400 c/s. The frequency response of the No. 13 transmitter is resonant at about 1,400 c/s.

Distortion

Poor articulation of certain sounds by the No. 13 transmitter may be attributed to its relatively high amplitude/amplitude distortion.* A considerable improvement was required.

Burning or Noise

All carbon transmitters are liable eventually to fail because of carbon or other deterioration causing noise, but the No. 13 transmitter has been reasonably satisfactory. Improvement, though desirable, was not essential.

Signalling Resistance

To meet the requirements of exchange signalling in Post Office subscribers' circuits, it is essential that the signalling resistance of any transmitter should not exceed 300 ohms under the most adverse circuit conditions and throughout the life of the transmitter.

Stability of Performance

Short-term variations of sensitivity, resistance, and

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*Amplitude/Amplitude Distortion—That part of non-linearity distortion which is an undesired variation, with respect to the magnitude of a sinusoidal excitation, of the ratio of the magnitude of the fundamental component of the response to the magnitude of the excitation (British Standards, B.S. 204: 1960).

noise occur due to the manner in which the handset is held, to the ambient atmospheric conditions and to the transient conditions as the transmitter "warms up." Additional long-term changes in performance, almost always adverse, occur due to the slow deterioration of the granular carbon or the electrode surfaces. The failure rate of No. 13 transmitters has not been excessive, but temporary losses of sensitivity after prolonged periods of rest have been observed in service. Because of the almost infinite variation of conditions which occur in use, laboratory testing alone cannot guarantee to detect all possible variations in performance, and extensive field trials are an essential part of transmitter assessment.

CONSIDERATION OF DESIGN OBJECTIVES

The design of a carbon transmitter may conveniently be considered as divided into two parts: first, the acousto-mechanical transducer that converts sound energy into mechanical displacement of the front electrode; second, the carbon chamber where this displacement compresses the carbon granules to produce resistance modulation.

The design of the acousto-mechanical transducer will control the frequency response and, to some extent, the sensitivity and amplitude/amplitude distortion of the complete transmitter. In its simplest form the diaphragm, electrode and carbon masses form a single series-resonant system with the sum of the stiffnesses due to the diaphragm flange, the air volume behind the diaphragm and the granular carbon. Unfortunately, both the effective mass and stiffness of granular carbon varies with the amplitude of displacement, so the design must ensure that their contribution to the total is sufficiently small to prevent high amplitude/amplitude distortion. The resonant response may be at least partially equalized by superimposing an anti-resonant system consisting of a second air volume behind the diaphragm, connected to the first through an acoustic hole or mass suitably damped. The resulting response is much smoother, but overall sensitivity is lowered and, as will be apparent later, some compromise is necessary. The holes in the handset mouthpiece and in the front cover of the transmitter, together with the air interspacings, form a low-pass filter. It is possible to adjust these to maintain output at higher frequencies, but this results in a fairly sharp drop in sensitivity above the cut-off frequency.

The carbon chamber design is influenced by so many complex interactions and often conflicting requirements that experimental work, past experience and manufacturing methods rather than calculation will largely determine the final configuration of the electrodes and boundary walls.

The general design will determine the sensitivity, the resistance, the distortion, the noise and the stability of the complete transmitter. Since electrode displacements imparted by the sound are exceedingly small, thermal expansions due to unequal or transient heating or ambient temperature change can be of the same order, so that materials must be chosen to eliminate differential expansions which could cause unwanted electrode movements.

Long-term stability is largely determined by the quality of the carbon granules, which normally tend to increase in resistance, become noisier, and decrease in efficiency during service. Considerable research has been carried out in this country and elsewhere to produce a more stable carbon. By suitable oxidation and mechanical pre-aging treatment it is possible to produce granules of greatly improved stability, and such granules have been employed in many telephone sets where a stable transmitter resistance is essential to the functioning of the automatic transmission regulator. Unfortunately, these pre-aged carbons have initial efficiencies somewhat lower than normal granules, and it has been considered that, for use in the 706-type of transmission circuit with a regulator action sensibly independent of transmitter resistance, the efficiency loss would outweigh the advantages. However, both research and field trials of various carbons are currently in progress, and, if satisfactory, new carbons will be brought into service later. It must be emphasized, however, that the risks inherent in introducing any new carbon without the most rigorous field trials are far too great, so progress is necessarily slow.

Lastly, as in all mass-produced articles, a very important consideration at all stages of the design is cost. In the No. 16 transmitter technical performance must be of prime importance, and because it is not always possible to predict stability or end-of-life behaviour with great certainty from laboratory tests, extreme caution must be exercised in the introduction of changes. Nevertheless, with the closest co-operation between the Post Office and the manufacturers, it has been possible to allow sufficient flexibility in the construction to give cost-saving ideas the chance of being tried out under conditions of full-scale production.

CONSTRUCTIONAL FEATURES

A cross-sectional diagram of the transmitter is shown in Fig. 2.

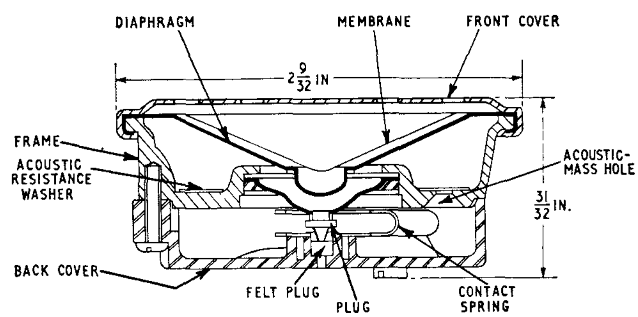


FIG. 2—CROSS-SECTION OF TRANSMITTER INSET NO. 16 MARK I

Electrodes

The front electrode is formed from thin sheet material, which forms into the required hemispherical shape with a fixing flange and allows the mass to be kept to a minimum. The electrode material is carbonized nickel manufactured from pure nickel strip by a series of processes which includes oxidation and subsequent replacement of the oxide by a pyrolytic deposition of carbon. The carbon deposit makes an excellent contact surface even after subsequent forming, and has the double advantage over plated surfaces of being considerably cheaper and involving no risk of plating salts contaminating the contact surface. It is, however, necessary to exercise extreme care during fabrication to avoid damage or contamination.

The shell-type back electrode is also manufactured from carbonized nickel strip.

Carbon Chamber

The general construction of the carbon chamber is apparent from Fig. 3, which shows that, by extending the

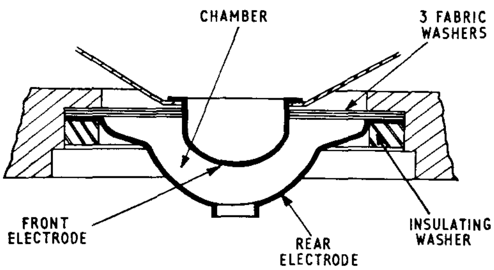


FIG. 3—CARBON CHAMBER

wall of the back electrode outwards, it is possible to complete the chamber boundaries by three flat artificial-silk washers through which the front electrode protrudes. All raw edges of the carbonized nickel are kept outside the carbon chamber.

To minimize variation in resistance when the transmitter is used in a handset, it is necessary to maintain a carbon filling of the order of 94 per cent of the total chamber volume. Since normal manufacturing tolerances lead to relatively large variations in the actual volumes of individual chambers, it is not easy to fill with a fixed-volume charge, and special techniques are necessary to obtain a 94 per cent fill for each transmitter.

The carbon chamber is closed by a small nylon plug which is a push fit in the central filling hole of the back electrode.

The strictest precautions against contamination of the carbon chamber and granules are essential, and all materials, particularly plastics, within the transmitter have been carefully selected to prevent any deterioration due to the slow exudation of harmful vapours, etc.

Sealing

Moisture from the breath has a highly corrosive action and must be prevented from reaching the carbon chamber, the diaphragm and the diaphragm-to-frame contact area. In the No. 13 transmitter an enamel finish is given to the diaphragm outer surface and a ring of rubber-based sealant is applied on both sides of the peripheral clamping ring. This has proved reasonably satisfactory, but there are manufacturing difficulties in ensuring a clean contact between the frame and the underside of the diaphragm, and best results have been obtained using expensive hand operations. Therefore, in the new transmitter protection has been obtained using a special formed-polypropylene membrane. A central conical depression closely couples the membrane to the diaphragm and eliminates any risk that the membrane might stretch in service and become stuck to the front plate; a turned-down lip round the periphery seals tightly on to the underside of the frame when the front cover is turned inwards, clamping the diaphragm at the same time. Some difficulty has been experienced in maintaining the rather close manufacturing tolerances necessary for this form of seal, and alternative constructions are being investigated; in fact, a modified design is already in use in a variant of the design—the Mark III transmitter, which is described in a later paragraph.

Other Constructional Features

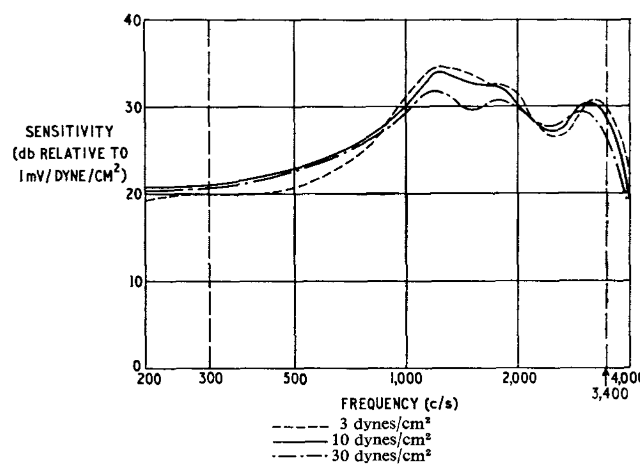
The diaphragm is pressed from aluminium-magnesium alloy and carries the front electrode securely fixed at the apex of the cone. This assembly rests on a diecast aluminium frame, which carries the carbon chamber staked into its central well, and a washer of acoustic-resistance material stuck over the three holes which form the mass of the acoustic equalizer.

The back cover carries the 6BA terminals and the nickel-silver spring contacts which bear with considerable force on the frame and on the insulated back-electrode. Recesses in the back cover allow for quick and direct connexion of the handset-cord tag-ends. The enclosed volume of the back cover also forms the acoustic equalizing volume. A reasonable seal to the frame is required, but it is also necessary to provide a high-resistance breathing hole to equalize the slow pressure changes caused by internal heating or ambient atmospheric conditions. A small central hole backed up by a felt plug is therefore provided; the resilience of the plug is also used as a safety device to prevent any possibility of the carbon-chamber nylon plug working loose in service.

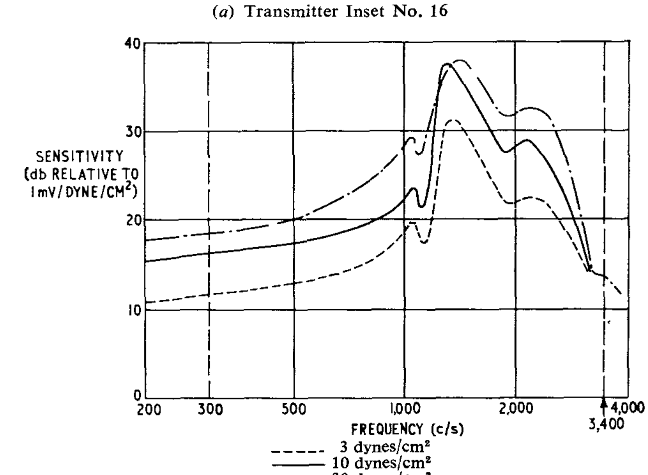
PERFORMANCE

Frequency Response and Amplitude/Amplitude Distortion

Fig. 4 (*a*) shows a typical frequency response measured under matched load conditions with constant freefield



(*a*) Transmitter Inset No. 16



(*b*) Transmitter Inset No. 13C

FIG. 4—SENSITIVITY/FREQUENCY CHARACTERISTICS OF TRANSMITTER INSETS NO. 13C AND NO. 16

applied sound pressures of 30, 10 and 3 dynes/cm^2. The improved frequency response and lower amplitude/amplitude distortion compared with that of the Transmitter Inset No. 13C shown in Fig. 4(*b*) are immediately apparent. Nevertheless, the response falls off rather than rises at higher frequencies as required by the design objective, but there are two reasons for this. First, a compromise had to be reached between loudness and quality, and to maintain the former some peakiness remains in the region of 1,300 c/s. Secondly, a dip in the frequency response between 2 and 2·5 kc/s is advantageous in avoiding any possible speech interference with the C.C.I.T.T.* signalling frequency of 2,280 c/s.

Transmission Performance

As might be expected from the design objectives the loudness efficacy and talking resistance of the No. 16 transmitter are substantially equal to those of its predecessor. On conversational opinion-rating tests the advantage of the new transmitter is of the order of 5 db. Articulation tests also show substantial improvement in certain final consonants for which the No. 13 transmitter has a relatively poor performance.

PERFORMANCE TESTS

Field Trials

Concurrently with laboratory testing, four separate forms of service trial had been undertaken satisfactorily before full-scale production was authorized.

First, limited numbers of No. 16 transmitters have been placed in selected public call-offices on main-line railway stations, where usage is virtually continuous throughout the day and evening, and the atmosphere is liable to be adverse. By making periodical laboratory measurements of frequency response, resistance and noise, it is possible to ascertain within 12 months the deterioration trends. The average life of 2 years obtained under these conditions is considered satisfactory.

Secondly, similar controlled tests were carried out with transmitters placed in selected busy telephones in a commercial office. Under these conditions the measurable deterioration after one year's service was nil, and there were no transmission complaints such as would be expected if the performance suffered from any short-term instabilities.

Thirdly, several thousand transmitters were fitted at random into new subscriber trunk dialling public-call offices. This test lacks, of course, the precision of controlled tests, but allows a much larger scale of testing with wider and more random distribution of operating conditions.

Lastly, No. 16 transmitters have been used to replace No. 13 transmitters where adverse transmission conditions were known to exist because line lengths exceeded normal, or where specific transmission complaints have been made.

Manufacturing Testing

For manufacturing testing it is necessary to limit the number of tests which can be made on each transmitter and to rely on general quality control and batch sampling for checking other parameters. In general, tests for sensitivity, frequency response, resistance and sealing will be carried out on all transmitters. The first three parameters may be checked simultaneously by the use of a white-noise band tester, which applies sequentially to the transmitter, through an artificial mouth, a broad band of noise covering the frequency range 300–3,400 c/s, followed by three narrow bands of noise positioned in the lower, middle and upper portions of the wideband spectrum. Sensitivity can be checked by measuring the mean output whilst the transmitter is energized by the broad band, and control of frequency response is maintained by allowing only very narrow spreads in the outputs of the three narrow bands relative to the particular broad-band output of the transmitter under test. Dynamic resistance may be checked during this test.

MOUNTING THE TRANSMITTER IN THE HANDSET

The transmitter is held in contact with the mouthpiece by a spring ring similar to the one used with the Receiver Inset No. 4T. The spring ring, supported by moulded lugs in the handset, presses against the back surface of the transmitter. The rotation of the transmitter is prevented by lugs which are positioned by ribs on the inside of the mouthpiece cavity.

The transmitter is about 0·9 oz less in weight than the Transmitter Inset No. 13. The adoption of ABS† material for the handset mouldings will further reduce the weight of the Handset No. 3 to about 7$\frac{3}{4}$ oz, excluding the cord. This worthwhile reduction can be passed on to the subscriber in all but the very few instances when the telephone has been fitted with add-on gravity-switch spring-sets with the maximum number of springs. For these telephones a small weight can be added to the handset to ensure the satisfactory operation of the gravity-switch mechanism.

DESIGN VARIATIONS

Two modifications to the original design (Mark 1) have been developed to permit manufacturers to make full use of their own production techniques. Both designs are physically interchangeable with the Mark I and have similar electrical performances.

The Mark II transmitter (Fig. 5) has a modified back cover which extends over the frame and is clamped by the rim of the front cover, thus making it unnecessary to have the three back-cover fixing screws.

FIG. 5—MARK II VERSION OF TRANSMITTER INSET NO. 16

The Mark III transmitter, which externally is identical to the Mark I design (Fig. 1), has a modified diaphragm assembly. The moving electrode is sealed to the diaphragm, which is protected by enamel, so that it is no

*C.C.I.T.T.—International Telegraph and Telephone Consultative Committee.

†ABS—acrylonitrile-butadienestyrene.

longer necessary to have a membrane in front of the diaphragm. The edge of the diaphragm is sealed with a pliant ring and sealing compound.

CONCLUSIONS

The Transmitter Inset No. 16 is now superseding the Transmitter Inset No. 13C for all 700-type telephones. Its slightly improved sensitivity, better frequency characteristics, lower amplitude/amplitude distortion, and freedom from angular positional effects will be of particular advantage under adverse transmission conditions; in all circumstances it will help to bring better quality to telephone speech. With its introduction into the 706-type telephones, the development of this telephone may now be said to be complete and it can the more readily take its place among the few first-grade telephone sets in general use throughout the world.

Only the test of time can determine beyond all doubt just how satisfactory in service the new design will prove to be, but in these days of rapidly increasing knowledge in the field of semiconductors, it could well be that the Transmitter Inset No. 16 could remain in production with only relatively minor design variations until the era of the carbon microphone for general telephonic use has ended.

ACKNOWLEDGMENTS

The new transmitter has been developed by Standard Telephones and Cables, Ltd., for the Post Office under the British Telephone Technical Development Committee procedure.

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Data Service to Ships

U.D.C. 621.394.5: 621.396.932

An experiment is being made of the use of data transmission between tankers of the Shell fleet and the Shell Centre in London to enable the day-to-day performance of the ships to be assessed. Such a service may be of interest to other organizations, and the equipment and operational requirements are being studied.

IN the summer of 1962 the British Post Office was informed of a requirement for the transmission of data from tankers of the Shell fleet to the Shell Centre, London, for processing by a computer. The requirement arose from an economic study by Shell which indicated that, compared with the cost of infrequent and expensive checks over a measured mile, considerable operational savings would result from day-to-day processing of ships' performance information. Shell proposed to make experimental fittings on up to 15 ships, and, thereafter, to assess results over 12 to 18 months before reaching a final conclusion, which might lead to equipping up to 100 or so tankers.

The Post Office part in this experiment was to act as the carrier of data traffic to and from the ships, the signalling equipment being installed and maintained by a contractor to Shell. During the following four months the Post Office Engineering Department co-operated closely with contractors in experimental transmissions to enable Shell to choose a system. That chosen for use during the experimental period was based on the Marconi Autospec (automatic single-path error-correcting) equipment, using 2-tone modulation of the radio transmitter at a modulation rate of 66 bauds. It was found essential, in order to minimize the effects of frequency-selective fading, to utilize space-diversity reception, and, since the conversion to direct-current signals was to be made at the Shell Centre, it was necessary to transmit signals on both diversity channels from the receiving station as tone frequencies on one pair. This was done by modifying a path of a diversity receiver so as to shift one pair of received tones in frequency, using diversity combination at Shell Centre.

The service was inaugurated in July 1964 and, as an example of the amount of traffic handled, 145 messages were passed in February 1965. Calls are, at present, set up on a speech basis via the Radio Telephony Terminal and the International Exchange, and then switched over to data transmission by each end, but the service will shortly be controlled at the Burnham coastal radio station, which will be served by receivers at Somerton and transmitters at Portishead and will have a 4-wire private circuit to the Shell Centre.

Other organizations are showing interest in both data and teleprinter services to ships, and a study is being made of the equipment and processing requirements that are likely to arise in the fairly near future. Considerations in such a study are basically three-fold. Firstly, the present system of putting both ends of the circuit into telephone contact before switching to data transmission is an uneconomic use of the radio-frequency spectrum and may well be replaced by utilizing teleprinter signal transmission, which requires a much narrower bandwidth. Secondly, because of the limited transmitter power and aerial gain on ships, the single-sideband mode of transmission is most desirable to improve received signal-to-noise ratio as well as to reduce the bandwidth required. Some form of diversity reception on ships will almost certainly be necessary if shore-to-ship data transmission is required, and, in this connexion, it is noteworthy that tests have shown that simultaneous bothway transmission is possible with suitable shipboard equipment. Thirdly, to make the service attractive to small users, it would be very desirable to be able to distribute the traffic over the inland telex network. This would involve converting the signals to and from direct current at the shore end of the circuit so that they could be transmitted over the inland voice-frequency telegraph system. This might make it necessary for the radio-path error-correcting equipment to be fitted at the Post Office radio stations and require the addition of error-protection equipment to cover the line extensions to the subscriber.

J.L.C.

Special Lighting for Motor-Transport Workshops

F. F. FRIDAY†

U.D.C. 628.978:629.119

The lighting necessary in motor-transport workshops has to fulfil certain special requirements. The way in which these requirements have been met by the present standard arrangements in Post Office motor-transport workshops is described.

INTRODUCTION

THE essence of good lighting is to provide, in the most economic way, enough light for the task in hand. Adequate lighting also lowers the accident rate and increases efficiency. The special lighting provided in Post Office motor-transport workshops is designed to fulfil these conditions.

The present standards of illumination for the workshops and their lighting layouts are based on the recommendations of a study group that included representatives of the staff associations as well as members of the Engineering Department. Good general lighting was prescribed for the accommodation, with the addition of special arrangements where work which requires extra illumination is carried out.

WORKSHOP LIGHTING

General lighting is provided throughout the working area of a workshop, and the work-benches are provided with wall-mounted bench lamps where required.

Work requiring the use of a hand-lamp is often carried out on vehicles, and because of the danger of electric shock a 25-volt system has been introduced. Difficulty was found in fixing the normal type of garage hand-lamp to give the correct throw of light, and so a lamp was provided fitted with a clip and swivel and using a 25-volt 24-watt pearl bulb. This lamp (coded Lamp No. 9) can be clipped to the vehicle and the light directed where it is required (Fig. 1).

Two methods are used to supply electrical power to the hand-lamp. In smaller garages and workshops with overhead gantries the lamps are fed from socket-outlets mounted at convenient points, the socket-outlets being connected to a step-down transformer giving a 25-volt output. The disadvantage of this system is the use of trailing leads which can be damaged by vehicles and can trip staff.

Alternatively, the Kelvin Norton system can be used. In this system the hand-lamp, with only a short trailing lead, is connected by a plug to a jack (Fig. 2) fitted at the bottom end of a long pole. The top of the pole has collector shoes (Fig. 3) that are dropped on to two parallel, overhead, bare conductors energized at 25 volts. With this system the trailing leads no longer touch the ground, and should a vehicle be inadvertently driven off with a hand-lamp still connected, the plug and jack part, preventing damage. This system is extremely flexible, as the pole may be connected to the overhead conductors at any point.

†Power Branch, E.-in-C.'s Office.

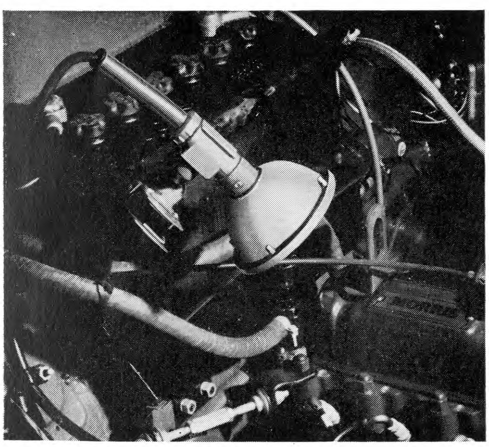

FIG. 1—LAMP NO. 9 IN USE

FIG. 2—PLUG AND JACK FOR CONNECTING LAMP NO. 9

PITS

The standard pit used in Post Office garages is 10 ft long, 2 ft 6 in. or 3 ft wide, and 4 ft 6 in. deep. The previous method of illuminating the underside of vehicles standing over the pit was by means of four 60-watt filament lamps. This gave insufficient illumination, however, and shadows were cast by parts of the vehicle and by the mechanic.

The present standard layout uses two 5 ft 80-watt fluorescent fittings recessed into opposite ends, and near the top, of the long walls of the pit (Fig. 4). Each fitting contains a reflector shaped to throw the light in an

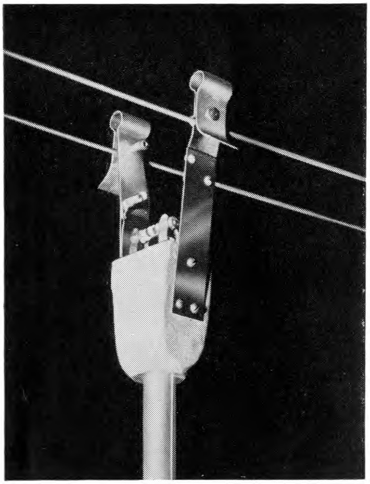

FIG. 3—COLLECTOR SHOES ON OVERHEAD CONDUCTORS

upward direction. To prevent glare causing discomfort to a mechanic working in the pit, the front of the fitting has a thick opal perspex window. The degree of illumination is adequate for inspection and adjustment work, and very little shadow is experienced because of the general diffusion from the large light sources. The fitting, although not certificated flameproof, is so constructed that it is vapour proof and can be cleaned by means of water spray.

VEHICLE LIFTS

Vehicle lifts are purchased by the Post Office without lighting attachments. After installation a system of fluorescent lights is fitted.

A method of illumination was devised to minimize excessive source brightness and shadows. The fittings (coded Fittings, E.L., Fluorescent, No. 13) are totally enclosed and vapour proof, with a glass panel in the top through which light is presented at the correct angle (Fig. 5). For the 3-ton lift four fittings are used, and for the 8-ton lift six are required, the fittings being so positioned that the parts of the vehicle that need more detailed inspection are the more highly illuminated. The use of mains voltage is acceptable because the fittings are adequately earthed.

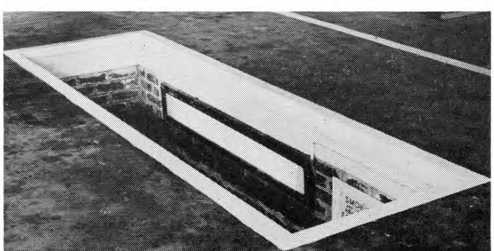

FIG. 4—FLUORESCENT FITTING WITH OPAL PERSPEX WINDOW IN PIT

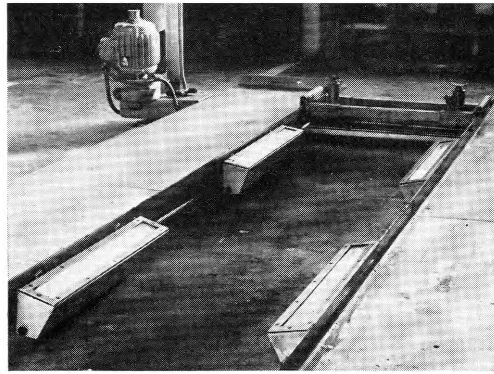

FIG. 5—FLUORESCENT FITTINGS FOR VEHICLE LIFT

WASH BAYS AND BEDS

In a Post Office garage vehicles are washed either on a wash bed provided by draining a section of the floor, or in a bay specially provided for the purpose. The bay is usually 30 ft × 25 ft, enclosed at one end and on the two sides by brick walls at least 9 ft high.

Because of its high efficiency and its comparatively shadow-free illumination fluorescent lighting is used to illuminate the wash bay. In a bay of the usual size three 4 ft 40-watt fittings are mounted along each side wall and one on the end wall, all at a height of 9 ft above floor level. A 5 ft 80-watt fitting is suspended at a height of 12 ft over the entrance of the bay, so that a vehicle can be driven into the bay without risk of damage. The fittings (coded Fittings, E.L., Fluorescent, No. 6) mounted on the walls of the bay are designed to throw the light downwards at an angle to the horizontal. They are waterproofed and have hinged glazed covers which allow access for maintenance and cleaning. The 5 ft 80-watt fitting is a commercial type, plastic-coated to prevent ingress of water.

If two or more adjacent bays are provided without party walls, 5 ft 80-watt fittings are suspended 12 ft above the floor level on the line where the partition wall would normally be provided. These fittings are of the same type as the one suspended over the entrance to the bay.

The type of lighting provided for a drained wash bed is similar to that provided for the accommodation in which the bed is situated. When fluorescent lights are used they are of the 5 ft 80-watt plastic-coated type suspended 12 ft above the floor, and placed round the edges of the bed. An additional row is positioned across the middle of the bed. Tungsten-filament fittings, when used, are mounted at the same height as those used elsewhere in the garage, and are disposed around and across the bed as for fluorescent lighting. It is essential that all fittings using filament lamps should be fitted with translucent covers to prevent water being sprayed on to hot lamps.

The layouts described above for wash bays and beds provide for the light to be directed primarily on to the sides and ends of the vehicle being cleaned.

PAINT SHOPS

In some of the larger garages special booths are provided for the paint-spraying of vehicles, but in many

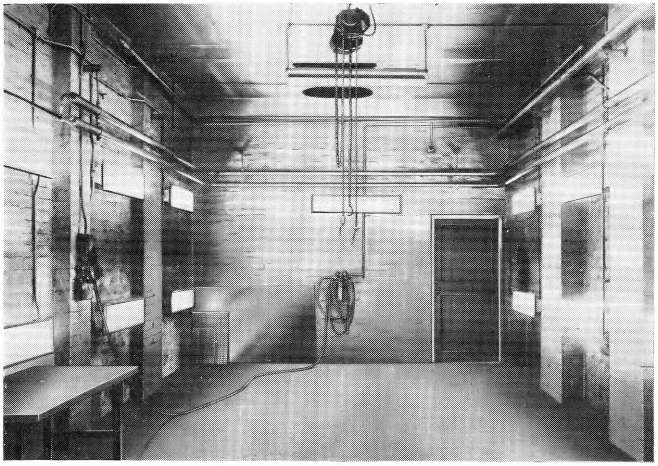

FIG. 6—ARRANGEMENT OF FITTINGS IN PAINTING BOOTH

instances the vehicles are brush-painted in some convenient place within the garage. The present practice in the Post Office is to use synthetic paint, which does not require the use of flameproof fittings. It must be stressed, however, that wherever cellulose paint is used the whole of the lighting and power installation must be flameproof.

To obtain the required standard of illumination on all surfaces of the vehicle being painted within a booth, a large number of fittings is required. Fluorescent lamps are necessary because of the problems of radiant heat and glaring reflections from point sources if tungsten-filament lamps are used. Four-foot 40-watt fluorescent fittings, vapour proofed to prevent the ingress of paint spray, are therefore used. Two horizontal rows of fittings are mounted on each wall, the rows being mounted at 3 ft and 7 ft above the floor level. The fittings are spaced at approximately 8 ft centre to centre. Two angled fittings are mounted in line with the higher row, one at each end of the booth, to throw light down on to the front and rear of the vehicle. One other fitting is suspended at a height of 10 ft above the floor midway down

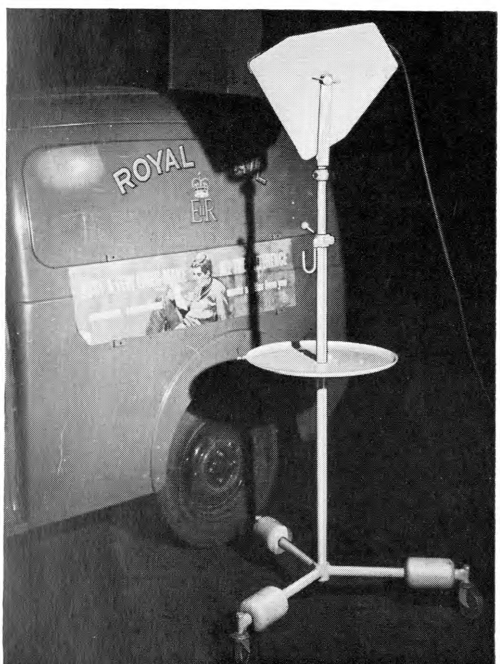

FIG. 7—THEATRICAL-TYPE PORTABLE FLOODLAMP (LAMP, ELECTRIC, NO. 21)

FIG. 8—PORTABLE FLUORESCENT LAMP FOR USE WHEN PAINTING INTERIORS OF VEHICLES

the length of a 25 ft booth. The arrangement of the fittings is shown in Fig. 6.

If brush painting is not done within a booth the level of illumination required on the surface to be painted is obtained by means of a portable theatrical-type floodlamp (Fig. 7) heavily diffused to prevent glare. The fitting is mounted on a telescopic column which allows positioning of the lamp, and the whole is mounted on a castored base to facilitate ease of movement around the vehicle. The lamp is not suitable when using cellulose paint.

Illumination is also required for painting the interiors of vehicles, and a portable fluorescent fitting (Lamp, Electric, No. 22) has been devised to help with this work. The fitting uses a 2 ft 20-watt fluorescent lamp contained in a perspex tube to which is fixed a spring clamp for attaching the item to a suitable part of the vehicle body (Fig. 8). The control gear is housed in a box remote from the lamp and can be wall-mounted adjacent to the socket-outlet that supplies the power. This lamp is vapour proof, but it should not be used when working with cellulose paint.

Book Reviews

"Taschenbuch der Fernsprech-Nebenstellenanlagen."(P.B.X. pocket book). Kurt Hantsche. Oldenbourg Verlag. 247 pp. 109 ill. DM32.

This is the second edition of a popular treatise on miscellaneous subscribers' apparatus found in the German telephone system. Although primarily concerned with P.B.X.s, both automatic and manual, it includes descriptions of individual telephones, repertory diallers, plan-number installations, house-exchange systems and inquiry desks. The first portion of the book is devoted to the general principles of the use of P.B.X.s and their interconnexion with one another and with the public network. This is followed by details of the various equipments at present in use. Throughout, the treatment is descriptive, with liberal illustrations, but with no circuit or similar technical information apart from some block diagrams. The larger P.B.X.s use apparatus similar to that for public exchanges, e.g. crossbar switches, motor-driven uniselectors and ferrite-core translators, and these are briefly described, together with a particular type of fully-automatic accounting system.

The photographs are extremely well done and in themselves give much useful information on German practice, but the text would be of little use to anyone without knowledge of the specialized German or access to a technical dictionary dealing with telephone terms. The presentation of the information is not helped by the question and answer technique adopted for much of the book.

H.B.

"Progress in Semiconductors" (Volume 8). Edited by Prof. A. F. Gibson, B.Sc., Ph.D. and R. E. Burgess, B.Sc., F.R.S.C. Temple Press Books, Ltd. 6 + 244 pp. 55 ill. 70s.

This volume is unique in the series in that it is entirely taken up by a single contribution, by Dr. E. G. S. Paige of R.R.E., Malvern, on "The Electrical Conductivity of Germanium." Many readers of this Journal might have thought that germanium was already becoming a material of only historical interest. It has, admittedly, higher electron and hole mobilities than its competitor silicon and it can, in principle therefore, offer the basis of higher frequency and faster transistors and diodes. Silicon seems to be winning the race in the achievement, in production, of reliable fast devices and also of high voltage and high power devices, partly because the technology of device production leads more confidently to adequate devices if silicon is used, and partly because the higher energy gap of silicon permits a higher working junction temperature to be used before the junction leakage current becomes a serious cause of junction power dissipation. Yet the fundamental physics of electrical conduction in germanium and silicon are essentially the same, and germanium has been studied intensively for longer, so that the appearance at this stage of a volume devoted solely to germanium, and its recommendation to suitably qualified readers of this Journal, are not entirely anomalous.

The formal theory of conduction occupies 45 pages and the theory of scattering a further 41 pages. Much experimental data on galvanomagnetic properties is presented and compared with theory in the next 59 pages. The effects of mechanical deformation and of high electric fields are examined in the next 24 and 44 pages, respectively. Introductory and concluding chapters, and a bibliography of 298 references, complete the text. The words transistor and diode do not appear in the text, though there is an incidental reference to the tunnel diode on page 225. This volume is essentially for researchers in semiconductor physics, though theoreticians in neighbouring fields will probably also find sections to interest them.

F.F.R.

"Philips Paperbacks." Prepared by Centrex, Ltd., Eindhoven. Distributed by Iliffe Books, Ltd.

(*a*) "Aerials." D. J. W. Sjobbema. 110 pp. 98 ill. 10s. 6d.
(*b*) "A.F. Amplification." Edited by E. J. Black. 109 pp. 82 ill. 10s. 6d.
(*c*) "Alternating Current and Acoustics." Edited by E. J. Black. 116 pp. 86 ill. 10s. 6d.
(*d*) "Direct Current and Magnetism." Edited by E. J. Black. 120 pp. 92 ill. 10s. 6d.
(*e*) "Radio Valves." Edited by E. J. Black. 126 pp. 90 ill. 10s. 6d.

This series is written in an elementary manner for the radio service man who wishes to advance rather further into an understanding of domestic radio receivers than is essential for fault location by "rule of thumb" methods. There are a number of books in this series, and the ones reviewed are listed above. "Aerials," by D. Sjobbema, is of a slightly more advanced standard than the others.

Each book is short, about 100 pages long, with many simple straightforward illustrations. The volume on aerials is perhaps the best technically: it explains the difficult phenomenon of radiation of electromagnetic waves clearly and covers groundwork usually neglected in elementary books on radio receivers. All are very easy to read, with a standard approximately that of the first year of the City and Guilds of London Institute Examinations. These books probably fulfil admirably their purpose of helping radio service men in an understanding of their craft, although at 10s. 6d. each they might be considered somewhat expensive.

C.F.F.

A Wire-Wrapping Tool for Solderless Joints

F. G. FINN†

U.D.C. 621.315.684

A simple and inexpensive wire-wrapping tool for solderless joints has been designed to meet British Post Office requirements. The tool can be easily converted from hand operation to power operation if required, and a range of tag and wire sizes can be dealt with.

INTRODUCTION

THE permanent connexion of wires on equipment racks and frames by solderless wrapped joints[1] has been carried out by the telecommunication equipment manufacturers' staff for some time and has been accepted for British Post Office work. As a result of experience gained from having had this type of joint in service, and some recent tests comparing this method with existing solder techniques, its use is being extended to Post Office staff for all future work of this nature. Full advantage will be taken of the overall economy and increased reliability of wrapped joints, and contact faults due to solder splashes and small pieces of bare wire will be avoided. In addition, the equipment manufacturers will be able to produce standard types of connexion strips for all work.

The provision of wire-wrapping tools for general issue to Post Office staff was therefore considered, and enquiries were made of tool manufacturers and equipment contractors to ascertain what tools were already available. From the information gathered it was apparent that the range was very limited and that all the tools had some feature that rendered them unsuitable for Post Office use. Moreover, many of the types available were very expensive. A tool[2] has, therefore, been designed which is cheap to produce and simple to operate, and which provides all the advantages of the wire-wrapping method.

TOOL REQUIREMENTS

General Requirements

Any wire-wrapping tool must be capable of producing a wrapped termination in such a way that

(*a*) during the whole time that the termination is being made the wire is kept under constant tension, i.e. the operation must be continuous,

(*b*) the completed termination has a minimum of six turns of bare wire around the tag,

(*c*) the insulation of the wire is close to the commencement of, or forms part of, the first turn of wire around the tag (if the insulation does form part of the first turn, it must not be counted as part of the termination as specified in (*b*) above),

(*d*) all the turns are closely wound and at least three are contiguous, but with no turn overlapping another, and

(*e*) the completed termination will pass two tests that have been devised to prove whether it is satisfactory.

The two tests referred to in (*e*) are not applied to working terminations but are carried out on a specially provided connexion strip on which each tag is used only once. Ten terminations are made on this strip. The two tests, which prove the capability of the wrapping tool to make satisfactory terminations and which are carried out each day prior to commencing work, are as follows.

Test 1. Five terminations are destroyed by the application of a gradually increasing tension, the latter being applied with a special tension gauge that has a hook which engages the rear of the termination. The tension is applied along the length of the tag and causes the termination to pull off, a "tell-tale" on the gauge indicating the tension reached when this occurs. A satisfactory termination will withstand a minimum tension of 10 lb. This test shows whether the wire was wrapped sufficiently tightly.

Test 2. The other five terminations are unwrapped in the plane of the wrap, and the wire must not break during the unwrapping process. The object of this test is to prove that the wire has not been wrapped too tightly and is not, therefore, liable to fracture.

Particular Requirements

The tools will be used on connexion strips and test jacks on frames, and must, therefore, be capable of dealing with the different sizes of tags and wires liable to be met in these positions. Two sizes of tag are involved: the first is 0·072 in. by 0·048 in. and the second is 0·056 in. by 0·024 in. Three sizes of wire are at present used: $6\frac{1}{2}$ lb, $9\frac{1}{4}$ lb and $12\frac{1}{2}$ lb per mile. There are, therefore, six possible combinations of wire and tag that may be met, and with which the tool should, in theory, be capable of dealing. It is unlikely, however, that $12\frac{1}{2}$ lb per mile wire will be used for wrapped terminations, as the method will not, for the time being, be extended to include jumper wires. It is also unlikely that $9\frac{1}{4}$ lb per mile wire will be used on the smaller tags. Three combinations therefore remain with which the tool must deal.

At present it may be necessary to terminate up to three wires on the same tag. The tool must, therefore, have means of setting the depth of engagement of the tool on the tag so that a second or a third termination can be made on the tag without overwrapping on to the previous termination.

Before the actual wrapped joint itself is commenced the wire must first be cut to the correct length and have the insulation removed from a sufficient length to provide the requisite number of turns around the tag. It is an obvious advantage to have a tool that will cut, strip and wrap the wire, and these three operations should occur, ideally, as a result of one movement on the part of the operator.

DESIGN CONSIDERATIONS

The introduction of wire wrapping on a national scale necessitates a very wide distribution of tools to ensure that they are available whenever required. To meet the need in the most efficient manner a simple, inexpensive, hand-operated tool, capable of being converted to power operation by means of the addition of a power unit, was chosen. Hand-operated tools of this type can be provided for all staff employed on wire wrapping, while

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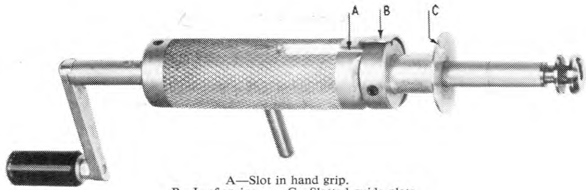
[1]Hix, K. W. Solderless Wrapped Joints in Telephone Exchanges. *P.O.E.E.J.*, Vol. 54, p. 204, Oct. 1961.

[2]British Patent Application No. 1697/64.

a small number of power units can be held centrally for issue when large jobs are to be carried out. Power operation of wire-wrapping tools does not substantially increase the rate at which the actual wire is wrapped, but it does save time by relieving the fatigue and tedium that is experienced when using hand-operated tools for long periods.

The various sizes of wire and tag are accommodated by variations in the end of the tool making the actual wrap. The only other variable, the length of stripped wire required, depends upon the size of tag. A design was therefore chosen in which the wrapping end is detachable, allowing it to be interchanged with other wrapping ends for different combinations of wire and tag, and in which the wrapping end is mounted on an extendable stem, allowing variation of the length of wire stripped. By using this design it becomes possible to concentrate all the intricate part of the tool into the end which makes the wrapped joint and which is known as the wrapping head. This leads to a considerable saving in production costs, as the greater part of the cost of producing any tool is accounted for by the machining time and the number of separate parts to be machined. Standard sizes of material, which are readily available, are used for all parts of the tool except the wrapping head.



A—Slot in hand grip.
B—Leaf spring. C—Slotted guide plate.

FIG. 2—WRAPPING TOOL ASSEMBLED

DESCRIPTION OF TOOL

The tool consists of four main parts (Fig. 1): the body, the stem, the spindle to which is attached the handle, and the wrapping head, which is made in three sizes.

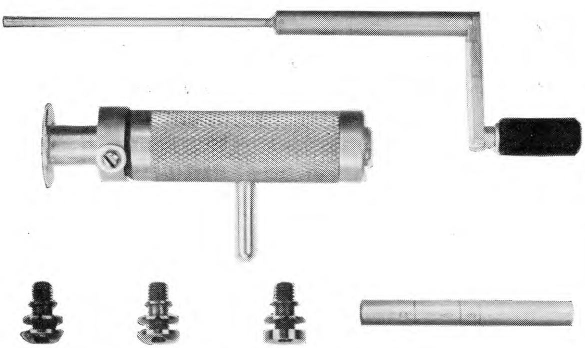


FIG. 1—MAIN PARTS OF WRAPPING TOOL

The Body

The body is 3 in. long and of $\frac{5}{8}$ in. diameter over the greater part of its length, and has a knurled hand-grip, 2 in. long, free to revolve on it. A small rod projects from the bottom of the hand-grip to provide a more positive grip during use and also to hold the hand-grip stationary when the tool is used with a power unit. At the forward end of the hand-grip a slot (A in Fig. 2) has been cut, forming one half of the wire-cropping device. The hand-grip is retained in position by two collars that prevent any end play. The forward collar has a slot similar to that in the hand grip, which forms the other half of the cropping device. A leaf spring (B in Fig. 2) covers the slot in the collar; this spring retains the wire in the slot prior to cropping and also prevents the empty piece of insulation becoming tangled around adjacent tags during the wrapping process. To assist further in preventing fouling of adjacent tags, a slotted guide plate (C in Fig. 2) is mounted on a tube that extends $\frac{1}{2}$ in. in front of the forward collar.

The Stem

The stem is a $\frac{1}{4}$ in. outside-diameter tube fixed to the body by means of a grubscrew through the forward collar. This fixing allows the stem to be adjusted in length and to be rotated to align the wire-feed hole and stripper in the wrapping head with the slot in the guide plate and with the cropper. A short length of the front end of the stem is threaded internally to accept the wrapping head.

The Wrapping Head

The wrapping head is made from a high-carbon spring steel, hardened and tempered to resist wear, and polished at points of contact with the wire to reduce friction. A wire-stripping device is incorporated in the head, the gap between the fixed stripping blades being determined by the thickness of the wire to be used. Three wrapping heads are provided, one for wrapping $6\frac{1}{2}$ lb per mile wire on connexion strips, one for wrapping $6\frac{1}{2}$ lb per mile wire on test jacks, and one for wrapping $9\frac{1}{4}$ lb per mile wire on connexion strips. The three types are coded for identification, the code being engraved on the face of the head.

The Spindle

The spindle has a removable cranked handle secured to its end by a screw; this cranked handle may be removed, allowing the attachment of the chuck of a flexible-drive shaft which can then be driven by a power unit. An extension in the form of a pin is attached to the front end of the spindle and can be extended far enough through the stem to engage the end of the tag during use. The spindle is locked into the body by means of a grubscrew, which is inserted through the rear collar and engages in any one of a series of indentations in the spindle. These indentations allow the spindle, and therefore the pin, to be moved into or out of the body to vary the depth of engagement of the tag.

METHOD OF USE

Preparing the Tool

The appropriate wrapping head, determined by the size of tag and the wire to be used, is screwed into the end of the stem. The grubscrew holding the stem is loosened using a hexagon wrench provided with the tool. The stem is adjusted so that the wrapping-head stripper slot is in line with the cropper, and also so that the line on the stem, marked with the code of the wrapping head in use, coincides with the front of the guide plate. The grubscrew is then tightened. To adjust the depth of engagement of the tag, the grubscrew locking the spindle is loosened and the spindle is moved so that the tool engages the tag at such a depth that a gap of $\frac{1}{32}$ in. is left between either the face of the tag block and the wrapping head in the case of the first termination on the tag, or between the last existing wrap and the face of the wrapping head for subsequent wraps. The grubscrew is then tightened so that it engages in one of the indentations on the spindle. These indentations are spaced at $\frac{3}{16}$ in. centres, the distance required to enable up to three terminations to be made along the length of the tag used on connexion strips, with a small gap left between each termination.

The tool is then ready for use.

Making the Termination

The first termination to be made on a connexion strip should be on the tag nearest to the fanning strip, the remaining tags on the same level being wrapped in turn, working towards the front of the strip. The wire is fed through the hole in the wrapping head, the tool being held in the left hand to avoid having to change hands later. With the wire held fairly taut the tool is fed along the wire until the orifice in the wrapping head just engages on the end of the tag. The wire is then forced down between the stripper blades, which nick the insulation and prepare the wire for stripping. The wire is then fed through the slot in the guide plate, under the retaining spring, and into the cropper slot in the forward collar. The tool is now slipped forward along the tag until the pin prevents further forward movement of the tool.

The handle is turned in a clockwise direction with the right hand. The first revolution causes the wire to be cropped immediately after the slots in the two halves of the wire-cropping device coincide. Continued rotation causes the wire between the wrapping-head stripper and the cropper to be stripped as it is wrapped around the tag, leaving the empty piece of insulation in the tool. As the termination is being made the tool is forced back along the tag by the turns of wire being applied, and only sufficient pressure to ensure that the turns of wire are just touching needs to be applied by the user. If excessive pressure is exerted the turns of wire override and give a poor termination. The empty piece of insulation is removed from the tool and the operation is repeated on the remaining wires to be terminated.

CONCLUSIONS

The adoption of the solderless wrapped-joint method of terminating wires will have the following advantages.

(*i*) The elimination of faults caused by solder splashes and small pieces of bare wire that may be dropped into equipment during soldering operations, as the wire that is severed whilst using the wrapping tool remains insulated.

(*ii*) A more consistent standard of termination will be possible. Apart from the need to keep the pressure against the tool at the right amount, the reliability of the termination is a function of the tool and less skill is, therefore, required on the part of the operator than when terminating by the soldered-joint method.

(*iii*) The Post Office wire-wrapping tool is easily transportable, and can be accommodated in the same bag as other small hand-tools.

(*iv*) The low cost of the hand-operated version of the tool will allow it to be widely distributed amongst the staff, obviating the necessity of arranging for tools to be available before the commencement of a job.

(*v*) The facility of being able to use it as a power-operated tool by the addition of a power unit is more economical than having expensive power-operated tools that are not fully employed.

(*vi*) The use of separate wrapping heads will allow the range of tag and wire sizes with which the tool is capable of dealing to be extended, as the need arises, by the addition of further suitable heads to the set.

Book Review

"Transistors—Theory and Circuitry." K. J. Dean. McGraw-Hill Publishing Co., Ltd. xii + 252 pp. 188 ill. 35s.

This book is intended as an introduction to the subject for students aiming at Degree or Higher National Certificate standard.

Apart from its first two chapters, the book has plainly been written as a practical guide to transistor circuits. The first chapter is a short and superficial introduction to semiconductor physics, and it is followed by a chapter describing the types of transistors and introducing their electrical properties; it is a pity that the chapter opens with such a confusing introduction to 2-port networks.

Chapter 3 deals with small-signal amplifiers, and is followed by a chapter on direct-coupled circuits and negative feedback. Here, most workers would question the statement on p. 74 that feedback amplifiers can be designed "with no more than the barest information about the small signal parameters. . . ."

Chapter 5 describes tuned amplifiers and includes material on the use of piezoelectric resonant elements. The next chapter deals with class-A and class-B power amplifiers and contains information on the design of heat sinks. Chapter 7 is devoted to diodes (including tunnel diodes), and it is followed by a chapter dealing with power supplies. Finally, there is a chapter on sinusoidal oscillators and one on switching circuits; it contains a useful account of the charge-control approach to switching.

There are plenty of exercises in the book, and each chapter ends with a useful bibliography. Chapters 3–10 contain plenty of practical detail for the experimenter, and the book should be regarded primarily as a guide for experimental work.

H.G.B.

Anthorn Very-Low-Frequency Radio Station

L. L. HALL†

U.D.C. 621.396.71

A high-power very-low-frequency radio station has been built for NATO at Anthorn on the Solway Firth. The British Post Office acted as technical adviser and agent of the Ministry of Defence, and supervised the construction of the station. The design requirements and main features of the installation are described.

INTRODUCTION

TO augment the communications facilities of NATO, a high-power very-low-frequency (v.l.f.) radio transmitting station has been built at Anthorn on the Solway Firth. In accordance with the normal procedure for such projects the provision of this station had to be the subject of international competition amongst eligible member countries of NATO. The British Post Office, acting in the capacity of technical adviser and agent of the Ministry of Defence, translated the operational requirements for this station into a technical specification (with assistance from the Ministry of Public Building and Works on matters relating to building work), determined the site, negotiated the contract and supervised the work.

The contract was placed on 26 October 1961 with Continental Electronics Systems Incorporated (C.E.S.I.) of Dallas, Texas, the contractor responsible for the earlier provision of a similar but much larger station in Maine, U.S.A.; work commenced on the site in February 1962, and the station was accepted on behalf of the Ministry of Defence in November 1964.

GENERAL REQUIREMENTS OF SPECIFICATION

Originally, the station was to be capable of radiating single-channel telegraph signals at speeds of up to 45·5 bauds and at powers ranging from 50 kW at a frequency of 16 kc/s to 100 kW at 20 kc/s, using either amplitude or angle modulation. The frequency of the carrier was to remain stable to one part in 10^6 over a period of one month. An additional requirement was the facility for increasing the transmitter bandwidth, and thus the maximum permissible signalling speed, to cater for possible signalling methods that might arise in the future, though it was accepted that this would involve sacrificing some output power.

Subsequently the signalling speed was altered to 50 bauds, and an improved frequency stability was demanded. A large measure of push-button control of the normal operating functions was called for, together with auto-tuning of the aerial circuit of the transmitter, and measures to safeguard the aerial system during bad weather were specified. The possibility of service interruptions due to power-supply failures was catered for by the provision of stand-by engine-driven generators capable of supplying the maximum demand of the station. The tenderers were left free to offer any design of station and type of equipment that would demonstrably meet the requirements and conform with established practice and principles of design.

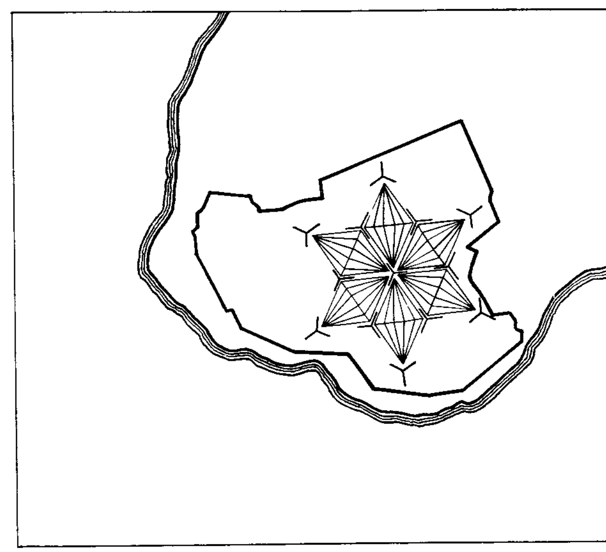
PROVISIONS BY THE HOST COUNTRY

For NATO works the host country is required to provide the site and the necessary public utilities such as access roads, power and water supplies. After extensive searching a suitable site was found in the form of a disused airfield at Anthorn, situated at the tip of a promontory in the Solway Firth, about 15 miles west of Carlisle. The subsoil characteristics were acceptable from the radio and civil-engineering viewpoints, the necessary public utilities existed, and housing for the staff was available in the vicinity.

OVERALL DESIGN OF STATION

The overall design of the station offered by C.E.S.I. was based upon that for the much more powerful station in Maine, which by 1961 had advanced sufficiently through its tests to inspire full confidence in the contractor's proposals for Anthorn.

The aerial system, shown in plan in Fig. 1, consists of six rhombic-shaped multi-cable panels radiating from a central mast and supported at a height of 600 ft above ground from this and from 12 further masts arranged in two concentric circles having diameters of 2,600 ft and 4,400 ft, respectively. Electrically, the aerial approximates to a flat plate of about 0·22 square miles in area, having a capacitance of 95,000 pF. The panels are individually fed at their inner ends by up-leads symmetrically disposed around the centre mast, an arrangement which permits any panel to be lowered clear of all mast stays for maintenance, without mechanical interference with the rest of the aerial. The aerial halyards supporting the corners of the panels are individually attached to 24 power winches, all push-button operated from a control room on the roof of the transmitter building so that one man can carry out any manœuvring of the aerial.



Scale: 1·25 in. to 1 mile

FIG. 1—PLAN OF SITE AND AERIAL SYSTEM

The aerial conductors are 1·1 in. and 1·5 in. diameter steel-cored aluminium cables, which, because of their high strength-to-weight ratio, are able to sustain the

†Overseas Radio Planning and Provision Branch, E.-in-C.'s Office.

specified solid-ice accretion up to an overall diameter of 3 in. in a wind of 40 miles/hour. By virtue of their diameter the cables can also withstand the aerial voltage without corona. A tension-sensing element in each halyard ensures that the appropriate winch will pay out automatically in the event of mechanical overload.

If a reasonable efficiency for a v.l.f. transmitting station is to be achieved, a low earth resistance is essential, and this requires both a high-conductivity subsoil and a very extensive earth-wire system. At Anthorn, which is an area of good soil conductivity, 400 lb/mile copper wires buried to a depth of 12 in. radiate at angular intervals of 2° to the extremities of the aerial system and continue at 4° intervals to the boundaries of the site, a total of some 75 miles of wire being used.

The station building is situated close to the centre mast and accommodates the transmitter together with its auxiliary equipment, the aerial-tuning and coupling circuits, and the stand-by power plant. The building is extensively screened to reduce the undesirable effects of the strong electric field which will exist in its vicinity.

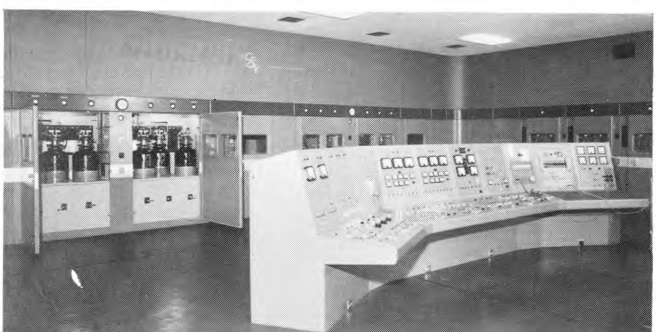
The transmitter, which is of conventional design, is capable of a continuous power output of 550 kW into the aerial circuit. To minimize the consequences of equipment failure the frequency-generator and amplifier chains are duplicated throughout. They consist of:

(*a*) the low-power carrier-generators and modulators forming the drive units and operating at an output level of 200 mW—one of these is regarded as the working equipment and the other as the stand-by, with automatic change-over in the event of a fault,

(*b*) wideband 4-stage amplifier units each capable of driving the output stages singly or together, and

(*c*) tuned class-C output amplifiers normally operated in parallel but capable of individual operation into the aerial at half power.

Control and supervision of the transmitter are exercised from a control console, shown in Fig. 2, at which alarms are also given if major abnormalities occur in the functioning of the power or external plant.



On the left, with cabinet doors open, is a final amplifier unit; on the right is the control console

FIG. 2—TRANSMITTER ROOM

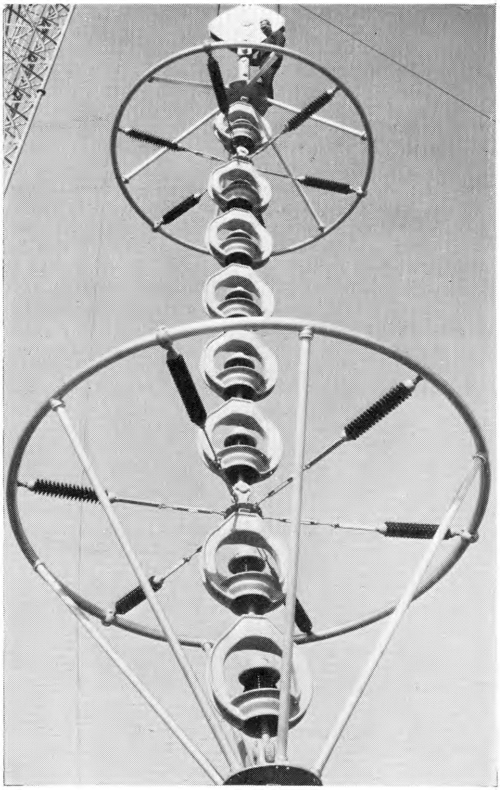
DETAILED DESIGN AND PROVISION

The mechanical design of the aerial system was executed to an exceptional degree of accuracy—even to the extent of allowing for the fact that the tops of 600 ft high vertical masts spaced at ½-mile intervals are nearly 1 in. further apart than are their bases—so operations on site commenced with a very accurate survey for the location of structures.

The physical data on subsoil characteristics given in the specification were supplemented by additional borings that confirmed the need for all foundations to be piled. In the event, a total of 1,139 piles was ultimately driven. Foundations that would be subject solely to dead weight, i.e. the building and mast foundations, needed bearing piles only, but the mast stay anchorages and halyard-winch foundations, which are subject to major horizontal loading with or without uplift, needed a combination of raking piles in compression and in tension. No reliance was placed on the stability of the immediate subsoil under sustained loading.

The safe bearing load for a pile is readily calculable from observation of its movement during the final stages of driving, but the resistance to uplift of such a pile is much less easily determined, especially when the pile is driven through a variable subsoil. As a result of calculation and tests the maximum load for individual bearing piles 17½ in. in diameter was taken as 60 tons and that for tension piles as 30 tons; division by these figures of the total pile reactions necessary for any particular foundation or anchor block gave the numbers of piles of each type required. During construction the driving performance of each tension pile was measured, and, whenever it was considered at all likely that the predicted resistance to uplift might not be achieved, the pile was tested. Twenty-nine out of a total of 671 tension piles were thus tested; of these eight proved to be unsatisfactory and additional piles were driven. For the most heavily loaded stay anchorages 11 tension piles and four bearing piles were required. The piles were driven in rows transverse to the stay and capped by a heavily reinforced concrete block to ensure a uniform distribution of load amongst them.

The aerial is designed to withstand the resultant stresses and remain workable when subjected to either a 100 miles/hour wind or to solid icing, up to 3 in. overall diameter, of conductors and supporting cables together with a 40 miles/hour wind. In a 100 miles/hour wind distortion of the aerial must be restricted to ensure that no conductors will foul a leeward mast or stay, and since, with either condition, the consequence of mechanical failure would be catastrophic, the induced stresses are kept well below the yield points of the components. Some 20 miles of steel-cored aluminium conductor were used in the construction of the aerial, the overall weight of which, including insulators, amounts to about 100 tons. All conductors were pre-stressed and measured under their normal working loads. Under the extreme loading conditions mentioned above, loads of up to 40 tons would be experienced at the panel corners. Accordingly, the supporting insulators (Fig. 3) are of the compression type and fail mechanically at a load of about 160 tons. Electrically, they can sustain



An engineer, standing near the top of the string of insulators, gives an indication of the size of the string

FIG. 3—AERIAL-PANEL CORNER INSULATOR

voltages up to 330 kV when wet and 525 kV when dry.

Each aerial halyard, which is some 2 in. in diameter, is anchored to a mast-head, where a tension-sensing electrical strain-gauge is incorporated; the halyard then passes round a sheave block attached to the aerial insulator and thence back to a mast-head sheave, down the face of the mast to a foot sheave and away to a winch located some 50 ft from the base of the mast. The tension-sensing element, which is located at the mast-head to enable it to give the most accurate indication of aerial loading, causes the winch to pay out the halyard automatically in the event of an overload due, for example, to excessive icing, until the tension falls to 95 per cent of the permitted maximum value. Halyard loads are displayed both at the winches and in the aerial-control room at the transmitter building, and when, after an overload, the tension is seen to be falling to a safe value, the aerial may be raised to its normal position by push-button operation of the winches from the control room. A halyard-position indicating device, equivalent to limit stops, prevents over-winding by the winch.

The masts, which are triangular in section, are stayed at four or five levels according to height and are pivoted at their bases. They were designed as continuous beams on sinking supports, subject to distributed loading by wind and to concentrated transverse loading and thrust by the aerial-halyard and stay pulls. Some 50 combinations of wind direction and aerial loading with all panels up, and alternatively with one panel down to cater for unbalanced loading, were investigated with the aid of a computer. As a result the sides of the masts were made 7 ft 6 in. wide between the centres of solid round posts which vary from 5 in. to 7 in. in diameter for the various types of masts. The masts are supported at approximately 150 ft intervals by pre-stressed stays, initially tensioned rather highly to restrict deflexion of, and therefore bending stresses in, the masts. Under the maximum-specified aerial loading the centre mast-top stay tension would rise to 72 tons and the thrust on the mast foundations would be some 800 tons. The masts are hot-dip galvanized, and in addition to the normal vertical ladders they are provided with petrol-engine-driven hoists climbing on external racks. Icing of the racks is no impediment to the operation of the hoists. Fig. 4 is a view of the base of the centre mast showing the general form of the structure, the main halyard winches, the lower portion of the aerial up-lead with its counter-weights, and the aerial lead-out bushing insulator.

Within the building the aerial is tuned to any frequency in the operating range by fixed and motorized variable inductors, shown in Fig. 5. A servo-controlled variable inductor automatically keeps the aerial in tune when the latter is distorted by wind or if its capacitance is otherwise altered. The inductors are wound with a special low-resistance cable 3 in. in diameter, constructed of 18,200 enamelled 36 s.w.g. copper wires formed round a hemp core and sheathed overall with plastic. The cable is supported on frameworks built of a synthetic-resin-bonded plywood of high mechanical strength and adequate dielectric properties. Because of the strong external r.f. magnetic fields produced by these inductors, the room containing them is lined with solid copper sheet 0·5 mm thick. This reduces losses in the building fabric and maintains the effective Q of the whole aerial-tuning inductance around 3,000.

A block schematic diagram of the transmitter with its duplicated chains of equipment is shown in Fig. 6. Each chain comprises a 100 kc/s master oscillator followed by a frequency synthesizer from which a carrier at any frequency in the operating range of the transmitter is derived and then modulated in amplitude or frequency by the telegraph signals. In the event of a fault in the working chain, the stand-by chain is automatically switched into circuit within 5 ms. The phases of the signals in the two chains are compared, and manually operated phase-shifters enable the carriers to be kept substantially in phase. A rubidium frequency-standard is also provided so that the frequency of the master oscillators can be checked periodically. The output of the modulator is amplified in four class AB resistance-capacitance coupled stages up to and including the penultimate stage, which has an output of 20 kW. In the event of a fault in any stage of the working amplifier chain the stand-by chain can be switched into service by the operation of a push-button. Either of the penultimate amplifiers can drive either or both of the final amplifiers, which together deliver 550 kW to the aerial circuit. Each final amplifier, one of which is

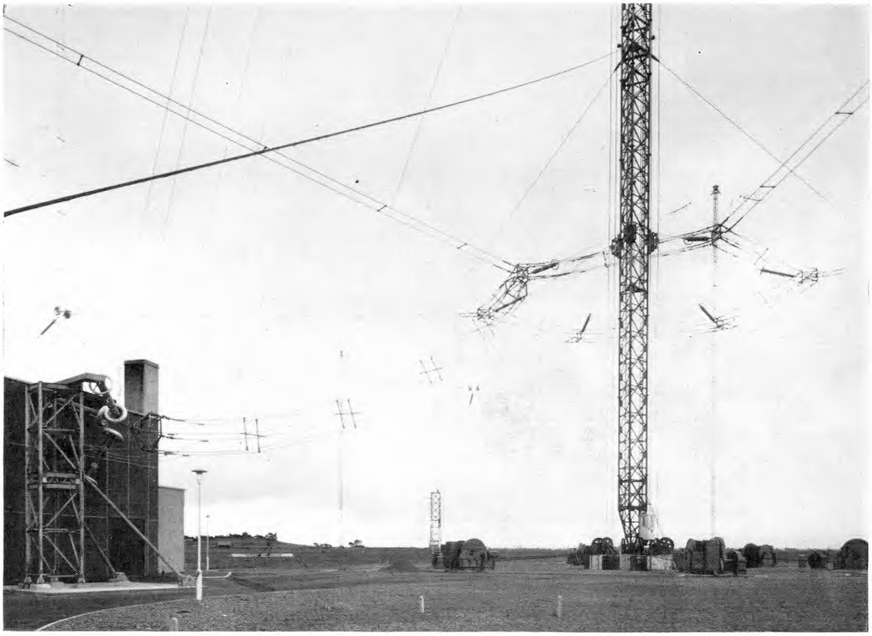


FIG. 4—BASE OF CENTRE MAST

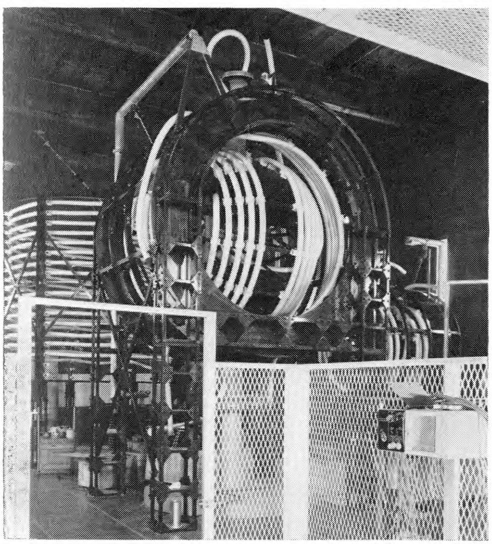


FIG. 5—INTERIOR OF HELIX ROOM, SHOWING INDUCTORS

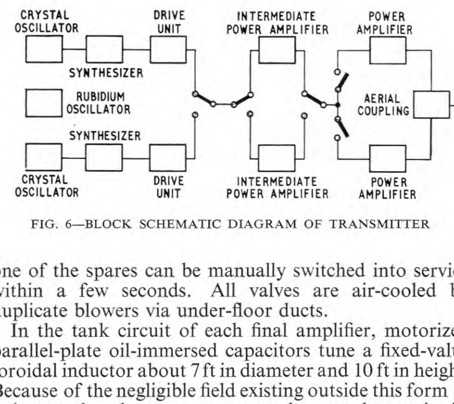


FIG. 6—BLOCK SCHEMATIC DIAGRAM OF TRANSMITTER

shown with its doors open in Fig. 2, is equipped with six English Electric Type VR194 valves, including two installed spares, so that on failure of a working valve one of the spares can be manually switched into service within a few seconds. All valves are air-cooled by duplicate blowers via under-floor ducts.

In the tank circuit of each final amplifier, motorized parallel-plate oil-immersed capacitors tune a fixed-value toroidal inductor about 7 ft in diameter and 10 ft in height. Because of the negligible field existing outside this form of inductor the clearance to any other conductor in its vicinity can safely be reduced to a few inches. For safety, the tank-circuit components are contained in a sheet-aluminium enclosure. Artificial loads facilitate the re-adjustment of any amplifier stage after its withdrawal from service for maintenance or repair.

The transmitter can be coupled to the aerial either directly, i.e. by tapping part of the total aerial-tuning inductance, or by an impedance-matching network. It has been confirmed by practical test that the latter method is preferable as, with the former, high transient voltages across the anode tank circuit are experienced when the transmitter is amplitude modulated; also, any mistuning of the aerial circuit causes a serious rise in the power dissipation of the valves—an effect which would be of major importance with frequency modulation.

To achieve an acceptable signal envelope at the specified modulation rates, the bandwidth of the naturally high-Q aerial circuit can be broadened to any desired extent by the controlled insertion of resistance.

D.C. power is supplied to the transmitter at 13 kV by mercury-vapour rectifiers. Damage to the expensive transmitter output valves by internal flash-over is prevented by the application of a short-circuit to the d.c. power supply within a few micro-seconds of the initiation of the arc. This is effected by the firing of an ignitron connected across the smoothed output of the rectifiers, the smoothing circuit itself and a 2-ohm current-limiting resistor being sufficient to avoid damaging the rectifiers. The effectiveness of this measure—aptly termed "crowbar protection"—is demonstrable by short-circuiting the anode and cathode of a transmitter output valve with a piece of tin foil: it is not disintegrated!

Station power is normally drawn from the public supply at 11 kV, but two 775 kVA diesel-generators have been provided for emergency purposes. As the major part of the station load is imposed by the two final amplifiers of the transmitter, the medium-voltage busbars are in two sections, each one serving one final amplifier and half the miscellaneous load of the station. Each section of the busbars is supplied by one mains transformer or one engine-driven generator, but bus-section switches (normally open) enable the sections to be interconnected or a spare transformer to be switched to either section. The generators may be operated in parallel with each other but not with the mains, as, after an interruption, the station load can be transferred back to the public supply within 2 or 3 seconds at any convenient gap in traffic.

Access to any part of the power system or radio equipment working at dangerous voltages is prevented by an extensive key-interlock system and the usual earthing facilities.

Functional control and supervision of the transmitter takes place at the multi-panel control console shown in Fig. 2. Day-to-day control is exercised from one particular control panel at which the transmitter can be switched on and off and caused to adjust itself in not more than 2 minutes to any of a number of pre-set frequencies and for either amplitude or frequency modulation by the operation of push-button or selector switches. An illuminated line diagram above the control panel indicates the signal path through the duplicate chains of equipment and shows which rectifiers are in use. Other panels are equipped with facilities for control and supervision of the intermediate and final amplifiers, selection and voltage control of the rectifiers, adjustment of the aerial circuit, starting and switching of the diesel-driven generators and for indicating the busbar voltage and power.

The transmitter can be adjusted from the console by a skilled operator to any "new" frequency within its operating range in about 15 minutes. Also mounted on the console is a fault indicator and an error counter which continuously compares the envelope of the radiated signal with that of the line signal after appropriate shaping and records the number of times that these two waveforms differ by more than a predetermined amount. Further, if the error rate becomes excessive, an alarm is given. An audible alarm is also given at the console for a number of peripheral events affecting service, such as high water or lubricating-oil temperatures on the stand-by set, abnormal rise in any aerial-halyard tension or the pay out of any winch.

In addition, the signal characteristics at various points in the transmitter chains may be examined via monitor jacks at the console.

ACKNOWLEDGEMENTS

In spite of the usual number of difficulties inherent in a project of this magnitude, the work on site, much of it of a specialized civil and structural engineering character, has been completed substantially to schedule and fully in accordance with the specification. Much credit for this is due to the prime contractor and his associates and sub-contractors. The author would also like to acknowledge the advice and assistance given by the Ministry of Public Building and Works regarding building work and by other Branches of the Post Office Engineering Department on specialized technical matters

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Book Review

"The Use of Ferrites at Microwave Frequencies." L. Thourel. Pergamon Press, Ltd. vii + 100 pp. 81 ill. 45s.

This little book is a condensed version of part of a series of lectures at L'École Nationale Supérieure d'Aéronautique on the application of ferrites to waveguide engineering. It opens with a few pages reviewing the modern ideas on magnetism and gyromagnetic effects, followed by a brief survey of ferrites, their structure and properties, insofar as these interest the microwave engineer. From this background, M. Thourel takes the logical step of explaining how ferrites can produce non-reciprocal transmission in a waveguide and then proceeds to a discussion of the application of the effects to ferrite isolators. A chapter is devoted to circulators and modulators that use the Faraday effect, and the book finishes by describing how ferrites can be used to provide variable-frequency filter cavities, the controlling parameter being the externally applied magnetic field.

The treatment is practical, as the original lectures were for microwave engineering students, probably of the standard of the British third-year undergraduate. Basic mathematical results are freely quoted, without the supporting derivations which can easily be found in more specialized texts. Photographs, dimensions and performance figures are given for some of the waveguide devices discussed and these are representative and up-to-date. The text contains many clear line diagrams, well drawn and neatly presented.

The translator has done his work carefully and there is little indication that the original source is French, except in the bibliography at the end of the book, where most of the references are to French and American publications. This is an admirable book for advanced students, as it will help to widen their appreciation of the importance of ferrites in microwave engineering.

C.F.F.

New Developments in Remote Auto-Manual Centre Working

R. H. G. KEARSLEY-BROWN, A.M.I.E.E., A.M.I.E.R.E., and F. G. JACKSON†

U.D.C. 621.395.392/4

The increasing percentage of trunk calls which are subscriber dialled has shown that greater flexibility in the siting of manual boards is required. Methods of greatly extending the working range of manual boards whilst retaining the full range of facilities are described.

INTRODUCTION

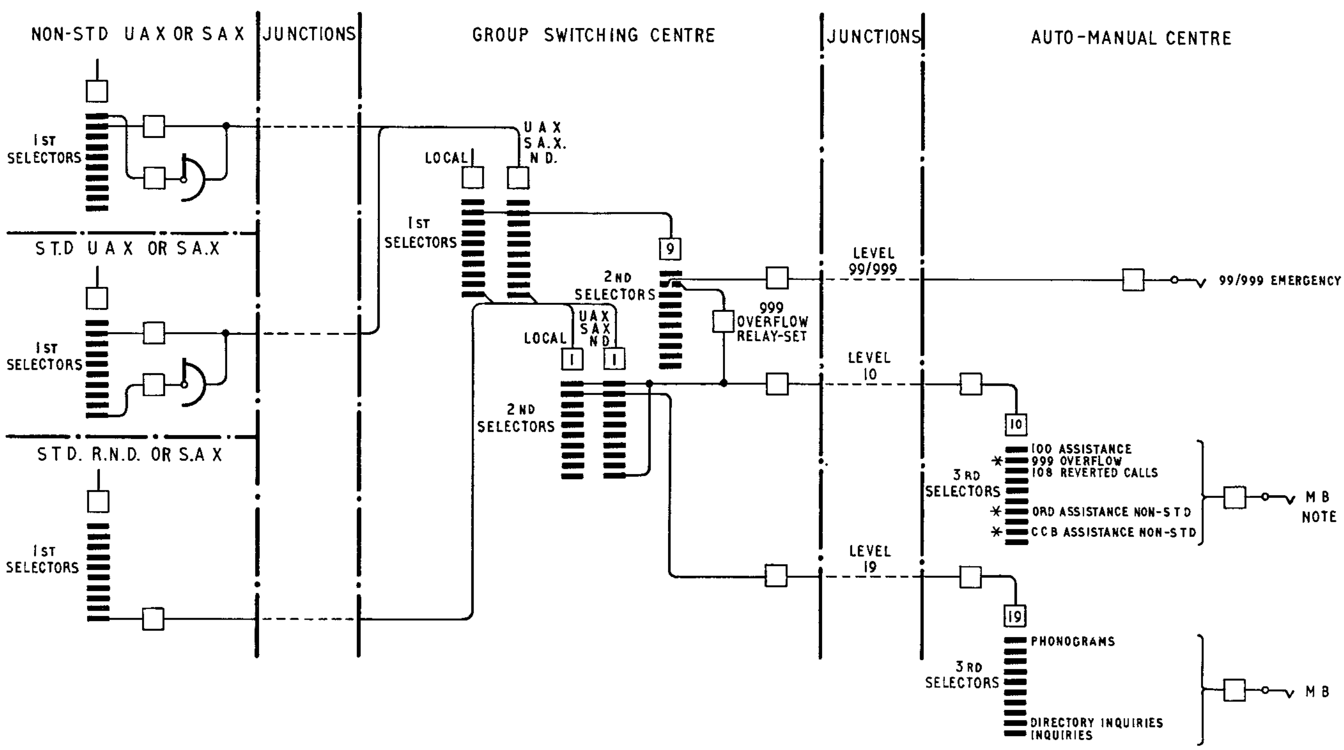
A MAJOR change in the role of auto-manual boards is being initiated by the subscriber trunk dialling (S.T.D.) program. As subscribers are gradually enabled to dial over wider areas, the percentage of operator-connected trunk calls is naturally dropping and, consequently, there is a growing tendency to concentrate manual-board traffic on to fewer auto-manual centres (A.M.C.s).

The change is being brought about not so much by the recovery of existing manual boards as by the non-provision of auto-manual boards at some group switching centres (G.S.C.s). Traffic from such G.S.C.s will normally be extended to an A.M.C. in an adjacent charging group. The average distance between G.S.C.s is about 15 miles, but in sparsely populated areas subscribers may possibly be situated up to 50 or 60 miles from their "local" manual board.

†Telephone Exchange Systems Development Branch, E.-in-C.'s Office.

TRAFFIC FROM G.S.C. TO A.M.C.

To meet the changing conditions, new circuits, which will enable a number of manual-board services to be concentrated, are being developed. Whilst it would be possible to combine all G.S.C.–A.M.C. traffic and route it over a single group of circuits, in practice it has been found that it is preferable to divide the traffic into two groups, as shown in Fig. 1. Assistance (100) traffic must be routed over high-grade junctions and, ultimately, be 4-wire switched at the A.M.C. when calls are extended via the transit network, so that the requisite transmission standards can be met. On the other hand, terminal manual-board traffic routed via level 19 can utilize lower-grade circuits and terminate on 2-wire incoming selectors. If amplified G.S.C.–A.M.C. circuits are necessary, 2-wire repeaters may be employed for terminal traffic. These factors make it more economic to segregate level-10 and level-19 traffic into two groups of circuits, and equipment is being developed on this basis.



*Typical only. M.B.—Manual board. R.N.D.—Remote non-director. S.A.X.—Small automatic exchange. C.C B.—Coin-box.
Note: Two-wire A M.C. equipment is shown, but this will ultimately be replaced by 4-wire A.M C. equipment.

FIG. 1—TYPICAL ROUTING OF TRAFFIC TO A REMOTE AUTO-MANUAL CENTRE

Assistance Traffic

Assistance traffic will be routed via a group of level-10 circuits between the G.S.C. and A.M.C. The circuits will terminate on incoming selectors to give access to levels 101 to 100.

Remote non-director and satellite exchanges will normally be provided with S.T.D. facilities for ordinary and coin-box subscribers by the time remote-manual-board working is introduced. Assistance traffic from these exchanges can therefore be routed over the level-10 group of G.S.C.–A.M.C. circuits to give access to level 100. The operator will identify pay-on-answer coin-box traffic by the normal coin-box discrimination tone given on these calls.

There will, however, be a mixture of S.T.D. and non-S.T.D. unit automatic exchanges (U.A.X.s) to cater for, and it will be necessary to give calling-lamp discrimination for all pre-payment coin-box subscribers. It would be impracticable to extend the existing type of U.A.X. junction signalling over the G.S.C.–A.M.C. circuits. Any non-S.T.D. U.A.X.s dependent on the G.S.C. will, therefore, be equipped with pulse-sending equipment to allow identification of ordinary and pre-payment coin-box subscribers. These facilities can conveniently be provided by fitting S.T.D. level-1/0 relay-sets[1] in advance of the provision of S.T.D. facilities at the U.A.X.s concerned. Each S.T.D. level-1/0 relay-set will be given facilities to identify the class of caller, i.e. S.T.D., non-S.T.D. ordinary, or non-S.T.D. coin-box, and to generate routing digits accordingly. All such calls will be routed over the normal U.A.X.–G.S.C. junction group and the G.S.C.–A.M.C. level-10 group of circuits. At the A.M.C. the traffic will be segregated and routed to the appropriate group of manual-board relay-sets, so that lamp-signal identification can be given.

Until the transit-network equipment becomes available, the incoming level-10 selectors at the A.M.C. will be normal 2-wire group selectors with access to jack-ended manual-board relay-sets (M.B. in Fig. 1). The circuits will be extended using standard cord circuits. Ultimately, the 2-wire A.M.C. incoming equipment will be replaced by equipment suitable for 4-wire switching.

Coin-Box Control

Where loop-disconnect signalling G.S.C.–A.M.C. circuits are provided, pay-on-answer coin-boxes will be controlled by the return of +50-volt pulse signals from the manual-board relay-set to the G.S.C. relay-set. For G.S.C.–A.M.C. circuits using longer d.c. signalling circuits, or where high-frequency carrier circuits are employed, the +50-volt pulse signal from the manual-board relay-set will be converted to an appropriate line signal. Signalling equipment is being developed for this purpose.

Level-19X Services (Inquiries, etc.)

For level-19X services, such as inquiries and phonograms, a separate group of junctions will be used, terminating on level-19 2-wire selectors at the A.M.C. Lower-grade junctions can be used for this group because the calls are not normally extended beyond the level-19X manual-board terminations.

Level-999 Emergency Service

For the level-999 emergency service, one or two relay-sets will be provided on the early choices of level 999 and will be routed direct to the manual board. Some of the subsequent choices will be connected to 999 overflow relay-sets, which in turn will be associated with nominated G.S.C.–A.M.C. traffic circuits to allow 999 calls to overflow on to the traffic circuits. When a 999 overflow relay-set is seized it will busy the associated traffic-circuit relay-set and generate a suitable digit to route the call to a 999 relay-set at the A.M.C. By this means, ample 999 circuits will be available, although only a small number of direct 999 circuits will be required.

Manual Hold

With some signalling systems which incorporate relatively-long clearing-signal recognition times there is insufficient time to return a manual-hold condition from the A.M.C. over two circuits in tandem. An alternative method of providing manual hold has therefore been developed for remote-manual-board working.

Manual-hold conditions will be returned within the local network from the equipment at the G.S.C. under the control of an answering signal on the G.S.C.–A.M.C. circuit. On services requiring the manual-hold facility the answering signal will be returned to prime the outgoing level-10 or level-19 relay-set at the G.S.C. as long as the plug is in the answering jack. Should a caller flash or attempt to clear under these conditions, manual hold will be returned locally from the G.S.C. outgoing relay-set. Normal manual-hold signals will be returned over the local incoming junction to minor exchanges, including U.A.X.s.

Reverted Calls to Coin-Box Lines

When an operator wishes to ring a pay-on-answer coin-box line and subsequently to control the coin slots, it is necessary to arrange for the coin-box user to call back the operator, using a special code—normally 108. A level-10 code is chosen to ensure satisfactory transmission standards and to permit the call to be 4-wire switched at the A.M.C. when such facilities become available.

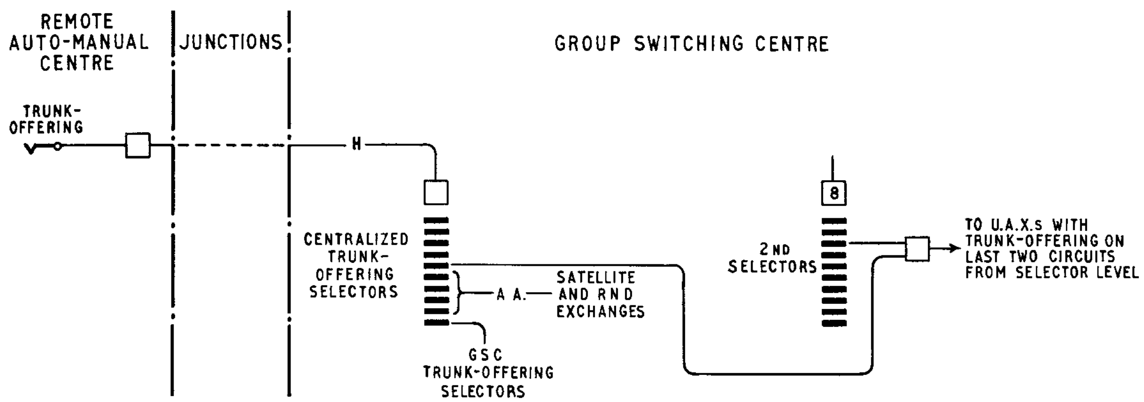
TRUNK OFFERING

The principle of centralized trunk offering has been outlined in a previous article.[2] Under this scheme a single group of junctions between the A.M.C. and the G.S.C. is provided to carry all trunk-offering traffic, as shown in Fig. 2. At the A.M.C., access will be given via outgoing manual-board relay-sets which can transmit a trunk-offering signal under the control of the cord-circuit RING key. At the G.S.C. each junction will terminate on a group selector which accepts two digits. The first digit will step the group selector vertically and the second will step it into the bank. Hunting facilities over two or more contacts will be available if required.

The selector will give access to the normal train of trunk-offering selectors provided to serve G.S.C. subscribers' lines. Access to satellite and remote non-director exchanges will be given via trunk-offering junctions using auto–auto relay-sets.

For non-director exchanges, including the G.S.C., the operator will prefix the required subscriber's local number by two arbitrary code-digits to obtain a local trunk-offering selector, or to select a trunk-offering junction to the appropriate exchange. Three code-digits may be required at some G.S.C.s; an additional rank of group selectors will then be used.

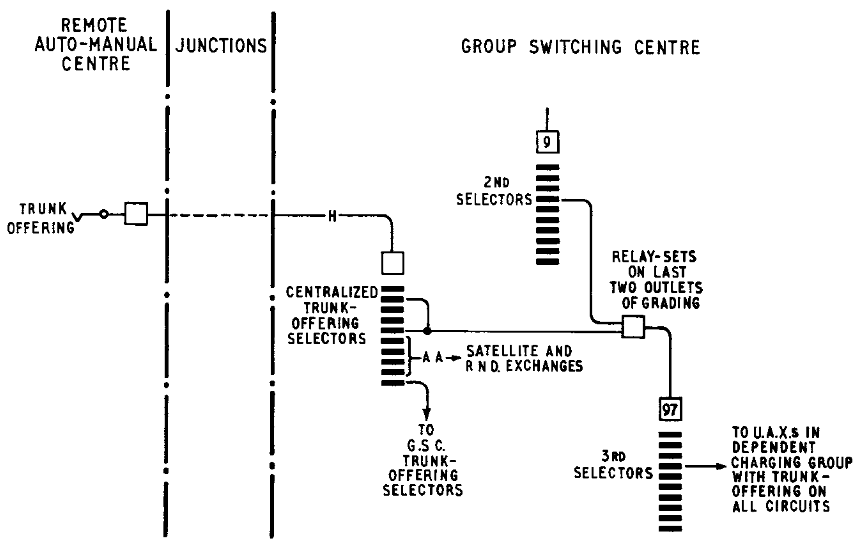
U.A.X.s will be arranged to fit into this basic scheme. For each U.A.X. two late-choice traffic junctions will be provided with dual-entry auto–auto relay-sets. These relay-sets have a normal traffic input and also a trunk-offering input, but only from the latter input will it be



H—Howler-control relay-set. A.A.—Auto-auto relay-set. R.N.D.—Remote non-director.
FIG. 2—SCHEME FOR CENTRALIZED TRUNK OFFERING

possible to repeat an earthed-loop (trunk-offering) signal. The 2-digit group selector will be given access to the trunk-offering inputs.

At some of the larger G.S.C.s 3rd selectors will be used by normal traffic to gain access to junctions, and a common group of auto–auto relay-sets will be interposed between the 2nd and 3rd selectors (see Fig. 3). At these G.S.C.s the trunk-offering 2-digit group selector will have access to two relay-sets per 2nd-selector level. These relay-sets will also be of the type with separate trunk-offering inputs, and trunk-offering facilities will be available on all U.A.X. junctions trunked via the 2nd-selector level concerned.



H.—Howler-control relay-set. A.A.—Auto-auto relay-set. R.N.D.—Remote non-director.
FIG. 3—SCHEME FOR CENTRALIZED TRUNK OFFERING TO INCLUDE A DEPENDENT CHARGING GROUP

HOWLER

Arrangements are being made for remote control of the howler in conjunction with centralized trunk offering. Relay-sets marked H in Fig. 2 and 3 are howler-control relay-sets.

Having established a trunk-offering call to the busy line, the operator will operate the RING key for at least 6 seconds. The howler-control relay-set will recognize the prolonged trunk-offering condition and will cause the graduated howler to be applied to the line and inverted ring tone to be returned to the operator. The howler will be disconnected when either (*a*) the subscriber replaces the handset, or (*b*) the operator releases the circuit.

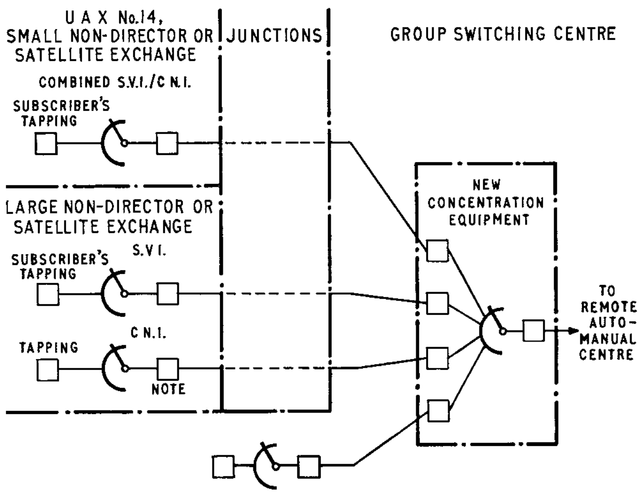
The application of the howler to certain junction routes may cause interference with other circuits or overloading of amplifiers, and it is, therefore, desirable to bar application of the howler to such routes. With the trunking arrangements shown in Fig. 2, by using the P2 bank of the centralized trunk-offering selector, strapping arrangements can be made to bar the howler from any selected junction route or routes. With trunking arranged as in Fig. 3, the levels of the 3rd selector are connected to junctions of which some are suitable for howler access while others require howler-barring facilities. In such circumstances two trunk-offering codes, e.g. 61 or 93, are used to gain access to the 3rd selector. Under these conditions the operator is given one code, e.g. 61, for exchanges with the howler facility, and the alternative code, e.g. 93, for exchanges requiring barring of the facility.

Alternatively, howler-control relay-sets may be fitted in trunk-offering junctions at the distant exchange, if this is justified.

MISCELLANEOUS SERVICES

Service Interception and Changed Number Interception

Up to the present, direct circuits have been provided to the parent manual board for service interception (S.V.I.) traffic and changed-number interception (C.N.I.) traffic from each exchange having S.V.I. and C.N.I. facilities. However, with remote manual board working, if other exchanges in addition to the G.S.C. have such facilities it becomes economic to concentrate the S.V.I. and C.N.I. traffic on to a small group of special G.S.C.–A.M.C. junctions. A new S.V.I./C.N.I. concentration circuit is therefore to be used for this purpose (see Fig. 4).



S.V.I.—Service interception. C.N.I.—Changed-number interception
Note: C.N.I.-type relay-set replaced by S.V.I.-type relay-set
FIG. 4—CONCENTRATION ARRANGEMENTS FOR SERVICE AND CHANGED-NUMBER INTERCEPTION

The existing type of S.V.I. and C.N.I. tapping and signalling equipment will continue to be used at individual exchanges, with the exception of any that have exclusive C.N.I. junctions. C.N.I. junction signalling is not compatible with that used for S.V.I. or joint S.V.I./C.N.I. working; consequently, an S.V.I.-type relay-set must be used instead of the C.N.I.-type at such exchanges to extend S.V.I.-type signalling conditions to the concentration equipment. The S.V.I. junction circuits from the dependent exchanges and the circuits from the G.S.C. are connected to the banks of a new type of finder equipment at the G.S.C. to allow concentration of the traffic on to a single G.S.C.–A.M.C. group of S.V.I./C.N.I. junctions. Standard S.V.I. signalling is employed on these junctions, enabling the existing type of manual-board S.V.I. relay-sets to be used.

Call-Check Circuit

The functions of the old meter-observation circuit have been split and the circuit is being superseded by two new circuits: one, the automatic meter-observation equipment, has been described in a previous issue of this Journal;[3] the other, the call-check circuit, is to be used for checking individual subscribers' lines. The latter has facilities that enable the operator at the remote A.M.C. to monitor each call. The operator will also be given an indication of whether the call is outgoing or incoming to the subscriber concerned. Because the call-check circuit may only be used occasionally, arrangements can be made for a traffic circuit to be switched out of service when required to provide the necessary junction for it.

Subscribers' Transfer and Night Busying

The existing facilities for controlling subscribers' transfer and night busying by the trunk-offering selector remain unchanged.

Centralized Service Observation

Arrangements for centralized service observations via separate junctions remain unchanged.

Extension of Alarms

At some G.S.C.s there will be a number of alarm conditions to be extended to the manual board. These alarm conditions originate not only at the G.S.C. but also at repeater stations or other outstations and at minor exchanges. In such circumstances a telemetering system is to be used to extend the alarms from the G.S.C. to the A.M.C. (see Fig. 5).

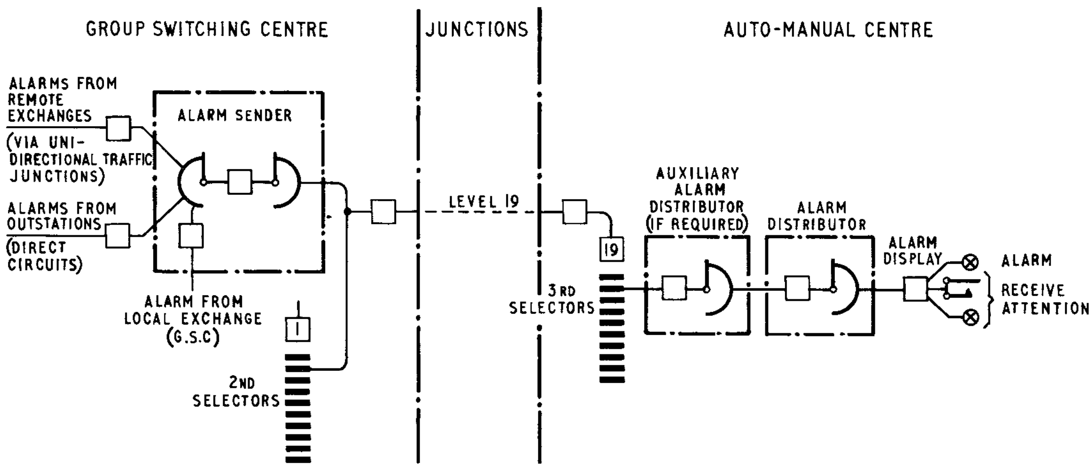


FIG. 5—SCHEME FOR EXTENSION OF ALARMS TO REMOTE AUTOMANUAL CENTRE

When a change of alarm conditions occurs the alarm-sender relay-set seizes a free level-19 junction relay-set. Predetermined digits are then sent to route the call to the distant alarm-distributor relay-set. After check signals have been exchanged the alarm-sender relay-set scans the incoming-alarm relay-sets, stepping the scanning uniselector in synchronism with pulses sent to line to step the distant alarm-distributor uniselector. Normal stepping is at 10 pulses/second, but an inter-train pause takes place on each outlet marked by an alarm condition. Each inter-train pause causes the alarm distributor to mark the corresponding alarm-display relay-set with an alarm condition. Any alarm-display relay-set passed over without an inter-train pause remains in, or is restored to, the alarm-clear condition. As all alarm relay-sets are scanned on each occasion, simultaneous alarms or clears present no problem. If, for any reason, e.g. busy conditions, the cycle of routing, checking and alarm signalling is not completed within a set period the whole cycle is recommenced.

Some A.M.C.s will have more than one dependent G.S.C. from which alarms are to be extended. To avoid the use of a separate selector level for each dependent G.S.C., auxiliary alarm-distributor relay-sets can be used to precede the alarm-distributor relay-sets; only one selector level is then required, and an additional digit is used to select the appropriate alarm-distributor relay-set.

CONCLUSIONS

The use of the techniques described in this article will allow greater freedom in the design of the telephone network by reducing the number of groups of junctions between G.S.C.s and A.M.C.s, and by extending the signalling range.

The type of G.S.C.–A.M.C. signalling outlined in this article is capable of reproduction in loop-disconnect, or Signalling System, D.C., No. 2, or Signalling System, A.C., No. 8 forms, and it will work in tandem with either d.c. or a.c. signalling junctions situated within a charging group.

References

[1]JACKSON, F. G. Subscriber Trunk Dialling for U.A.X. Subscribers. *P.O.E.E.J.*, Vol. 56, p. 21, Apr. 1963.

[2]WHERRY, A. B. Recent Developments in Automatic Telephone Exchange Trunking. *P.O.E.E.J.*, Vol. 54, p. 157, Oct. 1961.

[3]REDMAN, F. W. G., and DONN, G. S. An Automatic Meter-Observation Equipment. *P.O.E.E.J.*, Vol. 53, p. 124, July 1960.

Book Reviews

"Selected Papers on Semiconductor Microwave Electronics." Edited by Sumner N. Levine and Richard R. Kurzrok. Dover Publications Inc., New York. xi + 297 pp. 318 ill. 18s.

This is a collection of 26 papers, selected from journals published between 1958 and 1962, considered by the editors as representative of the development of semiconductor techniques and their application to microwave engineering. They have all appeared in either the *Physical Review*, *Bell System Technical Journal* or *Proceedings of the Institute of Radio Engineers*, and the book comprises pages made from photocopies of the original articles, now reduced to sheets of uniform size and bound between a paper-back type of cover. Some of the articles are already regarded as classics, if such a term can be used for a science hardly 10 years old; for example, Esaki's account of the tunnel diode principle, published in the *Physical Review* in January 1958. The book is divided under five separate headings: general survey, general theory of non-linear elements, device fabrication and characterization, parametric amplifiers and frequency multipliers, tunnel diodes.

This is a most useful collection of data for workers engaged on microwave developments. A copy of the book immediately available on the bookshelf would save time that might otherwise be wasted searching in the library for that elusive reference.

C.F.F.

"An Introduction to Electronics." B. V. Rollin, M.A., D.Phil. Clarendon Press: Oxford University Press. 13 + 216 pp. 185 ill. 30s.

It could be said that electronics is a science born of physics and reared by electrical engineers; it is practised by students of both disciplines. However, the attitude to electronics adopted by students of physics often seems very different from that adopted by electrical engineers, although the syllabii may have similar content in this particular subject. The physics teaching tends to be biased away from applications.

The author of this book is a lecturer in physics at Oxford. He has appreciated that many of his students are likely to become electrical engineers and has attempted to provide a link to help them to appreciate the practical applications of their basic theory. The coverage of the book is very wide and the standard of description is rather "patchy." The early chapters on linear-circuit theory, Thévenin's theorem and transmission-line theory lead naturally to the equations for transmission in waveguides, then to a useful account of transient phenomena in simple circuits. Three chapters on thermionic diodes and triodes, amplifiers, oscillators and mixers, and non-linear circuits follow. These seem rather elementary in treatment, but the author then launches into semiconductors with more thoroughness, explaining the basic principles and applications very clearly. This is the best part of the book. He follows with a good chapter on noise inherent in electrical circuits, negative feedback (which curiously he regards as something to be studied only on a second reading almost as if it were rather an advanced subject), then on to masers, microwaves, amplifiers and oscillators, and radiation, electromagnetic waves and aerials. The book concludes with some description of experiments to be done by students in support of their engineering reading. There is a good index, and each chapter concludes with a bibliography. A few examination questions are included for practice.

This is definitely a book for university students rather than practising engineers and could be useful in high-pressure examination revision. It is well printed and produced on excellent paper with good illustrations.

C.F.F.

"Teach Yourself Radio Servicing." L. Butterworth, A.M.Brit.I.R.E. The English Universities Press, Ltd. 254 pp. 226 ill. 10s. 6d.

This book is one of the "Teach Yourself" series and it is claimed by the author to follow a progressive course of instruction covering both the theoretical and practical aspects of radio servicing.

Each chapter does in fact maintain quite a nice balance between theory and practice, with very useful practical exercises listed at the end of each chapter. The book contains well over 200 illustrations with more than one diagram featuring in most of the figures. Some of the diagrams are not too clear and may confuse readers. The book only progresses as far as the servicing of broadcast receivers and this, plus the theoretical approach to the subject, will limit its appeal to the radio servicing engineer seeking a purely practical textbook on the subject. Costing only 10s. 6d. it should prove an attractive buy to a beginner, and it has been written in a manner which makes for easy reading.

P.N.P.

Field Trial of Repertory Diallers

G. R. LEGGETT†

U.D.C. 621.395.625.3:621.395.636.1

The introduction of subscriber trunk dialling and international subscriber dialling entails subscribers dialling many more numbers for themselves, and repertory diallers capable of storing a number of preselected addresses may become necessary for some subscribers. A repertory dialler being introduced as a field trial is described.

WITH the introduction of subscriber trunk dialling and international subscriber dialling, subscribers can and do dial many more telephone numbers for themselves. This trend must continue, and, as the number of digits to be dialled is increasing, there must be a human-factor threshold beyond which a subscriber needs assistance to recall from memory, refer to, or dial, a telephone address. To supplement the use of the dial and act as an *aide-mémoire*, devices capable of storing a number of preselected addresses will eventually be available on rental terms to subscribers.

Such a device, known as an Autodial,* was available to subscribers as early as 1934, but, as this repertory dialler could only store up to 50 7-digit addresses, its use nowadays would clearly be severely restricted, and hence it has become obsolete.

The limitations of the original design of Autodial were such that it was not suitable for development to meet modern needs. Various methods of storing information in such a device are possible, e.g. mechanical storage by pin-wheel or punched card, electrical storage by connexion patterns, and magnetic storage on tape or cores. The choice of storage principle to be used depends upon such factors as maximum storage needed, method of selection, and cost. Before embarking on the development of a repertory dialler for Post Office use, it was necessary to have some basic information upon the extent of the potential market and the desirable facilities. Accordingly, it was proposed that a limited user trial with an available proprietary machine should be conducted.

A review of repertory diallers immediately available in quantity early in 1964 showed that an American device known as the "Rapidial" met more of the Post Office requirements than any other device, and so some of these machines were purchased to test the possible market and subscribers' reactions to repertory diallers. The Rapidial was coded as a Sender No. 2, and a limited field trial with 50 machines was organized.

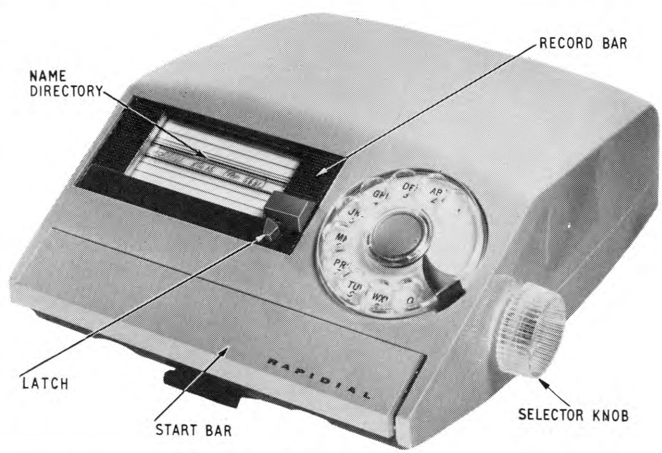
SENDER NO. 2

The Sender No. 2 is a magnetic-recording type of repertory dialler, and is used in conjunction with a normal telephone. Telephone numbers are recorded on magnetic tape in the form of voice-frequency pulses, the lengths of which are determined by the digits dialled on the special dial mounted on the sender. When a recorded address is to be transmitted the voice-frequency pulses on the tape are amplified and rectified, the d.c. pulses so produced operating a magnetic clutch. Loop-disconnect pulses are produced by cam-operated springs, the number of pulses produced depending upon the length of time the magnetic clutch is operated, which in turn depends upon the length of the voice-frequency pulse recorded on the tape. Cam-controlled off-normal springs, which operate before pulsing commences, are used to short-circuit the telephone instrument during pulsing.

The roll of magnetic tape is approximately 5 in. wide and is scanned transversely. Each track is approximately $\frac{1}{4}$ in. apart and can accommodate a 22-second recording, equivalent, for example, to 14 digits "7" (14×700 ms $= 9{\cdot}8$ seconds) $+$ 14 inter-digital pauses (14×850 ms $= 11{\cdot}9$ seconds). One track is used for each recorded telephone address.

A maximum of 290 telephone addresses may be recorded on the magnetic tape, which is positioned for recording or sending by rotating the selector knob on the right-hand side of the sender. Synchronized with the magnetic tape is a writing tape, which is divided into alphabetical sections to form a directory on which the recorded numbers and their associated names may be written in pencil.

The illustration shows the Sender No. 2, which has a beige-coloured plastic cover making the overall dimensions of the device approximately $9\frac{1}{2}$ in. wide $\times$ 12 in.



SENDER NO. 2

†Subscribers' Apparatus and Miscellaneous Services Branch, E.-in-C.'s Office.

*COLLETT, W. A. The Autodial. *P.O.E.E.J.*, Vol. 27, p. 161, Oct. 1934.

deep × 4½ in. high. The device is operated from an a.c. mains supply via a step-down transformer.

OPERATION OF SENDER NO. 2

The Sender No. 2 is operated entirely by the subscriber, as follows.

Recording a Number

The desired space on the alphabetical index is selected by turning the selector knob, and, after releasing the latch, the "record" bar is pushed down until it latches in the operated position. The dial on the sender, previously locked, is now free, and the appropriate digits can be dialled into the memory; normal inter-digital pauses are automatically inserted, the dial being locked until the memory is ready to receive the next digit. One long inter-digital pause may be inserted if required in an address, i.e. after an access digit. The number and/or name can be written on the exposed line of the name directory before restoring the record bar by releasing the latch.

To Make a Call

The selector knob is rotated until the desired number and/or name on the alphabetical index appears between the two black lines on the name-directory window. When dial tone is received on the associated telephone handset the start bar is momentarily depressed and the preselected address is automatically pulsed out as Strowger pulses.

To Change a Number

Recording a new address automatically erases any previous address stored in that particular position. If a new address is not required, then the action of operating and restoring the record bar erases any previously recorded address.

RESULTS OF FIELD TRIAL

As the field trial is still in progress it is premature to say what the final outcome will be. Furthermore, with such a small number of participants (50), the field trial is not necessarily completely representative of all telephone users.

The Sender No. 2 was the only repertory dialler available when the trial commenced, but since that time many new ideas have been conceived. Until the results of the present field trial have been analysed, however, and further investigation of other types of repertory diallers has been completed, no definite decisions can be made about the size and type of diallers required to meet every demand.

CONCLUSIONS

Repertory-dialling facilities provide a useful *aide-mémoire* for frequent users of the telephone, and it is possible that a market for such devices exists. More than one type of repertory dialler may be desirable, but the size and form of the dialler required can only be determined by further market research using field trials. To enable such investigations to be continued, the Post Office Engineering Department is developing various types of repertory dialler.

The Launch of the Communications Satellite HS-303 Early Bird

U.D.C. 621.396.946

On 6 April 1965 the communications satellite HS-303, "Early Bird", was launched from Cape Kennedy. The next two days were occupied in manœuvring the satellite into its correct orbital position* whilst telemetered information from the satellite was monitored at test stations.

It soon became clear that the orbit of the satellite would approach a truly stationary condition far more closely than at one time had been expected. Before the launch, it had been anticipated that the satellite would follow a near-circular orbit inclined by several degrees to the Equator so that it would appear, to observers on the Earth, to trace out a figure-of-eight pattern in the sky. Consequently, the earth stations on both sides of the Atlantic were fully prepared to steer their large aerials through a slow, but precisely controlled, repetitive track. In fact, however, by the third week in April the orbit of the satellite was inclined by only 0·13° to the equatorial plane, and the drift rate of the satellite relative to a fixed point on the Equator was 0·05° Eastward per day. As a result, it was possible to dispense with continuous aerial control, and at Goonhilly the aerial can be locked into one position for several hours at a time with just occasional movements of the aerial-feed position to trim the direction of the electrical axis.

During April a long series of technical tests was carried out to assess the multi-channel telephony and the television transmission capabilities of the satellite and the associated earth stations: Andover in the U.S.A., Pleumeur Bodou in France, Raisting in Germany, and Goonhilly in the United Kingdom. The results of these tests have not yet been fully processed, but the first indications are that HS-303 has met its target of providing a capacity of at least 200 telephone circuits. Its ability to carry television was ably demonstrated by the inaugural America–Europe program on 2 May.

The satellite tests as such were concluded by the beginning of the second week in May, and the satellite link was put through to the terrestrial spurs that connect the satellite system into the commercial telephony network of North America and Europe. The over-all line-up of the supergroups, groups, and circuits was completed and the satellite HS-303 was brought into service on 28 June 1965.

D.W.

*Taylor, F. J. D. The HS-303 Communications Satellite Project. *P.O.E.E.J.*, Vol. 57, p. 221, Jan. 1965.

Testing 625-Line Monochrome and Colour Television Transmission Systems

Part 1—Measurement of Distortion and Noise

R. K. R. TANNER†

U.D.C. 621.317.34: 621.397.74

This article, which will be published in two parts, describes the equipment and techniques that have been developed for testing 625-line monochrome and colour television transmission systems. Part 1 describes the methods employed for the measurement of distortion and noise, and Part 2 will deal with the apparatus used for picture monitoring.

INTRODUCTION

THIS article describes the equipment and techniques that have been developed, as an extension of previously described principles,[1,2] for the testing of 625-line monochrome and colour television transmission systems.[3] In general, test-console and trolley facilities developed for testing 405-line and 625-line television networks are similar; this article, therefore, concentrates on the individual items of 625-line test equipment being introduced, the new techniques employed, and the reasons for their choice.

Nature of the Colour Television Signal

The three principal colour television systems being considered for broadcasting in Europe are known as the N.T.S.C. system[4] modified for 625-line working, the SECAM system[5,6] and the PAL system;[7] these systems are similar insofar that they are fully compatible and give reverse compatibility, i.e. pictures transmitted in colour are capable of being reproduced in monochrome on a standard monochrome receiver, and pictures transmitted as conventional monochrome television signals may be reproduced in monochrome on a colour receiver. The compatibility is achieved by simultaneous transmission of the luminance (monochrome) picture information and chrominance (colour) information within a common video-frequency band. The differences between the systems are in the method of "coding" the chrominance information for this simultaneous transmission.

A simplified video waveform of one line of an N.T.S.C.-type signal, modified to the United Kingdom 625-line standards, is shown in Fig. 1; the "picture information" on the line shown in this example is that of a full-amptitude, 95 per cent saturated, gamma-corrected,* colour bar[8] (A colour-bar is a test signal used while checking or adjusting colour-television coding and decoding equipment).

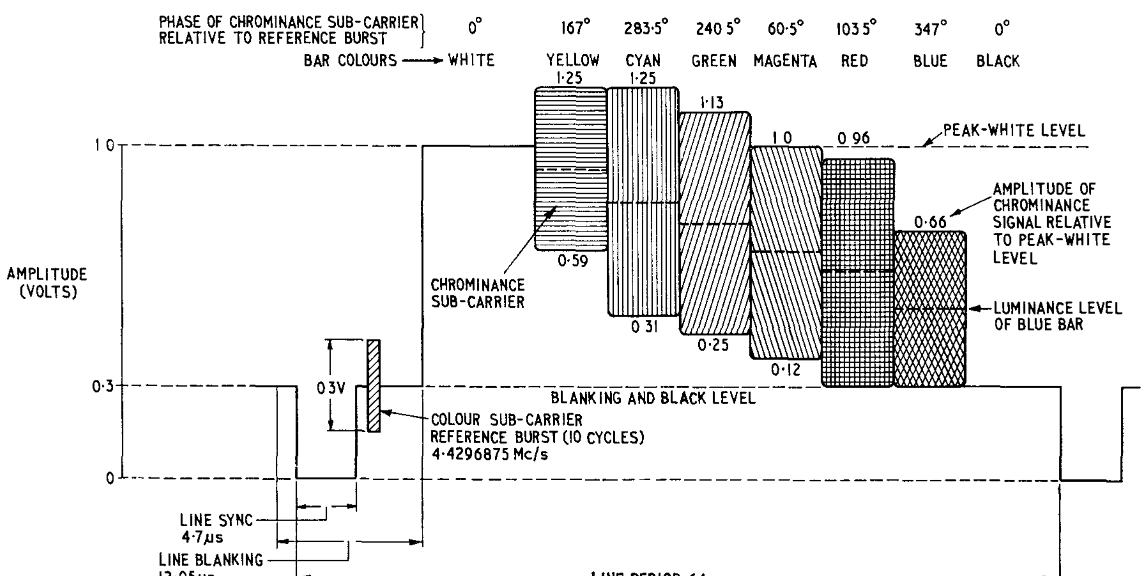


FIG.1—625-LINE COLOUR-BAR WAVEFORM (N.T.S.C. MODIFIED)

Frequency Bands to be Tested

For testing purposes, the luminance channel of a 625-line colour link, or a monochrome-only link, can be regarded as having a nominal video bandwidth of 5 Mc/s and the chrominance channel of a colour link as having a nominal bandwidth of 2 Mc/s centred on the colour sub-carrier frequency of about 4·43 Mc/s. The

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*Gamma correction: the constituent signal voltages (before coding) are raised to the power 1/2·2 to compensate for the non-linear voltage-input/light-output characteristic of the cathode-ray tube on which the "picture" will ultimately be displayed.

two channels can be considered separately where their transmission characteristics are independent, and in relation to one another where their transmission characteristics are interdependent.

The expression "nominal video bandwidth" used here concerning the luminance channel is defined as the minimum permissible cut-off frequency of an ideal low-pass filter that would be deemed to introduce zero waveform distortion if it were inserted in a video path of the system. In practice, normal television links will cut-off at a higher frequency than the nominal video bandwidth.

The nominal bandwidth of the chrominance channel is taken to be from 3·5 Mc/s to 5·5 Mc/s, in the analogous sense that an ideal band-pass filter having these cut-off frequencies would be deemed to introduce zero distortion.

Transmission Characteristics to be Tested

In addition to the general requirements such as insertion gain, terminating impedance, etc., colour-television transmission links require the following features to be specified and, consequently, tested.

(*i*) Luminance and chrominance channels considered separately: (*a*) linear waveform distortion, (*b*) non-linearity distortion in a luminance channel, and (*c*) noise.

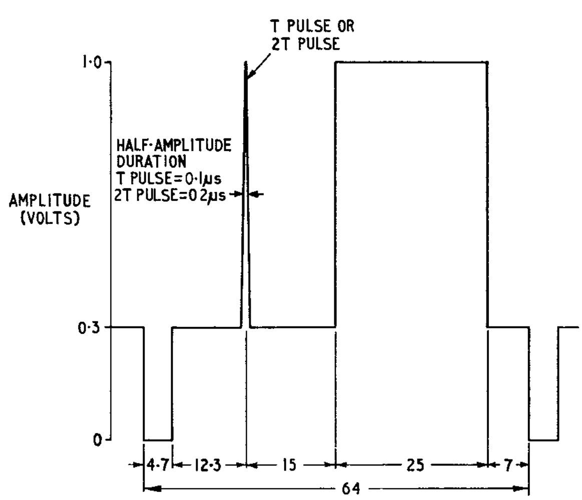
(*ii*) Luminance and chrominance channels considered together: (*a*) differential-gain and differential-phase distortion, (*b*) gain inequality, and (*c*) delay inequality.

Details of these characteristics and the equipment required to test them, relating to 625-line links, are given below. The techniques described for testing chrominance-channel performance have been developed for links and equipment designed for the transmission of N.T.S.C.-type signals.

LUMINANCE OR MONOCHROME CHANNEL

Linear Waveform Distortion in a Luminance (or Monochrome) Channel

The principles involved in this type of testing have been described elsewhere.[9] Waveforms for testing linear waveform distortion in 625-line television links have been recommended by the C.C.I.T.T.[10] and the C.C.I.R.,[11] and are known as Test Signal No. 1 and Test Signal No. 2, which are illustrated in Fig. 2 and 3,



All durations shown are microseconds

FIG. 2—625-LINE PULSE-AND-BAR WAVEFORM

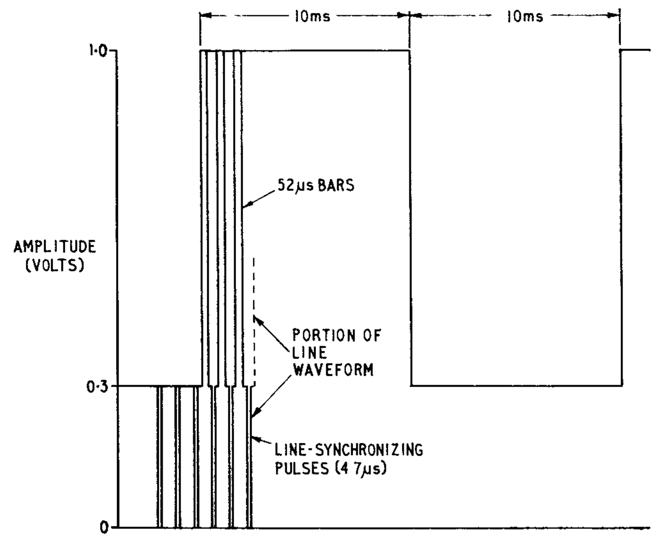


FIG. 3—50 c/s SQUARE WAVEFORM

respectively; waveforms very similar to Test Signal No. 2 are produced by Generators, Waveform, No. 4A and No. 6A. The earlier of these two generators was developed from the conventional 405-line pulse-and-bar generator by appropriately reducing the duration of the waveform component times; a modification was also incorporated to improve the stability of the height of both the pulse and the bar.

In addition to the pulse-and-bar waveform the Generator, Waveform, No. 6A also produces Test Signal No. 1. Further, it is interesting to note that since the impedance of the sine-squared shaping network has been increased to 150 ohms it has been made possible to feed the bar, synchronizing pulse and impulse waveform components into the network from valves drawing less current than that required to feed a 75-ohm network. This has allowed the same type of valve to be used in all stages in the generator, with the exception of the power-supply unit and one additional diode.

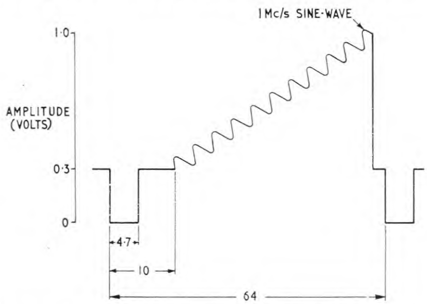
Two types of video oscilloscope are used at present in Post Office maintenance centres for displaying these waveforms. One is a precision television waveform-measuring instrument (No. 5A) that was originally designed for measuring 405-line test signals but is being modified for 625-line use. The other oscilloscope (No. 8A) is a smaller unit; it is a modified proprietary item which is used for general-purpose applications, including waveform measurements of a less precise nature.

Non-Linearity Distortion in a Luminance Channel

Non-linearity distortion in a luminance (or monochrome) channel may cause distortion of the picture signal or the synchronizing signals, or of both.

Picture-signal distortion may be subdivided into "field-time," "line-time" and "short-time" non-linearity distortion. It is the line-time variety that is usually most serious and is the only type for which a specification exists at present.

The principle involved in testing line-time non-linearity distortion of the picture signal is either to continuously sweep the voltage-output/voltage-input transfer characteristic of the system under test with a "search signal," or to test the characteristic at discrete points. The C.C.I.T.T. and C.C.I.R. recommend the former method, in which a sawtooth waveform is used to sweep the voltage-transfer characteristic. The sawtooth has superimposed on it a small-amplitude sine-wave with a frequency of $0{\cdot}2f_c$, where f_c is the nominal video bandwidth of the system, i.e. a 1 Mc/s sine-wave for a 5 Mc/s transmission system (Test Signal No. 3); the waveform of one "active line" of this signal is given in Fig. 4. At the output of the system under test

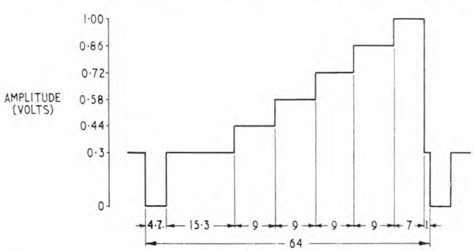


Notes:
1. The "picture signal" on the three following lines may be either full-line white bars or black level
2. All durations shown are microseconds

FIG. 4.—C.C.I.T.T. and C.C.I.R. TEST SIGNAL NO. 3

the sawtooth component is removed by a band-pass filter and the remaining sine-wave component is then displayed on a video oscilloscope, non-linearity distortion being indicated by variation in amplitude of the sine-wave signal.

The method used for testing the United Kingdom television networks is to check the transfer characteristic at discrete points using a "staircase" test signal with six horizontal treads and five equal-amplitude risers. Non-linearity distortion results in staircase risers of unequal amplitude being received at the output of the link under test. After each line of the staircase test signal the succeeding three lines in each 4-line cycle consist of synchronizing pulses with the intervening line-picture signal-period switched to either black level or white level. Thus the test waveform may be given an alternative high or low value d.c. component which will simulate the most extreme signals likely to be met in practice. The test is carried out with both these test waveforms, and the worst result obtained is taken as the picture-signal



Notes:
1. The "picture signal" on the three following lines may be either full-line white bars or black level
2. All durations shown are microseconds

FIG. 5—625-LINE 5-RISER STAIRCASE WAVEFORM

non-linearity distortion of the link under test. The staircase test signal is illustrated in Fig. 5.

To improve the ease and accuracy of measurement the received signal is passed through a differentiating and shaping filter (Filter, Frequency, No. 149A) which produces a pulse of approximately sine-squared shape and 2·0 μs half-amplitude duration for each riser of the staircase signal, the amplitude of each pulse being proportional to the amplitude of the riser producing it. This waveform can be examined on an oscilloscope display as a row of five pulses which differ in height by an amount proportional to the non-linearity distortion present. Fig. 6 shows an example of this type of display.

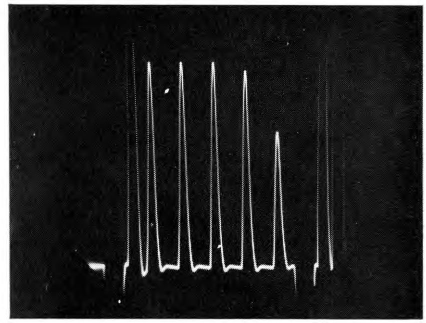


FIG. 6—NON-LINEARITY WAVEFORM INDICATED BY DIFFERENTIATED AND SHAPED 5-RISER STAIRCASE WAVEFORM

The distortion is calculated as a percentage, using the expression $100\,(1 - a/b)$, where a/b is the ratio of the amplitudes of the smallest pulse to the largest pulse.

To determine the amount of non-linearity distortion produced by a 625-line monochrome link, or the luminance channel in a colour-link, test equipment is interconnected as shown in Fig. 7.

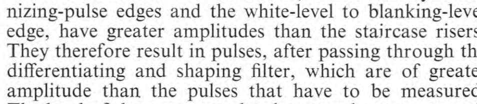


FIG. 7—INTERCONNEXION OF EQUIPMENT FOR NON-LINEARITY DISTORTION TEST

Transients in the test waveform, such as the synchronizing-pulse edges and the white-level to blanking-level edge, have greater amplitudes than the staircase risers. They therefore result in pulses, after passing through the differentiating and shaping filter, which are of greater amplitude than the pulses that have to be measured. The level of these unwanted pulses may be great enough to cause temporary overloading of the Y-amplifier in the oscilloscope; they are, therefore, reduced to safe proportions by a simple amplitude-limiting device (Limiter No. 1A). As shown in Fig. 8, the limiter consists basically of two similar diodes, MR1 and MR2. MR1 clips negative-going pulses, all of which are unwanted. The polarity of MR2 is such that it conducts when positive-going pulses are applied, the pulse level at

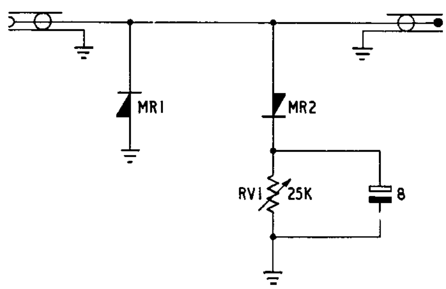


FIG. 8—CIRCUIT OF LIMITER NO. 1A

which it conducts being determined by the setting of potentiometer RV1; potentiometer RV1 is adjusted so that unwanted, high-level, positive-going pulses are clipped but the required pulses are unaffected. A video amplifier is included in the test circuit to make good the insertion loss of the preceding filter, thus ensuring that the oscilloscope is presented with pulses of adequate amplitude for measurements to be made with the required accuracy.

The staircase waveform rather than the sawtooth waveform is preferred in the United Kingdom for testing line-time non-linearity distortion of the picture signal for the following reasons.

(*i*) It enables precise results to be obtained in less time, particularly if it is desired to measure at several points in the black-to-white amplitude range.

(*ii*) It provides substantially greater discrimination against random noise.

(*iii*) A 4·43 Mc/s sine-wave of 0·14 volt peak-to-peak amplitude can be superimposed on the staircase to form a composite signal which serves both for the test described (because the sine-wave is effectively eliminated by the differentiating and shaping network), and for measurements of the differential-gain and differential-phase distortion of the colour sub-carrier in colour-television transmission links or apparatus as described later.

Non-linearity distortion of the synchronizing signal is measured by observing the amplitude of the synchronizing pulse on a video oscilloscope while the waveforms described above are applied to the system under test; it is expressed in terms of percentage departure of mid-point amplitude from the nominal amplitude.

Noise in a Luminance (or Monochrome) Channel

Because of marked differences in the subjective effect of noise on a television picture, according to the nature of the noise and the part of the video-frequency spectrum in which it occurs, noise is classified in various types as listed in Table 1.

To illustrate the technique used to measure random noise in a 625-line luminance or monochrome channel, test equipment is interconnected as shown in Fig. 9;

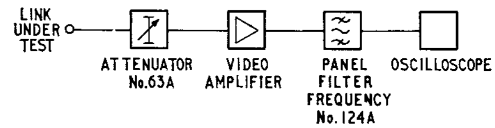


FIG. 9—INTERCONNEXION OF EQUIPMENT FOR 625-LINE NOISE MEASUREMENTS

the Panel, Filter, Frequency, No. 124A enables filters and a random-noise weighting network to be switched into circuit as required. A video oscilloscope, with adequate Y-amplifier bandwidth, is calibrated by means of a calibration waveform to display 0·7 volt (peak-to-peak) between two convenient horizontal lines on a graticule placed in front of the screen of the cathode-ray tube. The input of the transmission system to be tested is then correctly terminated and the output is connected to the test equipment. The display on the oscilloscope (with the line time-base inoperative) resulting from the system's noise is then adjusted by means of the variable attenuator until the peak-to-peak amplitude of the display is equal to the previously calibrated 0·7 volt display. The peak-to-peak noise level may then be calculated by deducting the attenuation remaining in the variable attenuator from the total video-amplifier gain in the test-equipment chain. A correction factor of 18 db to convert this peak-to-peak reading to r.m.s.

TABLE 1
Measurements of Signal-to-Noise Ratio

Type of Noise	Type of Link or Channel	Nominal Bandwidth Tested	Method of Expression
Periodic (hum)	Monochrome link or luminance channel of colour link	0 – 10 kc/s	The ratio, expressed in decibels, of the peak-to-peak amplitude of the picture signal to the peak-to-peak value of the interfering signal
Periodic (h.f.)	Monochrome link	1 kc/s–5·0 Mc/s	ditto
Periodic (h.f.)	Colour link	1 kc/s–5·5 Mc/s	ditto
Impulsive	Monochrome link	1 kc/s–5·0 Mc/s	ditto
Impulsive	Colour link	1 kc/s–5·5 Mc/s	ditto
Random (weighted)	Monochrome link or luminance channel of colour link	10 kc/s–5·0 Mc/s	The ratio, expressed in decibels, of the peak-to-peak amplitude of the picture signal to the r.m.s. value of the noise measured via the appropriate weighting network
Random (weighted)	Chrominance channel of colour link	3·4 Mc/s–5·4 Mc/s	ditto

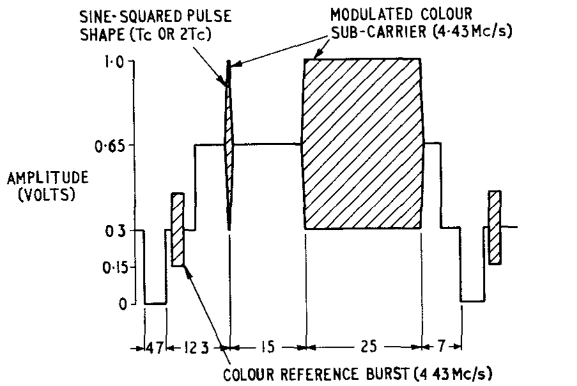
(as required in the case of random noise) may be added subsequently.

CHROMINANCE CHANNEL

Linear Waveform Distortion in a Chrominance Channel

Although the response to pulse-and-bar signals used for testing the luminance channel contains information about the performance of the chrominance channel, this information is not in a form which can readily be interpretated in terms of distortion of chrominance signals. The performance of the chrominance channel can more easily be obtained by using a pulse-and-bar-type signal with a waveform which is more closely related to a chrominance signal.

One test waveform proposed consists of a colour sub-carrier that is amplitude modulated (double-side-band) by a sine-squared pulse-and-bar waveform,[12] as illustrated in Fig. 10. The half-amplitude duration of



All durations shown are microseconds

FIG. 10—A WAVEFORM FOR MEASURING LINEAR DISTORTIONS WITHIN THE CHROMINANCE CHANNEL (625-LINE N.T.S.C.-TYPE SYSTEMS)

the sine-squared pulse may be either 0·5 or 1·0 μs, designated T_c and $2T_c$, respectively (T_c is the half-period of 1 Mc/s, which for testing purposes is regarded as the nominal bandwidth of one sideband of the chrominance signal). The modulated colour sub-carrier is raised on a 0·35-volt pedestal to ensure that the test-signal envelope does not go below black level. A transistor-operated 625-line colour pulse-and-bar generator (Generator, Waveform, No. 11A) has been developed to produce this test waveform in addition to the waveforms already mentioned for testing linear-waveform distortion in a luminance channel.

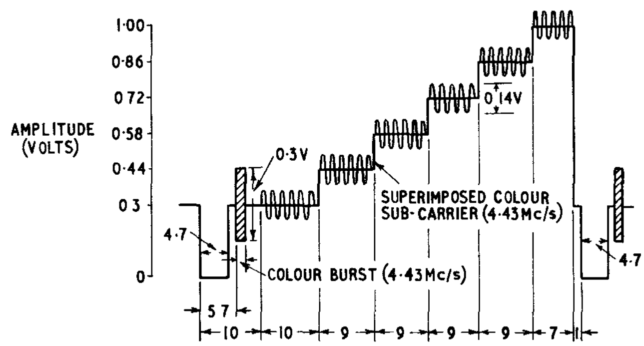
Non-Linearity Distortion in a Chrominance Channel

The most serious form of non-linearity which may occur in a chrominance channel is that which is dependent upon the amplitude of the signal in the luminance channel, and, therefore, may be regarded as a kind of intermodulation between the luminance and chrominance channels. This type of distortion is subdivided into two classes, termed differential-phase distortion and differential-gain distortion.

Differential-phase distortion is the change of phase of a sub-carrier signal, caused by a change in luminance-signal amplitude, relative to the phase at blanking level. Since the hue of the chrominance information in an N.T.S.C.-type colour-television signal is dependent upon the phase of the colour sub-carrier relative to the colour reference-burst (which is situated at blanking level), the subjective effect of differential-phase distortion is to change the hue of the picture as the amplitude of the luminance signal changes.

Differential-gain distortion is the change in amplitude of a sub-carrier signal caused by a change of luminance-signal amplitude. The subjective effect in this instance is to change the saturation of the colour information in the picture as the amplitude of the luminance signal changes.

The test signal used to examine both these effects is an adaptation of the 5-riser staircase waveform used for testing line-time non-linearity distortion in a luminance channel; the staircase has a 4·43 Mc/s sine-wave superimposed upon it as shown in Fig. 11.



Notes:
1. The "picture signal" on the three following lines may be either full-line white bars or black level
2. All durations shown are microseconds

FIG. 11—WAVEFORM FOR MEASURING DIFFERENTIAL GAIN AND DIFFERENTIAL PHASE DISTORTIONS (625-LINE)

Measurement of Differential-Phase Distortion. A typical differential-phase measuring-set has an internal 4·43 Mc/s oscillator which is kept locked in phase, by a conventional automatic phase-control (a.p.c.) loop circuit, to the mean phase of the colour sub-carrier frequency throughout the active line period of the test signal. The phase of the 4·43 Mc/s sine-wave on each of the steps of the test-signal is compared with the reference oscillator, and any difference is converted into d.c. by a phase detector. The output voltage from the phase detector is proportional to the difference in phase between the two colour sub-carrier signals applied to it. This output waveform is applied to an oscilloscope, the time-base of which is adjusted to be triggered once by each line of the test-signal, and the Y-amplifier gain is calibrated to indicate, say, 1 cm display per degree difference in phase between the two signals applied to the phase detector. The differential-phase distortion of the item under test may thus be determined by comparing the amplitude of that part of the display which represents the phase of the colour sub-carrier at blanking level with the parts that represent the phase of the colour sub-carrier on each of the staircase treads. The greatest difference in phase measured is regarded as the differential-phase distortion of the item under test.

Measurement of Differential-Gain Distortion. The test signal is applied to the input of the item under test and the output is connected to a differential-gain measuring-set which has a suitably adjusted and calibrated oscilloscope associated with it. The measuring-set rejects the luminance component of the test signal and rectifies the remaining colour sub-carrier frequency component, the amplitude of the d.c. being, therefore, proportional to the amplitude of the colour sub-carrier; the resulting waveform is then displayed on the associated oscilloscope. Thus, the differential-gain distortion of the link or equipment under test may be determined by measuring the amplitudes of the appropriate parts of the oscilloscope display. The greatest departure in amplitude from the amplitude of the signal at blanking level is taken as the differential-gain distortion of the item under test.

Effects of Noise on Differential-Phase and Differential-Gain Measurements. The two measurements described above necessarily allow noise, which may be present in the chrominance channel of the item under test, to pass through the test equipment and, hence, to be displayed on the oscilloscope as a random thickening of the trace. When measuring the distortion introduced by items of equipment that have low noise levels, or when making measurements in which a high degree of accuracy is not required, this is of no consequence. However, when approaching the full sensitivity of the measuring set, i.e. measuring differential-gain and differential-phase distortions in the region of 1·0 per cent and 1·0°, respectively, noise on a link which is within the recommended noise-performance limits thickens the oscilloscope trace to such an extent that accurate reading becomes difficult. By using sampling techniques it is possible to reduce the effective bandwidth of the measuring instrument, which will permit small amounts of distortion to be measured in the presence of random noise. Measuring sets using this method are under development.

Measurement of Noise in a Chrominance Channel

The signal-to-weighted-noise ratio for continuous random noise in a chrominance channel (Table 1) is measured through a combined chrominance band-pass filter and weighting network (Filter, Frequency, No. 162A), the response of which is given in Fig. 12. It will

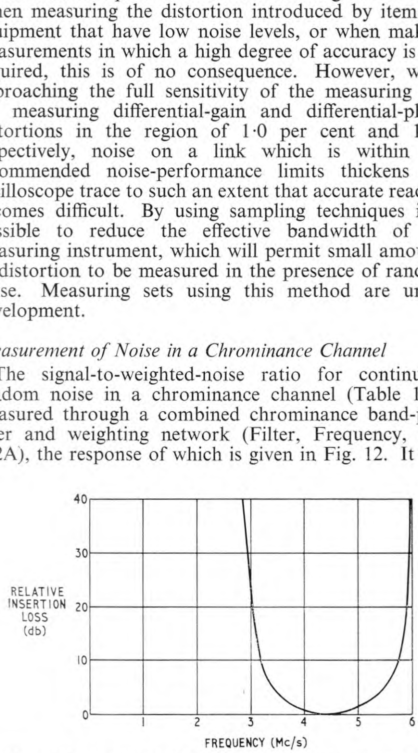


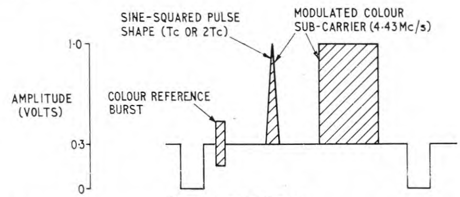
FIG. 12—ATTENUATION/FREQUENCY RESPONSE OF COMBINED BAND-PASS FILTER AND WEIGHTING NETWORK USED IN MEASURING SIGNAL-TO-RANDOM-NOISE RATIO IN A 625-LINE CHROMINANCE CHANNEL

be seen that the insertion loss increases on both sides of the logarithmic centre frequency (4·4 Mc/s), reaching about 4 db at the nominal cut-off frequencies (3·5 and 5·5 Mc/s). The network thus provides a noise weighting, on each sideband in the chrominance channel, which is approximately equivalent to that introduced in the 0–1 Mc/s band of the luminance (or monochrome) channel by the luminance-channel noise-weighting network (Network, Weighting, No. 4A).

LUMINANCE-CHROMINANCE GAIN INEQUALITY

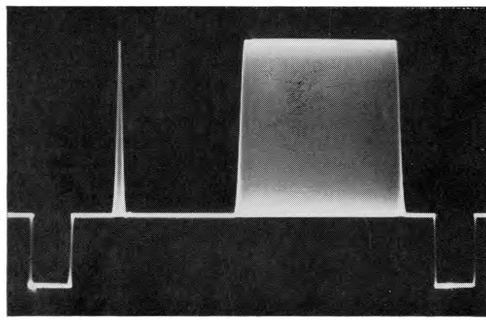
In colour television systems which employ amplitude modulation of the colour sub-carrier, the gain of the luminance channel must equal the gain of the chrominance channel to obtain faithful reproduction in saturation of the required colours.

One of the test signals being considered to detect gain inequality is illustrated in Fig. 13. A colour pulse-and-



Durations as for Fig. 10

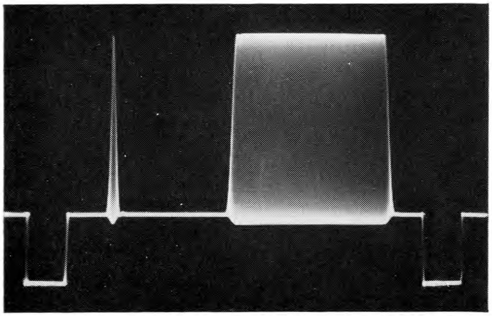
(*a*) A Waveform for Measuring Luminance-Chrominance Gain and Delay Inequalities



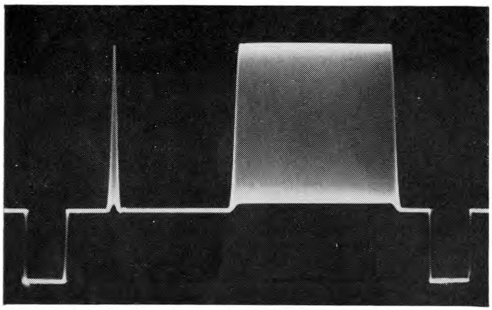
(*b*) Oscilloscope Display of a Waveform (without Reference Burst) for Measuring Luminance-Chrominance Gain and Delay Inequalities ($2T_c$)

FIG. 13—WAVEFORMS FOR MEASURING LUMINANCE-CHROMINANCE GAIN AND DELAY INEQUALITIES

bar generator produces this waveform by adding the waveform shown in Fig. 10 (less the 0·35-volt pedestal) to a pulse-and-bar signal (less synchronizing pulses) of 0·35-volt amptitude; the sine-squared pulse in both waveforms may be simultaneously switched to either T_c or $2T_c$. The component derived from the waveform shown in Fig. 10 may be regarded as the chrominance component of the composite test signal and the 0·35-volt pulse-and-bar as the luminance component. Thus, for example, if the mid-point of the bar is considered, the bottom of the chrominance component waveform at this time may be regarded as being raised from − 0·35 volts, relative to the blanking level, up to the actual blanking level. Therefore, inequality in the amptitude of the two components will be indicated by a difference in the level of the component waveforms at the point under consideration. Examples of an oscilloscope trace displaying this type of waveform, with luminance-chrominance gain inequality present, are given in Fig. 14 in which the amount of inequality shown is 10 per cent. It is expressed as the percentage departure of the amplitude of the modulated sub-carrier half-envelope from the amplitude of the modulating waveform.



(*a*) Gain of Chrominance Channel 10 per cent Higher than Gain of Luminance Channel



(*b*) Gain of Chrominance Channel 10 per cent Lower than Gain of Luminance Channel

FIG. 14—OSCILLOSCOPE DISPLAYS OF WAVEFORMS SHOWING INEQUALITY OF LUMINANCE GAIN AND CHROMINANCE GAIN

A convenient method of making the measurement is to introduce a calibrated amount of gain inequality, in the opposite sense, until the inequality is seen to be cancelled on the oscilloscope display, thus utilizing the advantages of a null-measurement technique.

LUMINANCE-CHROMINANCE DELAY INEQUALITY

In traversing a transmission system, delay incurred by the luminance component of the composite colour-television signal may differ from the delay incurred by the chrominance component. This results in the two signal components not arriving at their destination in time coincidence, and the subjective effect may be observed in the reproduced television picture as horizontal misregistration in which the magnitude of the picture impairment is proportional to the delay inequality.

To measure this distortion, any gain inequality present is first removed—typically by means of the type of network introduced to enable a null-measurement of gain inequality to be made—and the shape of the colour sub-carrier envelope of the waveform shown in Fig. 13 is then examined on a video oscilloscope. If no delay inequality is present the signal components will add linearly to give a straight line at blanking level (as in the generated waveform); this may be seen at the base of the bar component of the oscilloscope trace photograph

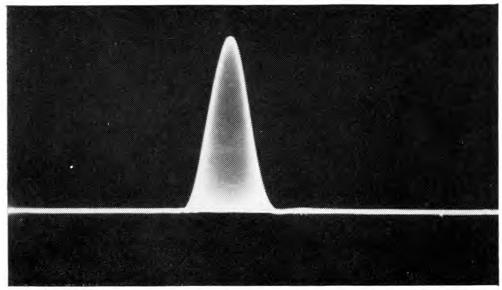
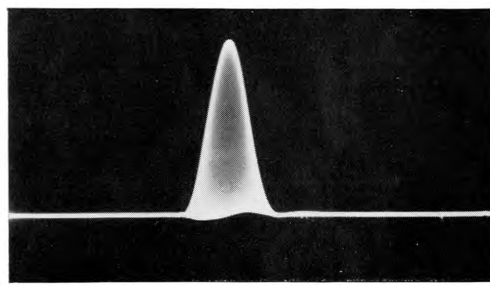


FIG. 15—ENLARGEMENT OF SINE-SQUARED PULSE OF WAVEFORM SHOWN IN FIG. 13(*b*)

shown in Fig. 13(*b*) and the enlargement of the sine-squared pulse component shown in Fig. 15. If, however, delay inequality exists, the addition of the waveform components will result in the bottom of the envelope no longer being straight, departures from straightness occurring underneath the transitions in the test signal. Provided that gain inequality is not present small amounts of delay inequality, say, up to 50 ns, will result in the shape of the envelope at blanking level adopting the shape of the time derivative of the original waveform, i.e. a sine-wave at blanking level for a sine-squared pulse in the test signal. An example of the type of oscilloscope display encountered is given in Fig. 16; the amount of



The luminance component is delayed by 30 ns relative to the chrominance component

FIG. 16—OSCILLOSCOPE DISPLAY OF LUMINANCE-CHROMINANCE DELAY INEQUALITY MEASUREMENT

delay inequality demonstrated in this instance is 30 ns.

It is possible to calculate the amount of delay inequality present from the amplitude of the disturbance at blanking level. However, a practical and more accurate method is to introduce a known amount of distortion, in the opposite sense, to nullify the effect of the delay inequality.

RANGE AND ACCURACY OF MEASUREMENTS

Provisional limits have been proposed for many of the distortions described, as they apply to the various categories of television links.[3] Since these limits determine the range and accuracy of measurements to be made, the figures for the longest and the shortest classes of links in the United Kingdom are given in Tables 2 and 3. Changes in these figures will no doubt be made from time to time as experience of the laws of addition

TABLE 2

Proposed Design Target Performance Limits for Two Classes of 625-Line Monochrome Links and Luminance and Chrominance Channels of Colour Links (Gain, Noise and Crosstalk)

Type of Link	Insertion Gain (db)	Gain Stability (db)		Random Noise (weighted) (db)		Periodic Noise (db)			Impulsive Noise (db)		Cross-talk (db)
		Short Term (1 sec)	Medium Term (1 hour)	Mono-chrome and Colour Links (10 kc/s–5 Mc/s)	Chrom-inance Channels	Mono-chrome and Colour Links (Hum)	Colour Links (1 kc/s–5·5 Mc/s)	Mono-chrome Links (1 kc/s–5 Mc/s)	Mono-chrome Links	Colour Links	
One Minor Local Link	0 ± 0·25	± 0·1	± 0·1	68	62	*	*	*	*	*	66
United Kingdom Reference Chain	0 ± 0·25	*	*	52	46	35	50	50	*	*	52

*Under Consideration

TABLE 3

Proposed Design Target Performance Limits for Two Classes of 625-Line Monochrome Links and Luminance and Crominance Channels of Colour Links (Distortions and Inequalities)

Type of Link	Linear Waveform Distortion (*k*-Rating as percentage)		Non-Linearity Distortion				Luminance-Chrominance Inequalities	
			Monochrome Links and Luminance Channels		Chrominance Channels			
	Mono-chrome Links and Luminance Channels	Chrom-inance Channels	Synchro-nizing Signal (per cent)	Picture Signal (per cent)	Differential Gain (per cent)	Differential Phase (degrees)	Gain (per cent)	Delay (ns)
One Minor Local Link	0·5	*	+ 1 to − 1	1	± 1	± 0·5	± 2	± 10
United Kingdom Reference Chain	4·0	*	+ 10 to − 20	12	± 8	± 4	± 10	± 100

*Under Consideration

is gained and as fresh experimental evidence of the impairments which may be tolerated becomes available.

Temporary links such as outside-broadcast cable circuits, are usually set-up on whatever spare line plant is available; consequently, each circuit is provided on a "best possible" basis, the target performance being that for a main link.

(*To be continued*)

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[10]C.C.I.T.T. Recommendation J 61, New Delhi, 1960.

[11]C.C.I.R. Recommendation 421, Geneva, 1963.

[12]Macdiarmid, I. F., and Phillips, B. A Pulse-and-Bar Waveform Generator for Testing Television Links. *Proceedings I.E.E.*, Paper No. 2687R, Sept. 1958 (Vol. 105, Part B, p. 440).

Notes and Comments

Birthday Honours

The Board of Editors offers congratulations to the following engineers honoured by Her Majesty the Queen in the Birthday Honours List:

Dundee Telephone Area	J. A. Lamb	Technical Officer	British Empire Medal
Engineering Department	L. L. Hall	Assistant Staff Engineer	Companion of the Imperial Service Order
Engineering Department	F. F. King	Technical Officer	British Empire Medal
London Telecommunications Region	C. F. Mullender	Technical Officer	British Empire Medal
Nottingham Telephone Area	T. A. Bish, E.R.D.	Executive Engineer	Member of the Most Excellent Order of the British Empire
Post Office Research Station	B. Ash	Executive Engineer	Member of the Most Excellent Order of the British Empire

Special Commendation

The Board notes with pleasure that the Postmaster General has personally commended Mr. J. R. Greenwood. Technician Class IIA, Lincoln Telephone Area, to whom the Royal Humane Society has awarded its Testimonial on Parchment for rescuing a three-year-old boy from the River Witham on 19 September 1964.

Obituary—Lt.-Col. J. Baines, O.B.E., T.D., B.Sc., A.M.I.E.E.

It seldom happens that a man becomes so wholly identified with one Region as Colonel Baines did with the North Eastern, or, for that matter, that so many people associate the Region with the man. The first arose from the fact that since he changed from traffic to engineering in 1926 his whole service was spent in that Region, apart from an initial period at Headquarters as an Assistant Engineer (old style). Between 1931 and his death in March 1965 he had been an Assistant Engineer (old style) in Bradford and the S.E.'s office, a Sectional Engineer and Area Engineer in Lincoln and Middlesbrough, a Regional Engineer, and, for the last 9 years, Chief Regional Engineer.

The second sprang from the fact that he was widely known to have strong views on many aspects of the job, views which he expressed forcibly and sometimes picturesquely and which have had a good deal of influence on the plant and policy of the Region, particularly on the external side.

"Joe," as he was widely referred to, was an unmistakable "tyke," with all the characteristics that the term conveys. Blunt, earthy, shrewd, sometimes scathing, he left no doubt as to who was boss and he was not easily persuaded to change his views, but his bonhomie and a robust sense of humour took much of the sting from verbal encounters. He was born, educated and lived most of his life in that real West Riding town, Halifax, and his character possibly owed something to that and to his lifelong hero, Wellington.

As a member of the Supplementary Reserve he saw early war service with the B.E.F. in France, and in 1942 formed 2 L of C Signals Regiment which, under his control, ran the beach-head cables in Normandy after D-day and worked their way through Europe into Germany. For his services he was awarded the O.B.E.

He has left a personal imprint on the communication network in the north east, and as an outstanding character he may become something of a legend. Certainly those who knew him will talk about him for a long time to come.

P.R.C.

W. J. Bray, M.Sc.(Eng.), A.C.G.I., D.I.C., M.I.E.E.

His many friends in the Post Office, and outside, at home and abroad, will be extremely pleased to learn of Mr. Bray's promotion to Deputy Director of Research, and those who know him well will feel that he is ideally suited to his new job.

Mr. Bray is a native of Portsmouth who started his career as an electrical-fitter apprentice in the Dockyard. There he distinguished himself early by getting his

Inter B.Sc.(Eng.), winning the Admiral Donaldson Prize as Top Apprentice of All Yards, and securing Royal and Kitchener Scholarships. He then spent 4 years at the City and Guilds Engineering College, where he graduated with 1st Class Honours and obtained his A.C.G.I., M.Sc.(Eng.), and D.I.C.

In 1934 he entered the Post Office Engineering Department as an Assistant Engineer (old style) and was posted to the Radio Experimental Laboratories at Dollis Hill. Until his recent promotion he has spent the whole of his "Post Office" life in extending the frontiers of radio communications. In the pre-war years he was concerned with various aspects of h.f. radio-telephony and telegraphy; in particular, he developed and designed the receivers and the transmitter-drive equipments that permitted the introduction of the single-sideband suppressed-carrier principle on our long-distance radio services. He also joined in designing the highly sophisticated M.U.S.A. receiving system which considerably improved radio communications across the North Atlantic—then, as now, our busiest overseas route. In 1942 he was promoted to Executive Engineer (old style).

After the war his attention was turned to higher and higher frequencies and he became an authority, in turn, on ionospheric-scatter, tropospheric-scatter and microwave radio-relay systems. In all these fields he made substantial contributions at the research level, publishing freely, and, where necessary, he carried his work forward with great success to the stage of development and exploitation.

In 1954 he was transferred to Headquarters to head a team concerned with planning and providing radio-relay systems for television and multi-channel telephony—work that was carried out under intense pressure because of the rapidity with which television was spreading over the country. At the same time the question of deciding upon the parameter values, or the essential characteristics, for radio-relay systems became a very important issue nationally and internationally. These were then in a very fluid state, and it was largely due to him that the C.C.I.R. and the United Kingdom adopted common values, thus permitting systems to be interconnected freely anywhere in the world outside North America. In this work Mr. Bray was awarded a Commonwealth Fund Fellowship for Advanced Studies and Travel in the U.S.A., where he spent nearly 12 months.

In 1959 he started to be concerned with the use of satellites for telecommunications, and in 1961 he was chosen to lead the newly formed Space Communication Systems Branch concerned exclusively with communication-satellite work. His earlier work on terrestrial radio-relay systems was of the greatest value, and he rapidly became an international authority in a field peopled by rocket and satellite designers rather than by people with a telecommunications background.

It is largely due to the soundness of his fundamental knowledge and his engineering judgment that the Post Office has participated in communication-satellite work with such marked success, not only at Goonhilly but, once again, in the C.C.I.R.

In 1963 he returned to the Research Branch at Dollis Hill to lead the team concerned with research in the communication-satellite field and in lasers.

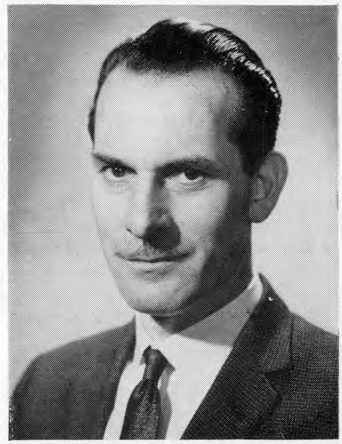
Mr. Bray is an engineer-scientist of quite outstanding qualities. He is able to apply himself with success to fundamental research of which his work, published and unpublished, on radio propagation is one example. At the same time he has green fingers in that the work he takes up and the team that he leads prosper and pay dividends. He has published and lectured widely, and has been awarded the Institution, the Fahie and Radio Section Premiums of the Institution of Electrical Engineers, of whose Council he is a Member. He is widely liked and sought after as a member of technical advisory committees, has an extraordinary capacity and zest for work, and yet finds time to enjoy himself. For recreation, travel is high on his list of priorities.

H.S.

S. C. Gordon, A.M.I.E.E.

Mr. S. C. Gordon was promoted Staff Engineer of the Microwaves and Space Communication Systems (RWD) Division of Research Branch on the 30 March 1965.

Entering the Department by Open Competition as a Probationary Inspector in 1937, he was posted to the newly-formed Wire Broadcasting Branch at Wembley



where he was engaged on the development of a multi-channel carrier broadcasting system for use over the local-line network. In 1939 he transferred to the Subscribers' Apparatus and Miscellaneous Services (S) Branch, and in the same year was seconded to the Royal Corps of Signals as a civilian radio instructor.

In 1940 he enlisted and was later commissioned in the Royal Corps of Signals. For most of his service career he was closely associated in developing techniques and in training staff for a wide range of radio and radar activities in the North African and European theatres of war; in 1947 he was appointed Staff Captain at the War Office.

On demobilization he rejoined S Branch, and in 1949 was promoted to Engineer, returning to the Local Lines Branch at Wembley to work on the development of equipment for an 8-channel carrier system for domestic rediffusion and later, on the design of equipment for a single-channel Civil Defence warning system. In 1954 he was promoted to Senior Executive Engineer and transferred to RS Division of Research Branch. Here he soon became the acknowledged expert in an original field of research and development work in which he was appointed Assistant Staff Engineer in 1960.

He transferred to RWD Division in 1962, and became involved immediately in satellite communications as one of the Controllers of Experiments at the Goonhilly earth station, working with TELSTAR and later with the RELAY type satellites; he also had the challenging task of analysing the results of the United Kingdom contribution to these experiments. During the past year he has played an active part in the design and development of equipment for use at Goonhilly in connexion with the first two-way multi-channel-telephony satellite Early Bird.

His many friends and colleagues in the Department will wish to congratulate "Ched" Gordon, in the knowledge that his friendly and helpful nature, combined with a remarkably wide technical appreciation and the flair for stimulating experimental ideas, will assure him of success in his present appointment.

R.D.G.

J. Knox, E.R.D., M.Sc., M.I.E.E.

John Knox, recently appointed Chief Regional Engineer in the North Eastern Region, was born on 31 March 1912 in Belfast, where he was educated at the Royal Academical Institution and Queen's University, graduating with 1st Class Honours in Electrical Engineering in 1933 and, in the following year, obtaining his M.Sc. for a thesis on "Power Factor Variations in Dielectrics."

Entering the Post Office in 1934 as an Assistant Traffic Superintendent and posted to Glasgow, he was

successful in the 1938 Open Competition for Probationary Assistant Engineer (Old Style) and was posted to the Scotland West Area.

During the war Mr. Knox served with Air Formation Signals in the Middle East, Italy, Greece and Malta, was twice mentioned in Despatches, and finished his service as Lieutenant-Colonel.

After a period on maintenance in the Scotland West Area he was appointed to Dundee as Area Engineer and inherited responsibility for the unique Peel Connor automatic exchange, originally installed in 1924 but now the subject of an exhibit in the Royal Scottish Museum in Edinburgh. But a greater preoccupation was his very successful achievement in the provision of service with a minimum expenditure on underground plant during one of our recurring periods of capital shortage. The consistently excellent control statistics exhibited by Dundee while Mr. Knox was Area Engineer led to the Area being one of those selected for special examination in an endeavour to determine why Areas of apparently similar characteristics should differ so widely in the size of the labour force employed. Although no single explanation was found, except perhaps that the similarities were more apparent than real, there seemed no escaping the conclusion that the control exercised in Dundee was real and effective. And the inquiry further quickened Mr. Knox's interest in the techniques of measuring performance.

From Dundee Mr. Knox went as Regional Engineer to the North Western Region where Manchester's insatiable demand for underground plant may have led him to wonder how he managed to get any money at all for underground development at Dundee.

The process of learning that there are at least two sides to any question was continued when, in 1961, he went to Belfast as Regional Engineer and Telecommunications Controller and found that, instead of having to deal with shortage of plant, he had to tackle a shortage of work for the labour force employed—a situation in which his good sense made possible an harmonious co-operation on the Whitley Committee. His eager concern for the achievement of low cost led him to push the introduction of gas pressurization of cables. Impatience with procedural impediments to productivity and his insistence on provision of service to new subscribers with minimum delay earned for him the name of "48-hour Knox."

Mr. Knox has served on I.E.E. Committees in Dundee, Manchester and Belfast, and was Chairman of the North Scotland Sub Centre during 1955–6.

It has been suggested that his ability to establish cordial relationships between the traffic and engineering staffs stems from the fact that he has served on both sides, but may more probably be due to the fact that he accords to the views of other people the respect attracted by his own. But there is no doubt that the variety of his experience will be of inestimable value to Mr. Knox in enabling him to pick up the threads of his new responsibilities without loss of time. Whatever may be the tasks awaiting him, he will apply a logical mind with pertinacity. The sudden death of his predecessor, Lt.-Col. Baines, was a grievous loss of an outstanding figure in the engineering field. It is not likely to be long before the North Eastern Region finds that the reins have been taken up by the firm, capable hands of a man who knows where he is driving.

We hope that Mr. Knox will soon find congenial venues for indulgence of his taste for sailing, golf, ice-skating, swimming and woodwork, and that his wife and son will find their experience of Leeds as agreeable and invigorating as most people do who are posted there.

R.J.H.

S. J. Edwards, M.I.E.E.

Mr. S. J. Edwards, who has been appointed Deputy Regional Director, South Western Region, entered the service in 1931 as a Probationary Inspector, having completed an apprenticeship at H.M. Dockyard, Portsmouth. After a period out-stationed at Bideford he joined the Superintending Engineer's Office in Bristol and was engaged on local-line planning until 1936 when he became Probationary Assistant Engineer (old style).

He then joined the Bristol Telephone Area in charge of maintenance, where he remained throughout the war, being concerned with the maintenance of many defence installations and also with the repair of heavy blitz damage.

He returned to the South Western Regional Headquarters in 1946 as Efficiency Engineer, a duty which also included running the Regional Engineering Training School. Always interested in sporting and social activities he played an active part in the Bristol Area Sports Association, serving as Secretary and Chairman. He was appointed Telephone Manager, Cambridge, in 1954 and became Telephone Manager, Brighton, in 1960. During this latter period he undertook Instructor's duties at the Post Office Management Training Centre.

His friendly disposition ensured a welcome return to an engineering role when he was appointed Chief Regional Engineer, London Telecommunications Region (L.T.R.), in 1962. In the L.T.R. he has specialized in the selection of staff, maintenance problems, line provision, efficiency and engineering training, and he tackled with zest such problems as improving the quality of service to the subscribers in the L.T.R., improving the productivity of the engineering labour force, and the training of engineering staff of all grades. He was instrumental in the establishment of the L.T.R. Management Conferences, which are attended by engineering, telecommunications and sales personnel. Always a keen member of the I.P.O.E.E., he was an able Chairman of the London Centre for the 1964–65 session. His many friends bid him farewell from the engineering field and wish him every success in his new appointment.

A.J.T.

Retirement of Mr. G. S. Berkeley, M.I.E.E.

Gordon Berkeley retired on the 8 March 1965 after serving in the Post Office for over 40 years subsequent to an apprenticeship in H.M. Dockyard, Chatham. Entering as an Open Competition Inspector, he spent 12 months in the Testing Branch and then transferred to the Telephone Development and Maintenance Branch of the Engineer-in-Chief's Office. He became Assistant Engineer (old-style) in 1928 by competitive examination, and for 7 years thereafter dealt with all aspects of trunking and grading as affecting automatic exchanges of whatever

type. Arising from this interest, there appeared in 1936 his well-known book on "Traffic and Trunking Principles in Automatic Telephony," which to this day is a recognized text book on the subject. In the same year he was promoted Senior Executive Engineer in the Telephone Branch and handled circuit problems involved in the development of 2,000-type director, non-director and U.A.X. circuits, and, later, of new systems, dialling limits and v.f. systems.

In 1941 he was transferred to the London Telecommunications Region (L.T.R.), where he gave valuable assistance in the restoration of emergency circuits after air attack. From 1942–45 he was in charge of internal maintenance in the City Telephone Area, and from 1945–51 was Regional Engineer on internal maintenance. In the latter post, he was largely concerned with the improvement of the standard of service given by the automatic exchanges in London which had suffered considerably as a result of enemy action.

He became Deputy Chief Regional Engineer responsible for staff and service in December 1951, and was promoted to C.R.E. in December 1954 in charge of the planning and works side of the now divided Engineering Branch of the L.T.R. During the 10 years he has occupied this post he has played a leading part in the development of the telephone system in London. This covered a period of very considerable expansion in spite of certain "stop-go" measures in the earlier years.

"Boss" Berkeley, as he became widely known, devoted a considerable amount of attention to the problem of providing enough line plant in the Region to meet the rising demand both for subscribers' lines and for junctions. This was a comparatively new field to him, and it must give him much satisfaction to know that at the time he retired there were relatively few customers waiting for either lines or equipment in the L.T.R.

Mr. Berkeley leaves the service with the good wishes of his many friends and acquaintances in the L.T.R., the Engineering Department, and elsewhere. A very large gathering at Camelford House on the 8 March 1965 gave tangible expression to the very high regard in which he is held by everyone knowing him.

S.J.E.

F. F. Roberts, B.Sc.(Eng.), A.M.I.E.E.

Mr. F. F. Roberts, who has been promoted to Senior Principal Scientific Officer, joined the Post Office in 1937 as a Probationary Inspector and completed

a sandwich course at the Northampton Engineering College for his B.Sc.(Eng.) degree the following year. He was appointed to the Radio Branch and soon showed his research ability in studies of pulse modulation and in the design of pulse-echo test gear. He became an Assistant Engineer (old style) in 1942 and continued with radio work until, on becoming a Senior Scientific Officer, he moved to Research Branch; there he worked on ferrites and demonstrated the Faraday effect at microwave frequencies, a discovery quickly seized upon by American scientists to father a range of microwave components. When, in 1951, there came realization of the potential of the transistor in telecommunications, Mr. Roberts was drafted into the Electronics Division of the Research Branch to study the physics and technology involved, being given a Group to do this in 1953 on his promotion to Principal Scientific Officer. He tackled his assignment with enthusiasm, finding his way through the jungle of devices, technologies and secondary effects, the work culminating in a thorough examination of the planar technique, of the reliability of units made by it, and of economic methods of assessing whether the reliability met the requirements of submerged-repeater schemes. His expert knowledge of transistor reliability is widely recognized, and he has co-ordinated much activity sponsored by the Government in this field. More recently, he has begun studies of possible new conduction processes in insulators.

Mr. Roberts is no narrow specialist, however, for he retains many interests in telecommunications applications. Seemingly reserved on first acquaintance, and essentially modest, he is very much at home amongst experts. His colleagues know very well that he can prepare both a closely-knit statement of any subject engaging his attention and a plan of action. With integrated circuits, new interactions in solids, and other developments threatening to revolutionize electronics, the Research Branch will have much need of his very considerable experience of research and development in solid-state physics and technology.

J.R.T.

J. I. Carasso, B.Sc.

Mr. Carasso, who joined the Post Office in 1949 as a Senior Scientific Officer, has been promoted to Senior Principal Scientific Officer in Research Branch (Materials Division) where he succeeds Dr. J. R. Tillman, recently appointed Deputy Director of Research.

He was born in Greece but spent his early life in Milan,

coming here in 1939 at the age of seventeen. His university studies at Leicester were interrupted by war service in a Royal Hellenic Navy corvette engaged in convoy escort duties. He saw active service in the North Atlantic and in the Middle East as well as during the

Normandy landings. After the war he completed his studies and graduated with honours in chemistry.

On coming to Dollis Hill he became involved in the study of the chemical problems associated with the production and behaviour of semiconductor devices based first on germanium and later on silicon. Here, his ready grasp of the physics of semiconductors soon made him the chemist to whom our physicists turned with their chemical problems—they are ready to testify to both his willingness and ability to help. As physicists invariably demand precise rather than qualitative information he attempted to put the chemistry of silicon and germanium on a sound quantitative basis. His efforts resulted in a number of original publications as well as a review, which established him as a world authority in this field and led to invitations to lecture both here and in the U.S.A.

His other main interests centre on the surface chemistry of semiconductors (he is the United Kingdom editor of *Surface Science*), which in view of the growing importance of thin-film devices and thin-film integrated circuits makes him a valuable asset to the Research Station. He is an expert linguist who exercises himself by translating Russian scientific books of interest to him into impeccable English, and cheerfully responds to calls for escorting foreign visitors round the Research Station.

He is an active research leader of a group of younger chemists and physicists in whom he inspires enthusiasm of high order, giving freely of his time for their guidance and education, often subordinating his interests to theirs, but at all time insisting on the application of rational scientific principles, rather than the *ad hoc* approach in research. Filling Dr. Tillman's place will not be easy; we wish Mr. Carasso luck.

M.M.F.

Board of Editors

The Council of the Institution has appointed Mr. J. H. H. Merriman, O.B.E., to be Chairman of the Board of Editors in place of Mr. D. A. Barron, C.B.E., who recently was appointed Engineer-in-Chief and is, thereby, President of the Institution.

Reprints of Articles from the Special S.T.D. Issue of the Journal (Vol. 51, Part 4, Jan. 1959).

It is regretted that copies of the reprint of selected articles from the special subscriber trunk dialling issue of the Journal (Vol. 51, Part 4, Jan. 1959) are no longer available.

Correction

It is regretted that an error occurred in the article entitled "Reed Relays in the Small Electronic Exchange Systems at Leamington and Peterborough" (Vol. 58, p. 52, Apr. 1965). The reed relay attributed to the General Electric Company (G.E.C.), and illustrated in Fig. 1 of the article, was manufactured by G.E.C. from information supplied by the developers and patentees, Associated Electrical Industries, Ltd.

Books Received

"Worked Examples in Electronics and Telecommunications: Vol. 1, Problems in Electronics; Vol. 2, Problems in Electronic Theory and Communications." B. Holdsworth, B.Sc.(Eng.), A.M.I.E.E., and Z. E. Jaworski, Dipl. Ing., D.I.C., A.M.I.E.E. Iliffe Books, Ltd. Vol. 1: 14 + 209 pp. 121 ill. 25s. Vol. 2: 14 + 134 pp. 71 ill. 22s. 6d.

These books are the first two in a series of four which, when completed, will specifically cover the needs of students preparing for the B.Sc. final examinations in electronics and electrical engineering and for the Graduate Examination of the Institution of Electrical Engineers. The problems were collected by the authors during years of work at Kwame Nkrumah University of Science and Technology, and have been graded and selected so as to cover the syllabus of Part II Electronics, a portion of Part II Electrical Theory and Measurement, and a portion of Part III of Electronics and Telecommunications. In the main, Part II problems have been collected in Volumes 1 and 2.

As explained by the authors in the book's preface, their aim was to use actual examination problems from the past few years, and only in exceptional circumstances, where it was felt that there was a gap in presenting the required material, have some original problems been added. They hope that this type of approach will give the student a feeling of reality in tackling the type of problems which will actually be met in an examination. In preparing the answers the authors have concentrated on general solutions, first giving as clearly as possible the basic principles and leaving the numerical part till the end, and they hope that students will adopt this line of approach in their own solutions, although it is not expected that answers should be produced exactly as they are given in the books.

"Probability and Information Theory with Applications to Radar" (Second Edition). P. M. Woodward, M.A. Pergamon Press, Ltd. x + 136 pp. 24 ill. 35s.

This book, now in its second edition, is Volume 3 in the International Series of Monographs on Electronics and Instrumentation, introduced by the Pergamon Press to provide specialists with a means for early publication of accounts of new work. Whenever practical the monographs have been kept short in length to enable those interested to find in a concentrated form the essentials necessary for their work; this particular volume has been described by the author as "an extended research paper."

Of the eight chapters in this book the first four cover "An Introduction to Probability Theory," "Waveform Analysis and Noise," "Information Theory" and "The Statistical Problem of Reception"; they are, therefore, of general interest to communications and electronics engineers. They summarize in an elementary way the simple classical theory of probability distributions, leading up to characteristic functions, entropy and the Gaussian law, and then give a mathematical description of waveforms, including noise, and a concise but comprehensive account of Shannon's information theory, which is a development of probability theory as applied to communication problems. The remaining four chapters refer specifically to the application to radar systems of the preceding theoretical treatment.

Institution of Post Office Electrical Engineers

Retired Members

The following members, who retired during 1964, have retained their membership of the Institution under Rule 11 (*a*):

S. Rudeforth, Far Rosedale, Castle Rise, South Cave, Brough, East Yorkshire.
L. R. Hargrave, 176 Cranbrook Road, Redland, Bristol 6.
F. A. Copley, 6 Fairfield Green, Whitley Bay, Northumberland.
C. Bradley, 1 Malpas Drive, West Timperley, Altrincham, Cheshire.
E. C. Benstead, 29 Bay Crescent, Swanage, Dorset.
J. C. H. Todd, 1 Woodhill Drive, Prestwick, Manchester.
L. F. Salter, 35 Rodenhurst Road, Clapham Park, London, S.W.4.
H. F. Epps, 29 Glendale Avenue, Edgware, Middlesex.
L. G. Dunford, 22 Reynards Road, Welwyn, Herts.
R. S. Phillips, 115 Upper Selsdon Road, Sanderstead, Surrey.
H. J. W. Millar, 5 Almond Avenue, Leamington Spa, Warwickshire.
R. J. Halsey, Cable & Wireless, Ltd., Mercury House, Theobalds Road, London, W.C.1.
R. J. Hines, 27 York Road, Edinburgh 5, Scotland.

Institution Field Medal Awards, 1963–64 Session

In addition to the Institution Senior and Junior silver and bronze medals, up to three bronze medals, the Field Medals, are awarded annually for the best papers read at meetings of the Institution on field subjects primarily of Regional interest.

Field Medals were awarded to the following authors for papers read during the 1963–64 session:

T. A. Barker, Leeds (North Eastern Region). "A Practical Method of Improving the Quality of Service Given by Large Telephone Exchanges."

L. B. Handley, Midland West (Midland Region), and B. J. Woollett, Bristol (South Western Region). "The Local Line Network in Sweden."

P. Barton and E. O. M. Grimshaw, Middlesbrough (North Eastern Region). "Valves and Transistors."

The Council of the Institution is indebted to Mr. J. W. Freebody, Chairman of the Papers Selection Committee of Council, for the following précis of the medal-winning papers:

"*A Practical Method of Improving the Quality of Service given by Large Telephone Exchanges*" (*T. A. Barker*)

The quality of service being provided by the Post Office telephone system has, in recent months, been the subject of much adverse comment in the Press. Whilst some of the statements are exaggerated, there is, at the same time, room for disquiet at the service results as shown in official statistics. Comparisons have been drawn which suggest that the service given by many overseas administrations is of higher quality at lower cost.

With this introductory comment the author proceeds to examine the adequacy of centralized service observations (C.S.O.) as an index of the quality of service given to subscribers, and concludes that they paint too optimistic a picture of the true state of affairs. Various figures are quoted to show how service has deteriorated since 1950, and indicate a need for a substantial effort by maintenance engineers, designers and managers to improve the standard—especially as S.T.D. highlights the difficulties.

Various factors which have played a part in the deterioration are touched upon, such as the doubling of the system since 1945, the introduction of multi-metering followed by the group-charging concept in 1958, the introduction of S.T.D., insertion of local-call-timing relay-sets, etc.—with all the consequent extensions, rearrangements and modifications of equipment and cabling these entailed. However, the author concludes that more fundamental factors than these are the main cause of call failures and argues that unreliability of the 2,000-type selector, particularly the older types, and of mechanical pulse-regenerators are substantial causes of poor service.

A description of typical causes of failures is given, and suggestions are made of action which can be taken to effect improvements rapidly. He stresses the dominant role of the large central exchanges in the overall quality of service, and describes the equipment and results of a concerted drive made at Basinghall Exchange (Leeds) to reduce plant failures. The original part of this exchange is 18 years old and includes a large number of the older-model 2,000-type switch. The equipped multiple is 17,700 lines with 13,300 working connexions. Including connexions at satellites, local-numbering-scheme connexions total 52,000. Prior to the special drive, the average C.S.O. figures were 3·3 per cent for Basinghall Exchange and 3 per cent for the Leeds linked-numbering scheme. Corresponding figures for the 12 months ending December 63 were 1·3 and 1·5 per cent.

The author is critical of the value of existing routiner tests, which fail to disclose some serious causes of call failure. He advocates the need for a simple functional test carried out fairly frequently, and a suitable rapid functional tester has been designed and developed locally for this purpose.

The author stresses the importance of the human element in the quality of service given and the need for the first-line supervisor to be an "auto-man."

"*The Local Line Network in Sweden*" (*L. B. Handley and B. J. Woollett*)

This paper is based on the studies made by the authors during their visit to Sweden in June 1963 in connexion with an interchange of engineering staff.

Although the authors have refrained from making any critical comments or comparisons with British Post Office practice, the facts given enable some interesting and stimulating comparisons to be made by the reader. The paper is of particular interest as Sweden rates second in the world in terms of telephones per head of population, and in Stockholm, for example, where most of the visit was spent, there are 641 telephone connexions per 1,000 inhabitants.

The paper includes a brief account of the organization of the Swedish Telecommunications Administration, its relations with Government, and the general arrangements for financing the provision, maintenance and operation of the service.

Special mention is made of the different position in Sweden of minor staff, particularly construction personnel. Minor staff are neither Civil Servants nor considered as permanent staff. For this reason, there is little centralized training, skills being taught in the field by foremen trained as "field teachers." Payment of field staff is made on the basis of results, i.e. a particular piece of work qualifies for a certain remuneration and the fast worker can earn much more than a slow one. Furthermore, workers are only paid for effective time, and travelling to and from work, for instance, is carried out in the workmen's own time. The piece-work system also tends to reduce the size of working parties, because the fewer the men employed on a certain task, the greater for each is the share of the payment for the work involved. Official transport is kept to a minimum, and tool losses are small because the worker realizes that without tools his earning power is much reduced.

There is little doubt that, arising from these arrangements, productivity is very much higher than in the United Kingdom. The authors, however, noted that safety precautions could only be described as adequate. The authors make no comment in their paper on the subject of the quality of the work performed.

A clear description is given of local-line network arrangements together with details of planning, works and installation processes. It is only possible in this note to mention a few practical matters which, because they differ from British practices, may be of general interest.

Generally, concrete ducts are employed over the main sections of the local-line networks, although small plastic piping is used from pillars to subscribers' premises. Where cable is laid direct in the ground, it is normal practice to lay the cable on a base-board and to cover it with an inverted "U" troughing.

In manholes the position of cable brackets is fully adjustable, enabling correct positioning of cables and joints to be effected. Furthermore, the routings of cables through each manhole and joint-box, and the positioning of cable joints within such structures, are fully planned in detail and documented on individual diagrams.

Interconnexions at cabinets are effected by jumpering, and the authors comment that there are no facilities for pinning as in the United Kingdom.

"*Valves and Transistors*" (*P. Barton and E. O. M. Grimshaw*)

The authors have set out to provide the stepping stones from familiar valve theory to the less-familiar transistor theory to help the reader to appreciate why the transistor has, or has not, replaced the valve for some purposes. Two important aspects of conduction are described: the existence of positive as well as negative current carriers and, secondly, the relative speed of these in different media.

From the electrical equivalent circuits of valves, their behaviour for small signals is derived, and this is followed by a clear description of those effects which limit the ability of the space-charge valve to amplify.

The behaviour of the semiconductor junction diode, transistors and the transistor amplifier are described. Equivalent electrical circuits, and the effects of inter-electrode capacitance, transit time and noise, are briefly discussed and give a good idea of the factors that need to be taken into account in using these devices. The importance from a practical point of view of unifying the power supplies to assemblies of transistors is also brought out in the paper.

The paper achieves its object of helping the reader whose experience has been mainly in the field of valves to get the valve and transistor into perspective. The authors wisely avoid attempting to bring us right up to date in the very rapidly changing technology of transistor fabrication, and stick to the basic ideas underlying the operation of semiconductor devices. With this background, readers should have little difficulty in appreciating how the limitations of performance described in the paper are being eroded away by new techniques on fabrication and the use of new geometries of semiconductor devices.

The paper is extremely well illustrated with diagrams.

Result of Essay Competition, 1964–65

Joint first prizes of £6 6s. each and Institution Certificates have been awarded to the following two competitors:

S. D. Ayers, Technical Officer, Plymouth. "From Tom-Tom to Telstar."

L. H. Mockridge, Technical Officer, Bournemouth. "A Youth and Varley's Disciple."

Prizes of £3 3s. each and Institution Certificates have been awarded to the following three competitors:

K. L. Garraway, Technical Officer, Maidenhead. "Amateur Satellite Communication."

G. D. Cumming, Technical Officer, Belfast. "Protection of Post Office Plant from Electrical Power Systems."

P. J. Froude, Technical Officer, London Postal Region. "An Introduction to Atmospheric Pollution."

Institution Certificates of Merit have been awarded to:

A. G. Hickson, Technical Officer, Northampton. "The First of Many."

A. L. Deighton, Technical Officer, Grimsby. "Summary of Broadcasting."

R. Brewer, Technical Officer, Newark-on-Trent. "Armed with a Test Lamp."

P. J. R. Evans, Technical Officer, Ramsgate. "Dear Boss."

K. J. Burfitt, Technical Officer, Cardiff. "Problems Encountered in Maintaining the Grade of Service."

The Council of the Institution records its appreciation to Messrs. R. O. Boocock, D. G. Jones and T. J. Rees, who kindly undertook to adjudicate upon the essays entered for the competition.

N.B.—Particulars for the next competition, entry for which closes 15 *January* 1966, *will be published later.*

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.

2804 *Matter and Energy.* J. H. MacLachlan, K.G. McNeill and J. M. Bell (Brit. 1964).
A survey of some of the foundations of modern physics.

2805 *The Core of Mathematics.* A. J. Moakes (Brit. 1964).
A short introduction to "modern" mathematics for those who desire something more than to develop power of manipulation and problem solving.

2806 *Engineering Science for Technicians.* S. C. Devereux (Brit. 1964).
For students taking the Mechanical Engineering Technicians' Course, and covers the first two years.

2807 *The Elements of Pulse Techniques.* O. H. Davie (Brit. 1964).
Emphasizes the underlying principles.

2808 *Early Electrical Communication.* E. A. Marland (Brit. 1964).
Recalls some of the early work by intellectual giants and the humbler investigators of the nineteenth century. Little mathematical knowledge is assumed.

2809 *General Engineering Mathematics.* W. R. Lawson (Brit. 1964).
Covers the two-year (G) course, in mathematics.

2810 *Irascible Genius.* M. Moseley (Brit. 1964).
A life of Charles Babbage, inventor.

2811 *Telecommunications Vol. 1.* J. Brown and E. D. V. Glazier (Brit. 1964).
A good knowledge of a.c. circuit theory is assumed, but only an elementary knowledge of electromagnetic wave propagation and electronic circuits is needed. The book covers the whole of the fundamental principles, and should meet the needs of University and Technical College students reading for a first Degree or a Diploma in Technology, so far as basic principles are concerned.

2812 *An Introduction to Cybernetics.* W. R. Ashby (Brit. 1964).
No knowledge of mathematics, beyond elementary algebra is required.

2813 *Principles of Telegraphy.* N. W. Biswas (Indian 1964).
The book emphasizes principles rather than individual practices, and includes worked-out problems.

W. D. FLORENCE,
Librarian.

Regional Notes

Home Counties Region

ERECTION OF AERIAL CABLE ON BUCKET ROPEWAY

The erection of self-supporting, combined aerial cable under somewhat unusual conditions was recently completed in the Tunbridge Wells Area.

It was necessary to link up two gypsum mines 4 miles apart, and, for various reasons, the route of the aerial ropeway used to carry the mineral was used. The pylons had been designed to carry various signalling wires required for the operation of the system and a spare position was available to which Post Office attachments could be made. The route contained 85 pylons, varying in height from 10–80 ft with spans of 40–140 yd. Buckets were spaced at 40 yd intervals and apart from short breaks for change of shift, etc., they remained in continuous use throughout. Our problems were mainly concerned, therefore, with safety and the difficulties of the terrain.

A safety code, incorporating Post Office and mine safety regulations, was drawn up so that work on the ropeway could continue without stopping the normal flow of the buckets. A gang of six men, augmented by a tractor, trailer and a Land Rover, was employed and an inspector was present throughout the work. The cable was erected and tensioned in 1,000 yd sections.

The terrain through which the ropeway passes is undulating woodland, and in places the ropeway crosses deep valleys containing water-courses flowing to neighbouring reservoirs. Two problems were the swampy ground and gaining access to the ropeway. Although the work started in ideal weather conditions, rain followed by snow reduced the area to a deep quagmire which was so bad that vehicles were useless and the final 2,000 yd of cable was manhandled through the snow. The photograph shows the cabling in progress.

G.E.O. and C.A.

MANHANDLING CABLE BEFORE ERECTION ON THE BUCKET ROPEWAY

Associate Section Notes

Aberdeen Centre

Our December 1964 meeting consisted of a visit to the local commercial television studios of Grampian TV, Ltd. Two evenings were originally booked but, due to the large response from members, another two evenings had to be arranged. The parties were conducted round the studios, production control, master control and tele-cine departments, but the background activities such as sales, public relations, news room and accounts department were also explained.

The opening meeting of 1965 was a lecture by Mr. W. T. Duerdoth, Research Branch, Dollis Hill, entitled "Electronic Exchanges." Mr. Duerdoth introduced his lecture by a brief mention of existing types of exchanges (Strowger and crossbar), and their disadvantages compared to the electronic exchanges. Some of the advantages of the electronic exchange mentioned were freedom from noise, lower power consumption, and faster setting-up of calls. Mr. Duerdoth also mentioned the additional facilities an electronic exchange could provide. The lecturer then went on to explain the general principles of a space division (reed relay) type of electronic exchange. Time division multiplex (t.d.m.) types of electronic exchange will perhaps be the exchange of the future. Mr. Duerdoth explained the principles of Highgate Wood exchange and the common control of a t.d.m. exchange. He then described a t.d.m. transmission system and the economies resulting from an integrated t.d.m. switching and transmission network. The 47 members and guests present enjoyed an excellent lecture.

On 4 February many of our members missed what was perhaps the most interesting visit we have had for many years. The Department of Scientific and Industrial Research at Torry, Aberdeen, deals with many aspects of research regarding caught fish as opposed to a study of fish in their natural environment. The party were conducted round the physics, engineering and freezing departments of the station and were intrigued by the experiments that were demonstrated. One very fascinating item the party was shown was an electrical test to establish the freshness of a fish in which the fish under test formed the dielectric of a capacitor.

Hobbies was the theme of our February meeting, the subject for the evening being "Tapespondence" by Mr. A. Christie (Thurso). This meeting was perhaps unique in that the talk was previously recorded by Mr. Christie and then relayed from Aberdeen on our broadcast line to Thurso and Wick. Mr. Christie gave a brief account of Tapespondence and the various clubs which one can join. He also described some of his experiences, and gave helpful tips on the initial contact with a fellow Tapesponder. Later Mr. Christie introduced some excerpts from his personal tapes which he had received from his club contacts in England, Australia, Rhodesia, South Africa, America and Holland.

On 18 March Mr. I. Hogg, Aberdeen, gave an extremely interesting talk entitled "Recent Changes in Exchange Equipment." Mr. Hogg, aided by diagrams, compared features of the pre-S.T.D. exchange with the S.T.D. exchange and explained the circuit differences. Non-director main and discriminating satellite exchanges were dealt with in regard to local-call timing, subscriber's private meter control equipment, coin and fee checking relay-sets and call-charging equipment. After the talk, Mr. Hogg dealt very ably with several questions and a lively discussion followed.

D.W. and G.D.A.

Inverness Centre

The Centre continued its 1964–65 program with a paper read by Mr. W. T. Duerdoth, Research Branch, Dollis Hill. The paper, entitled "Principles of Electronic Switching," was excellently presented and, judging by the volume of questions afterwards, very well received.

On 25 February Mr. A. Campbell of the Senior Section gave a talk on "Collecting Antiques." His treatment of this rather unusual subject was very enjoyable, and members were able to inspect antiques on display. This was followed by a talk on "Pressurization of Cables" given by Mr. J. MacDonald, and afterwards Mr. L. Nuttall demonstrated the latest fault-finding devices. A visit was paid to Invergordon distillery on 26 March, this being the final item of the program apart from the annual general meeting.

W.C.

Colchester Centre

At the start of the 1964–65 session Mr. Radcliffe, who was Chairman, moved to Bournemouth. As the present Area Engineer, Mr. P. E. Buck, was already committed to the Ipswich Local Centre, the committee asked Mr. D. W. Pyle, Executive Engineer, to act, which he agreed to do and was subsequently unanimously elected.

In October Mr. A. J. Russell's promotion resulted in the election of Mr. M. H. Martin as vice-chairman, and in January Mr. J. R. Clare's promotion created a vacancy of Treasurer which was taken by Mr. J. Huke. This necessitated an addition to the committee and Mr. V. Tucker was nominated and elected. The summer program, which was longer than usual, was satisfactorily completed, and the winter session commenced with Mr. C. Purvis' talk on "Satellite Communications" which was a great success. This was followed in November by a talk on "Roses" by a member of the firm of Cants, of Colchester, and a very interesting talk by a local Technical Officer, Mr. R. N. Heathfield, about a boat trip along the Norwegian coast into the Arctic Circle.

The new year started with the paper by Mr. R. A. M. Light and Mr. H. P. Brooks on "Cable Pressurization." A representative of the Consumer Advisory Council talked about the *Which* magazine in February, and Mr. W. A. Paul gave his paper entitled "Illustrating Lectures and Technical Articles," in March.

The program was complicated by the difficulty in obtaining suitable premises but was very well supported by the membership; sometimes the accommodation we did have was strained to capacity. With the opening of the new Telephone Manager's office the use of the canteen will mean that future meetings will be held in comfortable and more spacious surroundings.

The membership has increased steadily throughout the year to a very satisfactory total of 219.

T.T.S.

Barnstaple Centre

The winter program for the Barnstaple centre was as follows:

"The Training of Youths," by Mr. E. H. Piper.

"Modern Maintenance," by Mr. T. F. A. Urben, Telephone Exchange Standards and Maintenance Branch, Engineering Department.

"Illustrating Lectures and Technical Articles," by Mr. W. A. J. Paul, Research Branch, Dollis Hill.

"Subscribers' Telephone Instruments," by Mr. T. C. Harding, Subscribers' Apparatus and Miscellaneous Apparatus Branch, Engineering Department.

Attendances are improving and it is hoped to have a summer visit to a place of interest.

F.D.C.

Exeter Centre

The fourth meeting of the 1964–65 winter session was held on 4 February when Mr. C. A. May, of the Organization and Efficiency—Maintenance and Computers Branch, Engineering Department, gave a paper on "The Use of PERT for Planning and Control." The paper was illustrated with a film on the construction of a garage. The lecture was most interesting and was well received by members and visitors.

The following visits, three of which have now taken place, were arranged for the summer program.

8 May: Camborne School of Metalliferous Mining.

9 June: South-Western Gas Board, Exeter Basin Works.

3 July: Plymouth Water Board, water treatment works at Crownhill, Plymouth, Lopwell Dam and Rumphouse, and Burrator Reservoir.

11 August: Central Electricity Generating Board's power station, Newton Abbot.

4 September: B.B.C. transmitting station, Princetown, and studios at Plymouth.

30 September: Norman Lockyer Observatory at Sidmouth.

T.F.K.

Tunbridge Wells Centre

The autumn session of the Tunbridge Wells Centre has been a busy and rewarding one. Four papers have been presented, all by local members.

The first, on "Unusual Machines," ranged from the hovercraft, complete with working model, to nuclear reactors.

The following three papers each concerned a different aspect of the new Tunbridge Wells zone centre and between them covered the building: from power, subscribers and trunk units to the transmission systems in the repeater stations.

The final paper was presented to a joint meeting of Hastings and Tunbridge Wells centres and was followed by a complete tour of the building which proved of great interest to the many members present, some of whom were seeing it for the first time.

Our secretary, Mr. D. Vidler, left us during the session on promotion and our congratulations and best wishes for success go out to him. The chairman, Brian Ray, very ably combined both jobs to bring this session to its successful conclusion.

R.W.W.

Edinburgh Centre

At our January meeting Mr. J. C. Hay, Development Group, Edinburgh Area, gave his medal-winning lecture to members of the section. Mr. Hay had already read his paper to many senior sections of the I.P.O.E.E. throughout the country and had been awarded the Institution's Field Medal for outstanding papers. The subject, "Road Works," was a most interesting topic, and an excellent collection of colour slides added much to the evening's entertainment.

During February a party of our members visited Woodcroft trunk non-director exchange, Edinburgh. Among the many interesting features shown to us were the trunk tandem, group switching centre, repeater station, manual board, trunk test and power plant.

In March Mr. D. M. Plenderleith, Edinburgh Area, showed a program of films at the Regional Training School, Muirhouse, Edinburgh.

The program was as follows:

(*i*) "A Sound of Living," one of the latest films produced for the G.P.O.

(*ii*) "The Heart of Scotland," made for the Films of Scotland Committee, the focal point of the film being Stirlingshire.

(*iii*) "Crin Blanc," an award winning film by Albert Lamorisse.

A most pleasant evening's film show was greatly appreciated by the audience.

J.M.D.

Bournemouth Centre

Bournemouth Associate Section Centre were guests at a meeting arranged by Mullard's on 18 March when a most informative evening with refreshments was provided. The program included two films, "Electromagnetic Waves" and "Direct Vision." The film show was followed by a talk about circuit modules and microminiaturization.

R.A.W.

Plymouth Centre

About 40 members and guests attended our first meeting of the new year when Mr. S. G. Young, of the Radio Planning and Provision Branch, Engineering Department, presented his paper on the "New Post Office Radio Tower." This paper, of general interest, gave an overall picture of the necessity for such a tower, the trend toward more microwave links for a multiplicity of uses, and the way in which our existing trunk network is complemented by this comparative newcomer. Our speaker's witty and able presentation of this paper was much appreciated.

In February, Mr. A. H. C. Knox, Chief Regional Engineer, Home Counties Region, presented his paper on "Appraisement and Promotion." Again a well-attended meeting was given a straight from the shoulder chat by Mr. Knox on this very controversial subject. Time, however, terminated the meeting with numerous questions outstanding. This is one subject for which an early start to the meeting is a necessity.

The Marine Biological Laboratories and Aquarium were visited in March. Here Sir Frederick Russell, the Director, and his colleagues presented two films made by the unit on the activities of the establishment. This was followed by a short talk from Dr. T. I. Shaw who gave us an insight into one line of research at present being pursued which had a particular bearing on our own field. This concerned the neurological responses of nerves found in sea creatures to the transmission of signals. Dr. Shaw indicated that the nervous systems response was analogous to the section of a transmission line. He indicated that the speed of transmission was considerably slower than that of our communications and that speeds in the region of 100 ft/second were the usual. We were then shown around the various departments in the building. This was a fascinating evening, thoroughly enjoyed by all.

We completed our program for 1964–65 with an invitation from Mullard's to a meeting at which films on the electromagnetic spectrum and the new panoramic cathode-ray tube were shown. This was followed by a discussion on current trends and microminiaturization.

D.H.S.

Reading Centre

The 1964–65 summer session of the Reading Centre opened in May with a visit to Sterling Cables at Aldermaston, followed by a visit to Mullard's Mitcham factory in June. Tate & Lyle's sugar refinery at Plaistow was visited in July; Kodak's works at Harrow in August; and the series concluded with a visit to the Guinness Park Royal brewery in September.

Although our membership has increased to 240, the good attendances of our 1963–64 winter-session meetings were not maintained this session in spite of the fact that three of the talks were by our own members.

In October we were given a talk by a member, Mr. R. Woolton, on "Transmission," and in November Mr. Whittingham of Top Rank gave us a talk on the wired television system his company have recently installed in Reading.

December's talk on "Telex" was given by another member, Mr. M. Litten, and included a visit to the Telex switching centre. In January we were given a talk and film show by Mr. R. Thompson of the Automobile Association on the work of that organization.

In February another of our members, Mr. P. Bennett, gave us a talk, illustrated with slides, on "P.A.B.X.s," with particular reference to the P.A.B.X. No. 1. We concluded our series of talks with one in March on the work of the Road Research Laboratory, given by Col. Godfrey of the Laboratory and illustrated by three films.

The annual general meeting was held at the end of April and was followed by a film show.

The committee would like to take this opportunity of thanking Mr. R. Merry, lately promoted Assistant Executive Engineer, for his untiring efforts on behalf of the Centre since its inception.

R.L.C.

Centre Training School

The year 1964–65 was fairly successful for this Centre but support by our own members was noticeably poor. Our visits included Joules Brewery, Meaford Power Station, Hem Heath Colliery, and Cadburys (Bournville). Our lectures were "Elsie," by W. Piercy and M. Daniels, "Long Submarine Cables," by Dr. Bray, and "The Skeleton in the Cupboard," by Mr. A. F. G. Allan, Main Lines and Development Branch, Engineering Department.

Film shows proved to be more successful in obtaining the students' support, these being mainly non-technical.

At the annual general meeting, held 13 April, the following were elected; *Honorary Chairman:* Mr. T. K. Bellew (Deputy Principal, C.T.S.); *Vice-Chairman:* Mr. G. S. Milne; *Treasurer:* Mr. A. Hughes; *Secretary:* Mr. W. Paterson; *Committee:* Messrs. K. Brunning, G. Beaty, B. J. Hart, D. Nicholson and A. Taylor.

The program for the 1965–66 session will include the following visits: Cunard liner, *Carinthia*, and the Mersey Tunnel; Royal Ordnance Factory, Swynnerton; Lever Brothers, Ltd. (Port Sunlight); Rolls-Royce, Ltd. (Crewe).

Our lecture program includes, "Stereophonic Reproduction" (Mullard, Ltd.); "Colour Photography" (Kodak, Ltd.); "Modern Trends in Subscribers' Apparatus" (Mr. T. C. Harding, Subscribers' Apparatus and Miscellaneous Services Branch, Engineering Department); "Telecommunication Life in Malaysia" (Mr. D. T. Everett).

Any members visiting the school as students are asked to watch the notice boards, or contact the Secretary for news and details of visits, lectures and film shows. Your support will be appreciated.

W.P.

Stoke-on-Trent

In the 1964–65 session our President, Mr. H. Todkill, left to become Telephone Manager of the West Midlands Area. We also lost two more members of the Committee on promotion to A.E.E., Mr. C. Bell and Mr. R. Wilson. The Committee are grateful to these officers for their active interest in the work of the Centre, and offer them best wishes in their new spheres of work.

In his report at the annual general meeting, held on 13 April, the Chairman, Mr. J. A. Hart, announced a large increase in membership since the last a.g.m., 90 new members having been accepted.

The following lectures were given by members of the Engineering Department: "Progress in Space Communications" by Mr. W. J. Bray; "On the Accident Front" by Mr. F. G. Balcombe, External Plant and Protection Branch: "Signalling Systems for Dialling Over Transoceanic Telephone Cables" by Mr. S. Welch, Telephone Exchange Systems Development Branch; "The Skeleton in the Cupboard—How Sound is our Approach to Cable Maintenance" by Mr. A. F. G. Allan, Main Lines Development and Maintenance Branch; "Exchange Equipment Installations—Do We Get Value for Money?" by Mr. D. R. B. Ellis, Exchange Equipment and Accommodation Branch; "The Conveyor System at Crewe H.P.O." by Mr. P. E. Maddox and Mr. W. E. Williams (Stoke Telephone Area).

The following officers were elected to serve for the 1965–66 session: *Chairman:* Mr. J. A. Hart; *Vice-Chairman:* Mr. A. E. Fisher; *Secretary:* Mr. S. P. Hancock; *Assistant Secretary:* Mr. C. Bennion; *Treasurer:* Mr. E. A. Hudson; *Librarian:* Mr. E. J. Foden; *Committee:* Messrs. C. Winfield, W. D. Paterson, A. Gee, W. Roberts, and C. Rhead.

S.P.H.

Staff Changes

Promotions

Name	Region, etc.	Date
Staff Engineer to Deputy Director of Research		
Bray, W. J.	E.-in-C.O.	22.3.65
Chief Regional Engineer to Deputy Regional Director		
Edwards, S. J.	L.T. Reg. to S.W. Reg.	9.4.65
Regional Engineer and Telecommunications Controller to Chief Regional Engineer		
Knox, J.	N.I. to N.E. Reg.	3.5.65
Assistant Staff Engineer to Staff Engineer		
Gordon, S. C.	E.-in-C.O.	30.3.65
Senior Executive Engineer to Assistant Staff Engineer		
Walker, R. R.	E.-in-C.O.	11.1.65
Banham, H.	E.-in-C.O.	5.1.65
Rogers, M. J.	E.-in-C.O.	22.2.65
Haley, G.	E.-in-C.O.	15.12.64
Allery, G. D.	E.-in-C.O.	17.3.65
Cobbe, D. W. R.	E.-in-C.O.	17.3.65
Executive Engineer to Area Engineer		
Martin, H. R.	Mid. Reg.	5.1.65
Shaw, S.	H.C. Reg.	19.2.65
Executive Engineer to Efficiency Engineer		
Downing, S. A.	H.C. Reg.	1.2.65
Executive Engineer to Senior Executive Engineer		
Stevens, J. A.	L.T. Reg. to E.-in-C.O.	17.11.64
Hills, G. W. P.	L.T. Reg. to E.-in-C.O.	5.1.65
Woollett, B. J.	S.W. Reg. to E.-in-C.O.	18.1.65
Ready, W. E.	E.-in-C.O.	25.1.65
Shinn, E.	E.-in-C.O. to L.T. Reg.	29.3.65
Executive Engineer (Open Competition)		
Sayers, J. R.	E.-in-C.O.	8.3.65
Assistant Executive Engineer to Executive Engineer		
Lawson, R. N.	H.C. Reg. to E.-in-C.O.	4.1.65
Berry, N. J.	S.W. Reg. to E.-in-C.O.	1.1.65
Hayton, C. E.	H.C. Reg.	21.12.64
West, W. R.	H.C. Reg.	21.12.64
Grant, L. E.	S.W. Reg. to H.C. Reg.	18.1.65
Hambling, J. B.	H.C. Reg.	21.12.64
Knight, B. S.	Mid. Reg.	21.12.64
Brown, J.	Scot. to E.-in-C.O.	22.1.65
Tacchi, J. R.	H.C. Reg.	22.1.65
Machent, H.	E.-in-C.O.	2.2.65
Grandison, D. O.	E.-in-C.O.	2.2.65
Gill, G. E.	E.-in-C.O.	2.2.65
Lawrence, T.	H.C. Reg.	22.1.65
Roe, C. W.	H.C. Reg.	22.1.65
Clarke, W. A.	H.C. Reg. to L.P. Reg.	15.2.65
Warner, S. A.	L.T. Reg.	9.2.65
Thompson, J. A.	E.-in-C.O.	1.3.65
Wood, S.	Scot.	5.2.65
Wallis, F. J.	Scot.	5.2.65
Pollock, D. R.	E.-in-C.O.	31.3.65
Inspector to Assistant Executive Engineer		
Taylor, E. G. H.	H.C. Reg.	4.1.65
Green, A. J.	H.C. Reg.	1.2.65
Brayshaw, W.	N.E. Reg.	2.2.65
Ward, G. J.	Mid. Reg.	3.2.65
Sellers, E. H.	Scot.	1.2.65
Tracy, R. E.	Mid. Reg.	12.2.65
O'Neill, K.	N.W. Reg.	3.2.65
Ross, W. M.	Scot.	10.2.65
Beard, J. O.	L.T. Reg.	22.2.65
Ware, R. H.	L.T. Reg.	22.2.65
Inspector to Assistant Executive Engineer—continued		
White, H. V.	L.T. Reg.	22.2.65
Parrin, L. J.	L.T. Reg.	22.2.65
Lucas, E. J.	L.T. Reg.	22.2.65
Henderson, A. C.	Scot.	8.3.65
Haywood, L. W. T.	H.C. Reg.	10.3.65
Adams, T.	Scot.	8.3.65
Smith, H. I.	N.E. Reg.	19.3.65
Technical Officer to Assistant Executive Engineer		
Lever, V. F. S.	H.C. Reg.	4.1.65
Little, R. V.	H.C. Reg.	4.1.65
Lodge, E. G.	H.C. Reg.	4.1.65
Hobbs, K. O. L.	H.C. Reg.	4.1.65
Lawrence, D. P.	H.C. Reg.	4.1.65
Bridge, G. R.	H.C. Reg.	4.1.65
Barham, L. A. S.	H.C. Reg.	4.1.65
Hastings, S. C. G.	H.C. Reg.	4.1.65
Hayes, A. P.	H.C. Reg.	4.1.65
Goodey, R.	H.C. Reg.	4.1.65
Colson, H. G.	H.C. Reg.	4.1.65
Beckett, D. A. N.	H.C. Reg.	4.1.65
Boyd, F. T.	H.C. Reg.	4.1.65
Marks, F. J.	H.C. Reg.	4.1.65
Mackney, J. H	H.C. Reg.	4.1.65
Hudson, A. J.	H.C. Reg.	5.1.65
Wingrove, D. P. A.	H.C. Reg.	4.1.65
Riddle, P. G. H.	H.C. Reg.	4.1.65
Mitchell, J.	H.C. Reg.	4.1.65
Merry, H. R.	H.C. Reg.	4.1.65
Allen, R. C.	H.C. Reg.	4.1.65
Brown, P. W.	H.C. Reg.	4.1.65
Hurdle, W. L. G.	H.C. Reg.	4.1.65
Mutton, E. F.	H.C. Reg.	4.1.65
Nichols, B. G.	H.C. Reg.	25.1.65
Pearce, B. A.	H.C. Reg.	4.1.65
Ford, J. G.	H.C. Reg.	4.1.65
Thorn, C. J.	H.C. Reg.	4.1.65
Bartrum, J. S. K.	H.C. Reg.	4.1.65
Smith, R. J.	H.C. Reg.	4.1.65
Heasman, B. J.	H.C. Reg.	4.1.65
Dodd, P. E.	H.C. Reg.	25.1.65
Wootten, R. W.	H.C. Reg.	4.1.65
Willmin, E. R. G.	H.C. Reg.	4.1.65
Nudd, W. J. E.	H.C. Reg.	4.1.65
Jacobs, F. G.	H.C. Reg.	4.1.65
Coggs, C. D.	H.C. Reg.	4.1.65
Cocks, K.	H.C. Reg.	13.1.65
Coleman, D. J.	H.C. Reg.	4.1.65
Thake, B. N. E.	H.C. Reg.	25.1.65
Jones, D. N.	H.C. Reg.	4.1.65
Russell, A. J.	H.C. Reg.	4.1.65
Watts, W. A.	H.C. Reg.	4.1.65
Cadle, M. J.	H.C. Reg.	4.1.65
Beaumont, D. O.	H.C. Reg.	12.1.65
Attwood, D. A.	H.C. Reg.	4.1.65
Finch, R. B.	H.C. Reg.	4.1.65
Wonfor, K. P.	H.C. Reg.	4.1.65
Smith, J. M.	H.C. Reg.	11.1.65
Jones, V. M.	H.C. Reg. to Mid. Reg.	1.1.65
Pateman, S. W.	S.W. Reg.	11.1.65
Gardner, C. H.	S.W. Reg.	18.1.65
Barlow, C. J.	Mid. Reg.	1.11.64
Dobson, P. A.	H.C. Reg.	11.1.65
Wildsmith, W. J.	Mid. Reg.	1.1.65
Millward, A. R.	Mid. Reg.	1.1.65
Westall, L. M.	H.C. Reg.	25.1.65
Baker, A. G.	S.W. Reg.	6.1.65
Searle, E. J.	S.W. Reg.	14.1.65
Harris, S. V.	S.W. Reg.	6.1.65
Rogers, T. A.	W.B.C.	12.1.65
Simmonds, W. D.	W.B.C.	12.1.65
Frewin, D.	H.C. Reg.	1.2.65
Greenwood, T.	N.E. Reg.	2.2.65
Todd, J.	N.I.	19.11.64

Name	Region, etc.	Date
Technical Officer to Assistant Executive Engineer—continued		
Smith, D. K.	N.E. Reg.	24.2.65
Peddle, R. O.	S.W. Reg.	1.2.65
Lees, K. A.	Mid. Reg.	3.2.65
Wheeler, P. R.	Mid. Reg.	3.2.65
Wilson, R.	Mid. Reg.	3.2.65
Morrison, J. A.	Scot.	23.2.65
Stewart, J. W.	Scot.	8.2.65
Dunn, J.	Scot.	15.2.65
Brown, A. T.	Scot.	25.1.65
Wallond, F. P.	H.C. Reg.	9.2.65
Johnson, R. W.	H.C. Reg.	9.2.65
Baker, J. H.	H.C. Reg.	9.2.65
Gillbanks, P. S.	H.C. Reg.	9.2.65
Johnstone, R. A.	H.C. Reg.	9.2.65
Clare, J. R.	H.C. Reg.	9.2.65
Barwell, A. E. A.	S.W. Reg.	8.2.65
Davis, F. D. J.	S.W. Reg.	1.2.65
Mockridge, L. H.	S.W. Reg.	2.2.65
Howard, K. H.	S.W. Reg.	1.2.65
Poole, H. N.	Mid. Reg.	12.2.65
Wiggins, J. C.	Mid. Reg.	12.2.65
Buxton, J. F.	H.C. Reg.	10.2.65
Morgan, R. J.	H.C. Reg.	10.2.65
Hooper, P. G.	H.C. Reg.	10.2.65
Deuchars, G.	Scot.	10.2.65
Simpson, A. A.	Scot.	10.2.65
Carrick, W. M.	Scot.	10.2.65
Young, A. S.	Scot.	10.2.65
Wilkinson, G.	N.W. Reg.	13.2.65
Partner, A. R.	S.W. Reg.	22.2.65
Hunt, L. H.	N.E. Reg.	24.2.65
Green, A. J.	L.T. Reg.	23.2.65
Tennant, A. L.	L.T. Reg.	23.2.65
McMahon, P. L.	L.T. Reg.	23.2.65
Smith, R. J.	L.T. Reg.	23.2.65
Donaldson, W. T. C.	L.T. Reg.	23.2.65
Tamsley, G. R. E.	L.T. Reg.	23.2.65
Slater, N. J. H.	L.T. Reg.	23.2.65
Darley, L.	L.T. Reg.	23.2.65
Allen, E. W. G.	L.T. Reg.	23.2.65
Parham, R. W.	L.T. Reg.	23.2.65
Hollington, E. T.	L.T. Reg.	23.2.65
Andrews, C. W. G.	L.T. Reg.	23.2.65
McSweeney, J. M.	H.C. Reg.	10.3.65
Kirkby, A. J.	N.W. Reg.	10.3.65
Campbell, D. M.	Scot.	25.1.65
Ellice, W.	Scot.	25.1.65
Murray, W. T. G.	Scot.	1.3.65
Graham, A.	Scot.	8.3.65
Cosh, D. P.	S.W. Reg.	1.3.65
Harvey, C. V.	Mid. Reg.	15.3.65
Bruce, R.	Mid. Reg.	15.3.65
Ashley, O. G.	H.C. Reg.	1.3.65
Garthley, A.	Scot.	11.3.65
Logan, R. R.	Scot.	1.3.65
Burns, C. F.	H.C. Reg.	9.3.65
Rimmell, D. F.	S.W. Reg.	5.3.65
Ottrey, K. J.	S.W. Reg.	12.3.65
Maguire, P. J.	L.P. Reg.	23.2.65
Tansley, A. C.	H.C. Reg.	9.3.65
Kibbels, D. E. J.	H.C. Reg.	9.3.65
Pottle, P. G. D.	H.C. Reg.	9.3.65
Wilby, R. J.	H.C. Reg.	9.3.65
Howell, J. H. H.	Mid. Reg.	17.3.65
Willetts, F.	Mid. Reg.	17.3.65
Smith, J.	Mid. Reg.	17.3.65
Beech, E. H.	Mid. Reg.	17.3.65
Williams, A. D.	W.B.C.	10.3.65
Barlow, D.	W.B.C.	10.3.65
Baker, B. A.	L.P. Reg.	23.2.65
Cooper, J.	L.T. Reg.	12.3.65
Butler, L. A.	L.T. Reg.	9.3.65
King, W. T.	L.T. Reg.	12.3.65
Harvey J.	L.T. Reg.	12.3.65
Down, R. H.	N.E. Reg.	19.3.65
Hollingsworth, G. D.	E.-in-C.O.	22.3.65
Draughtsman to Assistant Executive Engineer		
Newcombe, S. T. J.	H.C. Reg.	4.1.65
Lynas, K.	N.E. Reg.	2.2.65
Technical Officer to Inspector		
McLoughlin, J.	N.I.	4.1.65
Jones, E.	W.B.C.	4.1.65
Clines, H. D.	W.B.C.	3.2.65
Wood, C. W. S.	L.T. Reg.	8.2.65
Webber, W. R.	Scot.	15.2.65
Crawford, N.	L.T. Reg.	4.2.65
Senior Technician to Inspector		
Kearin, E. F.	H.C. Reg.	17.3.65
Technician I to Inspector		
White, J.	H.C. Reg.	4.1.65
Cocker, F.	N.W. Reg.	18.1.65
Anderson, A.	Scot.	31.12.64
Ferion, T. A.	Scot.	25.1.65
Davies, C. L.	W.B.C.	12.1.65
Kirby, K. H.	W.B.C.	6.1.65
Smith, E. A.	Mid. Reg.	11.1.65
Plante, F. R.	Mid. Reg.	11.1.65
Fryar, B. H.	Mid. Reg.	11.1.65
Bray, J. A.	Mid. Reg.	11.1.65
Baskill, J. E.	Mid. Reg.	11.1.65
James, B.	Mid. Reg.	11.1.65
Adams, T. A.	Mid. Reg.	11.1.65
Grundy, T. B.	Mid. Reg.	11.1.65
Shipley, J. G.	Mid. Reg.	11.1.65
Moon, L. G.	H.C. Reg.	25.1.65
Silvester, J.	S.W. Reg.	4.1.65
Cooper, C. R.	S.W. Reg.	14.1.65
Whitehead, G. E.	S.W. Reg.	14.1.65
Akerman, S. C.	Mid. Reg.	3.2.65
Gardner, F. J. A.	N.E. Reg.	25.2.65
Hibberd, J. M.	N.E. Reg.	25.2.65
Sheppard, W. P. J.	Scot.	10.2.65
Turner, P. G.	S.W. Reg.	29.3.65
Pritchard, D. S.	S.W. Reg.	29.3.65
Bentley, J.	Mid. Reg.	17.3.65
Lancaster, H.	N.E. Reg.	19.3.65
Horner, E. R.	N.E. Reg.	19.3.65
Levett, F.	H.C. Reg.	24.3.65
Bushell, E. R.	H.C. Reg.	24.3.65
Adams, D.	H.C. Reg.	24.3.65
Principal Scientific Officer to Senior Principal Scientific Officer		
Roberts, F. F.	E.-in-C.O.	1.2.65
Carasso, J. I.	E.-in-C.O.	1.2.65
Experimental Officer to Senior Experimental Officer		
Kauffmann, B.	E.-in-C.O.	15.1.65
Wells, C. R.	E.-in-C.O.	15.1.65
Scientific Officer (Open Competition)		
Simmons, T. S.	E.-in-C.O.	15.3.65
Watson, P. A.	E.-in-C.O.	25.3.65
Fanton, A. E.	E.-in-C.O.	29.3.65
Assistant Experimental Officer (Open Competition)		
Earsdon, M. R. (Miss)	E.-in-C.O.	7.1.65
Hill, D. A. J.	E.-in-C.O.	18.1.65
Upton, C. P. (Miss)	E.-in-C.O.	19.1.65
Taylor, J. M.	E.-in-C.O.	10.3.65
Assistant (Scientific) (Open Competition)		
Cooper, K.	E.-in-C.O.	15.2.65
Beken, J. D.	E.-in-C.O.	26.2.65
Stammers, J. F.	E.-in-C.O.	3.3.65
Amey, R. A.	E.-in-C.O.	5.3.65
Drake, J. V. G.	E.-in-C.O.	5.3.65

Promotions—*continued*

Name	Region, etc.	Date
Assistant (Scientific) (Open Competition)—continued		
McDougall, A. W.	E.-in-C.O.	17.3.65
Crowford, J. G.	E.-in-C.O.	19.3.65
Leading Draughtsman to Senior Draughtsman		
Morris, J. S.	E.-in-C.O.	31.3.65
Hall, G. H.	Mid. Reg.	31.3.65
McDonald, J. W.	Scot.	31.3.65
Gay, D. K.	H.C. Reg. to Scot.	31.3.65
Youde, A. L.	W.B.C. to S.W. Reg.	31.3.65
Nountford, E. D.	Mid. Reg. to N.W. Reg.	31.1.65
Warner, G. W.	N.W. Reg.	31.3.65
Whitehouse, J.	N.W. Reg.	31.3.65
Normington, A.	Mid. Reg. to N.E. Reg.	31.3.65
Lindley, J. R.	H.C. Reg. to N.W. Reg.	31.3.65
Johnson, F. C.	E.-in-C.O. to Mid. Reg.	31.3.65
Draughtsman to Leading Draughtsman		
Ferris, L. E.	W.B.C.	7.12.64
Spilling, R. D.	H.C. Reg. to Mid. Reg.	7.12.64
Simpson, A. G.	S.W. Reg. to H.C. Reg.	7.12.64
Rawcliffe, T. R.	N.W. Reg.	7.12.64
Rickard, K.	N.W. Reg. to Mid. Reg.	7.12.64
Jeffrey, M. A.	H.C. Reg. to L.T. Reg.	7.12.64
Draughtsman (Open Competition)		
Ramsey, R. G.	E.-in-C.O.	15.3.65
Draughtsman (Limited Competition)		
Morgan, R. B. C.	E.-in-C.O.	8.3.65
Mott, C. L.	E.-in-C.O.	9.3.65
Knibb, H. W.	E.-in-C.O.	15.3.65
Executive Officer (Open Competition)		
Wilson, W.	E.-in-C.O.	8.2.65
Fleming, R. W.	E.-in-C.O.	1.1.65
Executive Officer (Limited Competition)		
Lodge, J. R.	E.-in-C.O.	8.3.65
Clerical Officer to Executive Officer		
Coney, A.	E.-in-C.O.	4.1.65
Heath, V. C.	E.-in-C.O.	4.1.65
Hasluem, W. C.	E.-in-C.O.	19.3.65
Lowe, A. E.	E.-in-C.O.	19.3.65
Horgan, J.	E.-in-C.O.	19.3.65

Retirements and Resignations

Name	Region, etc.	Date
Chief Regional Engineer		
Berkeley, G. S.	L.T. Reg.	8.3.65
Regional Engineer		
Jackman, A. J.	L.T. Reg.	30.1.65
Senior Executive Engineer		
Gleadle-Richards, E. M.	L.T. Reg.	23.3.65
Executive Engineer		
Miller, R. W.	E.-in-C.O.	4.1.65
Pearson, F. C.	E.-in-C.O.	23.1.65
Griffin, I. St. J. (*Resigned*)	E.-in-C.O.	8.1.65
Dickinson, R. B.	E.-in-C.O.	6.2.65
Corp, B.	W.B.C.	7.2.65
Worts, W. G.	L.T. Reg.	8.3.65
Hamilton, F. A.	L.T. Reg.	22.3.65
Prosser, R. D.	E.-in-C.O.	28.2.65
Blake, W. S.	E.-in-C.O.	31.3.65
Assistant Executive Engineer		
Hannocks, J. W.	H.C. Reg.	30.9.64
Blacoe, T.	N.I.	18.12.64
Warren, J. L.	L.T. Reg.	21.1.65
Allum, F. H.	E.T.E.	31.1.65
Dixie, J. A. (*Resigned*)	L.P. Reg.	1.1.65
Naisbitt, R. D. (*Resigned*)	E.-in-C.O.	31.1.65
Lamb, E. R. (*Resigned*)	E.-in-C.O.	31.1.65
Whiteside, L. T. (*Resigned*)	E.-in-C.O.	31.1.65
Russell, J. H.	Scot.	31.1.65
Manley, E. H.	S.W. Reg.	2.2.65
Mills, W. A.	L.T. Reg.	3.2.65
Swift, F. H.	E.-in-C.O.	15.2.65
Buchan, A. C.	Scot.	22.2.65
Hall, H. H.	H.C. Reg.	28.2.65
Johnston, W. (*Resigned*)	Scot.	8.1.65
Assistant Executive Engineer—continued		
Wilkie, N. R.	Scot.	3.2.65
Smith, J. W.	N.E. Reg.	1.3.65
Aitchison, J. K.	Scot.	5.3.65
Thorne, W. J.	H.C. Reg.	8.3.65
Stanton, C. G.	E.-in-C.O.	10.3.65
Hollis, J. S.	S.W. Reg.	13.3.65
Holbrook, F. H.	L.T. Reg.	16.3.65
Roberts, E. W.	W.B.C.	19.3.65
Rawson, J. R.	Mid. Reg.	19.3.65
Barron, D. F. J.	L.P. Reg.	22.3.65
Broderick, E. C.	L.T. Reg.	25.3.65
Smith, A. F.	H.C. Reg.	27.3.65
Middleton, A. M.	E.T.E.	31.3.65
Careswell, C. E.	L.T. Reg.	31.3.65
Corke, L. C. W.	N.W. Reg.	31.3.65
Wells, B. C. (*Resigned*)	E.-in-C.O.	12.3.65
Minta, T. A. (*Resigned*)	E.-in-C.O.	12.3.65
Moss, B. (*Resigned*)	E.-in-C.O.	19.3.65
Inspector		
Price, W. C.	W.B.C.	12.1.65
Bimson, W. T.	W.B.C.	26.1.65
Robinson, S. R. R.	H.C. Reg.	18.2.65
Senior Scientific Officer		
Bingham, J. A. C. (*Resigned*)	E.-in-C.O.	19.2.65
Assistant (Scientific)		
Moran, P. A. V. (Mrs.) (*Resigned*)	E.-in-C.O.	1.1.65
Technical Assistant		
Smith, W.	E.-in-C.O.	23.2.65
Executive Officer		
Little, E. E. (Miss)	E.-in-C.O.	22.2.65

Transfers

Name	Region, etc.	Date
Deputy Director of Research to Assistant Engineer-in-Chief		
Stanesby, H.	E.-in-C.O.	22.3.65
Assistant Staff Engineer		
Partington, E. V. I.	Approved Employment to E.-in-C.O.	26.3.65
Regional Engineer		
Greening, F. C. G.	E.-in-C.O. to L.T. Reg.	1.2.65
Area Engineer		
Bearham, D. R.	E.-in-C.O. to L.T. Reg.	22.2.65
Executive Engineer		
Killip, R. H.	E.-in-C.O. to N.W. Reg.	4.1.65
Chatwin, W.	Approved Employment to N.W. Reg.	1.1.65
Vigar, C. D.	Ministry of Aviation to E.-in-C.O.	1.1.65
Hempseed, P. H.	E.-in-C.O. to Scot.	1.1.65
Whittle, A. D.	E.-in-C.O. to L.T. Reg.	18.1.65
Dickie, W.	E.-in-C.O. to N.W. Reg.	1.2.65
Watt, S. A.	E.-in-C.O. to Scot.	15.2.65
Anderson, G. P.	E.-in-C.O. to G.C.H.Q.	1.3.65
Gresswell, F.	E.-in-C.O. to H.C. Reg.	8.3.65
Palmer, E. C.	E.-in-C.O. to L.P. Reg.	15.3.56
Hunter, R. S.	E.-in-C.O. to L.P. Reg.	15.3.65
Assistant Executive Engineer		
Dovey, J. F.	E.-in-C.O. to W.B.C.	1.2.65
Smith, E. J. S.	E.-in-C.O. to L.T. Reg.	1.2.65
Rushby, A. C.	E.-in-C.O. to L.T. Reg.	1.2.65
Garland, J. L.	E.-in-C.O. to Ministry of Transport	1.2.65
Senior Scientific Officer		
Parsons, P. L.	E.-in-C.O. to Home Office	22.2.65
Assistant Experimental Officer		
McAndrew, J.	E.-in-C.O. to Ministry of Defence	15.3.65
Assistant (Scientific)		
Amey, R. A.	E.-in-C.O. to D.S.I.R.	31.3.65
Draughtsman		
Tucker, R. J.	E.-in-C.O. to L.T. Reg.	1.2.65
Adamson, P. P.	E.-in-C.O. to N.W. Reg.	15.2.65
Executive Officer		
Ives, T. G.	E.-in-C.O. to C.M.B.D.	25.1.65
Eaton, R. M. (Miss)	E.-in-C.O. to C.M.B.D.	25.1.65

Deaths

Name	Region, etc.	Date
Chief Regional Engineer		
Baines, J.	N.E. Reg.	1.3.65
Executive Engineer		
Mills, D. E.	E.-in-C.O.	13.3.65
Assistant Executive Engineer		
Carrington, J. E.	N.E. Reg.	21.12.64
Assistant Executive Engineer—continued		
Rumsey, A. C. E.	L.T. Reg.	16.1.65
Nettleingham, G. H.	Mid. Reg.	25.1.65
Inspector		
Hicks, R. G.	L.T. Reg.	13.2.65
Warwick, R. A.	L.P. Reg.	28.2.65

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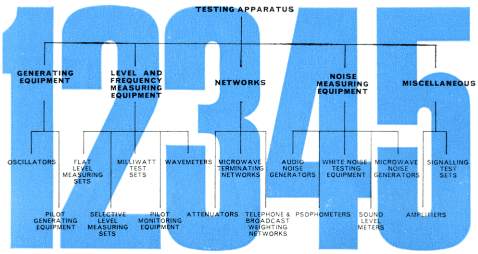
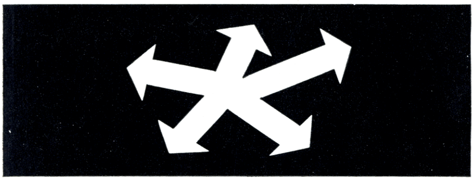
STC TELECOMMUNICATIONS REVIEW

JULY 1965





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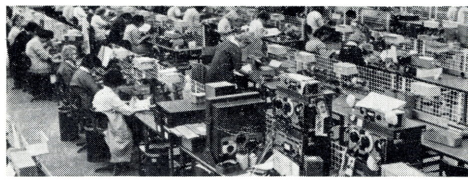

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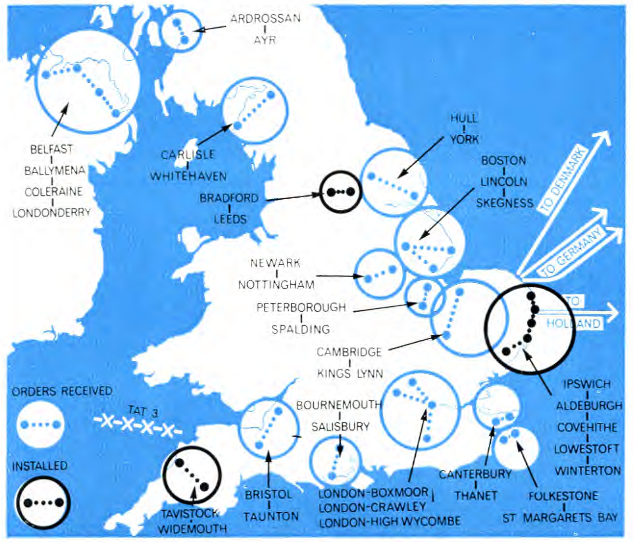
Standard Telephones and Cables Limited, Transmission Systems Group, Basildon, Essex. Telephone: Basildon 3040. Telex: 99101.

Lightweights ahead!

STC lightweight headsets are designed for use by private and public telephone operators. These are fast superseding the use of the older breast-type instruments. Main advantages are: Extraordinary light weight, high degree of comfort, stability and manoeuvrability and constant level of transmission regardless of head movement. Made of nylon plastic, and virtually unbreakable, the headsets are available in black and grey (colours approved by the British Post Office) and also in ivory. The "Rocking Armature" principle—an important STC development in telephone receiver design—which gives improved sensitivity and frequency response has been incorporated into these instruments.

Standard Telephones and Cables Limited, Telephone Switching Division, Oakleigh Road, New Southgate, London, N.11. Telephone: ENTerprise 1234. Telex: 21612.



New coaxial cable main line systems

STC has led in the design of small core systems since 1961, when they installed the first system in Sardinia. Following this success, systems of this earlier type were installed in the United Kingdom and abroad. Now, many more STC 300 circuit small core systems of the later design, operating over their associated 0·174 in. (4,4 mm.) diameter coaxial cores are to be installed in the United Kingdom trunk telephone network.

Similar STC systems already carry inland the trunk telephone traffic from the new STC North Sea submarine cable systems to the Continent, and from "TAT-3", the first direct submarine cable telephone link between the United Kingdom and the United States of America.

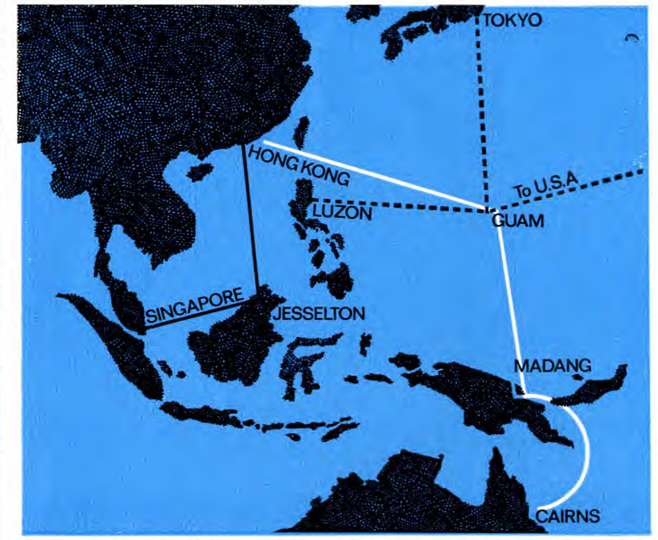
Also to be installed this year, between Bournemouth and Salisbury, is the first STC 960-CIRCUIT small core system, which will introduce a new concept in economy for medium density trunk routes.

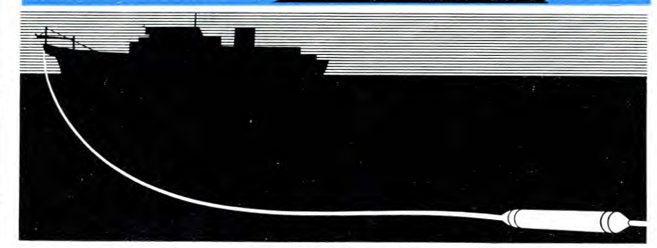
Standard Telephones and Cables Limited, Transmission Systems Group, Basildon, Essex. Telephone: Basildon 3040. Telex: 99101.

Good communication

Good communication facilities in an industrial organization are now recognized as a necessity at all administrative levels. Time saved by obtaining immediate contact with other members of the staff is of inestimable value to all, from the Managing Director to the junior clerk, and the capital cost of providing a properly planned system is small compared with the incalculable losses sustained by having inefficient communications. For many years STC has designed, manufactured and installed Private Automatic Branch Exchanges of various types. As a result of this experience a large fund of expert knowledge is available, and any technical advice that may be required will be furnished gladly on request. New light-weight high performance handset □ B.P.O. type "long life" components □ transistorized ringing and tone circuits □ all "plug-in" type equipment □ quick and easy expansion to full capacity □ simple installation and maintenance □ full tropical finish.

Standard Telephones and Cables Limited, Telephone Switching Division, Oakleigh Road, New Southgate, London, N.11. Telephone: ENTerprise 1234. Telex: 21612.





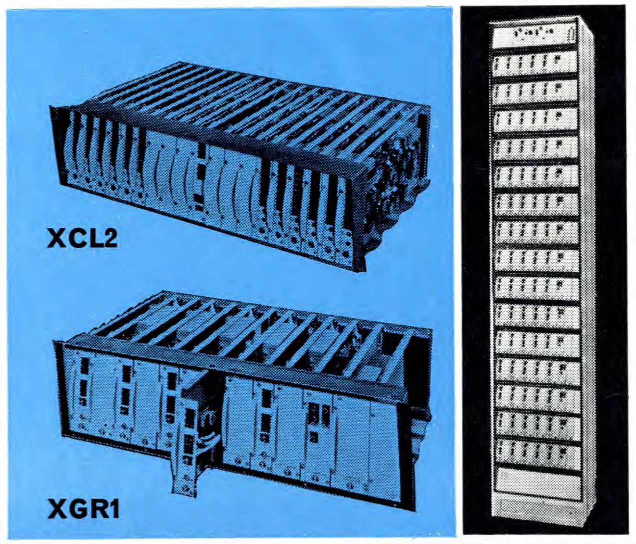
STC and the final Seacom link

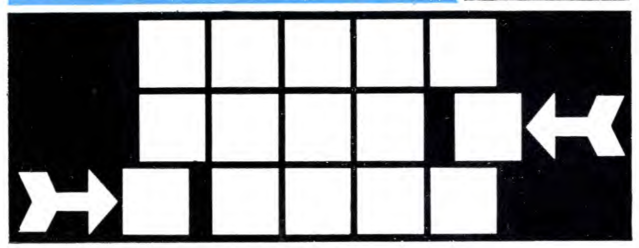
With the orders placed with STC for the final phase of the South-East Asia section of the round-the-world Commonwealth telephone cable, STC will have contributed over £8,000,000 worth of equipment to the SEACOM project. This includes more than 2,600 miles of lightweight and shallow water armoured submarine telephone cable, 265 submerged repeaters, 35 submerged equalizers and shore terminal equipment for both phases of the project. Phase 1, linking Singapore, Jesselton and Hong Kong is now in service and cable laying operations for the second phase are well advanced for linking Hong Kong, Guam, Madang (New Guinea) and Cairns (Australia). Landing SEACOM at Guam permits interworking with the USA-Japan submarine cable (for which STC supplied 2,000 miles of cable) and provides through circuits to the Philippines, Japan and USA.

160-circuit equipment is being used for the Guam-Madang-Cairns route to cope with increasing telephone traffic between Japan and Australia. STC are supplying all the 160-channel terminal equipment submerged equalizers and 75% of the submerged repeaters. Its use marks a significant departure from the 80-circuit design of the round-the-world cable so far laid between the UK, Canada, New Zealand and Australia.

From Cairns an overland link will extend the system to Sydney. Here it will connect with the COMPAC and CANTAT systems to provide clear and reliable telephone communications for the first time between South-East Asia and Europe.

Standard Telephones and Cables Limited, Submarine Cable Division, West Bay Road, Southampton, Hants. Telephone: Southampton 74751. Transmission Systems Group, Basildon, Essex. Telephone: Basildon 3040. Telex: 99101.



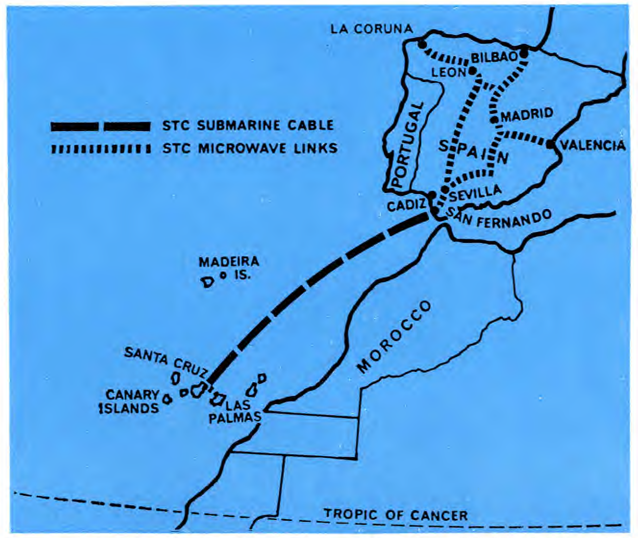


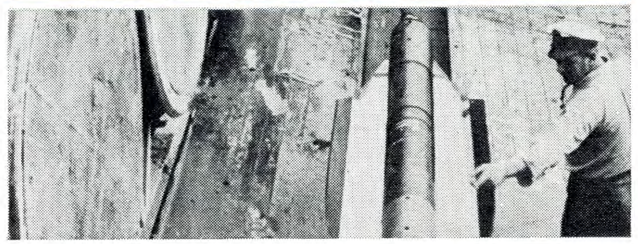
Standard Mark 6 Multiplex

The Standard Mark 6 range of multiplex equipment from STC is for use with all coaxial, carrier-on-cable and radio transmission systems planned to CCITT recommendations for international telephone circuits. Both STC Channel Translating Equipment type XCL2 and STC Group Translating Equipment type XGR1 are high performance transistor equipments which are easy to install and economical on cost and space. Full depth (450mm) racks accommodate equipment shelves which house plug-in apparatus cards and units. Each shelf is a complete wired assembly which provides equipment for a 12-circuit group in the XCL2 and one super group in the XGR1. Fourteen XCL2 shelves (168 circuits) or fifteen XGR1 shelves (75 groups) can be mounted on a 9 ft. (2·74m) rack. Rear access to intershelf and station wiring allows unequipped positions in the racks to be fitted with shelves at any time without disturbing existing circuits.

XCL2 is described in leaflet C/AE48 and XGR1 in leaflet C/AE50.

Standard Telephones and Cables Limited, Transmission Systems Group, Basildon, Essex. Telephone: Basildon 3040. Telex: 99101.

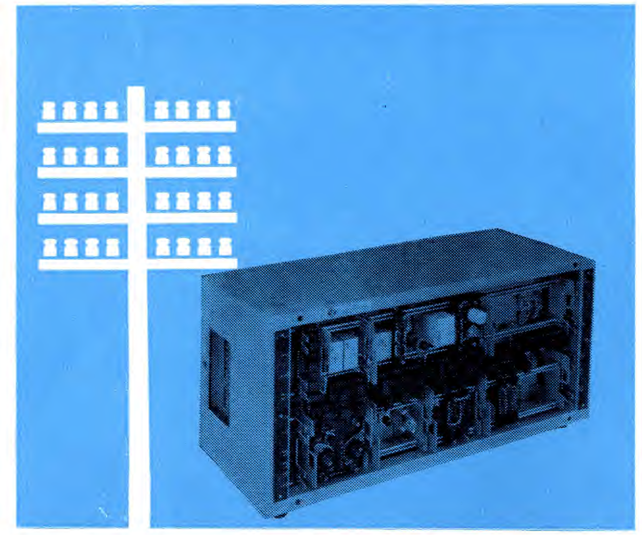


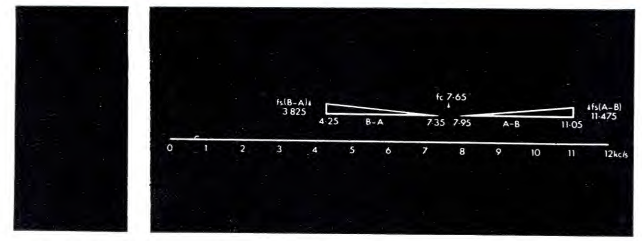


Canaries on the line

STC are manufacturing and laying Spain's first-ever submarine telephone cable link between the Peninsula and Canary Islands. The system is designed for 160 telephone circuits in both directions over a single cable and thus is the highest capacity long-distance cable yet installed. This £2,500,000 order represents a key feature of Spain's major expansion in telecommunications. The link, measuring 750 nautical miles—710 miles of deep-sea lightweight cable and 20 miles of shallow-water armoured cable at each end—will connect San Fernando, 10 miles south of Cadiz with Santa Cruz de Tenerife. 45 STC deep-sea repeaters, 3 adjustable submerged equalizers and terminal equipment are being supplied with the cable. STC with its associated company, Standard Electrica S.A. is also providing a microwave link between Tenerife and Las Palmas which will form part of the service. High-quality speech circuits will be provided, day and night, with Europe (direct dialling to Madrid) and North America.

Standard Telephones and Cables Limited, Submarine Cable Division, West Bay Road, Southampton, Hants. Telephone: Southampton 74751. Transmission Systems Group, Basildon, Essex. Telephone: Basildon 3040. Telex: 99101.

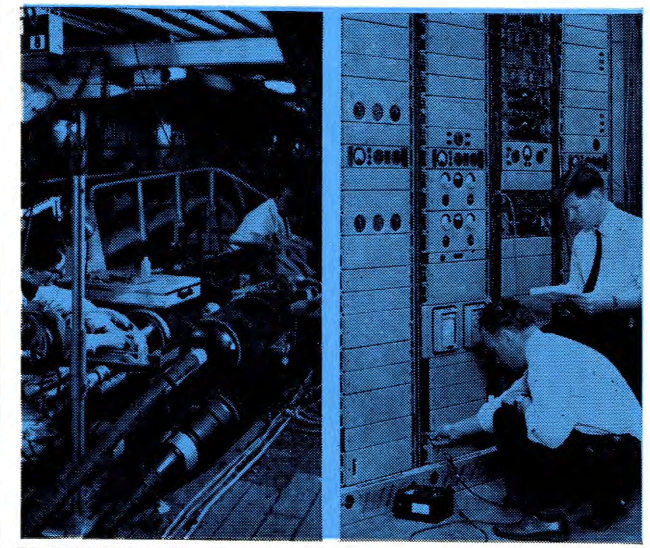


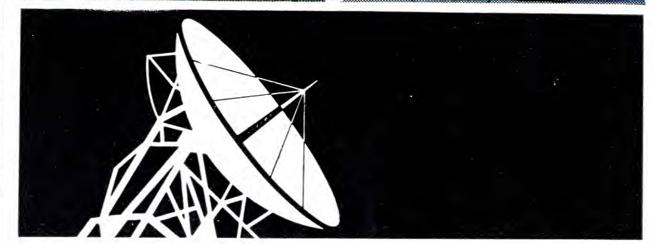


SO1-B single-circuit open-wire carrier telephone system

A short-haul system ideally suited to the provision of additional junctions to outlying minor exchanges. The equipment operates in the frequency band 3·825 kc/s to 11·475 kc/s, just above the normal audio channel and it utilizes one carrier frequency from which, after speech modulation, either the upper or lower sideband can be selected for transmission; the other sideband is used for reception. The SO1-B can be used as a speech plus duplex telegraph system and has out-of-band signalling. Transistors are used throughout the equipment which will operate from either a 24 or 50 volt d.c. supply; for mains operation, separate power units can be supplied. Equipment for one terminal is normally housed in a portable cabinet 21×10×10 inches (53×25·4×25·4 cm.) and weighs 50 lb (23 kg), but it can also be supplied for rack mounting.

Standard Telephones and Cables Limited, Transmission Systems Group, Basildon, Essex. Telephone: Basildon 3040. Telex: 99101.





Installation services for transmission systems

The STC Transmission Systems Group Installation Division offers a world-wide service for the installation, maintenance and overhaul of all types of telecommunications transmission systems manufactured by STC and other companies. It covers tropospheric scatter, microwave and VHF radio, coaxial cable, repeatered submarine cable, and open-wire carrier systems, including all associated telegraph and multiplex terminal equipments. Allied specialized services can also be provided.

This service is invaluable to administrations requiring extra facilities to cope with the rapid and vigorous expansion of their telecommunications networks. The administration's own personnel can be instructed and trained in the work of installing and maintaining equipment and the provision of technical advisers for extended periods can be arranged.

Standard Telephones and Cables Limited, Transmission Systems Group, Basildon, Essex. Telephone: Basildon 3040. Telex: 99101.

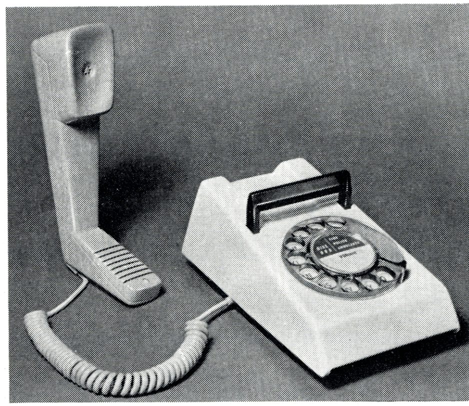
Complete submarine cable telephone systems

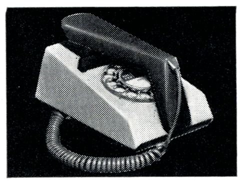
STC are fully equipped to cover every phase of submarine cabling for telephonic and telegraphic transmission. Plan, design, supply and install—a complete service from drawing-board to operation. Systems providing up to 640 high quality telephone circuits can be supplied.

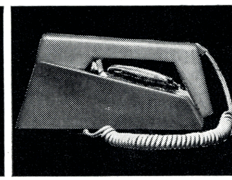
STC systems include shallow or deep water submerged repeaters, land based terminal equipment and repeater power feeding equipment for long and short systems. One of the few commercial organizations in the world qualified to provide fully integrated systems tailored to any location and specification, STC have supplied equipment now in operation over a total route length of twenty thousand nautical miles.

The illustrations show STC submarine repeaters on the deck of the cable ship "Monarch" ready for laying, and a suite of terminal equipment.

Standard Telephones and Cables Limited, Transmission Systems Group, Basildon, Essex. Telephone: Basildon 3040. Telex: 99101.







Talking point

Design conscious but supremely functional—the new STC Deltaphone represents an entirely new approach to telephone design. A choice of restrained colours, lightweight handset, electronic tone caller with volume control, optional dial illumination, compactness . . . everything new!

The STC Deltaphone is particularly suited for use in homes, hotels, reception lounges and 'front offices', where harmony of design, functional elegance and prestige are essential. As well as its superb modern appearance, fit to grace any expensive service flat, the basic economies of space and effort give this new telephone utmost utility in offices and other business premises.

High technical specifications match the trend-setting symmetry of this truly new telephone.

Standard Telephones and Cables Limited, Telephone Switching Division, Oakleigh Road, New Southgate, London, N.11. Telephone: ENTerprise 1234. Telex: 21612.

world-wide telecommunications and electronics **STC**

Most people with a 'pluge' in mind would look no further than the Gresham PL4.

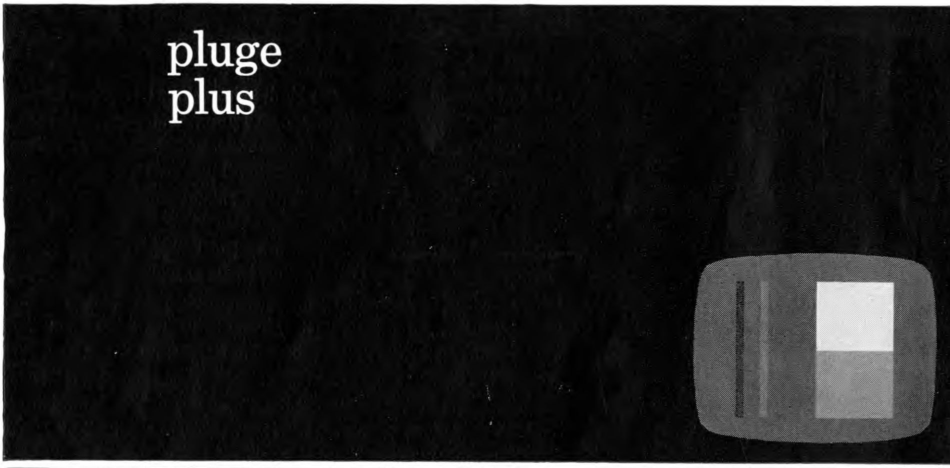
Like a great many Gresham instruments, the PL4 is based on recommendations of the British Broadcasting Corporation. It has earned the confidence of engineers, in maintaining consistent levels of brightness and contrast throughout the station or network.

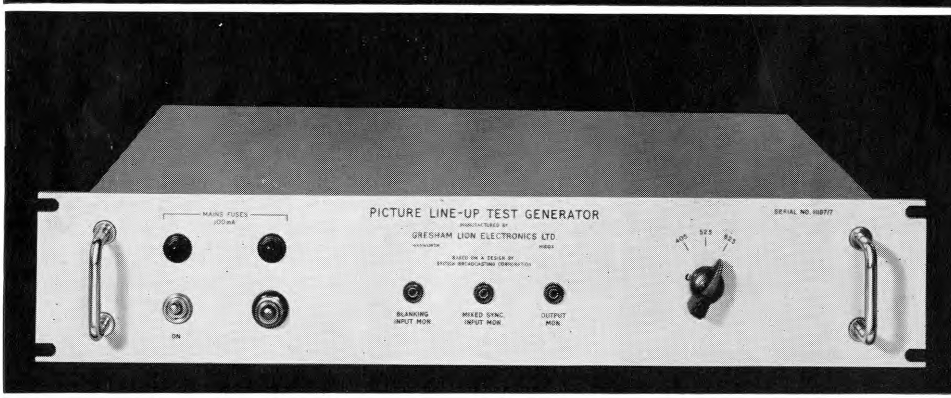
The PL4 generates a composite video test signal for video picture monitors. Quick and accurate setting up of the monitors is easily achieved. Using semi-conductors throughout, this 'pluge' is light, compact and trouble free. It is completely self contained with its own power supply. The waveform includes an overall pedestal, to facilitate adjustment of monitors in reasonable ambient light conditions.

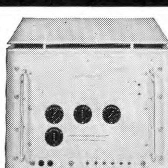
The waveform produces a display consisting of two narrow pulses (black and white) and a wide bar split horizontally—peak white at the top, and grey at the bottom. The combination permits extreme accuracy in setting up, particularly at black level and peak white. Multi standard, for 405, 525 or 625 line operation.

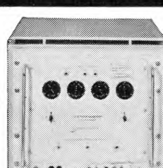
GRESHAM LION ELECTRONICS LIMITED
Twickenham Road, Hanworth, Middlesex, England
TWIckenham Green 5511. Cables: Gresham, Feltham, Middlesex

GRESHAM TV Test Waveform





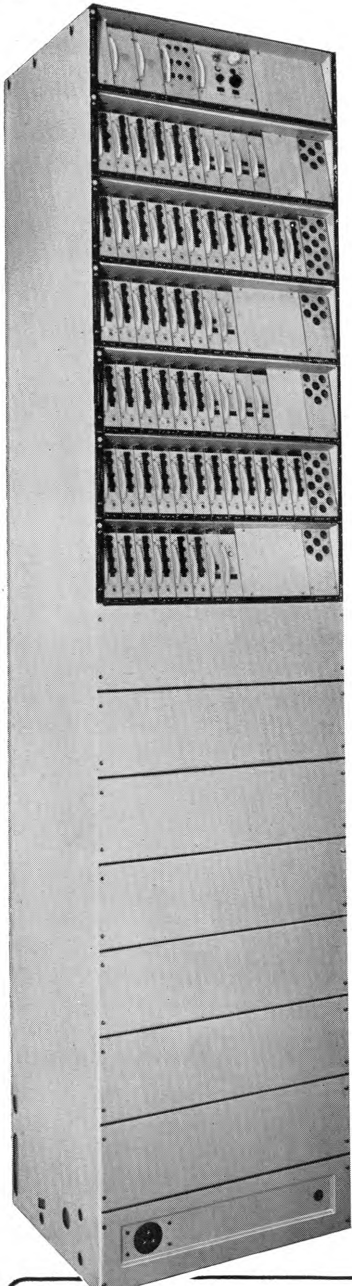




ABOVE: Gresham Type PL4 picture line-up generator.

LEFT: CPB2 sine-squared pulse and bar composite waveform generator.

RIGHT: SL3 'Staircase' linearity waveform generator.



NEW 24 CHANNEL VOICE FREQUENCY TELEGRAPH SYSTEMS BY G.E.C.

G.E.C. (Telecommunications) Limited introduces a new 24 Duplex Channel Voice Frequency Telegraph equipment for operation at 50 bauds (up to 75 bauds for some applications) over any 4-wire speech circuit effectively transmitting frequencies between 300 c/s and 3400 c/s. The equipment is in accordance with C.C.I.T.T. recommendation.

The system is readily extensible from 6 to 24 duplex channels; employs frequency shift modulation and is completely transistored.

Using the latest C.A.S.E. (62-Type) construction, up to four complete 24 channel systems may be mounted on a 7 ft. 6 ins. (2286 mm.) rack; five systems on a 9 ft. (2743 mm.) rack.

A choice of output stages is offered; transistor or mercury wetted reed relay. The transistor output stage has an indefinitely long life but is slightly more expensive and less flexible in application than the mercury wetted reed relay, which has a life expectancy of at least 1,000,000,000 operations at 50 milliamps output and covers a wider range of applications.

An optional facility provides correction for bearer channel asynchronism before the VFT tones reach their respective filters.

80-0-80 volt telegraph battery supplies may be provided by equipment mounted in the rack, if required.

The associated test equipment is designed to serve as a shelf-mounted arrangement within the rack or as portable items, according to local requirements.

This equipment is already on order for the General Post Office and Administrations in Malaysia, New Zealand, Zambia and El Salvador.

Two complete 24 channel V.F.T. systems mounted in a C.A.S.E. rack.

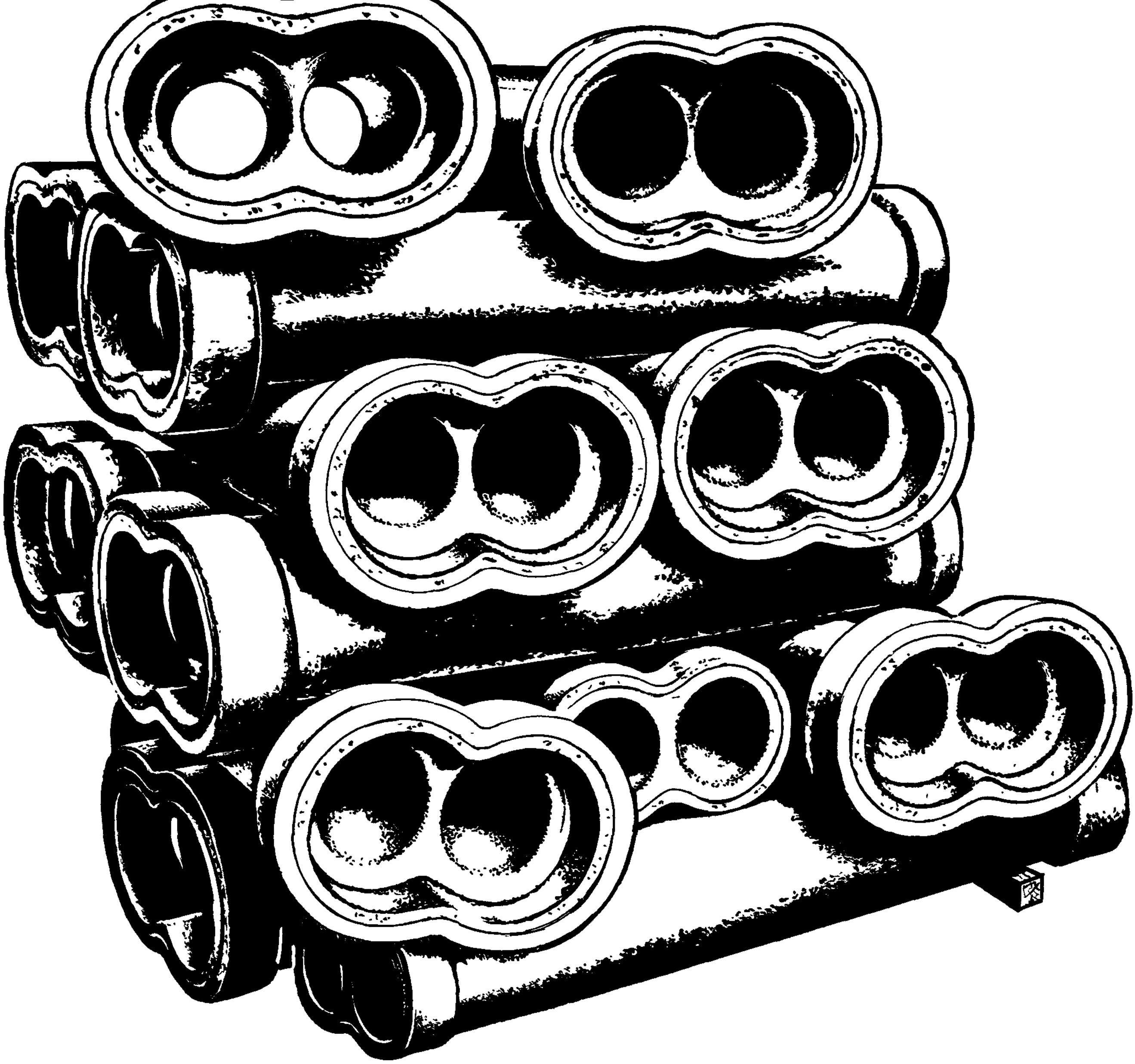
G.E.C.

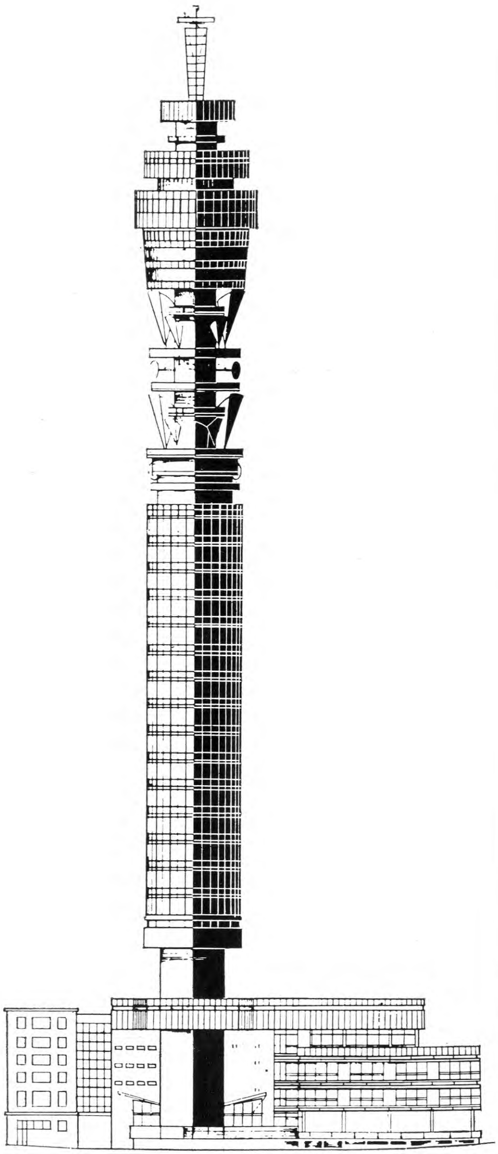
For further information send for Standard Specification SPO 1405

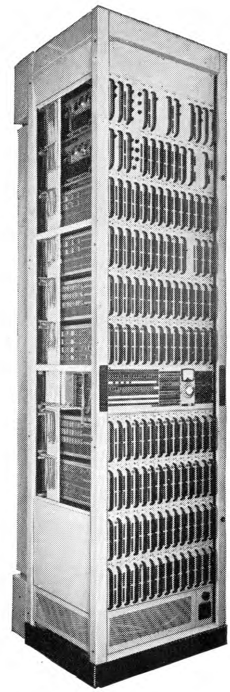
everything for telecommunications

Transmission Division, G.E.C. (Telecommunications) Ltd
Telephone Works, Coventry, England

SP31







Incoming Register Translator

The Trunk Switching Equipment is controlled electronically by the Ferrite-Core and Transistor Register Translator developed by E.T.L. for this and similar applications. Housed in units based on an equipment practice of the company's design, it occupies aproximately $\frac{1}{6}$th of the floor area of an electromechanical equivalent. In addition it offers potentially much greater reliability and flexibility in use.

MERCURY the largest

ERICSSON

A Principal Operating Company of the Plesse

Thorn Television Monitoring Equipment

O.B. MONITORING TELEVISION RECEIVER TYPE WJ.11

This portable weatherproof receiver provides standard level video and audio outputs suitable for feeding video monitors and associated audio equipment. No picture tube is incorporated, but a built-in loudspeaker enables the television sound channel to be monitored. The receiver is designed to accept signals in Bands I and III on the 405 line system and in Bands IV and V on the 625 line system.

Features include black level AGC and the provision of automatic frequency control on the UHF bands.

A rack mounting version, type WJ.12 is also available.

TELEVISION PICTURE MONITORS
19″—Type VM606 23″—Type VM608

These Thorn monitors are intended for general purpose studio applications. They incorporate a 110° picture tube with bonded face plate thus ensuring minimal physical size and avoiding the need for a separate implosion guard.

Automatic or manual 405/525/625 line standard selection is provided, together with remote control of brightness and contrast. Remote selection of two alternative video inputs is also available.

The monitors feature high picture brightness with stabilised E.H.T. and 8 Mc/s video bandwidth. Picture centering controls are on the front panel. Single standard and non-automatic 3-standard models are also available.

Thorn Electronics Limited

THORN ELECTRONICS LIMITED Wellington Crescent, New Malden, Surrey. (MALden 8701).

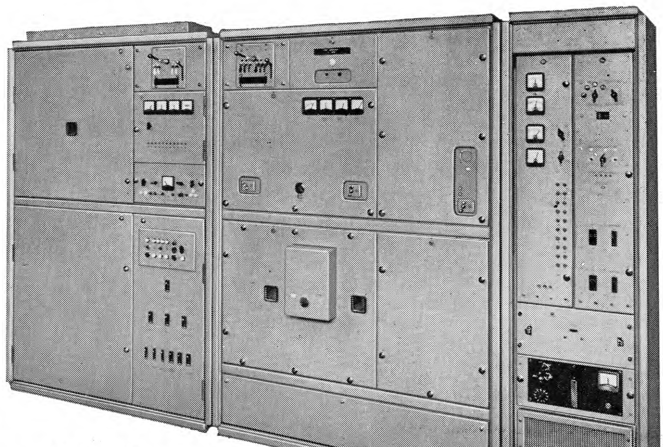
A MEMBER OF THE THORN ELECTRICAL INDUSTRIES GROUP OF COMPANIES

Marconi self-tuning H.F system—
the first in the world to be station
planned from input to output.

breakthrough

MST 30kW transmitter type H1200

An h.f linear amplifier transmitter for high-grade telecommunications.
Frequency range: 4-27.5 Mc/s.
Output power: 30 kW p.e.p, 20 kW c.w.
Meets all CCIR Recommendations.



saves 80% floor space

Transmitters can be mounted side by side and back to back or against a wall. Floor-ducts are eliminated and all power supply components are built-in. These features lead to smaller, simpler, cheaper buildings or more services in existing buildings.

rugged reliability

R.F circuits have been simplified and the number of mechanical parts reduced to a minimum. Highest engineering standards are applied to the design of these parts: stainless steel shafts in ball-bearings in heavy, rigid, machined castings; stainless steel spur gears meshing with silicon bronze; heavy r.f coil contacts with high contact pressure. Specified performance is maintained with ample margins.

simplicity

MST reliability allows continuous unattended operation with extended or remote control, saving maintenance and operating staff. Any fault in the servo control circuits can quickly be located with simple test routines. Transistors and printed wiring give these circuits maximum reliability.

self-tuning

The H1200 has a frequency following servo tuning system. Any frequency may be selected on the synthesizer decade dials in the associated MST drive equipment; the unattended transmitter automatically tunes itself in an average time of twenty seconds. Final stage tuning and loading servos continuously ensure automatic compensation for changes in aerial feeder impedance caused by weather conditions. Self-tuning gives *one-man* control of an entire transmitting station.

Marconi telecommunications systems

The Marconi Company Limited, Communications Division, Chelmsford, Essex, England.

LTD/H51

TELEPHONE CABLES

the makers with... **experience** 1837-1965

techniques paper–polythene–moisture barrier–water block–coaxial

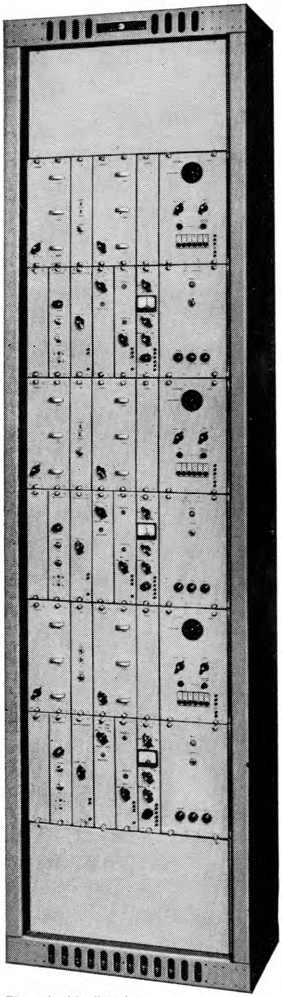
capacity
audio–1,500,000 pair miles a year
coaxial–5000 tube miles a year

current export orders exceed £7,000,000

CABLE · PLANNING · INSTALLATION

TELEPHONE CABLES LIMITED · DAGENHAM · ENGLAND

Marconi SELF-TUNING h.f. receivers



Three double diversity H2002 receivers

The H2002 Series of MST receivers for high grade point-to-point h.f. communication services.
H2002 double diversity f.s.k.
H2102 double diversity i.s.b. or s.s.b.
H2112 single path i.s.b. or s.s.b.

NO OSCILLATORS
NO VARIABLE CAPACITORS
NO MECHANICAL TELEGRAPH RELAYS
NO TUNING SCALES

The new range of MST transistorized receivers uses synthesizers to provide accurate selection of 250,000 frequencies.

Elimination of manual tuning by a unique self-tuning system (using servo controlled varactor diodes) allows centralized extended control.

Exceptionally good frequency stability renders a.f.c. unnecessary on stable transmissions.

One man control of an entire receiving station.

60% space saved by much smaller equipment and back to back and side by side installation.

RECEIVER MST BREAKTHROUGH

Marconi telecommunications systems

The Marconi Company Limited, Communications Division, Chelmsford, Essex, England

LTD/H55

we can help transmit passengers, too

M E L

Telecommunications–
The Pulse of Progress

Because of the increasing complexities involved in routing large numbers of passengers, B.E.A. and PAN-AM are now using the M.E.L. Automatic Telegraph Routing System to help give their passengers an even more efficient service. As well as handling booking information, the M.E.L. System helps to achieve safer flight conditions by coping with the growing number of flight operations and other messages, passing between control centres and between aircraft and control centres.

The same technique will effectively handle large volumes of messages sent on other commercial or military networks, increasing capacity and reducing the number of people needed to handle such things as routing, storage and priority.

We produce a wide range of electro-mechanical and electronic equipment for the improvement and fuller use of line or radio transmission. There are advanced M.E.L. transceivers for the high speed handling of large amounts of data. There are special M.E.L. systems for telemetry and telecontrol of remote installations in industrial and public utility enterprises.

And we build fully automatic private telephone exchanges, together with radio link equipment extending from single channel operation in the V.H.F. band to 1800-CCITT channels in the microwave frequencies.

The booklet illustrated here, will tell you much more about our activities in the field of telecommunications. The Automatic Telegraph Routing System, for instance, is fully described on pages 14 and 15. Make sure of receiving your copy now by dropping us a line today.

M E L

The M.E.L. Equipment Company Ltd.,
Manor Royal, Crawley, Sussex.
Telephone: Crawley 28787. Telex: 87267.

we can always pass your message on

M E L

Telecommunications –
The Pulse of Progress

The M.E.L. range of Broadcast Link Equipment contains systems capable of relaying or repeating any type of broadcast signal. There are V.H.F. music links suitable for a fixed link service between studios and broadcast transmitter, and as O.B. links.

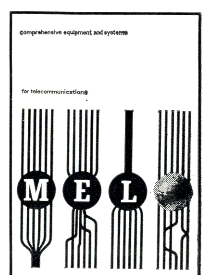
In the microwave bands, there are a fixed 4Gc/s radio relay designed for remote and unattended operation as a repeater or terminal station for long distance operation, and a link specially designed for relaying high quality T.V. sound.

The latest addition to our range is a portable broadband link in the 11Gc/s frequency band, transmitting 625 line signals in black and white or colour and permitting two-way failsafe working from one bowl.

But radio links cover only one area in which we specialise. M.E.L. equipment also includes a series of Building Brick type H.F. Transmitters ranging in output from 1 kW to 30 kW, and Lower Power Transmitters with outputs of 100W to 300W, there are also 50W and 250W transmitters and transceivers for ground-to-air communication. Recently introduced is the M.E.L. Transistorised Automatic Error Detection and Correction Equipment based on the use of the 7 unit Code No. 3, for detecting and counter-acting errors in Telegraph Traffic over Radio caused by noise and fading.

Needless to say, we also produce a comprehensive range of ancillary equipment, including radio terminals for telephony, tone modulators, line amplifiers, aerial matching units and transformers, and variable and crystal oscillators.

This interesting, illustrated booklet will tell you much more about our activities in the field of telecommunications. Broadcast Link Equipment, for instance, is fully described on page 6. Make sure of receiving your copy now by dropping us a line today.



M E L

The M.E.L. Equipment Company Ltd.,
Manor Royal, Crawley, Sussex.
Telephone : Crawley 28787, Telex : 87267.

THE G.E.C. SERIES OF ELECTRONIC EXCHANGES

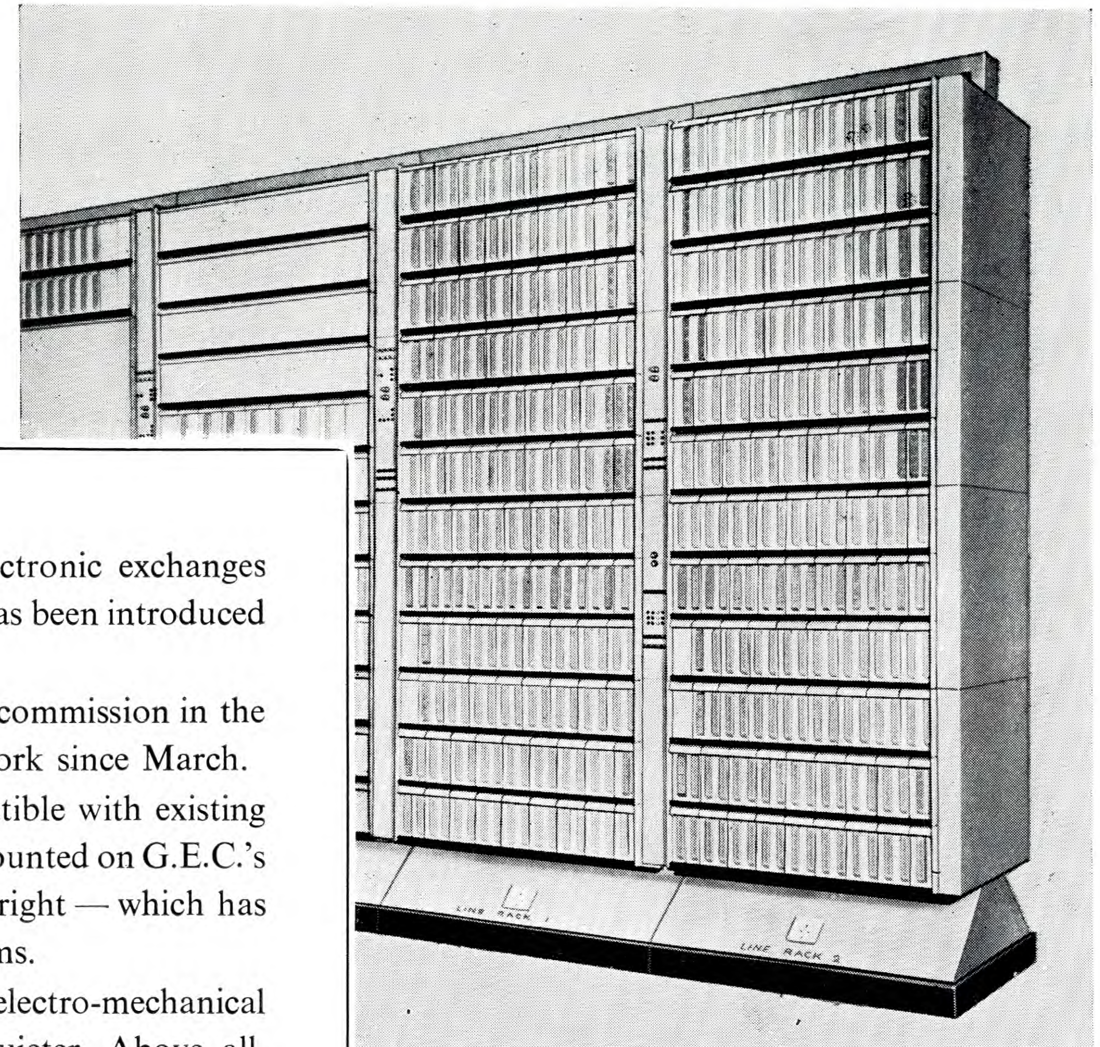
RS 31 *-reliable in public service*

RS 41

RGS 41

RS 42

RGS 42



A new series of space-division reed-relay electronic exchanges using modern centralised control techniques has been introduced by G.E.C.

The first of the series, the RS 31, has been in commission in the United Kingdom Post Office's national network since March.

The RS and RGS 40 series are fully compatible with existing crossbar and step-by-step systems. They are mounted on G.E.C.'s new 3E equipment practice — shown on the right — which has been specially developed for electronic systems.

Electronics have many advantages over electro-mechanical systems. They are smaller and faster, yet quieter. Above all, they are more reliable. No extra maintenance effort is needed — existing staff can learn the new principles quickly and easily.

Electronics also give improved subscriber facilities — features such as multi-frequency signalling (whether between subscriber and exchange or from one exchange to another) and short-code dialling can be used to full advantage.

G.E.C. **everything for telecommunications** EXCHANGE DIVISION, G.E.C. (TELECOMMUNICATIONS) LTD · TELEPHONE WORKS · COVENTRY ENGLAND

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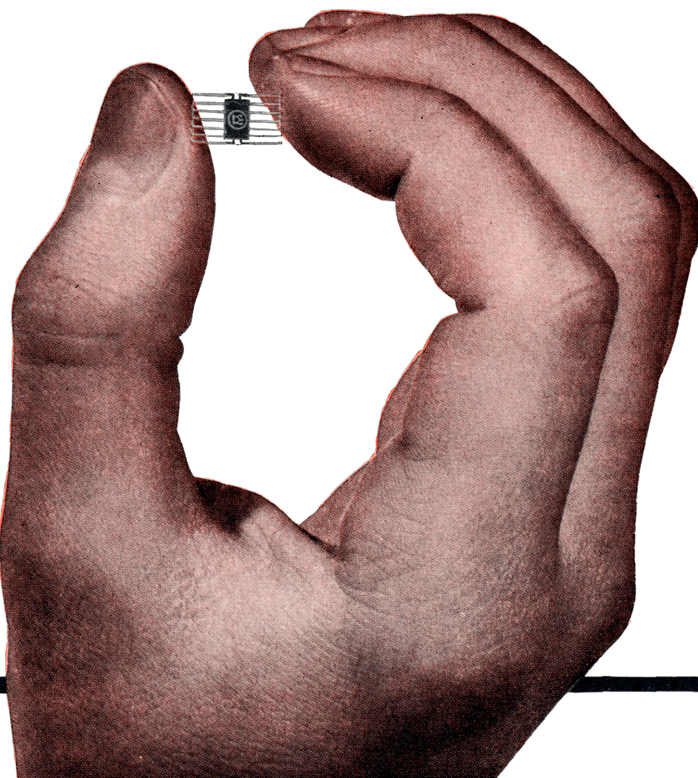

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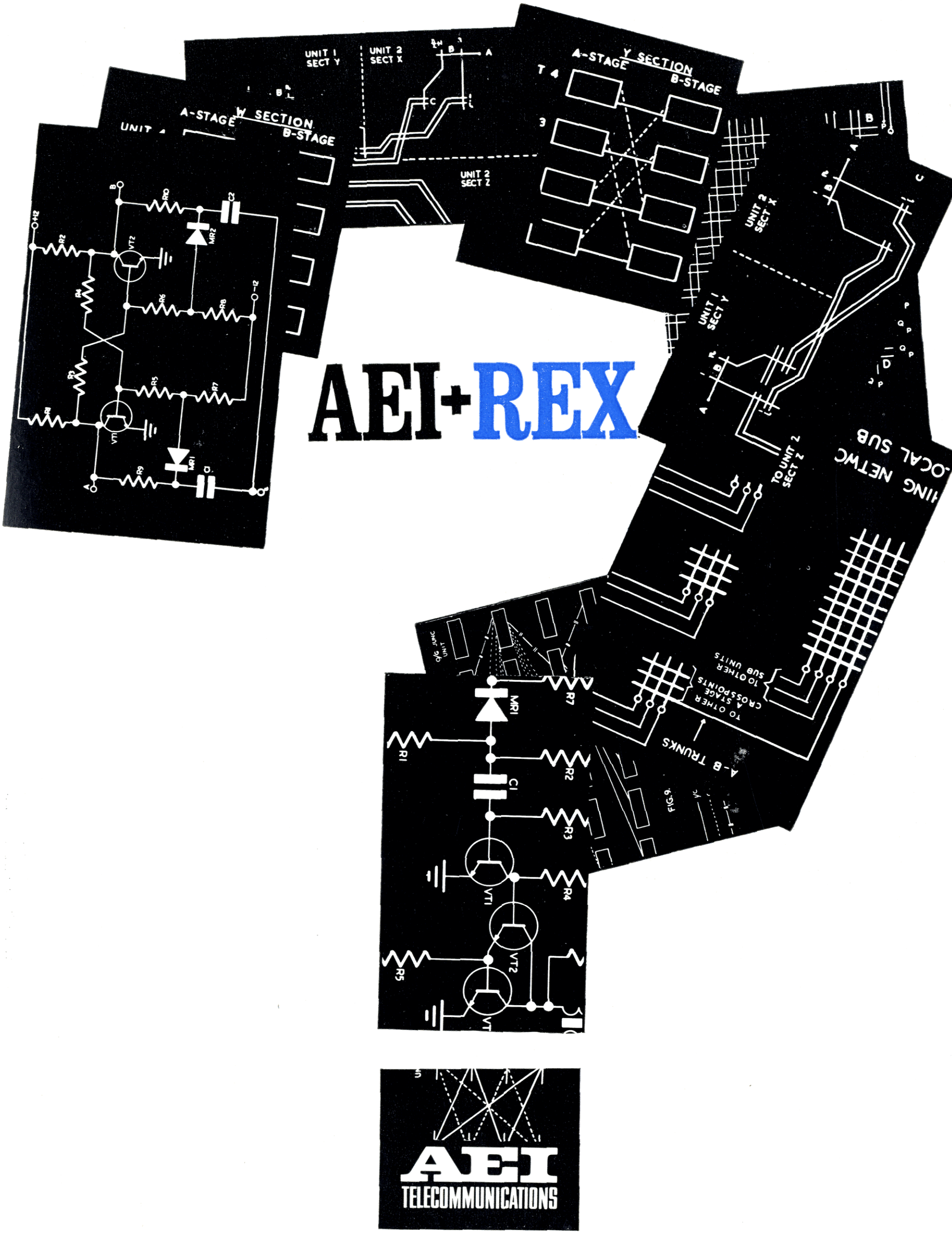
AEI+REX
UNIT 1 SECT Y
UNIT 2 SECT X
UNIT 2 SECT Z
A-STAGE
W SECTION
B-STAGE
Y SECTION
TO UNIT 2 SECT Z
TO OTHER A STAGE CROSSPOINTS
TO OTHER SUB UNITS
A-B TRUNKS
FIG. 9.
AEI
TELECOMMUNICATIONS

INDEX TO ADVERTISERS

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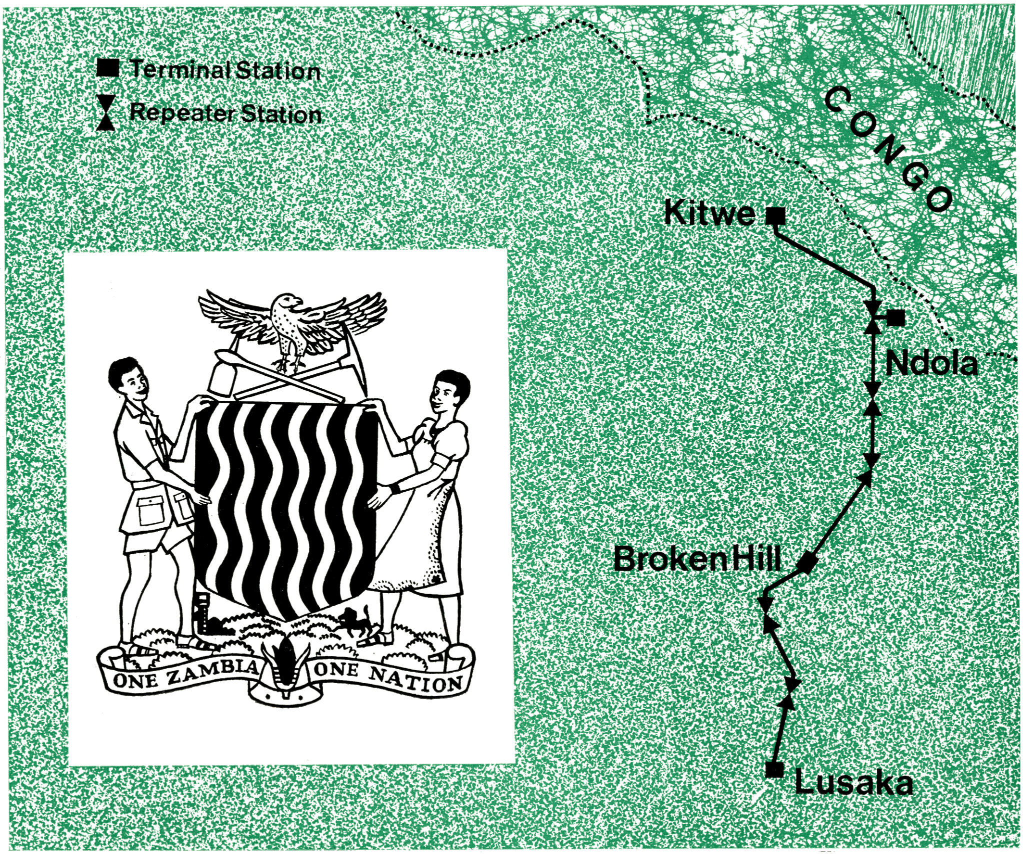
ZAMBIA another vital G.E.C link



In developing this exciting new country the government of ZAMBIA has chosen G.E.C.s most modern all semi-conductored microwave equipment to provide a new £308,000 radio link between Lusaka and Kitwe. Three broadband radio frequency channels will operate in each direction between the capital Lusaka, Broken Hill, Ndola and Kitwe, via five repeaters. One channel will convey a 625-line video signal plus sound channel. Another channel will be allocated for 960 telephone channels. The third channel will act as a protection channel which will automatically replace either of the working channels in the event of a fault.

In addition to the broadband channels, an auxiliary radio channel operating in the 2Gc/s band, and also completely semi-conductored, will provide an engineer's order wire and remote alarm facilities linking all stations.

The G.E.C. equipment for this vital new step in Zambia's progress is identical to that being supplied to the United Kingdom Post Office.

G.E.C. everything for telecommunications

Transmission Division, G.E.C. (Telecommunications) Limited, Telephone Works, Coventry, England