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THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

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The Opening of the Post Office Tower, London

U.D.C. 624.97:621.396.67

ON Friday, 8 October 1965, the Post Office Tower in London was officially opened for service by the Prime Minister, the Right Honourable Harold Wilson, M.P., before an invited audience including three former Postmasters-General (Lord Attlee, the Right Honourable Ness Edwards, M.P., and Lord Hill of Luton), the Minister of Public Building and Works, the Postmaster-General, members of Parliament, and representatives of industry and the press. The ceremony was relayed by a closed-circuit television link between the Tower and Birmingham, where the Lord Mayor, Alderman G. Corbyn Barrow, joined the ceremony.

The Postmaster-General, the Right Honourable Anthony Wedgwood Benn, M.P., after thanking all those concerned with the project, said "the Tower symbolizes the 20th century, and it is appropriate that the first Prime Minister to have made science and technology his special interest, should be invited to open the Tower."

The Prime Minister emphasized that work in the Public Service, of which the Tower was a typical example, could be exciting and demanding, and dubbed the tower "Big Bedford," the 20th-century equivalent of Big Ben, after its architect, Mr. Eric Bedford, Chief Architect of the Ministry of Public Building and Works. He then made the opening call, via a microwave radio-relay link, to the Lord Mayor of Birmingham, who welcomed the valuable addition to the communications to the Midlands and assured the Prime Minister that Birmingham, in its turn, would be proud of its Post Office Tower now nearing completion but, alas, without a restaurant. In repartee, the Prime Minister invited the Lord Mayor to the Tower restaurant in London, an invitation which was confirmed by Sir Billy Butlin, the restaurateur concerned.

The Tower, and its complex facilities, was then accepted into the Post Office service by the Director of the London Telecommunications Region, Mr. A. B. Harnden, who promised that it would be maintained and employed in the public service in accordance with the high standards set by his telecommunications staff.

At the conclusion of the opening ceremony the Prime Minister and Postmaster-General, accompanied by their wives, toured the building, visiting the Tower and Mercury trunk-switching units and the new television network switching centre, and then unveiled a plaque at the base of the Tower. The tour concluded with an ascent to the restaurant floor at the top of the Tower. Parties of the guests were then conducted on tours of the installations.

Previous articles[1,2] have given full descriptions of the Tower and its radio services, and a further article[3] in this issue of the Journal describes the high-speed lifts. When fully equipped the Tower will provide up to 150,000 trunk telephone circuits and up to 40 television distribution channels, carried over microwave radio-relay systems. The television network switching centre can accommodate up to 400 incoming and outgoing video circuits, of which nearly half are in the course of being provided. All the new radio broadbands operating from the Tower are suitable for either colour television or telephony, and the two types of service share common protection

THE PRIME MINISTER SPEAKING AT THE OPENING CEREMONY

A

channels. At the present time B.B.C. 2 television services are provided to Birmingham, Manchester (serving also Scotland, Northern Ireland and the north-east of England), Norwich, and, by temporary radio circuits, to Bristol and Cardiff, and to the Isle of Wight. A broadband radio circuit of 1,800 telephone channels to Birmingham and Manchester is in service, and a second is in the course of being commissioned. During 1966 a third telephony broadband, plus a television channel (transferred from the existing steel tower), will be put into service to Birmingham, followed, at the end of the year, by three television channels to the Isle of Wight and four to Bristol. In 1967 additional telephony broadbands will open to Folkestone, Southampton and the Goonhilly Downs satellite earth station, together with a Eurovision channel to the Continent via a cross-channel radio link. The build-up of telephony broadbands will continue in 1968 with two more to Birmingham and two, on a new route, to Peterborough and Leeds. Orders are already being negotiated for four more broadbands on the London–Birmingham–Manchester route, and for an additional broadband to Leeds.

The television and telephony services will then be evenly balanced, each having a dozen or so broadbands. Despite the upsurge in telephony requirements, it seems likely that television development will keep this balance between the two services for some years to come. In the words of the Prime Minister "the Tower will be the nerve centre of a system which will help to ensure that both national and international telecommunications will be adequate during the next decade and beyond. It is a magnificent example of British engineering skill, and Post Office enterprise."

S.G.Y.

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[1]KNEE, H., and BALCOMBE, F. G. Museum Radio Tower. *P.O.E.E.J.*, Vol. 55, p. 73, July 1962.

[2]JONES, D. G., and EDWARDS, P. J. Post Office Tower, London, and the United Kingdom Network of Microwave Links. *P.O.E.E.J.*, Vol. 58, p. 149, Oct. 1965.

[3]MARRIOTT, P. E. Passenger Lifts in the Post Office Tower, London. (In this issue of the *P.O.E.E.J.*)

THE PRIME MINISTER AND MRS. WILSON AND THE POSTMASTER-GENERAL AND MRS. WEDGWOOD BENN TOURING THE BUILDING AFTER THE OPENING CEREMONY

New Cables and Distribution Frames for Block-Wired Buildings

E. H. SEYMOUR, A.M.I.E.E.†

U.D.C. 621.315.3:621.316.172

The supersession of paper-insulated lead-sheathed external-type cables necessitated the introduction of a new range of cables for block-wired buildings. In addition, the distribution frames used in such buildings have been redesigned.

INTRODUCTION

THE internal cabling provided in large block-wired buildings is divided into two broad categories. The first, termed the main cabling, consists of a series of main cables emanating from a central point, usually a distribution frame on one of the lower floors, and rising vertically through the floors in a series of vertical wall chases. These main cables, or spurs from them, terminate on distribution cases at various points at the floor levels and virtually form an extension of the external local-line plant. The cables are planned and provided on a development-forecast basis, and local-line-plant records are prepared and held at the appropriate Installation-Control Offices.

The second category consists of the distribution cables which run from the floor distribution cases to the telephone instruments and switchboards. These cables, which have internal-wiring colour coding (i.e. as shown on Post Office N and SA diagrams) are provided under Advice Note* authority.

This article is concerned with the first category, i.e. the main cables, and with a new design of distribution frame.

NEW MAIN-CABLE RANGE

Main-Cable Types Available

The main cables used previously were of the paper-insulated lead-sheathed external type. This was partly because of the affinity with the external local-line plant already referred to, but mainly because only this type of cable provided the necessary range of cable-pair capacity. The supersession of the lead-sheathed cables by polythene-sheathed and polythene-insulated or paper-insulated types, led to the need for a change in the types of cable required for block-wiring purposes. Since the sizes of the new external cables, in terms of pair capacity, were not ideally suited to the needs of block-wiring, and also because polythene cable in long lengths is not permitted inside buildings because of the fire risk (polythene is inflammable), it was decided to introduce a completely new range of cables. The floor distribution cases and the distribution frames on which the main cables terminate have capacities in multiples of 40 pairs, and the new range of cables was made to have the same multiple sequence to enable cable planners to avoid the provision of dead stumped pairs.

The new cables, which have the generic title of Cable, P.V.C., No. 9, are available in the sizes 20, 40, 80, 160 and 320 pairs. The small 20-pair cable is for terminating on a 40-pair distribution case if the latter is used as a cross-connexion point; the effective capacity of the case is then 20 pairs. The cables are p.v.c. insulated and sheathed, the sheath being coloured cream, and have $6\frac{1}{2}$ lb/mile conductors laid up on the unit-pair basis in a similar manner to the conductors in external unit-pair cables, but with 20 pairs to the unit. All cables contain a rip-cord to facilitate stripping the sheath at the cable ends prior to jointing, and, as appreciable lengths of cable are used in large buildings, the specification includes a capacitance-unbalance clause to ensure that crosstalk between pairs is within the required limits.

A larger cable of 640 pairs may be introduced later if field requirements indicate that a larger size is necessary.

Multiple Cable Joints

Ideally, the simplest way of cabling a building is to run separate cables from the main distribution frame (M.D.F.), or its equivalent, up through the vertical wall chases and to terminate each cable, without intermediate joints, directly on to its own particular distribution case. For buildings of moderate height, floor area, or telephone density, this method is practicable and is to be preferred. For buildings having many storeys or larger floor areas, however, this simple method becomes impracticable or expensive, because it requires a multiplicity of small cables in vertical chases, in which there may be insufficient space. Furthermore, excessively large groups of small cables are expensive compared with small groups of large cables. Therefore, for very large buildings the main-cable lay-out has usually to be planned on a tapering basis, and multiple joints become necessary. To make these joints, a series of plastic cable-sleeves and expanding plugs are available.

The cable sleeves are tubes of extruded p.v.c. available in three sizes, one for each of the 80-pair, 160-pair and 320-pair cables. Coupled with these is a range of 12 expanding plugs, identical in general design and purpose with those used on external cables. There are four varieties of plug for each of the 80-pair, 160-pair and 320-pair cables, and they provide for breaking down each of these cables into all the necessary combinations of smaller cables. For example, the 160-pair cable can be jointed to two 80-pair cables, one 80-pair plus two 40-pair cables, or four 40-pair cables, and similarly for the other cable sizes. The plugs and sleeves also make provision for straight joints. Straight joints have not hitherto been a normal requirement of block-wiring systems, and they should still be avoided whenever possible, but, with new buildings already in excess of 30 storeys, straight joints may be unavoidable in some instances because the cable lengths in vertical chases become too long and heavy to handle as one continuous length. Neither straight nor multiple joints should ever be necessary on the 20-pair and 40-pair cables.

The jointing of the cable pairs follows established external practice: the two conductors are twisted together, and then covered with a small plastic sleeve.

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

*Advice Note—A document issued by the Sales Division of a Telephone Manager's office and which constitutes the authority for carrying out installation or other work at a subscriber's or renter's premises.

Securing Cables

In vertical chases the dead-weight of the cables has to be supported. With five cable sizes arranged in groups of up to 10 or more cables, the possible number of different shaped cable-group formations is very large. This makes it impossible to introduce a range of multiple-cable fasteners of fixed shape and at the same time ensure that each cable is securely held. With fixed-shape metal fasteners individual fixing of each cable is the only practicable solution, and for this purpose a range of five sizes of half-round aluminium cable cleats, one for each of the five cable sizes, is available.

A more flexible arrangement, giving secure fixing either for individual cables or moderately sized groups of cables, is the use of nylon straps with back-fasteners. The method of use, and typical applications, are shown in Fig. 1. The back-fastener is first fixed to the wall, the nylon strap is passed through it and then around the cable or cables and finally pulled tight. The inner surface of the strap is serrated to grip the cable sheaths, and once the strap is pulled tight it locks in its buckle and cannot retract. If a strap has to be removed for any reason it has to be cut away and a new strap provided.

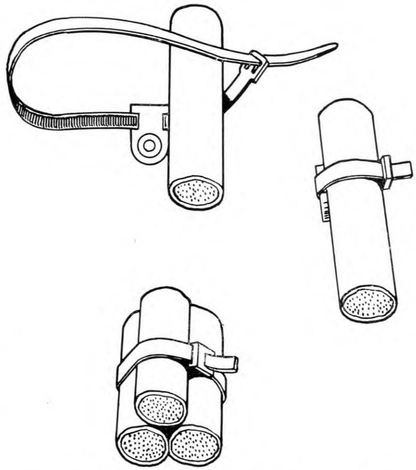
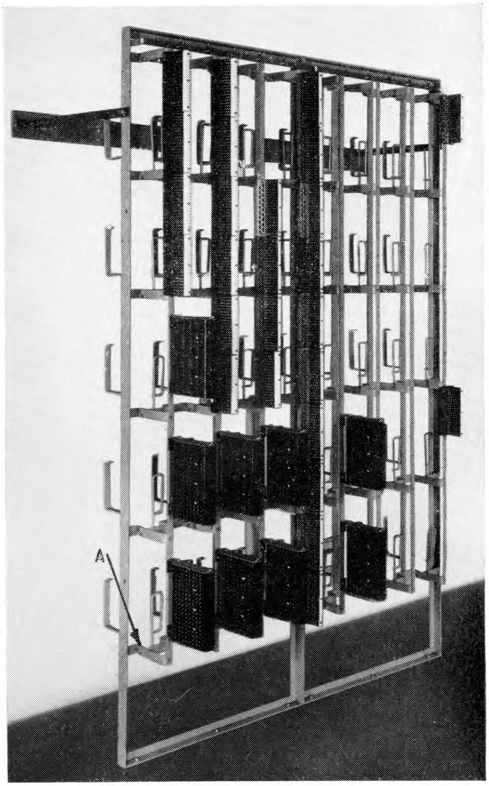


FIG. 1—METHOD OF USING NYLON CABLE STRAPS

Where there are only one or two cables in a vertical chase, the aluminium cleats or the nylon back-fasteners may be fixed directly to the wall. Where there is a large number of cables and multiple joints as well, the preferred method is first to secure a wooden back-board to the wall, and then fix the cleats or back-fasteners to the back-board.

DISTRIBUTION FRAMES

The new distribution frames are of unit rack-type construction, and, because in subscribers' premises such frames have often to be placed against a wall, they are single-sided. Frames of any length are provided by erecting as many units as required side by side. Two sizes of unit are available: one has four verticals each accommodating 200 circuit terminations, giving a total capacity of 800 circuits; the other has two verticals each with a capacity of 160 circuits, giving a total of 320 circuits. The ironwork is enamelled with a cream colour to align with current practice in telephone and telegraph exchanges. Fig. 2 shows two prototype 4-vertical units, uncabled and partly equipped with fuse mountings and connexion strips fitted at random.



A—Recess to accommodate wholly vertical jumpers.

FIG. 2—PROTOTYPE DISTRIBUTION FRAME FOR USE IN BLOCK-WIRED BUILDINGS

The component fixing space on the verticals is a module of 13 in. Into each of these spaces a fuse mounting, or a test jack, or two connexion strips may be fitted, the circuit-termination capacity being 40 circuits in each case. The three types of component can be fitted in any proportion and in any position, and, hence, the frame can be used as an M.D.F., or an intermediate distribution frame (I.D.F.) or a combined M. and I.D.F., as required. The top of the frame carries an earthing bar, and several earth wires may be connected if required on each unit.

For any given number of circuit-terminations per vertical, the maximum number of jumpers in the vertical jumper-field is invariable irrespective of the total length of a multi-unit frame. In the horizontal jumper-field, however, the number of jumpers to be accommodated increases as the length of the frame increases. The horizontal jumpers are run in jumper brackets at the rear of the frame, and, to allow for the variability in the maximum numbers of these jumpers, four different sizes of jumper bracket are available, the particular size fitted depending on the number of unit frames erected. For any particular installation only one size of jumper bracket is fitted, and this size is selected initially to meet the ultimate requirements. The fixing centres for the jumper brackets are the same for each of the four sizes, and, in the event of the ultimate size of frame exceeding the forecasted ultimate size, it is possible for the original brackets to be changed for larger ones without any real disturbance to the existing jumpers.

The jumper brackets are open-topped, and this allows the horizontal jumpers to be simply placed in the brackets throughout the whole frame length, thus avoiding the tedium of having to pass a jumper-end through a series of enclosed loops. This method also avoids the "pulling through" of jumpers and prevents the insulation abrasion attendant upon this practice. However, in the event of the rear of the frame being against a wall because of shortage of accommodation space, this facility is lost, but it is the intention that, whenever possible, the rear of the frame should be spaced at least 18 in. from a wall. The positions of the horizontal jumper brackets in relation to the positions of the vertical jumper rings is designed to ensure that what tension there is on the jumpers, and this should be slight, pulls the jumpers downwards into the bracket, i.e. they cannot override the open top.

With a single-sided frame, as distinct from a double-sided frame, provision has to be made for running jumpers between cable terminations on the same vertical, as well as between different verticals on the same or different horizontal levels. To provide for this extra requirement the rear of the frame has a recessed division on each vertical to accommodate this particular category of wholly vertical jumpers (see Fig. 2).

The 2-vertical unit frame is intended primarily for small buildings or for buildings where the telephone density is low in relation to the building size, as, for example, with some types of council flats. Where multi-unit frames are required, the larger 4-vertical units should normally be used. However, in those situations where the ceiling height is unduly restrictive, the shorter 2-vertical unit may also be used for multi-unit installations.

The 4-vertical unit is 6 ft 8 in. high by 2 ft 3 in. wide, and the 2-vertical unit 5 ft 7 in. high by 1 ft $1\frac{1}{2}$ in. wide. The depth varies, depending partly on the size of the installation, and partly on the component mountings. The following table gives the minimum and maximum limits for various conditions.

Maximum and Minimum Depths of Frame

Equipment of Frame	Minimum Depth (3 units or less)	Maximum Depth (10 units or more)
Frame ironwork only	$9\frac{1}{4}$ in.	$14\frac{1}{4}$ in.
Fitted with connexion strips only	13 in.	18 in.
Fitted with test jacks	14 in.	19 in.
Fitted with fuse mountings	16 in.	21 in.

The single-sided construction, and the simplicity of the open horizontal jumper-field, allow multi-unit frames to be used equally well whether erected in one straight length, or in two or more lengths in tandem around the walls of a room, whether the walls are at right angles or not. Where accommodation is limited or awkwardly shaped this facility may often be advantageous. Also, the small depth of the units when fitted only with connexion strips allows them to be used as an I.D.F., or for any other cross-connecting purpose, and placed *en suite* with apparatus racks in private branch exchange or other apparatus rooms.

The frames are suitable for installations requiring up to a maximum of 15 or so 4-vertical units, i.e. a total capacity of about 12,000 circuit terminations. This should cover most subscribers' installations, and in the few exceptionally large premises where this limit is exceeded it will usually be preferable to use telephone-exchange-type distribution frames.

ACKNOWLEDGEMENTS

Appreciation is expressed to colleagues in the Test and Inspection Branch, Engineering Department, for their co-operation in introducing the new cables, and to the External Plant and Protection Branch, Engineering Department, for their co-operation in the development of the expanding plugs.

Book Review

"Practical Stereophony." H. Burrell Hadden. Iliffe Books, Ltd. 159 pp. 134 ill. 37s. 6d.

This is a most interesting and useful book by an instructor in the B.B.C. It begins with a review of the theories of directional hearing and the creation of stereophonic effects. Then, after chapters on the historical background and technical production, there is a section on the fascinating topic of the production of stereophonic effects from monophonic sources, called pseudo-stereophony.

The choice and positioning of microphones for stereophonic broadcasting and recording are fully described for all kinds of music, from "pop" groups to symphony orchestras, and for opera and drama. There follow chapters on the various methods for recording and broadcasting.

The book then deals with domestic recording and reproduction. Simple, high quality, valve circuits which the amateur can build for himself are described in detail, including every component value and the precise layout for chassis and panels. The layout of rooms for best results is discussed, including possible acoustic treatment of the walls, the use of curtains and the final balancing of the system. The last chapter deals with the reproduction of stereophony in large auditoria.

The style is very readable and clear with no loss of precision; the diagrams are many and informative. This book would serve alike as an introduction to the serious study of stereophonic effects and as a practical guide for the amateur enthusiast.

A.N.R.

Passenger Lifts in the Post Office Tower, London

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U.D.C. 624.97.026.6:621.396.67

A brief description of the two passenger lifts in the Post Office Tower is followed by information on the special equipment needed because of the high speed, long travel and large number of floors served.

BASIC REQUIREMENTS AND LIMITATIONS

An outline description of the lifts in the Post Office Tower has already been given in this Journal,[1] but to make the present article reasonably self-contained the basic details are repeated below. Although the two lifts are primarily passenger lifts they will be continuously and heavily used for a wide range of work. This includes transportation of:

(*a*) the public to the high-level observation floors,
(*b*) customers to the high-level restaurant,
(*c*) staff to the public floors, restaurant and kitchen,
(*d*) kitchen supplies,
(*e*) Post Office staff and visitors to the operational floors and aerial galleries,
(*f*) aerials and equipment to the aerial galleries,
(*g*) equipment racks to the operational floors, and
(*h*) maintenance staff and their equipment to all floors.

The number, size and disposition of the lifts were largely dictated by structural limitations. The space available in the central concrete core was sufficient for two lifts, each rated to carry 15 passengers or a 2,250 lb load in a car 6 ft 3 in. deep by 4 ft 6 in. wide, and having a 3 ft 6 in. wide entrance. Although the entrance height is only 7 ft the lift cars have been made 12 ft high to enable large aerial sections and tall equipment racks to be carried.[2] A removable ceiling at 7 ft 9 in. high preserves reasonable internal proportions when the car is carrying passengers. The main duty of the lifts will be transporting passengers from the public entrance (first floor) to the high-level observation and restaurant floors. Because the total travel is 539 ft and there are 30 entrances to serve, a contract speed of 1,000 ft/min was adopted. This is the highest speed so far used in this country, and it enables a top-to-bottom non-stop journey to be made in about 40 seconds.

LIFT MACHINES, ROPING AND GUIDING

The lift machine is gearless; that is, the driving sheave, which is 38 in. in diameter and 13 in. wide, is mounted directly on the motor shaft and there is no reduction gear. This means that the 90 h.p. d.c. lift motor rotates at only 100 rev/min.

The machine is mounted in the motor room over the lift well, and the lift car and the counterweight are suspended by six steel-wire ropes which pass over the driving sheave. In order to give sufficient traction and avoid excessive rope slip the six ropes are double wrapped around the driving sheave and an auxiliary pulley fixed below the driving sheave. Thus, each rope passes over the driving sheave twice, in adjacent grooves. The offset of the rope to enable this to be done causes no difficulty as the offset angle (rope lead) is only about 0·3°.

The car and counterweight are balanced when 43 per cent of the contract load is in the car (1,000 lb). The suspension ropes weigh over 1 ton, however, and if simple suspension of car and counterweight were used the balance would vary considerably as the car travelled between ground and top floors, with consequent appreciable variation of lift performance. Compensating ropes are, therefore, suspended from the underside of the lift car to the underside of the counterweight to eliminate any out of balance due to the weight of the suspension ropes. The complete roping arrangement is illustrated in Fig. 1, and Fig. 2 shows the lift machine

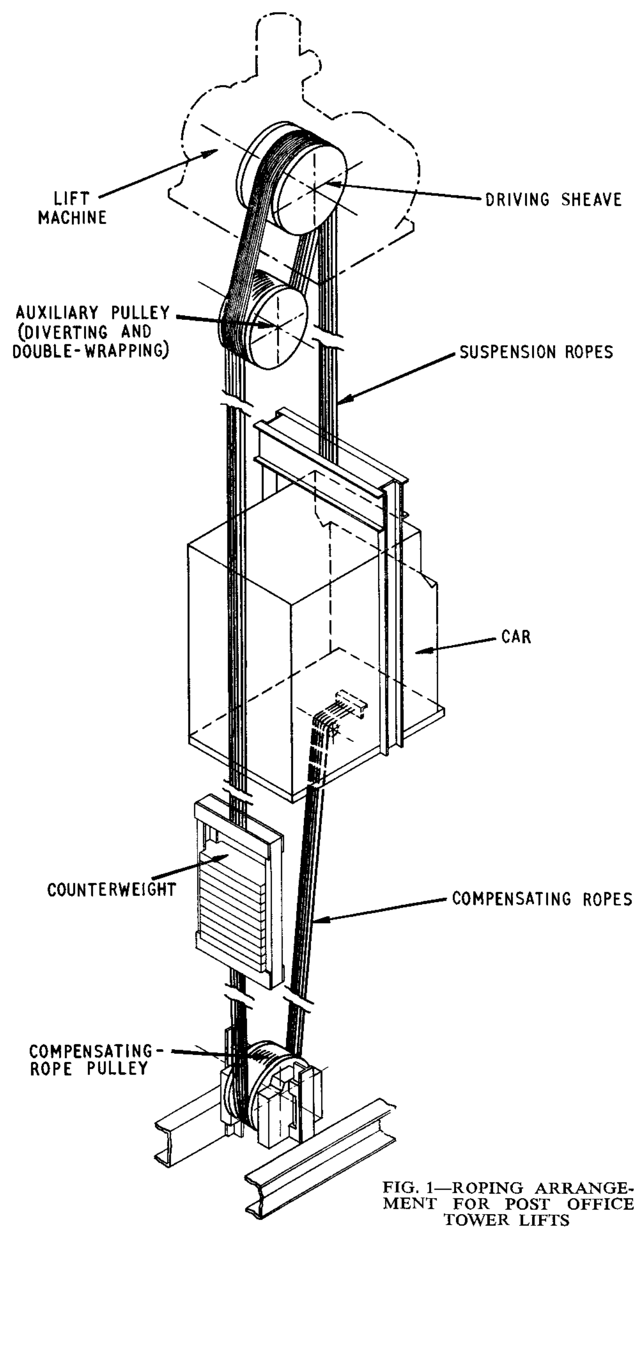


FIG. 1—ROPING ARRANGEMENT FOR POST OFFICE TOWER LIFTS

†Power Branch, E.-in-C.'s Office.

[1]Knee, H., and Balcombe, F. G. Museum Radio Tower. *P.O.E.E.J.*, Vol. 55, p. 73, July 1962.

[2]Jones, D. G. and Edwards, P .J. Post Office Tower, London, and the United Kingdom Network of Microwave Links. *P.O.E.E.J.*, Vol. 58, p. 149, Oct. 1965.

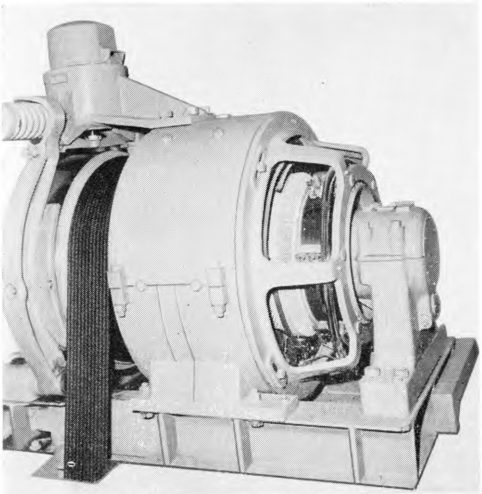


FIG. 2—LIFT MACHINE

with the six ropes each passing twice over the driving sheave.

Allowance has been made for variations in the lengths of the lift wells due to concrete shrinkage and to thermal expansion and contraction of the tower; the total change is expected to be about 4 in. The guide rails for the car and the counterweight are anchored by special clips. These exert constant pressure on the guide rails, holding them firmly to the well but allowing the rails to move through the clip as the well expands or contracts.

SAFETY DEVICES AND FIRE PRECAUTIONS

The principal safety devices on any lift are:

(*a*) an electromechanical door lock at every landing entrance to ensure that all the landing doors are closed and locked except at the landing at which the lift car is standing,

(*b*) an electric switch on the car door to ensure that the lift car cannot travel unless the car door is closed,

(*c*) a governor in the motor room and safety-gear on the car to ensure that the lift car is brought to rest promptly but gradually if it overspeeds,

(*d*) buffers in the pit to ensure that no harm nor damage results if the lift car over-runs either terminal floor, and

(*e*) overload relays and timers to protect the equipment against misoperation, overload or stalling.

All these devices are, of course, provided on the Tower lifts. In addition, because the lift well is curved on the landing side and there is, therefore, a large gap between the car and the well wall, the car doors are arranged to be locked while the lift car is travelling between floors. Furthermore, the governor has three switches. The first operates at 1,100 ft/min to reduce the car speed electrically to 500 ft/min; the car then travels at the reduced speed to the next stop, where it cannot be re-started until the governor switch is re-set. The second switch operates at 1,200 ft/min and stops the car electrically at once; at 1,250 ft/min the governor trips mechanically and operates the safety-gear on the lift car. The safety-gear is of the type which, when actuated, exerts constant pressure on the guide rails, and this ensures a smooth but rapid stop. The third switch on the governor operates at 800 ft/min but is ineffective until the lift car is within about 20 ft of either terminal floor. Thus, the lift car is stopped promptly if it approaches within 20 ft of a terminal floor at more than 800 ft/min.

The buffers beneath the car and counterweight are oil damped, and provide smooth but rapid deceleration with a peak of less than 3*g*.

Fire precautions consist of preventing smoke finding its way between floors via the lift well. This is done by enclosing each landing entrance in a small lobby with ordinary hand-operated swing doors. A vent to the open air is provided in the top of each lift well to enable any smoke in the well to disperse. Fireman's switches are provided at the first-floor entrance to enable a fireman to obtain priority use of either lift for fire-fighting purposes. If there is a general fire alarm the lift attendant is warned by an illuminated signal in the car.

LIFT-MOTOR CONTROL

The high running speed of the lift makes it essential to use high rates of acceleration and deceleration, but these must be carefully controlled to give a smooth ride. Fig. 3 shows a typical variable-voltage (Ward-Leonard)

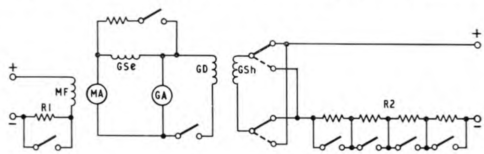


FIG. 3—TYPICAL VARIABLE-VOLTAGE MOTOR-CONTROL CIRCUIT

motor-control circuit for lifts. Speed control of the lift motor is effected by varying the output voltage of the generator, GA, supplying the lift-motor armature, MA. The generator output voltage is varied by adjustment of the generator shunt field (winding GSh). A generator series-field winding, GSe, is included in the loop circuit to compensate for variations in the load current. In practice, several additional refinements are incorporated: a differential-field winding, GD, is switched in for a short period during levelling to "kill" any residual generator voltage; the generator series-field winding is provided with diverters to allow different compounding at top speed from that at levelling speed; the strength of the lift-motor field (winding MF) is usually fixed until the generator output voltage has reached its maximum, at which point it is weakened slightly to give the final acceleration to full speed.

For the Tower lifts the above system is unsuitable for the high rates of acceleration and deceleration required, because:

(*a*) the natural rate of change of the generator output voltage is too slow,

(*b*) it is difficult to provide a generator series-field winding of adequate current rating in the space available in the generator frame, and

(*c*) changes in the resistance of the series-field winding, resulting from temperature changes, can cause instability in the generator output voltage.

The arrangement adopted to give a stable generator output voltage that will respond rapidly to any change in input signal is shown in Fig. 4. Control is effected by

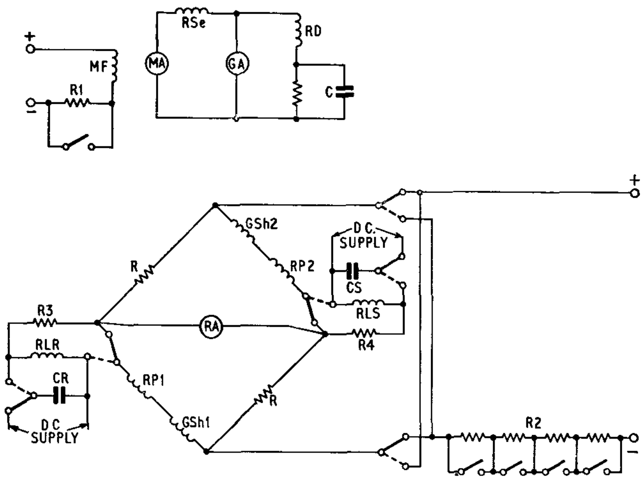


FIG. 4—VARIABLE-VOLTAGE MOTOR-CONTROL CIRCUIT USING REGULATOR

a small d.c. regulator generator driven independently at constant speed, with an armature, RA, and four sets of field windings arranged as follows.

(*i*) Field windings RP1 and RP2 are a pair of low-resistance running-pattern field windings in series with the main generator shunt-field windings GSh1 and GSh 2, respectively.

(*ii*) Field windings RLR and RLS are low-resistance levelling-pattern field windings inserted, during levelling, in series with field windings RP1 and GSh1 and field windings RP2 and GSh2, respectively, in two arms of a bridge circuit.

(*iii*) Field winding RD is a high-resistance differential-field winding shunting the main loop circuit.

(*iv*) Field winding RSe is a low-resistance field winding in series in the main loop circuit.

The running-pattern and differential fields are pre-set so that they neutralize each other when the loop-circuit voltage has reached the required value. Resistor R2 is automatically set to a value corresponding to the final lift speed required for the particular journey selected. The running-pattern fields then excite the regulator, which has a short time-constant, and its output voltage builds up rapidly. This helps the generator voltage to rise quickly. As the generator voltage grows the differential field increases until, when the generator voltage has reached its required value, the differential and running-pattern fields neutralize each other and the regulator output is zero. Thus, the differential and running-pattern fields tend to hold the generator voltage stable but hasten any required change to or from that voltage.

The regulator series field produces a change in the regulator output voltage which is proportional to the loop load current, thus compensating for any variation of lift-motor load, whether the lift car is lifting or overhauling.

Acceleration and deceleration are achieved by varying the value of resistor R2 in steps; this is described more fully in the signal-control section. The inclusion of capacitor C in series with the regulator differential-field winding smooths the change in the generator voltage, thus giving smoother acceleration or deceleration.

The lift-motor field is kept constant except when the lift is set to travel at maximum speed. The final acceleration step is then achieved by inserting resistor R1 in the circuit.

The regulator levelling-field windings RLR and RLS are inoperative except during levelling, and are then energized by the discharge of capacitors CR and CS. These capacitors are charged from an external source while the lift is running and discharged at the appropriate time after the lift car has been slowed to levelling speed. Field winding RLR is given a high current, short-duration reversing pulse which causes the regulator output to produce a reverse voltage in the main generator. This brings the lift car to rest electrically without the use of the brake. Field winding RLS is given a longer pulse which prevents the lift car reversing due to the reversing pulse and holds the car at floor level until the brake is applied.

Should the car run more than $\frac{1}{2}$ in. past the floor, means are provided to reverse the car slowly to floor level. Also, because the suspension ropes are very long, the car will move from floor level during loading or unloading as the rope stretch varies. As soon as the car is $\frac{1}{2}$ in. from floor level, a re-levelling circuit is energized to bring the car back to floor level. A high torque is required initially to overcome friction, especially if the lift motor has been idle for some time before levelling is required, and this torque is obtained by switching in the levelling fields and by setting the bridge supply voltage to a high value, i.e. by reducing the value of resistor R2. A silicon controlled rectifier (SCR in Fig. 5) connected

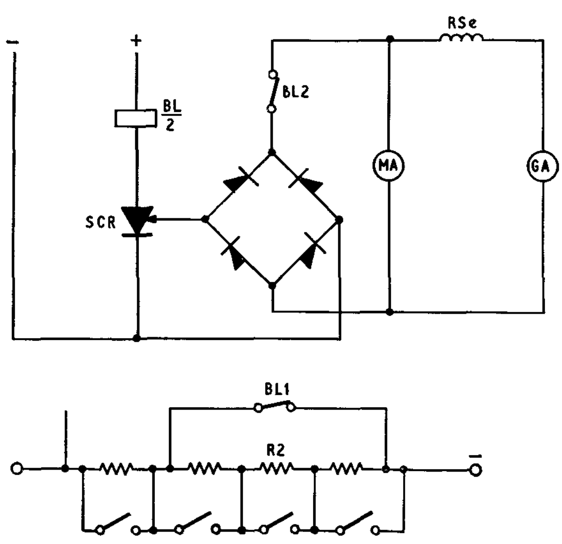


FIG. 5—ESSENTIAL DETAILS OF RE-LEVELLING CIRCUIT

across the lift-motor armature triggers when the loop voltage reaches a pre-determined value and, by operating relay BL, increases the value of resistor R2 to a more moderate value. This results in quick response to a re-levelling signal, but, as the brake is partially applied throughout the operation, the actual re-levelling is smooth. The full-wave rectifier ensures that a positive

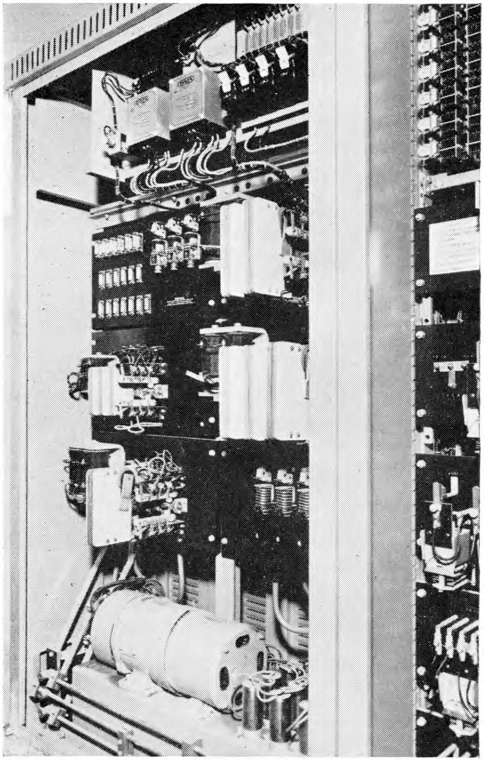


FIG. 6—LIFT-MOTOR MAIN CONTROLLER WITH REGULATOR

voltage is applied to rectifier SCR irrespective of the loop-voltage polarity. Fig. 6 and 7 show the motor-control cubicle for one lift, with the regulator generator at the bottom of the cubicle illustrated in Fig. 6.

SIGNAL CONTROL

Each lift operates independently of the other on directional collective control. This is the normal system whereby landing and car calls are registered at random but answered in sequence: first, all calls for the UP direction, then, all calls for the DOWN direction. The lift can be operated with or without an attendant in the car.

The Express Lift Company's standard controller incorporates a floor selector to determine which way the lift car shall travel and which floor it shall stop at next. The selector is a multi-contact rotary switch operated by two driving magnets, one for each direction. The driving magnets are operated by an "inductor" fitted on the car top. Every time the inductor passes one of a series of steel plates fixed in the lift well a contact in the inductor closes. Closing of this contact energizes one of the driving magnets. Several sets of contacts are fitted to the selector, but, for the purpose of describing the basic system, mention will be made only of the control contacts, S, and the position contacts, P. The S contacts

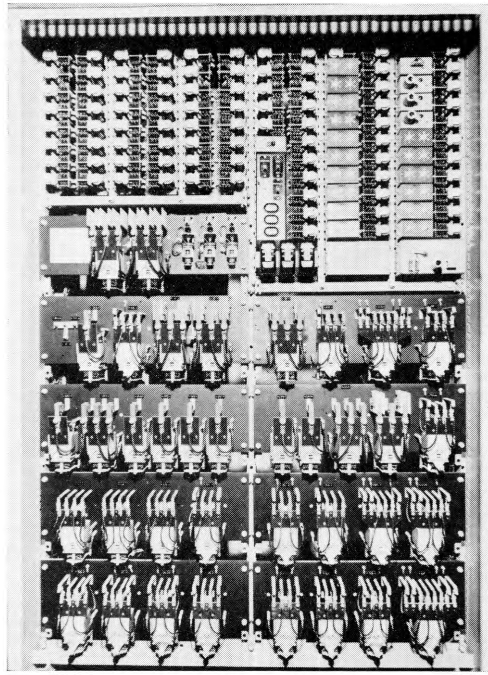


FIG. 7—LIFT-MOTOR CONTROLLER

establish the direction of travel, and the P contacts initiate car slow-down as it approaches a floor at which it is to stop.

Fig. 8 shows a typical arrangement for a normal

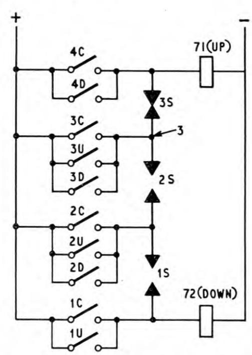
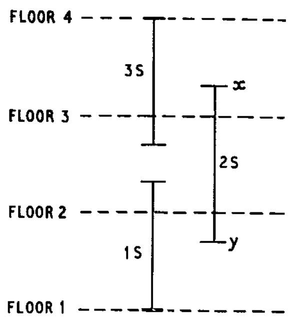


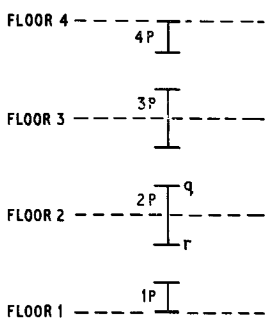
FIG. 8—BASIC SIGNAL-CONTROL CIRCUIT

collective-control lift with the car standing at the second floor. Contacts 3C, 3U and 3D are the contacts on the third-floor car relay, and landing UP and DOWN relays, respectively. When a call is registered by a third-floor car button or landing button being pressed, the appropriate relay closes, holds via one of its own contacts, and applies a positive potential to point 3 on the circuit. Fig. 9(*a*) shows that when the car is standing at the



Contacts 1S, 2S and 3S on the selector are open while the lift car is in the sections of the lift well indicated, e.g. contact 2S is open while the lift car is between points x and y.

(*a*) Control Plates (S)



Contacts 1P, 2P, 3P and 4P on the selector are closed while the lift car is in the sections of the lift well indicated, e.g. contact 2P is closed while the lift car is between points q and r.

(*b*) Position Plates (P)

FIG. 9—ARRANGEMENT OF INDUCTOR PLATES IN LIFT WELL

second floor, contacts 1S and 2S are both open. Thus, the closing of a third-floor relay contact, such as 3C, results in a positive potential being applied to relay 71, which operates to initiate car travel upwards. Also, while any car or landing calls for floors above the car remain, relay 71 remains energized and the car continues to make upward journeys. Similarly, relay 72, if energized, will initiate downward journeys after all calls above the car have been answered.

Fig. 9(*b*) and Fig. 10 illustrate the function of the P contacts. Fig. 9(*b*) shows that the P contact for a given floor closes only while the car is within the slowing zone of that floor. Fig. 10 shows the simplest arrangement of three floors, with the car in the slowing zone of the second floor, i.e. with contacts 2P closed. Slow-down is initiated by the operation of one of the relays 78, 79 or 80. Stopping at the next floor is then automatic. Contact 83 is operated to the UP or DOWN position according to the direction for which the car is set. It will be seen that when the car enters the second-floor slowing zone, contacts 2P close. If the car is travelling upwards and call relay 2C or call relay 2U is energized, slow-down relay 78 or 80 will be energized and the car will stop at the second floor. If call relay 2D is energized, slow-down relay 79 will be energized on an UP journey only if no call exists above the second floor, i.e. if neither relay 3C nor relay 3D is energized. Thus, the operation of relay 79 not only initiates slow-down but also signals that the car will reverse its direction of motion for the next journey.

On high-speed lifts there is the complication that a

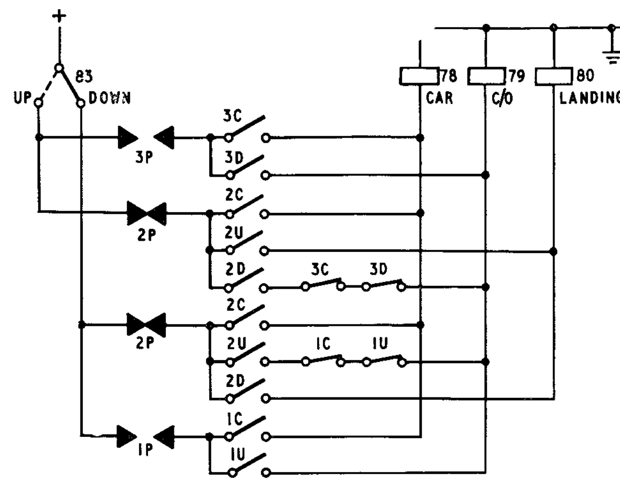


FIG 10—BASIC SLOWING AND DIRECTION CIRCUITS

distance of several floors is needed to accelerate up to full speed or to decelerate and stop. For the Tower lifts nearly five normal floors (each 15 ft) are needed, so that the lift car is set to accelerate to 1,000 ft/min only if the next stop is at least five normal floors away. For shorter journeys one of three lower maximum speeds must be pre-selected, the precise value depending on the distance to be travelled. Additional floor selectors are provided in order to separate the control and slowing functions of the selectors. There are three sets of selectors, used as follows:

(*i*) The main selector carries the S contacts and performs the normal function, described above, of directing calls to the 71 (UP) or 72 (DOWN) relays.

(*ii*) The advance selector, which carries the P contacts, searches for the next stop and initiates car slow-down in a similar manner to that described above. The selector is, however, set to search up to five floors ahead of the main selector. It advances ahead of the main selector, but in step with it, until it locates a call. It then stops and allows the main selector to catch up.

(*iii*) A count selector is provided for each direction of motion. The selector sets itself to the difference between the main and advance selectors, and its contacts allow the contactors controlling the generator-field control circuits to operate to determine the speed which the car shall be allowed to attain. The rate at which these contactors operate during acceleration is pre-determined by timing. During slow-down, however, the release of these contactors is directly controlled by the count selector, so that the car speed is related to the distance of the car from the landing at which it is to stop. Additional circuits and inductor plates are provided so that the slow-down from top speed is done in nine steps over two and a half normal floors while the count selector steps back only five steps. The table outlines a typical sequence for the car leaving the fourth floor, moving upwards and accelerating to full speed, locating a car call at floor 13, decelerating and stopping.

Special measures have to be taken where the distance between adjacent floors is considerably more than the usual 15 ft. For instance, the two-floor journey from the first to the third floor is over 100 ft, and there is ample distance for the lift car to reach full speed. This part of the well is, therefore, taken as seven sections, and a two-floor journey between floors 1 and 3 is counted by

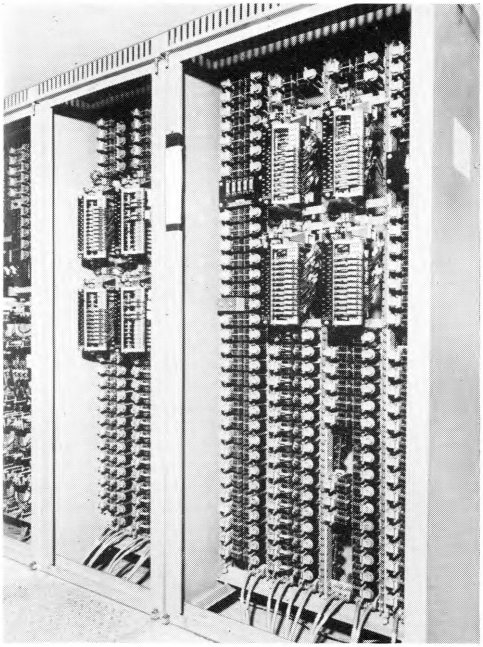


FIG. 11—SIGNAL-CONTROL PANELS SHOWING SELECTORS

Typical Operating Sequence of Floor Selectors

Floor Position of Car	Position of Main Selector	Position of Advance Selector	Position of Count Selector	Event
4	4	4	0	Car call for floor 13 registered
Leaving 4, upwards	4	9	5 (Sets generator field for top speed)	Car accelerates to top speed
8	8	13 (Locates call at floor 13, energizes relay 78)	5 (Starts to step back)	Car passing floor 8 at top speed
10	10	13	3 (Starts to reduce generator field)	Car starts to slow
Approaching 13	13	13	0	Car at levelling speed

the lift controller as seven "floors"; the lift car is, therefore, set to accelerate to full speed. Thus, the lift well is divided into 37 "floors" although there are only 30 actual floors. Fig. 11 illustrates the two signal control panels required for one lift and shows the selectors.

ACKNOWLEDGEMENT

The lifts were designed and manufactured by the Express Lift Co., Ltd., under various patents, and installed by them to a specification produced by the Power Branch of the Post Office Engineering Department. Acknowledgement is made to the firm for permission to publish the design information given in this article. The descriptions of circuit details have been considerably simplified and adapted in order to indicate the principles of operation rather than show completely and accurately every detail of the complete equipment.

Book Review

"Power Travelling-Wave Tubes." J. F. Gittins, B.Sc., A.R.C.S. English Universities Press, Ltd. xii + 276 pp. 198 ill. 50s.

The history of the travelling-wave tube displays—very nearly—the usual 10-year gap between an invention and its commercial exploitation. Kompfner produced his first laboratory model in 1943, and the first tubes to go into operational service were used in the Manchester–Kirk O'Shotts television relay link, which opened in 1952. British manufacturers have continued to be pre-eminent in this field; thousands of tubes are exported to the United States and other countries, and the high-powered tube used at the Goonhilly Earth Station and elsewhere, and which is probably unequalled in the world, was developed by the Admiralty's Services Electronics Research Laboratory.

Mr. J. F. Gittins, the author of the book under review, is a member of the S.E.R.L. staff, and is exceptionally well qualified to discuss the problems and potentialities of the high-power travelling-wave tube. His approach is admirable in its logical sequence, its lucidity, and its fairness. He starts by presenting the Pierce and Slater theories of travelling-wave amplification, and then proceeds to examine slow-wave structures, electron-beam focussing systems, guns and collectors, transitions, severs, and windows. The book concludes with chapters on constructional and measurement techniques. Each step receives both a thorough analytical treatment and consideration of the practical problems. Constructional drawings and test results are liberally deployed.

It is in the area of slow-wave structures, where the requirements for power and bandwidth are in conflict, that this book will probably arouse the greatest interest. The clover-leaf structure (as used in the Goonhilly tube) is treated very thoroughly, but, inevitably, technical developments outstrip publication dates, and the ring-and-bar structure, which receives only slight treatment here, is now the favourite for future developments. Even the simple helix, which the author considers unsuitable for tubes carrying more than 1 kW, may come back into its own.

This book is particularly aimed at the designer of power travelling-wave tubes. A knowledge of the principles of the components of a system is, of course, of great interest to a system designer, but he will find little or nothing here about the factors that really interest him—matters such as bandwidth, amplitude/phase conversion, linearity, and cross-modulation under multi-carrier working; nor will the transmitter designer find much to help him on optimum supply voltages.

This book, then, is admirable in its restricted field, but would be greatly improved if it could be extended to cover the performance of a travelling-wave tube in a communications system. After all, one imagines that there are many more users than designers of power travelling-wave tubes.

D.W.

Planning Telephone Plant for New Housing Estates

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Overhead distribution of subscribers' telephone services on new housing estates continues to be cheaper than direct underground distribution, but an estate developer can make a standard contribution in cash or "kind," worth £5 per dwelling, to have underground distribution. The preferred form of contribution is described, together with some of the difficulties affecting the planning of Post Office plant on new estates, and the desirability of obtaining early notice of all new building projects is stressed. An estate developer can now sell houses with working telephones installed.

INTRODUCTION

THE demand for telephone service has reached unprecedented levels (Fig. 1), but, despite this, progress has been maintained in reducing the number of outstanding applications waiting the provision of external line plant (Fig. 2). Growth of the service is expected to continue at a high rate over the next 20-year planning period (Fig. 3). If the objectives of eliminating the waiting list as soon as possible, greatly increasing the speed of provision of subscribers' services and securing an average return of 8 per cent on the net assets, are to be fully achieved and maintained over the period, the most economical and flexible methods of providing the local-line plant and subscribers' services must be used. The forecast of 17·5 million exchange connexions by 1981 suggests that the residential telephone penetration for the United Kingdom could reach 68 per cent at that date. Whilst this implies a considerably increased penetration into existing lower-grade residential estates, the major planning effort will continue to be concerned with providing telephone plant in new housing estates and development areas, and it is in these that the most difficult conditions are met.

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OVERHEAD VERSUS UNDERGROUND DISTRIBUTION

The approach to the provision of distribution plant in Telephone Areas has varied in the past due to differing conditions prevailing in the various parts of the United Kingdom. This has applied, in particular, to the question as to whether the basic distribution method should be overhead or underground. Hitherto, where a local authority or developer has requested underground rather than overhead distribution of services, a contribution in the form of assistance in the work of providing

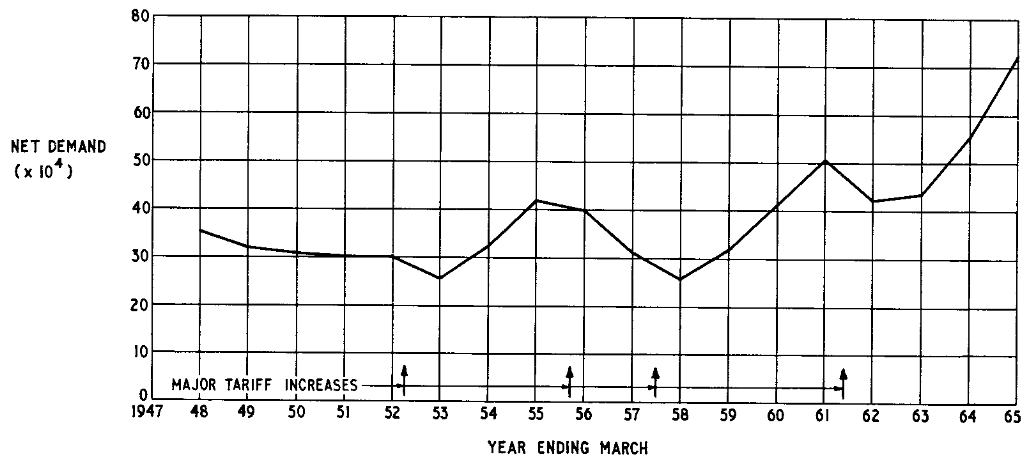


FIG. 1—ANNUAL NET UNITED KINGDOM DEMAND FOR EXCHANGE CONNEXIONS, 1948–1965

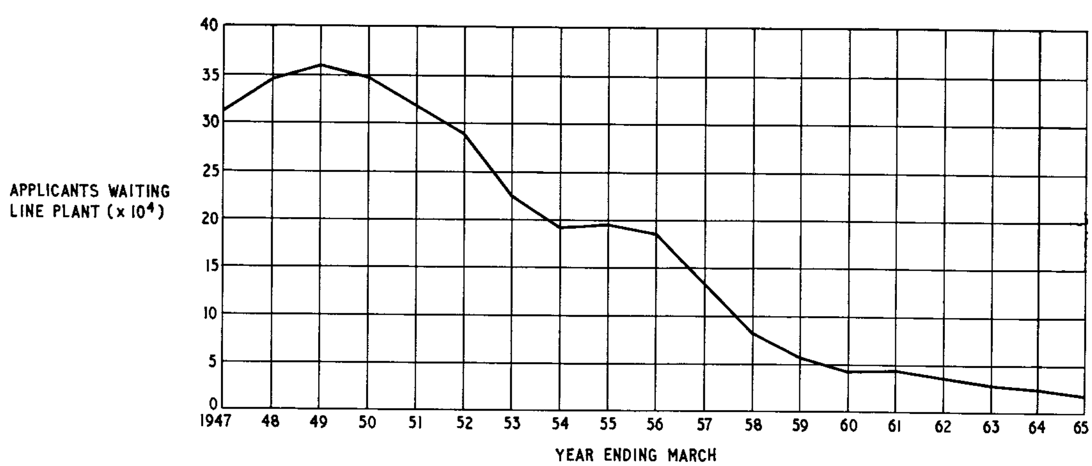


FIG. 2—NUMBER OF APPLICANTS AWAITING PROVISION OF LINE PLANT, 1947–1965

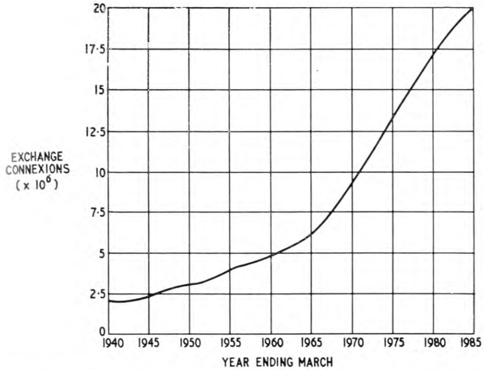


FIG. 3—PAST GROWTH AND FORECAST INCREASE IN NUMBER OF EXCHANGE CONNEXIONS

the underground services, equal to the difference in cost between the two methods, has been required. This necessitated the time-consuming preparation by the Post Office planning engineer of a hypothetical comparison of the costs of the two methods in advance in each case; for various reasons this led, in practice, to minimal contributions only being obtained for provision of underground services in some instances.

A recent re-examination of the costs involved in present-day Post Office construction methods has shown that, for new housing estates, overhead distribution of subscribers' services continues to be cheaper than direct underground distribution. The study showed this to be true for all telephone penetrations up to 100 per cent at the end of the 20-year planning period and for costings carried out on both the inclusive-capital-cost and present-value-of-annual-charges bases.

Following the study, a figure of £5 per dwelling has been adopted as an equitable estimate of the national average difference in cost between the overhead and underground methods, and for new estates this will be used as the basis for assessing contributions in all cases in future.

The main reasons for the differences in cost are as follows.

(*a*) Underground distribution generally necessitates the laying of frontage distribution cables on both sides of the road. Further, since it is not known at the planning stage which houses will require telephones initially and over the years, it is necessary to provide lead-in cables to all houses at the outset to avoid subsequent costly re-instatements of pavings and disturbance of cultivated front gardens after the estates have been completed.

(*b*) Overhead distribution, on the other hand, normally involves the laying of a distribution cable on one side of the road only. The cable is laid as far as is necessary to feed pole distribution points from which overhead connexions to the houses on both sides of the road can be provided subsequently, as required.

These considerations, together with the Post Office responsibility to provide the community with telephones at reasonable cost and at the same time to improve and expand the system rapidly towards the present objectives, have led to the decision that overhead distribution must continue as the standard method of providing subscribers' services in residential housing estates.

OBJECTIONS TO OVERHEAD DISTRIBUTION

Local authorities and private estate-developers are increasingly objecting on aesthetic grounds to overhead distribution of services. The Post Office fully appreciates this concern and is anxious to co-operate to the maximum extent possible in the preservation of local amenities.

To this end, current developments in overhead plant* and the associated house fittings (Fig. 4 and 5) are resulting in a less obtrusive and more acceptable form of construction than the now obsolescent open-wire methods. The new standard is for subscribers' services

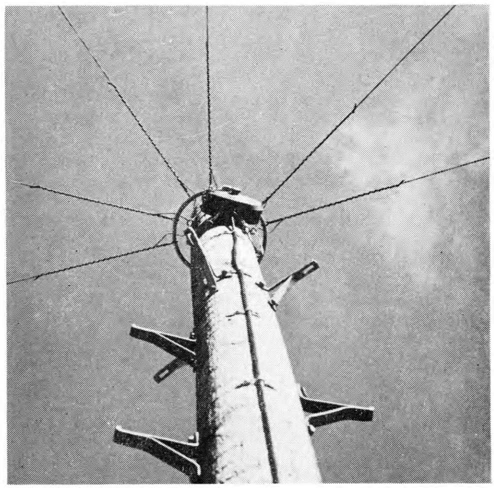
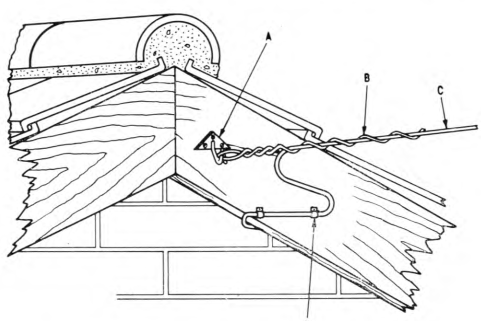


FIG. 4—DROP-WIRE TERMINATIONS ON DISTRIBUTION POLE



A—Bracket No. 22. B—Drop-Wire Clamp No. 3.
C—Drop-Wire Cable No. 3. D—Wiring Cleat No. 5.

FIG. 5—DROP-WIRE TERMINATION ON HOUSE

*HAINES, G. E., and WILSON, W. T. Developments in Overhead Construction. *P.O.E.E.J.*, Vol. 57, p. 260, Jan. 1965.

to be provided overhead to houses, bungalows and 2-storey maisonettes, using light ring-type distribution poles and single spans of the new light drop-wire (Cable, Drop-Wire, No. 3) wherever possible. Underground cables to feed the poles are provided as far as is economically justified, which means that, in general, the only overhead plant will be distribution poles having single spans of drop-wire to the houses. Only in low-penetration estates will it be necessary to feed distribution poles from aerial cable erected between the poles. In siting all poles the wishes of local authorities are met to the maximum extent possible (consistent with the statutory obligations on the siting of poles) even if this means slightly increasing the cost to the Post Office.

CONTRIBUTION FOR UNDERGROUND DISTRIBUTION

Where, nevertheless, wholly underground construction is requested, the wishes of the developer may still be met if he is willing to make a contribution towards the extra cost involved. The Post Office planning engineer then has to negotiate with the developer the form which the contribution will take.

The contribution made by a developer for underground distribution is regarded as assistance towards the extra cost of improving the amenity on an estate. It does not affect the normal charges payable by the telephone subscribers and is in no way a connexion charge.

Contribution by Direct Assistance

The Post Office very much prefers the contribution to be in the form of direct assistance with the actual work of providing the services underground, i.e. by the laying free of charge of the service lead-in cables, the frontage distribution cables in the footpaths, the provision of road-crossing ducts, etc. A contribution is negotiated equal to that total amount of work which the developer would be expected to perform for the Post Office for £5 per dwelling on the estate (for blocks of 2-storey maisonettes and flats only the dwellings on the ground floor are counted).

A proviso is that the minimum contribution in kind will consist of the developer laying the individual service cable to each dwelling from an agreed point on the distribution cable in the street. An earth-wire should also be provided in the same trench, and both service cable and earth-wire led through a lead-in pipe to a flush-fitting connexion box in the wall at an agreed point inside (usually the hall), all work to be done free of charge. The Post Office supply free the cable, earth-wire, lead-in pipe, connexion box and cover, as necessary. This form of lead-in is the one preferred by the Post Office and has the advantage that, if the developer lays the cable and earth-wire in the water-pipe service trench to the house as far as possible, the additional cost to the developer is small.

Cash Contribution

If the developer is unwilling to contribute in kind the Post Office is now prepared, exceptionally, to accept a cash contribution of £5 for every dwelling on the estate other than those in high blocks of flats (again counting only those on the ground floors of 2-storey maisonettes and flats). Cash contribution is far less desirable, because the Post Office has then to carry out the extra work itself. Underground leads-in terminate in internal connexion boxes, and the fitting of these boxes in the fabric of the houses requires the assistance of the developer during the construction of the buildings; the less satisfactory and unsightly method of terminating the underground service cables in external terminal blocks on the outside walls of the houses has, therefore, to be adopted. When telephone service is subsequently required it is then necessary to provide further wiring from the external blocks to inside the houses, and external earth-spikes and the associated wiring may also be necessary.

PROVISION PROBLEMS IN NEW ESTATES

A number of factors are considered by the planning engineer in his approach to the design of a plant layout for a new estate, in addition to the relatively straightforward selection of economic cable sizes and other plant to meet a given forecast telephone penetration. Firstly, the layout of modern estates often permits alternative designs for the distribution-cable layout, and the planning engineer determines the most economical one. The types of plant selected and the degree of protection afforded (and therefore the cost of provision) are often based directly on previous local experience. Where this has been, for example, of the high fault liability of a particular method, such as the initial experiences in some Telephone Areas with directly buried cable, an uneconomic degree of protection has often been given thereafter.

There is an understandable reluctance to risk exposure again to complaints about the scarring of newly surfaced footpaths caused by fault-clearance operations on directly buried cable, even though much of the original trouble could have been avoided with improved local liaison and co-operation and the use of more certain jointing techniques. Nevertheless, such factors are real, and much effort is at present being given to developing means of overcoming economically some current sources of difficulty.

To enable subscribers' services to be provided with minimum delay, the new external plant must be provided by the time houses are occupied, and it should, wherever possible, be the planned permanent distribution network for the estate. Temporary construction to provide early service is wasteful, and it is desirable to limit its use to estates that develop from a direction which would render the initial provision of the permanent plant either uneconomic or impracticable. Successful early installation of the permanent plant, however, requires the closest possible co-operation between the Post Office and local authorities, developers, builders and the other statutory undertakers.

As stated above, for normal forecast telephone penetrations, underground distribution cables are required in the streets (normally in the footway) from which either the overhead pole distribution points are cabled or the direct underground connexions are made to the houses. The present standard is for polythene-sheathed and polythene-insulated distribution cables (Cable, Polythene) to be buried directly in the ground and protected where necessary by strips of expanded metal placed above them when the cables are laid in an open trench. The cables need be provided in duct only at road crossings and some types of carriageway entrance. In footpaths, duct is only required if further cables may have to be laid subsequently to future extensions of the estate.

Construction work on estates often starts with the defining and laying out of the roads by the placing of kerbs on concrete haunches and providing the hardcore carriageway foundations between them. These operations also define the final levels of the footpaths. It is economically desirable to make the maximum use of mechanical aids, such as trench excavators and mole-ploughs, in the provision of distribution cables over the estate, and, if the site conditions are otherwise suitable, the most favourable conditions for this prevail when the cables are laid at an early stage, i.e. as soon as the roads are laid out. At this stage there are fewer obstructions to the cable laying and longer runs are possible. Disadvantages are that the builder may be required to roughly level the footpaths up or down to near the final levels, and there is increased danger of damage to the cables from the subsequent operations of other service undertakers. The cables also have to be re-excavated later to provide the underground leads when the houses are built or feeds to overhead distribution points are required.

There is less liability to damage if the cables are laid at a later stage when the other undertakers' works are completed and their service connexions made, but before the footpaths are finally paved. At this stage, however, the work tends to become disjointed due to the stacking of building materials, etc., and the use of mechanical aids is then less satisfactory.

Many of the problems that arise in providing Post Office plant can be minimized by correct timing of the work. This necessitates the maintenance of very close liaison with the estate developers, builders and other undertakers involved at all stages of the site works.

HOUSING-ESTATE LIAISON OFFICERS

To achieve the high degree of co-operation and co-ordination necessary to ensure that, once site works commence, the telephone plant is installed at the appropriate times as previously planned and agreed, housing-estate liaison officers are being appointed in all Telephone Areas. It is expected that the appointment of the liaison officers will resolve many of the difficulties that have arisen on new estates in the past.

EARLY WARNING OF NEW BUILDING

From the above it is seen to be essential that the earliest possible notice be obtained of all proposed new building estates, preferably as soon as planning consents have been granted. This is to allow adequate time for forecasts to be made of the telephone requirements of the estates and for plans to be prepared of the new external telephone plant required to meet the forecasts. The proposals have then to be agreed with the developers, estimates for the works prepared, the necessary stores ordered and obtained, and the works fitted into the Telephone Area program for execution at the appropriate times, if service is to be provided with minimum delay. The basic early information required is as follows:

(*a*) name and address of developer,
(*b*) position and layout of site,
(*c*) proposed numbers and types of dwellings,
(*d*) estimated starting date of site works,
(*e*) proposed rate of progress of building, and
(*f*) sequence of development.

Whilst each Telephone Area is responsible for obtaining early information about relevant planning consents granted, the Post Office Public Relations Department is currently assisting in this with a publicity campaign designed to encourage developers and local authorities to take the initiative and consult the Post Office at an early stage about the requirements for telephone plant on their estates. The campaign is in the form of direct advertisement, the release of information about Post Office housing-estate policy to architects, builders and local-authority journals, and of providing suitable exhibits at the national architects', town planners' and building exhibitions.

A new booklet entitled "Provision of Telephone Facilities on New Housing Estates" has also been published for issue to architects and developers. The booklet sets out the policy and practice followed in providing telephones for new estates and the basic requirements for proper co-ordination and execution of the work.

ADVANCE PROVISION OF TELEPHONES

It has recently been made possible for developers to be able to sell houses with telephones already installed. Administrative arrangements have been completed whereby the developer may pay the standard connexion charges in respect of properties in which he wishes to have telephones installed in advance of occupation. A purchaser or tenant has then only to make formal application for service and advise the proposed date of occupation; arrangements will then be made for the line to be working immediately he moves in. Requests for advance provision will be accepted provided there is no waiting list in the area and that it is reasonably certain that it will be possible to provide service on occupation of the properties.

The foregoing arrangement is a desirable one since such developers will probably wish also to contribute towards underground distribution, and the new procedure will allow whole estates to be more economically cabled and wired, and the plant to become revenue-earning with minimum delay.

CONCLUSION

Present Post Office policy and requirements regarding the provision of telephone-distribution plant for new housing estates have been briefly described. Planning aspects of some of the difficulties encountered have been mentioned, together with some new methods and procedures being adopted to facilitate plant provision and thereby further the effort towards speedy provision of a more reliable service.

ACKNOWLEDGEMENTS

The author wishes to acknowledge that the work of many colleagues in the Engineering Department and Inland Telecommunications Department of the Post Office is embraced by the subject matter of this article.

A Standard Unattended P.A.B.X.—P.A.B.X. No. 6

A. H. HEARNDEN†

U.D.C. 621.395.25

For small private automatic branch exchanges (P.A.B.X.s) with light incoming traffic it is possible to dispense with the services of an operator and to allow extension users to deal with the routing of incoming calls. The first Post Office standard unattended P.A.B.X. (P.A.B.X. No. 5) was introduced in 1963. This article describes a superseding design (P.A.B.X. No. 6) with improved facilities.

INTRODUCTION

In the conventional private automatic branch exchange (P.A.B.X.), extension-to-extension calls and outgoing exchange calls are connected automatically, but incoming traffic is dealt with by an operator for whom a special position or cabinet is provided. When, however, the installation is small and the incoming traffic is light it is possible to dispense with the operator and to allow extension users themselves to answer incoming calls and to transfer them as necessary. This type of installation, known as an unattended P.A.B.X., is cheaper than its conventional equivalent and has for some time been supplied by telephone manufacturers for the export market. To meet a growing demand the Post Office adopted one of the proprietary designs and introduced it in the autumn of 1963 as the P.A.B.X. No. 5. This design has certain limitations, however, and is to be superseded by the P.A.B.X. No. 6, which has been developed jointly by the Post Office and the manufacturers.

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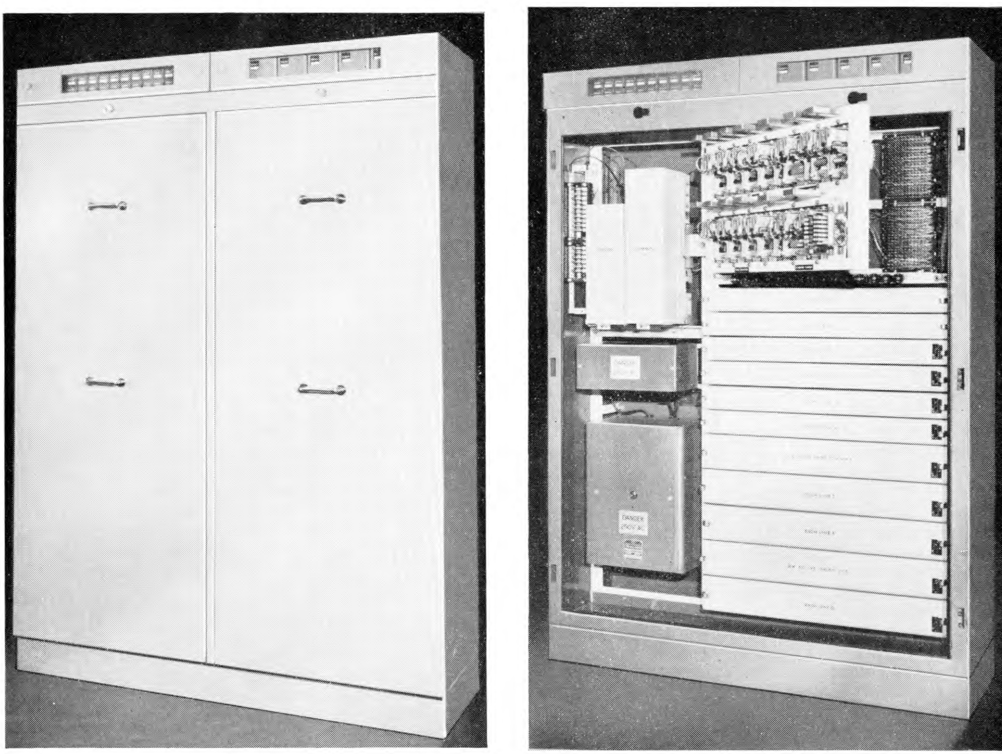
SIZE AND SCOPE OF THE P.A.B.X. NO. 6

All the equipment for the P.A.B.X. No. 6 is contained in a cabinet 3 ft 9½ in. wide, 5 ft 4 in. high and 1 ft 2 in. deep (Fig. 1). All circuits are designed to use standard components: 3,000-type relays and Post Office standard uniselectors, which act as linefinders and final selectors.



(*a*) Cabinet Closed (*b*) Cabinet with Doors Removed

FIG. 1—P.A.B.X. No. 6

The P.A.B.X. No. 6 has capacity for five exchange lines, 20 extensions and four connecting circuits; two inter-switchboard circuits can be provided in place of two exchange lines.

The exchange-line circuits, inter-switchboard-line circuits and connecting circuits are all jack-in-type relay-sets of novel design. In appearance (Fig. 2) they resemble strip-mounted sets, and the wiring terminates on plugs that engage with corresponding jacks wired on the rack. Extension-line circuits are also strip-mounted, but are permanently wired to the equipment rack. A common-service circuit, which occupies two standard 2,000-type relay-sets, is conventionally mounted. Ringing current is supplied from a Converter, Ringing, No. 4[1] and the 50-volt negative d.c. power is supplied from a mains-driven power unit (Power Unit No. 70A).

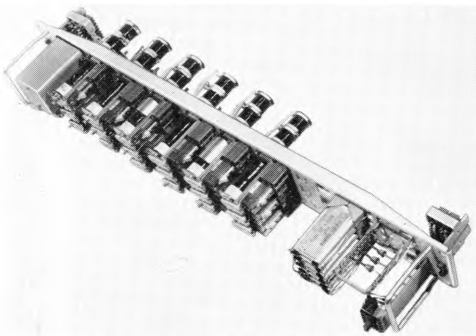


FIG. 2—STRIP-MOUNTED JACK-IN-TYPE RELAY-SET

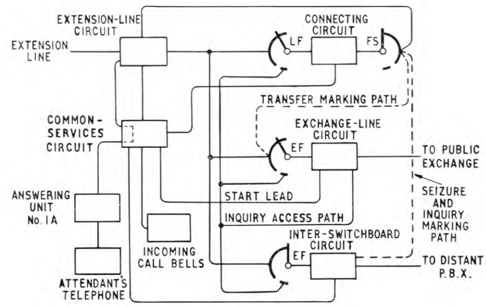
Each P.A.B.X. No. 6, as stocked, is fully wired for the maximum of 20 extensions, four connecting circuits, five exchange lines and two common-services relay-sets. One strip of extension-line relays (extensions No. 21–20) is also provided together with the mechanisms for two connecting-circuit linefinders, two final selectors and two exchange linefinders. Additional equipment is fitted as required to make up a complete installation.

FACILITIES AND CIRCUIT OPERATION

The facilities given by an unattended P.A.B.X. are generally similar to those of the standard P.A.B.X. No. 1 when the latter is switched to night service. Most of the facilities are common to the general pattern of P.A.B.X. design, but some call for particular comment.

Extension-line circuits appear on a common multiple on the banks of the linefinders associated with the exchange-line circuits and inter-switchboard-line circuits and on the banks of the linefinders and final selectors of the connecting circuits. The extension numbering range is 21–20 (10 extensions) and 31–30 (10 extensions). The final selector, which is stepped by dialled pulses, selects the appropriate extension in two stages by discriminating between the initial digit 2 or 3. If the first digit dialled is 2, the final selector remains on outlet 2 until the second digit is dialled; it then steps to the outlet between 3 and 12 corresponding to the required extension in the numbering range 21–20. If the first digit dialled is 3, the final selector is automatically self-driven to outlet 13, where it waits for the second digit to step it to an outlet between 14 and 23 corresponding to the required extension number in the range 31–30.

Fig. 3 shows the trunking arrangements of the P.A.B.X. No. 6.



LF—Linefinder associated with connecting circuit.
EF—Linefinder associated with exchange-line circuit or inter-switchboard-line circuit.
FS—Final selector associated with connecting circuit.
Extensions No. 21–20 appear on outlets 3–12 and extensions No. 31–30 appear on outlets 14–23. These outlets are represented on this diagram by the first (large) sector on each uniselector arc. The remaining five outlets are used for inquiry and transfer purposes, and are represented by the second (small) sector on each uniselector arc.

FIG. 3—TRUNKING DIAGRAM OF P.A.B.X. No. 6

Extension Classification

Extensions are classified as designated or non-designated, according to whether they are or are not allowed to answer and deal with incoming exchange calls. Each class of extension may further be allowed or barred outgoing exchange-line calls, and non-designated extensions may also be allowed or barred transferred incoming exchange-line calls.

The class of an extension is pre-determined by suitable straps in the extension-line circuit that control certain relays in the common-services circuit when the extension user makes a call.

Fig. 4 shows the elements of an extension-line circuit associated with the common-services circuit and the terminals that require to be strapped, as indicated in Tables 1 and 2, for allowing or barring exchange calls to designated or non-designated extensions.

The −50-volt and earth potentials which operate relay LS in Fig. 4 when the extension user seizes the extension-line circuit are derived from the common-services circuit, which disconnects the supply under congestion conditions, i.e. when all connecting circuits are engaged. In Fig. 4 those terminals marked x and z are allocated to designated extensions; terminals marked y are allocated to non-designated extensions.

Extension-to-Extension Calls

Calls between extensions are unrestricted and are set up in the usual way. The first party to replace the handset releases the connexion.

When the handset of a calling extension is lifted the extension line is marked on the connecting-circuit linefinder multiple, and a start signal is applied to the

[1]Moore, M. B., and Gore, J. S. A New Range of Ringing Converters for Subscribers' Apparatus. *P.O.E.E.J.*, Vol. 57, p. 187, Oct. 1964.

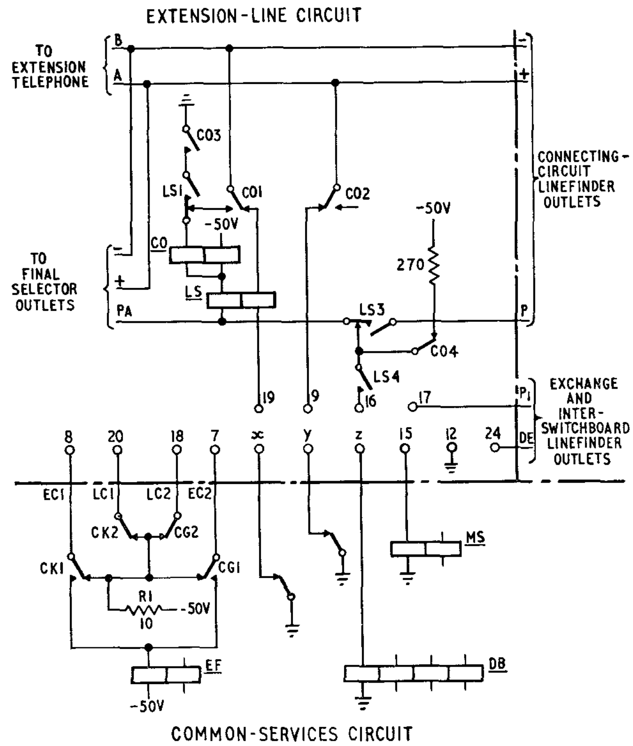


FIG. 4—EXTENSION-LINE CIRCUIT ASSOCIATED WITH COMMON-SERVICES CIRCUIT

TABLE 1
Extension-Line Circuit Strapping for Designated Extensions

Terminals Always Strapped	Additional Terminals Strapped to	
	Allow Outgoing Exchange Calls	Bar Outgoing Exchange Calls
9–x 16–z 16–17 12–24	19–8	19–20

TABLE 2
Extension-Line Circuit Strapping for Non-Designated Extensions

Terminals Always Strapped	Additional Terminals Strapped to	
	Allow Outgoing Exchange Calls	Bar Outgoing Exchange Calls
9–y 16–15	19–7	19–18

common-services circuit to allocate a free connecting circuit. The extension marking signal is a —50-volt potential on the P lead via windings of relays LS and CO in series, and, if the calling extension is designated, the start condition is a —50-volt potential via a 270-ohm resistor on the z terminal to operate relay DB. A similar start signal on terminal 15 operates relay MS if the calling extension is non-designated (Fig. 4). A free connecting circuit is allocated via a start chain controlled by the common-services switch (not shown in Fig. 4). The linefinder hunts for and switches to the marked outlet and dial tone is returned to the caller.

The required extension number is now dialled. If the number is in the range 21–20 the connecting-circuit final selector is stepped directly by the dialled pulses and the wipers are positioned accordingly. If the number is in the range 31–30, then, during the inter-digital pause following the initial digit 3, the final selector is driven past the contacts used for extensions 21–20 and the switch subsequently responds to the second digit dialled. From the foregoing it will be seen that outlets 0, 1, 2, 13 and 24 are not used for extension numbers.

If the called extension is free the connecting circuit applies ringing current, and ring tone is returned to the caller; if the called extension is engaged, busy tone is returned. If the called extension number is spare or is in the handset-off-rest (P.G.) condition, number-unobtainable tone is returned. If the calling extension should delay dialling either the first or the second digit for a period of 25–50 seconds, forcible release is applied under the control of the common-services equipment. The connecting circuit is then made available for further use while the extension-line circuit is held in the P.G. lock-out condition. A connecting circuit is held for the duration of an extension-to-extension call and supplies transmitter-feed current to both extensions from its transmission bridge.

Incoming Exchange-Line Call

When a call is received from the public exchange the exchange-line-circuit calling relay detects the ringing current and causes the common calling bells to ring. The first designated extension user to lift his handset is then automatically connected to the incoming call in the following manner (see Fig. 5).

The exchange-line-circuit relay LA operates to ringing current. Contact LA7 operates relay MH, which holds to the exchange-line ringing-return condition, and relay LA is disconnected from the line. Rectifier MR1 terminal 18 is strapped either to terminal 16 or 17 to suit the type of ringing-return condition at the main exchange. Rectifier MR1 ensures that the flux in both coils of relay MH is always series-aiding.

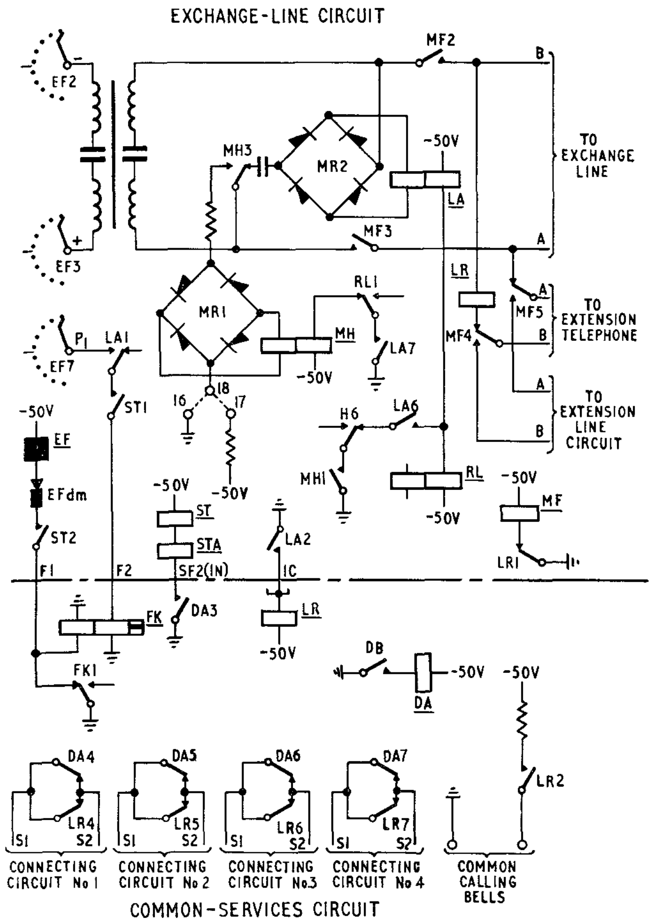
Relay LR, in conjunction with relay DA in the common-services circuit, disconnects the S1 and S2 leads of all the connecting circuits to prevent a connecting-circuit linefinder hunting when the handset is lifted at a designated extension under these conditions.

The designated-extension circuit connects —50 volts via a 270-ohm resistor to give a marking signal on the linefinder P1 outlet. A start condition is extended to the common-services circuit to operate relay DA. Relay ST operates in the exchange-line circuit, causing the linefinder to drive to the marked outlet; relay FK then operates to cut the drive and the designated extension is switched through to the exchange line.

The answering extension then connects the call to the required extension by means of the inquiry and transfer facility. This is only possible if the required extension is not barred incoming exchange-line calls. The answering extension is then free to make or receive other calls.

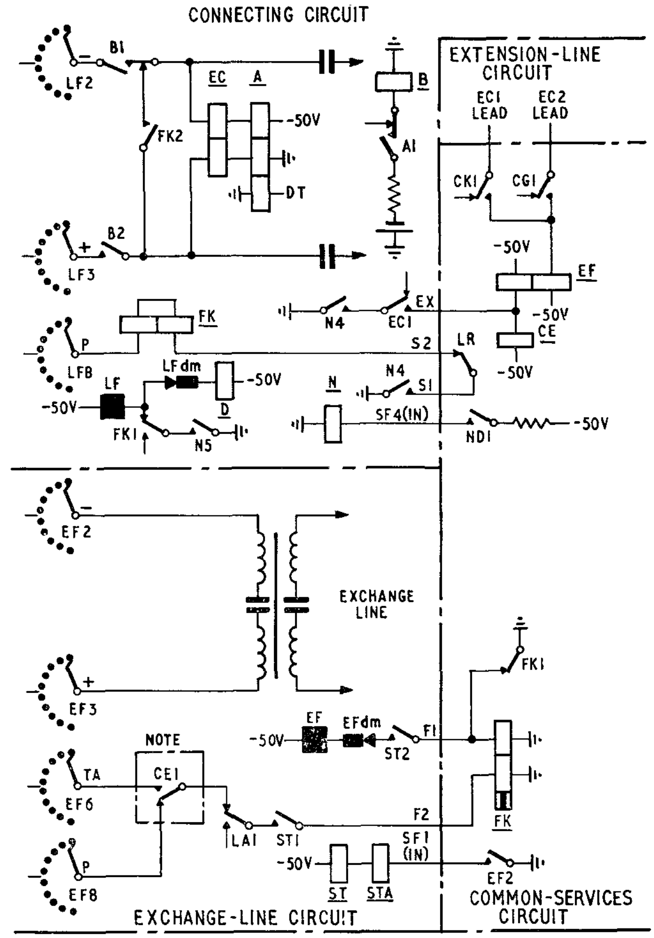
Outgoing Exchange-Line Call

Any extension, designated or otherwise, can be allowed outgoing exchange calls. When the handset is lifted from an extension telephone, calling conditions are set up as for an extension-to-extension call. To obtain access to the public exchange the telephone instrument



EF—Linefinder associated with exchange-line circuit.

FIG. 5—CIRCUIT ELEMENTS FOR INCOMING EXCHANGE-LINE CALL



LF—Linefinder associated with connecting circuits,
EF—Linefinder associated with exchange-line circuit.
Note: Part of common-services circuit.

FIG. 6—CIRCUIT ELEMENTS FOR SETTING UP OUTGOING EXCHANGE-LINE CALL

button is pressed and, provided that the extension is allowed outgoing exchange calls, the connecting circuit detects this condition and marks the outlet on the multiple of the exchange-line-circuit linefinder corresponding to the calling extension. The linefinder hunts and finds the marked extension, which is then switched through to the public exchange and the connecting circuit is released. The exchange-line circuit then automatically sends a calling signal to line. If the public exchange is automatic, dial tone is returned and the P.A.B.X. extension can dial into the public network.

If, when an extension originates a call, all connecting circuits are engaged, it is still possible to gain access to a free exchange line. The telephone-instrument button is pressed in the usual way and operates relay EF in the common-services circuit (see Fig. 4). This causes a linefinder associated with a free exchange line to hunt for the calling extension.

Fig. 6 shows the elements of a connecting circuit and an exchange-line circuit associated with the common-services circuit for the purpose of setting up an outgoing call.

When the handset is lifted the extension-line circuit connects a marking potential to the P lead of the connecting-circuit linefinder multiple and at the same time connects —50 volts from the common-services circuit via contact ND1 to operate relay N in a free connecting circuit. The connecting-circuit linefinder hunts for and switches to the marking condition. When the marked extension is found, relay FK operates. Contact FK1 cuts the linefinder drive and FK2 operates relay A, which in turn operates relay B, and dial tone is returned. When the telephone-instrument button is pressed, relay EC in the connecting circuit operates; relay EC in turn operates relays CE and EF in the common-services circuit. A free exchange-line-circuit linefinder hunts for the extension, which has now been marked by —50 volts on the TA arc.

If all connecting circuits are engaged when the extension user originates the call the congestion relay, CG, will be operated so that when the extension user presses the telephone-instrument button, relay EF only will operate. A free exchange line is seized over the SF1 (IN) lead and the linefinder hunts for the extension, which is now marked by —50 volts on the P arc, as described above.

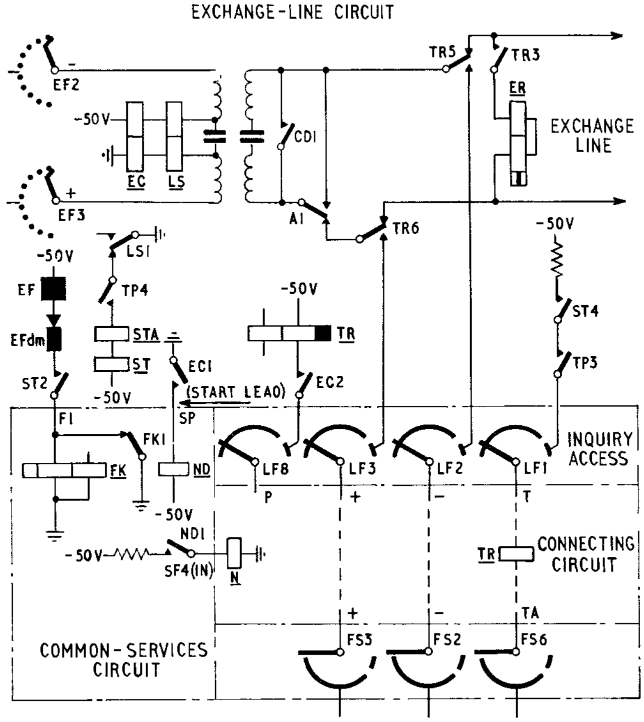
Inquiry and Transfer

In the absence of an operator it is a fundamental requirement than an extension which has answered an incoming exchange call should be able to hold it while an inquiry is made of another extension, and the first extension should be able to transfer the call if necessary. Inquiry access is open to all extensions (including barred extensions), or to an extension or operator over an inter-switchboard circuit. To make an inquiry call the telephone-instrument button is depressed and the appropriate extension or inter-switchboard-line number is dialled. A holding condition is applied to the exchange line during the period of the inquiry. The original extension can return to the exchange line at the conclusion of the inquiry by depressing the button again.

If, during an inquiry, an incoming exchange-line caller should clear, the exchange line is re-seized in order to busy the line at the public exchange, the inquiry call remaining uninterrupted. At the conclusion of the inquiry, when the extension returns to the exchange line forcible-release is applied and the extension reverts to the P.G. condition.

Having made an inquiry call to a second extension, an exchange call may be transferred to the second extension simply by asking the second extension to hold on while the handset is replaced at the original extension, without the telephone button being depressed. Transfer will not take place if the inquiry has been made to an extension which is barred incoming exchange calls, or to an extension or operator over an inter-switchboard private circuit. If, for any reason, transfer does not take place the original extension will be re-rung automatically from the exchange-line circuit.

Fig. 7 shows the basic circuit elements necessary for setting up an inquiry call and subsequent transfer.



EF—Linefinder associated with exchange-line circuit.
LF—Linefinder associated with connecting circuit.
FIG. 7—CIRCUIT ELEMENTS FOR SETTING UP INQUIRY CALL

When the instrument button is depressed, relay EC operates (relay EC is differentially connected). An earth is connected to the start lead (SP) to operate relay ND in the common-services circuit. A marking potential via relay TR is connected to the inquiry access-path (P) lead. A connecting-circuit linefinder hunts for the marked outlet, which, when found, returns dial tone to the extension, and relay TR in the exchange-line circuit operates. Dial pulses from the extension are repeated by the exchange-line circuit relay A, and a holding loop is applied to the exchange line via relay ER. The connecting-circuit final selector is positioned on the required extension outlet.

To transfer the call the originating extension replaces the handset and relay LS releases; provided that the extension or inter-switchboard circuit is permitted transferred calls, relay TP will be operated and a marking potential connected to the T lead, which is extended by the connecting circuit to the TA outlet on the final-selector multiple corresponding to the called-extension outlet, or extended by the inter-switchboard-line circuit to the TA outlet on the inquiry portion of the multiple on which the inter-switchboard-circuit linefinder is standing. The linefinder associated with the exchange-line circuit is driven to find the marking potential, and the call is switched through to the called extension.

Trunk Offering

If, in attempting to transfer a call, the second extension is found to be busy, intrusion is possible by dialling a further digit 1, which overrides the busy condition. A speech path is then established in the connecting circuit and the call may be offered. While the intrusion is occurring warn tone is connected. The designated extension can return to the exchange line by pressing the telephone-instrument button again.

The trunk-offering facility is only available to designated extensions.

Ring-When-Free

If a designated extension makes an inquiry call to a busy extension with the intention of transferring it, the call can be trunk offered as already described. The designated extension receiver may then be replaced, and the call will be "parked" on the required extension, which will be re-rung as soon as the call in progress is terminated. This facility has the obvious advantage, in an unattended installation, of reducing to a minimum the time required by designated extensions for the supervision of incoming calls.

Outgoing Inter-Switchboard-Circuit Call

When an outgoing inter-switchboard call is initiated a connecting circuit is seized in the same way as for an extension-to-extension call. To obtain access to the inter-switchboard circuit the code digit 7 is dialled, so stepping the final selector to the corresponding outlet. An earth is extended over the seizure-and-inquiry marking path (see Fig. 3) to a free inter-switchboard line. A marking signal is returned from the inter-switchboard-line circuit on the TA lead, which is connected through to the T lead to mark the outlet on the extension multiple. The inter-switchboard-circuit linefinder hunts for this marking condition and, when it has found the marked outlet, the extension is switched through directly to the inter-switchboard-line circuit and the connecting circuit is released. If the inter-switchboard circuit is to a P.M.B.X. a calling signal now appears on the distant switchboard; if it is to a P.A.B.X. then dial tone will be returned and the P.A.B.X. No. 6 extension can dial the required number.

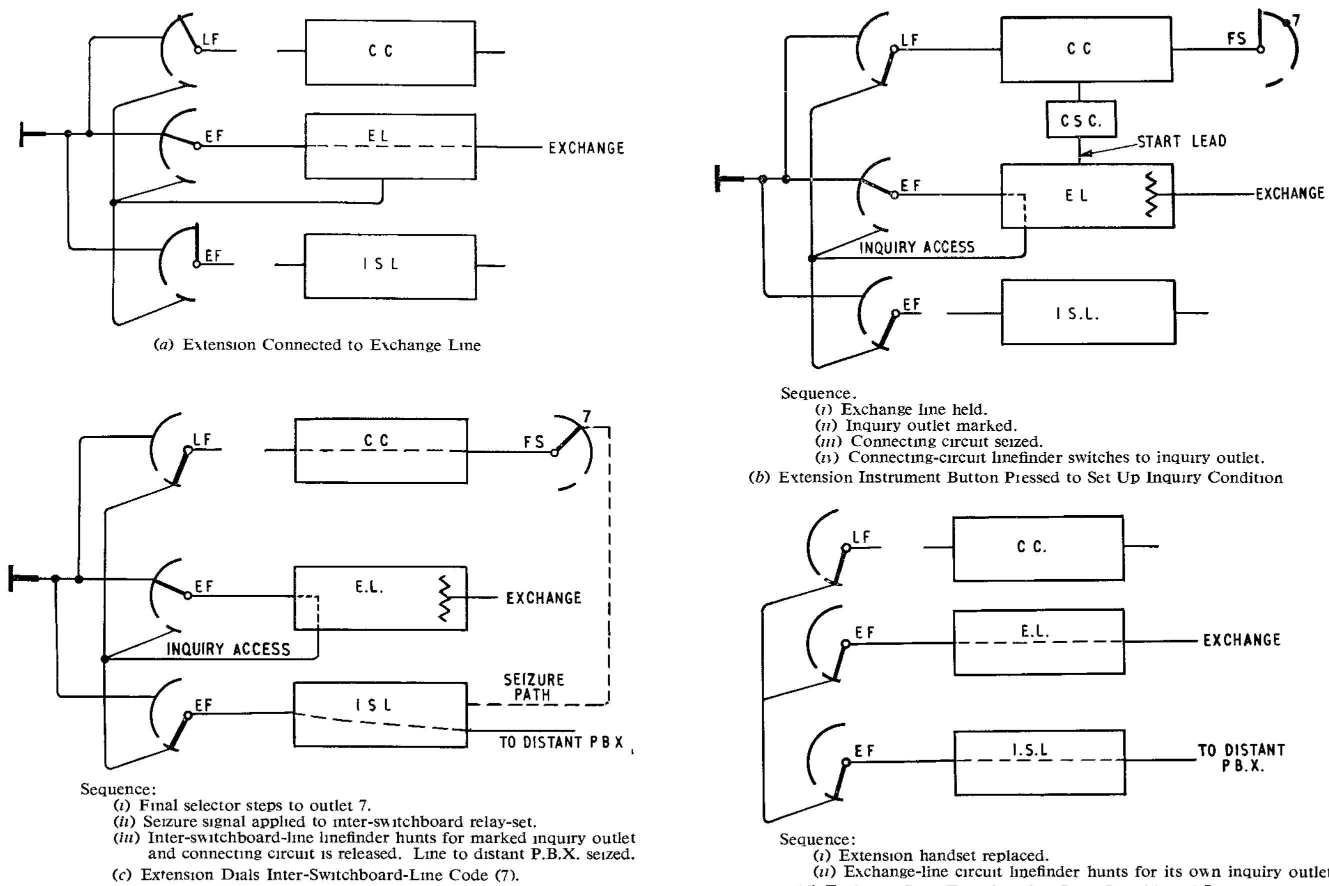
Incoming Inter-Switchboard-Circuit Call

When the circuit is seized by the distant P.B.X., dial tone is returned and the number of the required P.A.B.X. extension can be dialled. The inter-switchboard-circuit linefinder acts as a final selector and, responding to the dialled pulses, steps to the required extension outlet. Ringing current is applied by the inter-switchboard circuit. Supervisory tones—ringing, dial, busy or number unobtainable—are returned to the distant end from the inter-switchboard circuit, as required.

Inquiry and Transfer to an Inter-Switchboard Circuit

The following sequence of events takes place during inquiry and transfer to an inter-switchboard line.

(*a*) An extension user already speaking to a caller on an exchange line wishes to make an inquiry call to an inter-switchboard line (Fig. 8(*a*)) and. accordingly, presses the telephone-instrument button.



(*a*) Extension Connected to Exchange Line

Sequence.
(*i*) Exchange line held.
(*ii*) Inquiry outlet marked.
(*iii*) Connecting circuit seized.
(*iv*) Connecting-circuit linefinder switches to inquiry outlet.
(*b*) Extension Instrument Button Pressed to Set Up Inquiry Condition

Sequence:
(*i*) Final selector steps to outlet 7.
(*ii*) Seizure signal applied to inter-switchboard relay-set.
(*iii*) Inter-switchboard-line linefinder hunts for marked inquiry outlet and connecting circuit is released. Line to distant P.B.X. seized.
(*c*) Extension Dials Inter-Switchboard-Line Code (7).

Sequence:
(*i*) Extension handset replaced.
(*ii*) Exchange-line circuit linefinder hunts for its own inquiry outlet.
(*d*) Exchange Line Transferred to Inter-Switchboard Line

LF—Linefinder associated with connecting circuit. EF—Linefinder associated with exchange line or inter-switchboard line. C.C —Connecting circuit. E.L.—Exchange-line relay-set. I.S.L.—Inter-switchboard-line relay-set. C.S.C.—Common-services circuit. FS—Final selector.

FIG 8—SIMPLIFIED TRUNKING DIAGRAMS SHOWING SEQUENCE OF OPERATIONS FOR AN INQUIRY CALL INVOLVING TRANSFER TO AN INTER-SWITCHBOARD LINE

(*b*) A connecting circuit is seized and a hold condition is applied to the exchange line.

(*c*) The connecting-circuit linefinder switches to the inquiry outlet corresponding to the particular exchange line (Fig. 8(*b*)).

(*d*) The extension dials the routing digit, say 7.

(*e*) The final selector is stepped to outlet 7.

(*f*) Start conditions are applied to the inter-switchboard-line circuit, whose linefinder hunts for the marked inquiry outlet.

(*g*) When the inquiry outlet is found by the inter-switchboard-circuit linefinder the connecting circuit is released and the inter-switchboard-line relay-set is held by the exchange-line relay-set over the inquiry outlet multiple (Fig. 8(*c*)).

(*h*) To transfer the call the extension handset is replaced.

(*i*) The exchange-line-circuit linefinder hunts for its own marking condition on the TA arc.

The connexion from the exchange line to the inter-switchboard line is thus established via the linefinders of both circuits switched to the inquiry outlet corresponding to the exchange line in use (Fig. 8(*d*)).

The facility of subsequent transfer is not provided.

Night Service

The concept of night service on an unattended P.A.B.X. is different from that for other P.A.B.X.s. Night service on the P.A.B.X. No. 6 is essentially a method of altering the classification of extensions to suit the night-staffing arrangements.

By operating the night-service key provided on an allocated designated extension the normal extension conditions may be altered, e.g. extensions which are designated by day can be made non-designated by night, or vice-versa. Similarly, extensions which are barred exchange calls during the day can be given the facility for the night, or vice-versa. It is also possible under night-service conditions to arrange for additional, or different, call bells to be operated on incoming calls.

Night-service relays can be fitted, as required, to provide the appropriate facilities for each particular installation. Four relays can be mounted on spaces reserved on each extension-line-circuit mounting plate.

Additional Facilities

Attendant's Telephone. It is, perhaps, anomalous to provide a special attendant's telephone at an unattended P.A.B.X., but it has been realized that on many installations it will inevitably be necessary for a typist/secretary to answer the bulk of incoming exchange calls. To cater for this requirement a special instrument has been designed, based upon the N 625 plinth[2] (Fig. 9). The telephone concentrates two designated extensions at one station and provides facilities for hoiding a call on either line. During busy periods, therefore, the user can deal with incoming traffic without the need for two designated extension instruments on the desk.

FIG. 9—ATTENDANT'S TELEPHONE

Metering. Metering units and cyclometer meters for recording S.T.D. calls can be fitted, and exchange line and extension metering provided as required.

Connexion to Magneto or Central Battery Signalling (C.B.S.) Exchanges. A separate exchange-line relay-set is required for working to magneto or C.B.S. exchanges.

OPERATION DURING MAINS FAILURE

If the mains supply fails relay MF (Fig. 5) releases and each exchange line is diverted to a pre-determined extension which then functions as an exchange line. Any call in progress at the time of failure is lost, but on restoration of the power supply any call in progress is maintained until the call is completed.

ACKNOWLEDGEMENTS

The P.A.B.X. No. 6 was developed by the General Electric Co., Ltd. (G.E.C.), for the Post Office under the British Telephone Technical Development Committee procedure.

The author is indebted to Mr. R. Smithers of G.E.C. Private Systems Division for his technical advice in the preparation of this article.

[2]AKESTER, K. M. A Switching Unit for Use with 700-Type Telephones—Plan Set N 625. *P.O.E.E.J.*, Vol. 53, p. 242, Jan. 1961.

The Failure of Plastics Insulants due to Silver Migration

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The problem of insulation failure by silver migration has been known for many years. Interest has recently revived, owing partly to the increased use of closely spaced electrodes in combination with various plastics. The basic phenomena are reviewed, and work on this problem, done in the laboratory and in conjunction with field trials, is summarized. The emphasis is on the influence which the insulants have on the failure mechanism, and attention is drawn to factors of design, choice of materials and operating conditions, all of which influence the rate of failure.

SILVER MIGRATION

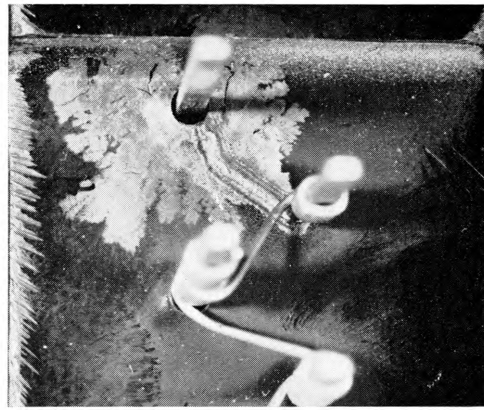
SILVER makes a good mating surface for electrical connectors, giving a low contact resistance in conditions where contact forces are high. It is widely used for plug-and-socket connexions in telecommunication circuits, and it offers a good balance of performance and relative cost. However, in certain conditions the use of silver connexions leads to the development of low insulation resistance, or even complete breakdown of insulating gaps, through the phenomenon known as silver migration. Even chemically stable surfaces such as quartz or mica[1] can show this effect in conditions of high humidity. Less stable or more hygroscopic surfaces readily permit migration at a lower relative humidity.

Silver migration is often seen as a dendritic (branched or tree-like) deposit of metallic silver which grows over the surface of the insulant between two silver electrodes at different potentials. The form of the silver deposit may give the impression that metallic silver migrates as if it were a kind of whisker growth from one of the electrodes, but this is not so. The process is like that of an electroplating bath in which silver dissolves from the anode as silver ions Ag^+. It is these ions which, under a potential gradient, migrate over the insulating surface. They are eventually discharged or reduced and deposited as metallic silver.

In one of the earlier publications on the subject, Kohman, Hermance and Downes[2] showed that silver is uniquely prone to cause this kind of insulation failure under d.c. potential in the presence of moisture. Most of the metals likely to be found in electrical assemblies are either not attacked anodically (e.g. gold or palladium) or are attacked initially and then passivated—that is, an oxide layer forms on the surface and acts as an unreactive barrier (e.g. on copper, nickel and aluminium). The presence of various salts in the moist electrolyte may modify this mechanism, but it is generally correct. Silver falls into neither group. It has a low free energy of oxidation (i.e. it is easily oxidized and easily reduced), but a silver anode is not passivated, because the oxide readily reacts with water to give a soluble product.

The rate of growth of the deposit is enhanced by a high d.c. potential, a low surface resistivity of the insulant, and high relative humidity in the environment. It seems to be a requirement that there should be an adsorbed layer of water more than one molecule thick on the insulating surface before the ions become readily mobile at normal temperatures.

In the simplest case, silver ions are discharged at the cathode and the dendritic deposit grows out from there, progressively narrowing the insulation gap. However, there are more complicated chemical and photochemical reactions which can lead to deposition anywhere in the inter-electrode area, and such processes are nearly always involved where high failure rates are found. Fig. 1 shows a connector with a dendritic silver growth around the positive pin and the charred track resulting from breakdown.



A potential of 200 volts d.c. existed between the pins where tracking has occurred.
FIG. 1—SILVER MIGRATION AND TRACKING ON A PHENOLIC CONNECTOR

OCCURRENCE OF EXCHANGE FAULTS DUE TO SILVER MIGRATION

Silver migration first gave trouble on a large scale in Post Office equipment following an attempt to minimize contact resistance by silver plating all nickel-silver contact springs in shelf-plugs and jacks. The migration caused faults due either to low resistance or complete breakdown. It was rapidly established that the problem was closely associated with the use of phenolic mouldings and synthetic-resin-bonded paper (s.r.b.p.) separators. Preliminary tests showed that chemical reduction was occurring, leading to deposition of surface films of metallic silver in the area between the electrodes.

Over a period of about 10 years, the Research Branch and the Telephone Exchange Standards and Maintenance Branch of the Post Office Engineering Department co-operated in a series of laboratory tests and a field-service trial to elucidate the main factors involved in high failure rates due to silver migration. In these, alternative metals to silver as well as various plastics insulants were tested.

ALTERNATIVES TO SILVER ELECTRODES

Usually, silver is used as a plating on a nickel-silver base to lower the cost and allow the choice of a pin

†Post Office Research Station.

having suitable mechanical properties. Several alternatives to silver have been considered, such as, gold, palladium and platinum, which are virtually incorrodible, but their higher cost makes them uneconomic. Gold is, however, recommended for use as a flash coating over silver plating in certain circumstances.

Silver-copper alloys (in particular coin silver, containing 10 per cent copper) are reported[3] to reduce silver migration considerably. Contact springs made from this alloy and from another alloy containing 80 per cent silver 20 per cent copper, were tested under accelerated laboratory life-test conditions. Migration was slower than with pure silver but it still occurred. These alloys are, therefore, not satisfactory where long-term reliability is needed. In passing, it may be mentioned that the improved performance of silver-copper alloys appears, from Research Branch tests, to be due to the preferential reduction of cupric ions to cuprous ions in solution and not, as Chacken[3] suggested, to changes at the anodic surface of the alloy. Cupric ions are known[4] to prevent the reduction of palladium salts by a similar mechanism.

Another alternative, which has been rejected for general use for economic reasons but is used under special circumstances,[5] is the bimetallic strip. The contact spring is made of phosphor bronze but it has a strip of silver rolled into it during manufacture, so placed that it makes contact with a similar silver strip in the other spring; these silver strips do not come into contact with the plastics insulant and migration cannot, therefore, take place.

ALTERNATIVES TO PHENOL-FORMALDEHYDE RESINS

Consideration of the factors involved suggested that there were three properties of an insulant which might affect the rapidity and extent of silver migration and deposition. They were:

(*a*) the moisture absorbing properties of the plastics insulant,

(*b*) the ionizable salt content, which would affect the leakage current in conditions of high humidity, and

(*c*) the presence in the insulant of compounds which could chemically reduce the silver ions to metallic silver.

Tests were devised to measure these three properties quantitatively, and they were then applied to a wide range of plastics materials. In applying these tests it became clear that phenolic materials had higher values for each than most other plastics insulants. Moisture absorption is high, 2·5 per cent or more, because of the fibrous type of filler, paper or wood flour, which is used in most phenolic materials. The latter also contain ionic salts, which are used as catalysts in the manufacture of the resin and remain in small quantities as impurities which can be leached out by the absorbed moisture to form an electrolyte. Phenolic resins may contain traces of phenol and formaldehyde which have not reacted during the manufacturing process; both substances can act as reducing agents, reducing the silver salts to metallic silver in the inter-electrode gap.

Arbitrary limits for each property were chosen, and certain materials complying with these limits were selected having regard to their suitability from the point of view of mechanical and electrical properties, availability and cost, together with phenolic laminate and moulding materials for comparison. These were subjected to accelerated laboratory life tests and used in a field trial in telephone exchanges.

TESTING METHODS

Accelerated Life Tests

Materials, selected as indicated above, have been subjected to a series of accelerated laboratory life tests in association with the silver alloys and noble metals previously mentioned. Most materials were tested in experimental shelf plugs and jacks or similar assemblies. The life tests were conducted at 40°C in a sulphur-polluted atmosphere (similar to an industrial atmosphere) with a 95 per cent relative humidity. A d.c. potential of 50 volts was maintained across pairs of contact springs, and the insulation resistance was measured periodically using a 500-volt ohmmeter.

The tests lasted 1 or 2 years depending on the materials. Those pairs which had failed were inspected under a microscope to try and discover where and how failure had taken place.

Materials tested in this way have included polystyrene, polycarbonate, alkyd and glass-fibre-filled epoxy-resin laminates. Phenolic materials were used as a comparison. A similar test of a much shorter duration and without sulphur pollution was made on polyacetal.

Field Trial

A field trial of assemblies similar to those in one series of the accelerated tests was conducted throughout the British Isles in selected telephone exchanges where atmospheric conditions are believed to have previously caused electrical breakdown. The trial lasted about 3½ years, during which time a record of periodic insulation-resistance measurements was made. At the end of the field trial the assemblies were broken down and the individual faults examined in the laboratory.

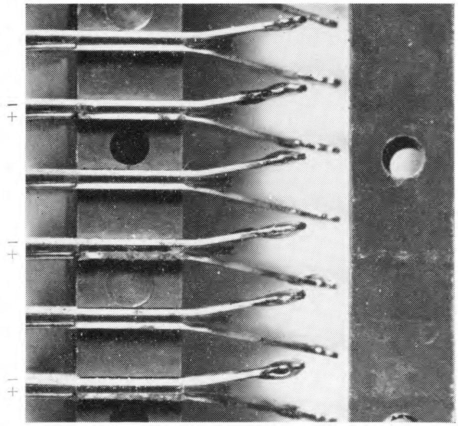
Most of the conclusions reached are described in the following sections, but one interesting result arose concerning alkyd material. In the laboratory life test this material caused a number of faults to develop (Fig. 2 shows silver migration in an alkyd shelf plug), but in the field trial it behaved well. It appeared that the acid from the sulphur pollution in the life test had decomposed the alkyd, giving products capable of reducing silver. The degree of sulphur pollution was higher than is normally met with in exchange conditions, and the acceleration was too severe for this material. The result illustrates the difficulties involved in trying to gain useful information from accelerated laboratory life tests.

FACTORS INFLUENCING THE TENDENCY FOR SILVER MIGRATION TO OCCUR

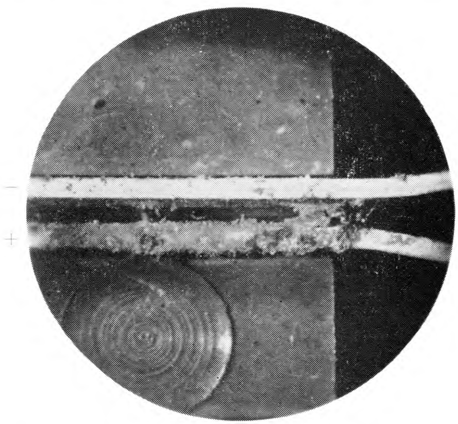
Design

Examination of failed components from the accelerated life tests, the field trial, and from normal service equipment has underlined the importance of correct design in minimizing the occurrence of silver migration. Particularly with the phenolic materials is the effect of design noticeable. Some design features which have been shown to be of importance are (*i*) the spacing of tags and contact springs, (*ii*) the positioning of flash lines* and

*In the formation of a moulding, excess material is squeezed out at the join as the two halves of the mould come together; the excess material is known as the "flash." The flash line is the scar that is left behind on the moulding by the subsequent removal of this unwanted material.



(*a*) Alkyd Comb Block and Securing Strip with Polyvinyl Chloride-Polyvinyl Acetate Copolymer Separators and Silver-Plated Springs



(*b*) Enlarged View of Affected Springs
Contact springs not marked + or − were not subjected to maintained p.d.

FIG. 2—SILVER MIGRATION IN AN ALKYD SHELF-PLUG

recesses in critical areas, and (*iii*) where separators are used, whether they are proud of, or flush with, the contact springs.

The voltage gradient between pairs of contacts should be as low as possible—that is, the widest practicable spacing between contacts should be used.

The siting of flash lines so that they do not form a line of weakness between pairs of silver contacts is particularly important. With thermosetting materials (e.g. phenolics and alkyd resins) the moulded surfaces of an article normally have a smooth, resin-rich skin. This skin does not exist along the flash line, where the rough surface allows higher moisture absorption together with greater likelihood of dust accumulation. This also applies to the thermoplastic materials like polystyrene, but here it is thought not to be so critical. Contrary to expectations, specimens of epoxy-resin glass-fibre-filled laminates which have been tested have not been particularly satisfactory. This is due to the fact that the separators are cut from the laminate sheet and glass-fibre ends are exposed at the cut edges. The cut edges are rough and uneven, giving rise to higher moisture absorption along these surfaces. In addition, micro-pores exist where the adhesion between resin and glass is poor, providing leakage paths in conditions of high humidity.

In certain plug and jack assemblies, recesses in separators have been shown to be sites where the insulation has failed; again, dust accumulation and the fact that absorbed moisture in this position will not dry out as quickly as in other parts is believed to be the cause. Where separators are used, the incorporation of separators extending beyond the springs which they are separating gives a longer migratory path, hence hindering silver migration.

Working Conditions

The influence of a high d.c. potential has already been mentioned. The effect is aggravated in poor working conditions, such as a dusty atmosphere or where high humidity is present. Airborne dust can absorb industrial gases such as sulphur dioxide from the atmosphere and, when deposited on an insulating surface, can provide the electrolyte for leakage currents to flow in conditions of high humidity. Plastics materials having high surface resistivity, like polystyrene, easily accumulate dust electrostatically. Although these insulants themselves contain little ionic material it may be provided by the dust. It has also been observed that silver can migrate over the surface of a fibrous dust particle, and it is believed that in one case this was the reason for a low-resistance fault which occurred between two silver contacts separated by an insulator of polystyrene.

Condensation, obviously, is liable to bring about rapid failure of components by silver migration, especially if contacts are closely spaced; even the best insulants are liable to fail under these conditions.

PHYSICO-CHEMICAL PROPERTIES OF INSULANTS

Reference has been made to moisture absorption, and to the presence of salts and reducing compounds in plastics, as being measurable quantities which could have an influence on the performance of plastics used with silver electrodes. In measuring these properties, two problems arise: (*a*) how to design the test method so that results are both repeatable and significant, and (*b*) at what limit to set the acceptance level so that unsatisfactory and satisfactory materials are clearly separated.

The requirements of (*a*) for the achievement of repeatability and practical significance may not always be compatible, and a compromise may have to be made. Thus, moisture absorption is a phenomenon involving surfaces and, at any time before the attainment of full equilibrium, the percentage of moisture absorbed by a particular material varies with the surface-to-volume ratio. This is generally recognized, and test mouldings of specified dimensions (e.g. British Standard 2572) are used to measure this property. In actual components, however, there may not only be variations in surface-to-volume ratio but, also, cut surfaces having different properties from those of the as-moulded condition, so that, whilst the British Standard test method gives repeatability, in practice the results may not always have the same significance in difference cases.

In the tests made by Research Branch, British Standard size mouldings were used for moisture absorption, and the other tests were made on material ground up and sieved so that the surface exposed per unit volume was substantially constant.

Ionic salt content was assessed by making an aqueous extract of the comminuted material and measuring the conductivity of the extract.

Silver-reducing substances were determined by extracting the comminuted plastics material with aqueous alkali and then allowing the filtered extract to react with ammoniacal silver-nitrate solution. A considerable program of experimentation was necessary before test conditions were finalized to give results that were both repeatable and significant.

At present, the application of a special limit for moisture absorption has been discarded, since the results did not lend themselves easily to condition (*b*). Proposed limits for conductivity and silver-reducing power have been set from a study of all the data available from the field trial and accelerated tests. The full-scale field trial still remains the final arbiter, but the assessment of modified or new plastics materials can now be made with a high degree of confidence.

In view of recent widespread interest in the problem of silver migration over plastics, the results of these tests for a number of materials are given in the Table together with the proposed test limits.

Results of Tests on Various Plastics Materials used in Accelerated Life Tests and in a Field Trial, together with Proposed Test Limits

Material	Specific Conductivity of Aqueous Extract (micromhos cm^{-1})	Moisture Absorption Per Cent on Original Weight		Silver-Reducing Power (Grammes Silver Reduced by 100 Grammes of Insulant)	
		After 1 Week	At Equilibrium	Former Method	Revised Method
Proposed limits	10	1	2	1	0 5
Phenolic moulding	114	0 9	2 5	21	—
Control s.r b.p.	10	1 1	2 3	37	12
Epoxy-resin glass-fibre laminate A	7 4	0·06	0 3	2	—
Epoxy-resin glass-fibre laminate B	5 8	0 26	1·0	1·4	—
Polystyrene	2 2	0 12	0·15	2 5	Nil
Polycarbonate	0 9	0·19	0·19	4 3	Nil
Polyacetal	1 6	0 42	0·58	11	0 24
Alkyd	10	0 85	1·05	1·1	0 2

Limitations of the Chemical Tests on Materials

It must be stressed that the results of tests on specimens of thermosetting materials can be misleading if actual components or laminates themselves are not properly cured, and there is still a place for accelerated tests on finished components on a check-sampling basis. Such tests will also take account of design features.

Futhermore, there is inadequate knowledge of how these materials will withstand the effects of aging over long periods in normal atmospheres. Surface deterioration, with a consequently increased liability to promote silver migration, may occur to different extents with aged plastics materials. It may be necessary to carry out the chemical tests on aged samples to give a better evaluation of long-life performance.

CONCLUSIONS

The problem of silver migration is not an easy one to solve because of the many complicating factors which are involved. The simple solution is not to use silver at all and replace it with gold or one of the platinum group metals, but this is not always economically practicable.

It is necessary, therefore, to find plastics materials which will give the minimum liability to promote silver migration. New plastics materials may be selected by applying physico-chemical tests for which limits have been proposed. Accelerated life testing or field trials may be used to confirm the choice.

Phenolic-resin mouldings, which for many years have been used in the telecommunications field, tend to give high failure rates due to silver migration except under ideal conditions. Alkyd resins of the di-allyl phthalate type, and ordinary and toughened polystyrene, can provide satisfactory alternatives to the phenolics, especially when used with a flash gold-plating over silver-plated electrodes. Polycarbonate and polyacetal resins are also satisfactory, but due to their high cost these will only be used in special applications.

Epoxy-resin glass-fibre-filled laminates cut into separators are unsuitable for use with silver because of the effects of cut edges. Other glass-fibre-filled materials are liable to suffer from this defect where the cut edges lie in the inter-electrode area.

Silver-copper alloys effect a slowing down of failure by migration but will not prevent it. The benefits obtained from them will be more apparent with the better insulants than with phenolic materials.

Correct design has long been recognized as important in minimizing the effects of migration. Points which are of particular importance are (*a*) to maintain voltage gradients between electrodes as low as possible, (*b*) to site flash lines so that they do not occur in the inter-electrode area, (*c*) to avoid recesses where dust can accumulate in the inter-electrode area, and (*d*) to use separators proud of electrodes to provide a longer leakage path.

Environmental effects are important in minimizing migration. High humidity, and particularly condensation, can cause rapid failure of insulants by silver migration, and, where possible, steps should be taken to ensure the relative humidity is kept below 70 per cent. Dust deposition also assists migration and should be minimized.

No insulating materials yet tested can be guaranteed to give freedom from silver migration. However, the better plastics materials, such as alkyd, ordinary and toughened polystyrene, polycarbonate and polyacetal, will give reliable service if the precautions mentioned above are taken.

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Measurement of the Inductance of Transmission Lines—A Correction to be Applied to Bridge Readings

R. J. EDWARDS†

U.D.C. 621.317.334:621.372.2

The inductance of a transmission line can be determined from measurements of the input impedance of the line. It is, however, necessary to apply a correction to bridge measurements made for this purpose, and an expression is derived for such a correction.

A PRACTICAL method of determining the inductance of a transmission line which does not involve extensive calculations is to measure the input impedance of the transmission line, with its remote end short-circuited, by using a direct-reading inductance bridge. It is generally assumed that the inductive component of the input impedance is asymptotic to the line inductance as the testing frequency decreases, and, therefore, at a sufficiently low frequency the bridge at balance will indicate the line inductance directly. However, the assumption is invalid, and in some circumstances a substantial correction must be applied. With lines above a critical length it becomes impossible to balance the bridge even when the frequency is allowed to decrease indefinitely.

From basic transmission theory it may be shown that the input impedance of a uniform line short-circuited at its remote end is given by

$$Z_{SC} = Z_0 \tanh Pl, \quad \ldots\ldots (1)$$

where $Z_0 = \sqrt{Z/Y}$
= characteristic impedance,
$P = \sqrt{ZY}$
= complex propagation coefficient,
$Z = R + j\omega L$
= impedance per unit length, ...(2)
$Y = G + j\omega C$
= admittance per unit length, ...(3)
and l = overall line length.

Expanding the hyperbolic tangent of equation (1) as a series of powers of Pl, i.e. $l\sqrt{ZY}$, and multiplying each term by Z_0, i.e. $\sqrt{Z/Y}$, gives

$$Z_{SC} = lZ - \tfrac{1}{3}l^3Z^2Y + \tfrac{2}{15}l^5Z^3Y^2 - \tfrac{17}{315}l^7Z^4Y^3 + \ldots\ldots (4)$$

This series converges rapidly for small values of $|Pl|$. By retaining the first two terms, substituting equations (2) and (3) into equation (4), separating the real and imaginary components, and dividing the imaginary components by jω, it will be seen that the resistive component of Z_{SC}

$$= lR - \tfrac{1}{3}l^3GR^2 + \omega^2l^3(\tfrac{1}{3}L^2G + \tfrac{2}{3}LCR) \ldots (5)$$
$$= R',$$

and the inductive component of Z_{SC}

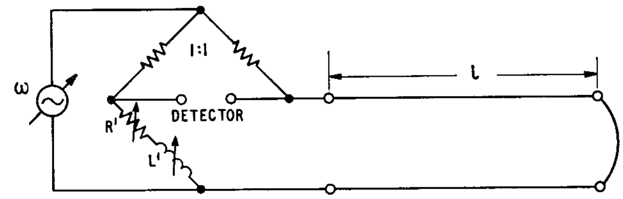
$$= lL - \tfrac{1}{3}l^3CR^2 - \tfrac{2}{3}l^3LRG + \tfrac{1}{3}\omega^2l^3L^2C \ldots (6)$$
$$= L'.$$

In modern lines and cables the leakance G is small enough to be neglected. Therefore, putting $G = 0$ in equations (5) and (6) it will be apparent that, at sufficiently small values of ω,

$$R' = lR,$$
$$\text{and } L' = lL - \tfrac{1}{3}l^3CR^2, \quad \ldots\ldots (7)$$

with negligible error.

An arrangement for measuring line inductance is shown in the figure. Because this method requires a variable inductance, it serves better to illustrate this note. In practice, a Maxwell bridge, with which the reading of a variable capacitor is directly proportional to inductance, would be preferable.



CIRCUIT ARRANGEMENT FOR MEASURING LINE INDUCTANCE

At bridge balance, it has been shown above that as the testing frequency ω becomes sufficiently small, and if the line leakance G can be neglected, then

$$L' = lL - \tfrac{1}{3}l^3CR^2 \text{ henrys,}$$

where L' is the bridge reading, L, C and R are the line primary parameters per unit length in henrys, farads and ohms, respectively, and l is the overall length of line under test. This may be stated alternatively as

overall line inductance = bridge reading + $\tfrac{1}{3}l^3CR^2$ henrys.

This equation has considerable practical value because R and C are usually known. If not, then $lR = R'$ is obtained simultaneously with L' from the short-circuit measurement, and lC may, at a sufficiently low frequency, be obtained from an open-circuit test without correction.

An interesting feature of equation (7) is that it shows L' is equal to zero at a critical length, l_C, given by

$$l_C = \frac{1}{R}\sqrt{\frac{3L}{C}} \text{ units,}$$

and, when $l > l_C$, L' becomes negative, implying that the short-circuit input impedance has a negative angle. In these circumstances a balance can be obtained only by replacing the bridge inductance L' by a capacitance C', which gives

$$\text{overall line inductance} = \tfrac{1}{3}l^3CR^2 - \frac{1}{\omega^2C'} \text{ henrys.}$$

However, since this equation re-introduces frequency, bridge readings do not indicate that the frequency has been sufficiently reduced to validate the correction and its usefulness is limited.

The above correction has been used to determine the inductance of repeater sections of coaxial-type cable at sub-audio frequencies in circumstances which prohibited derivation of line parameters from physical considerations. The information obtained assisted in the design of artificial lines for cable-fault location purposes.*

†Test and Inspection Branch, E.-in-C.'s Office.

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A 700-Type Telephone Handset Providing Lamp Calling Signals—Handset No. 7

C. W. HOGBEN, B.Sc.†

U.D.C. 621.395.632.21:621.395.612.383

The Handset No. 7 incorporates a neon lamp visible through a clear window forming part of the handle. The lighting of the lamp provides a calling signal in addition to the sound of the telephone bell.

INTRODUCTION

Where a number of telephones are used close together, the provision of a calling-signal lamp on each telephone enables an incoming call to be quickly associated with a particular instrument. If automatic ringing is applied, the light flashes in unison with the bell; with manual working the lamp is lit when ringing current is first applied and it remains alight until the handset is lifted. On 200-type and 300-type telephones the facility has been provided by a filament lamp mounted on a bracket attached to the telephone case. The lamp is lit from a 24-volt local power supply connected in circuit by a remotely-mounted 3,000-type relay.

HANDSET NO. 7

Telephones No. 710[1] and No. 711,[2] but not Telephone No. 706,[3] have provision for the mounting of one or two lamps within the telephone case. These are used to indicate line-engaged conditions on extension-plan arrangements, but are not suitable for calling signals as they can only be seen satisfactorily from the front.

The handset of the 700-type telephones was therefore chosen to mount the calling lamp, because the handset is always prominently placed on the telephone. The hollow construction of the 700-type handset, utilized in the Handset No. 4[4] to contain amplifier components, provides a suitable housing for such a lamp. A clear Perspex window inserted in the back of the handle gives the lamp a wide range of visibility, and avoids the need for any brackets that would mar the appearance of the telephone. The new 700-type telephone handset with the lamp-calling device is known as Handset No. 7 and is illustrated in Fig. 1.

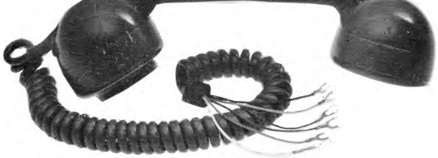


FIG. 1—HANDSET No. 7

The use of a filament lamp was rejected because of the possibility of damage by heat to the thermoplastic moulding and because of the fragility of the filament: a neon lamp is a gas-discharge tube and has neither of these limitations. Furthermore, neon lamps have a long life at a low current-rating and can, in many instances, be lit directly by the ringing current because they operate satisfactorily to a 60-volt or 75-volt a.c. supply.

The handle of the Handset No. 7 was originally made by moulding the body and window separately and then cementing the two together. This process proved unsuitable for mass production, and a further examination of the problem resulted in the double-moulding technique now employed. By this method the body is made in coloured ABS (acrylonitrile-butadiene-styrene) with an aperture left for the window. The window is afterwards moulded in place over projections in the body moulding which ensure that the window is kept in position even when the handset is deliberately distorted.

The neon lamp is mounted on a printed-wiring board and fitted in the hollow handle so that the lamp is under the window, the printed-wiring board being inserted in the handle through the cord-entry hole. The moulded block that anchors the cord is normally cemented in place, but in the Handset No. 7 it is removable and is held in position by a spring clip contained in the transmitter cavity. This clip, in conjunction with the small synthetic-resin-bonded paper (s.r.b.p.) strip fitting over the terminals, also provides a location for the printed-wiring board.

Because an extra pair of conductors is always needed for the lamp connexions a six-way extensible cord is supplied with the handset. The component parts of the Handset No. 7 are illustrated in Fig. 2.

CIRCUIT ARRANGEMENTS

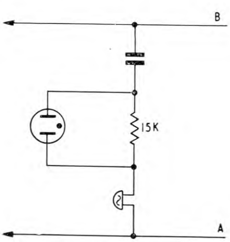
In the ideal arrangement the lamp is powered from the ringing current on the line and flashes until the call is either answered or abandoned. Such an arrangement can be achieved if automatic ringing is derived from a 75-volt ringing generator and the lamp is connected directly in series with the bell (Fig. 3(*a*)). A shunt resistor is used to prolong the life of the lamp by restricting the current flowing through it and also to retain the normal d.c. conditions for line testing, i.e. by providing an alternative connexion to the telephone capacitor. The high value of the shunt-resistor ensures that a large proportion of the available ringing voltage is developed across the lamp.

In U.A.X. or P.A.B.X. systems in which vibrator ringers are employed, the voltage available may be insufficient to strike the lamp in a Handset No. 7. For such systems a relay wired in a full-wave bridge-rectifier network is connected in series with the bell (Fig. 3(*b*)). The relay operates to the ringing current and the lamp lights to a local power supply connected via the relay contacts. Because neon lamps do not operate satisfactorily in series or directly in parallel, this arrangement is also used where more than one telephone with a

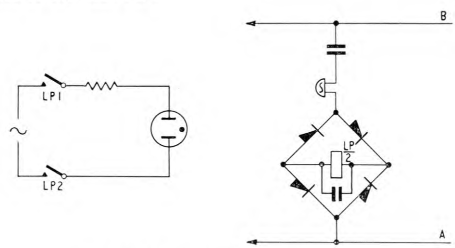
†Subscribers' Apparatus and Miscellaneous Services Branch, E.-in-C.'s Office.

A—Mouthpiece. B—Earpiece. C—S.R.B.P. strip to slot over screw terminals. D—Metal retaining clip. E—Cord-anchor moulding. F—Transmitter. G—Printed-wiring board with neon lamp. H—Spring clips for transmitter and receiver. I—Receiver.
Items C and D keep items E and G in position.

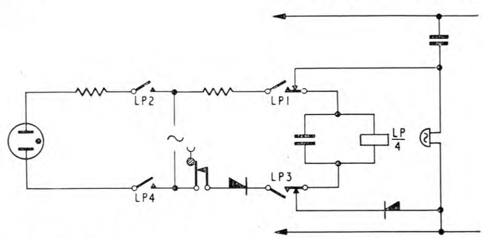
FIG. 2—PARTS OF HANDSET No. 7



(*a*) Lamp Connected in Series with Bell



(*b*) Lamp Controlled by Relay in Series with Bell



(*c*) Lamp Controlled by Relay Held Operated by Local Power Supply until Handset Lifted

FIG. 3—METHODS OF CONTROLLING HANDSET LAMP

Handset No. 7 is connected to a single automatic exchange line or P.A.B.X. extension.

On manual systems the lamp lights when ringing current is first received, and it stays alight until the call is answered. This is effected by a relay connected across the bell; when ringing current is received the relay operates and is disconnected from the telephone circuit by its own contacts. Until the handset is lifted the relay is held operated to the local power supply, which also lights the lamp (Fig. 3(*c*)). In a similar way, the lamp-signalling units can be used to ring bells, if required.

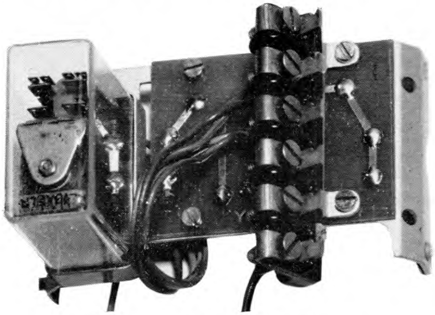


FIG. 4—LAMP-SIGNALLING UNIT No. 1

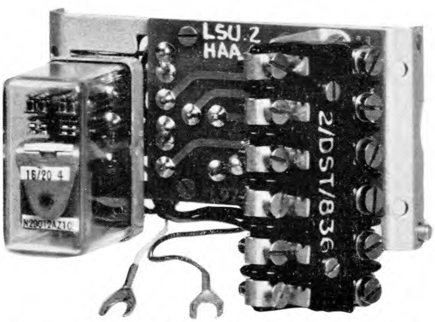


FIG. 5—LAMP-SIGNALLING UNIT No. 2 WITH ADDITIONAL TERMINAL STRIP

AUXILIARY APPARATUS

To simplify the mounting and the wiring of the relay assemblies, miniature units have been designed to fit inside the telephone. These units are clipped between the gravity-switch supporting brackets at the rear of the regulator, and are known as Lamp-Signalling Units No. 1 and 2. They include a Post Office Type 16 relay, a printed-wiring board with components, and a terminal strip. The terminal strip is secured by long fixing screws that can take an extra strip (Part 2/DST/836) if additional terminals are needed (Fig. 4 and 5).

The local power supply used with the lamp-signalling units may be provided by one of the following: a 75-volt $16\frac{2}{3}$ c/s or 25 c/s ringing generator; 60-volt 25 c/s ringing converter; a 75-volt 50 c/s plug-in a.c. mains transformer. The latter consists of a transformer combined with a standard-size mains plug and is available in two versions, known as Transformers No. 431A and 431B. It should be noted, however, that 50 c/s current is not suitable for ringing extension bells.

The Transformer No. 431A has a 15-amp plug with round pins, and the Transformer No. 431B has a 13-amp plug with flat pins; the large size of the plugs gives stability to the units when they are inserted in the appropriate mains outlet sockets. Both primary and secondary windings are protected by fuses and are separated by an earthed screen; the laminations are also earthed. The transformers are supplied with a lead-out pair already connected to the low-voltage output terminals to avoid having to dismantle the unit during installation.

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Book Received

"Guide to the Specification and Purchase of Electronic Equipment for Industrial Systems." Publication No. 209, The British Electrical and Allied Manufacturers' Association (Incorporated). 21s.

The purpose of this booklet is clearly outlined in its foreword, which is reproduced below.

"The growing interdependence of electronic and power engineering is creating a situation in which neither the detailed electronic specifications of the telecommunication field nor the standards created for the heavy power equipment can adequately cover the systems and equipment aspects of much of the electronics ancillary equipment now used in industrial applications.

Accordingly, the Industrial Control and Electronics Division of BEAMA has prepared this Guide, the purpose of which is to help both customer and manufacturer to ensure that all the necessary conditions for the successful specification of the full requirements of a system are initially known by both parties, and that at the conclusion of the contract adequate predetermined tests can confirm that these requirements have been met.

In many cases equipment is called upon to meet specifications which are unnecessarily stringent for the stated operating conditions, thereby increasing the cost of new equipment or involving the redesign of existing equipment.

This is often due to the lack of any general specification for industrial electronic equipment, resulting in the use of existing specifications from the telecommunications, light current engineering and Services (special applications) fields, many of which are inappropriate and in some cases unnecessarily stringent.

It is evident that where existing specifications can be used, benefits will accrue both to supplier and customer.

It is desirable, however, that all contracts involving a mixture of electronic and power or electromechanical devices should be based on a full system specification accepted at the time of placing the order by both contracting parties. This Guide specifies standard types of equipment to meet the requirements for various applications and other facets of operation which need to be considered within the concept of a system."

Trunk-Traffic Analysis Equipment

C. D. VIGAR, A.M.I.E.E.†

U.D.C. 621.395.31:621.395.374

With subscriber trunk dialling, switchboard operators are no longer available to make records of the origins and destinations of trunk calls. An automatic equipment has therefore been developed that enables trunk traffic at group switching centres to be sampled; details of the calls so selected are recorded for subsequent analysis by computer.

INTRODUCTION

DATA about trunk traffic are required for planning future routes, tariffs, and plant growth. These data were obtained in the past by sampling the trunk tickets made out by operators when calls were originated.

With the advent of subscriber trunk dialling (S.T.D.), the trunk switching network is without the services of operators by which records of the origins and destinations of calls were made. For this reason an equipment has been developed which is connected to the register-access relay-sets at a group switching centre (G.S.C.) and randomly samples the traffic. The equipment is called the trunk-traffic analysis equipment. It counts all the calls coming into the centre and, when the count reaches a predetermined value (designated n), it records details of that particular call as a sample of all the calls that are being made.

FACILITIES PROVIDED BY THE EQUIPMENT

The connexions between the trunk-traffic analysis equipment and the register-access relay-sets are shown in Fig. 1. Pulses on the "count" wires step a counter in the

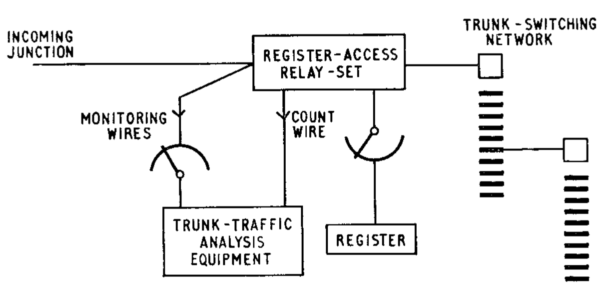


FIG. 1—CONNEXION OF TRUNK-TRAFFIC ANALYSIS EQUIPMENT AT A GROUP SWITCHING CENTRE

analysis equipment thus enabling it to count all the calls that arrive at the G.S.C. When the count reaches the value of n a motor-uniselector in the analysis equipment finds the relay-set in which the nth call has occurred and records such information as the dialled digits and meter pulses. These are punched on to a paper tape, which is eventually fed to a computer. While the sampled call is being observed the counter continues counting the next batch of n calls.

METHOD OF TAKING THE SAMPLE

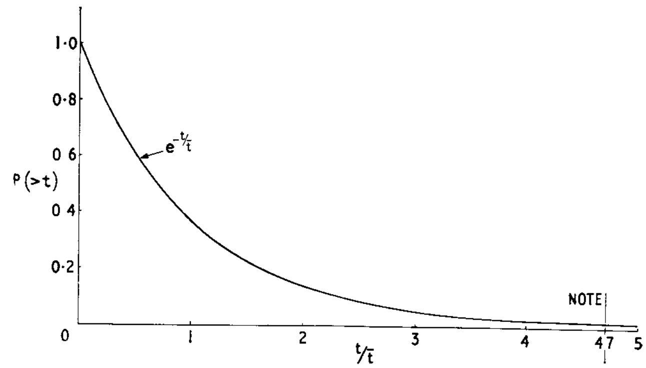
The design of the equipment had to take into account two practical aspects of taking the sample. The first is that the holding times of calls vary considerably, and any one of the calls which is being sampled (i.e. an nth call) may hold for such a long time that the succeeding nth call arrives during the observation of the first. If this should happen the first observation is forcibly terminated and the succeeding nth call observed. The second is that an error in counting the total number of calls arriving at the switching centre may occur because of the possibility of two calls arriving simultaneously, with their arrival signals thus overlapping.

If the sample is to be representative of the behaviour of all the trunk traffic then these errors must, on average, be within the following limits.

(*i*) Not more than 1 per cent of the observations must be forcibly terminated.

(*ii*) The error in the count must not be more than 2 per cent.

The number of forcibly-released observations is kept to less than 1 per cent by setting the value of n at five times the total traffic (in erlangs) arriving at the switching centre. The reason for choosing this value can be seen by reference to the graph in Fig. 2, which shows the



$P(>t)$ is the probability of a call lasting longer than t.
$\bar{t}$ is the average holding time of all calls.
Note: At point where $t/\bar{t} = 4{\cdot}7$, $P(>t) = 1$ per cent

FIG. 2—PROBABILITY OF A CALL LASTING FOR A GIVEN PERIOD

probability (P) of a call still being in progress at a time $t/\bar{t}$ after its commencement,

where t = holding time of a particular call, and
$\bar{t}$ = average holding time of all calls.

At the point where $t/\bar{t} = 4{\cdot}7$ the probability that the call will still be in progress is 0·01, i.e. there is a 1 per cent chance that the call will still be in progress. At the point of $t/\bar{t} = 5$ there is less than a 1 per cent chance that the call will still be in progress. It follows, therefore, that if n is so chosen that the time taken to count from zero to n is five times the average holding time for all calls then less than 1 per cent of the observations will be forcibly terminated. The optimum value for n may be calculated, in the following manner, from a knowledge of the total traffic flowing into the trunk centre.

Total traffic flow = A erlangs.

$$\therefore\ A = C\bar{t}, \qquad (1)$$

where C = total call arrivals per hour, and
$\bar{t}$ = average holding time of all calls (in hours).

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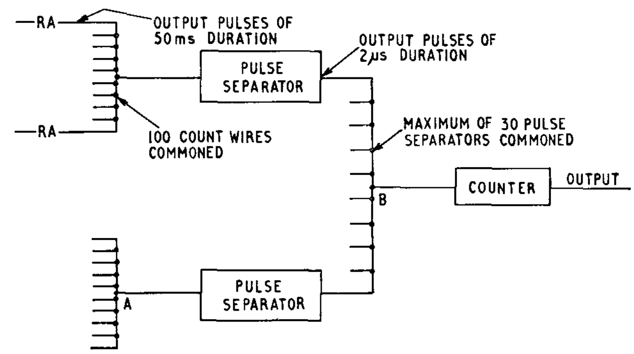
Also, from the previous discussion, the time taken for a cycle of n calls must equal five times the average holding time,

$$\text{i.e. } n/C = 5\bar{t}.$$
$$\therefore C\bar{t} = n/5$$
Thus, from equation (1), $n/5 = A$
$$\text{and } n = 5A$$

Thus, if n is chosen to be five times the total traffic in erlangs, then less than 1 per cent of the observations will be forcibly terminated. As there are considerable fluctuations in total traffic flow the value of n must be altered as the traffic flow changes, in order to obtain the best sample. To meet this requirement the equipment has been designed so that the value of n can be changed according to a preset program over a period of a week. The program can be adjusted on each equipment to suit the pattern of traffic flow at the centre where it is installed.

The method of counting the total number of calls arriving at a switching centre is shown in Fig. 3. Each



R.A.—Register-access relay-set

Note. A maximum of 3,000 register-access relay-sets in 30 groups can be connected

FIG. 3—METHOD OF COUNTING CALLS INCOMING TO A GROUP SWITCHING CENTRE

register-access relay-set has a count wire on which it gives a 50 ms earth pulse when it is seized. The count wires are connected together in groups of 100, and each group is connected to the input of a pulse separator. The pulse separator produces a 2 μs pulse at its output for every 50 ms pulse arriving at the input. The outputs of all pulse separators can then be connected together with an exceedingly low probability of the pulses overlapping even at the largest centre, where there may be 30 pulse separators. The common of the outputs from the pulse separators will carry a 2 μs pulse every time a call enters the centre; the common is connected to the input to the counter, which is set to give an output when a count of n is reached.

The error in counting the number of calls occurs at the commoning points A and B (Fig. 3). The error at A can be calculated by considering the probability of two calls arriving within 50 ms of each other. This calculation shows the error to be an undercount of about 1·6 per cent. The error at B can be calculated by considering the pulses as pure-chance traffic being offered to one trunk. Although the pulses are 2 μs in length the limiting parameter in practice is the recovery time of the counter, which is 30 μs. The undercount estimated at B is only 0·03 per cent.

Provision of Access Relays

A considerable economy can be achieved at the expense of a small error in the count by only providing access relays and wiring for a chosen proportion of the register-access relay-sets. This is possible because 90 per cent of the traffic in a grading group is carried in the first half of the grading. The observed relay-sets are chosen to be every alternate relay-set in the first half of the grading. If the nth call should arrive on a non-observed relay-set it will be counted but not observed; the observed call will be the next to arrive on an observed relay-set and may be number $(n + 1)$ or $(n + 2)$. In this way only $\frac{3}{8}$ths of the relay-sets are observed at an average increase in the count of n of 1·2.

Pulse Separator

The 50 ms pulse received on the count wire from the relay-set is used to fire a silicon controlled rectifier (s.c.r.). The output from the s.c.r. switches a ferrite core, which produces a short pulse on an output wire suitable for connecting to the counter. The ferrite core is restored to its original state every 60 ms by a pulse from a multivibrator.

The circuit of the pulse separator is shown in Fig. 4. The ferrite core SL1 is pulsed to its "0" state every

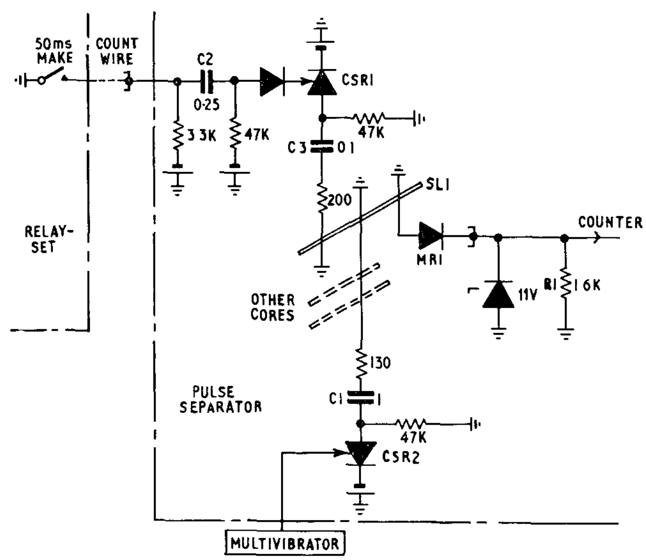


FIG 4—PULSE SEPARATOR

60 ms. The output of the multivibrator fires s.c.r. CSR2, which sends a pulse through capacitor C1 to switch all cores in the equipment to the 0 state. Most of the cores will actually be resting in the 0 state; only those which have received a pulse from a relay-set in the preceding 60 ms will be in the "1" state. The s.c.r. is then extinguished by the action of current starvation (see Appendix), so that it has restored before the next pulse is sent from the multivibrator 60 ms later.

When a relay-set is seized, a 50 ms pulse is received on its count wire at the pulse-separator input. The pulse is differentiated by the capacitor C2 and fires the s.c.r. CSR1. The change of potential at the anode of CSR1 passes across capacitor C3 to set the ferrite core, SL1, to the 1 state. The s.c.r. is extinguished by current starvation. When the core is switched to the 1 state it gives a 2 μs pulse on the output lead, which passes through the rectifier MR1 to step the counter. All the rectifiers such as MR1 form an OR gate in conjunction with resistor R1, thus enabling the outputs from all the cores to be connected to the input wire of the counter.

The reason for using a ferrite core in this way is to mask the effect of bounce of the relay contact. This bounce may cause the s.c.r. CSR1 to fire several times at each operation of the relay contact, but the ferrite core will only be switched once, unless by a very remote chance it was restored to the 0 state by the pulse from the multivibrator while contact bounce was taking place. The s.c.r. CSR1 is required to give a fast rise-time pulse to switch the core. The pulse received at the analysis-equipment end of the count wire is distorted in shape because of the capacitance of the count wires, and this makes direct switching of the core from the relay contact unreliable. However, the s.c.r. fires satisfactorily to the pulse on the count wire and the output of an s.c.r. will reliably switch a core.

METHOD OF OBSERVATION

The method of associating the analysis equipment with the relay-set carrying the nth call is shown in Fig. 5.

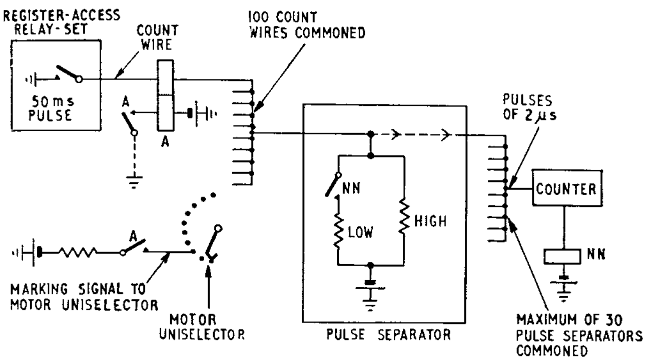


FIG. 5—METHOD OF MARKING THE REGISTER-ACCESS RELAY-SET CARRYING nth CALL

When the counter reaches the value of $(n - 1)$ it operates the NN relay. Contacts of relay NN connect a low resistance across the high-value resistor normally connected to the count wire at the pulse separator. Thus, the A relay in the count wire connected to the next relay-set operates when a call arrives, and its contact marks the bank of the motor uniselector, whose hunting action is started by the operation of relay A.

The connexions between the analysis equipment and the relay-set on which observation is being made are shown in Fig. 6. Transistor-type line-signal monitoring

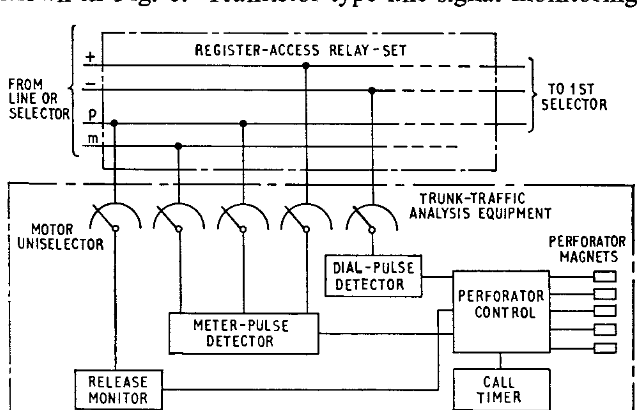


FIG. 6—MONITORING CONNEXIONS OF EQUIPMENT

units* are connected to the positive and negative wires to detect dial pulses and meter pulses transmitted by metering-over-junction relay-sets. The signals on the P and M wires are detected by high-impedance relays. These signals are stored and switched by orthodox electro-mechanical circuits in the perforator control to operate the perforator magnets. The dial pulses are stored on a uniselector until an inter-digital pause indicates that a complete digit has arrived. This digit is punched on the tape, and the uniselector homes. Two uniselectors are used for digit storage, because a following digit may arrive while the uniselector which stored the previous digit is in the process of homing. The call timer is set in motion on receipt of a seizure signal and punches a time signal on the tape at every meter pulse and on clear-down of the call.

Punching Information on the Tape

Two aspects of the sampling process are recorded on the tape:

(*i*) the date and the time of day, and

(*ii*) details of the observed call and the value of n when the record was made.

The date is recorded by punching codes every midnight, showing the week of the year and the day of the week. In addition, a time character is punched on the tape every 5 minutes throughout each 24 hours.

The details of an observed call are punched by using various symbols of an Elliott code to represent the occurrences in setting up and releasing a call. The characters of the code record the dialled number, the meter pulses, the originator's charging group, and the class of service (C.C.B., ordinary, etc.). The call-timer starts timing when the observation of a call commences, and it supplies time pulses to the perforator control so that the time from the beginning of the call to each event can be punched on the tape.

A tape showing the codes used for recording various events is illustrated in Fig. 7.

COMPUTER PROGRAM

The computer program is arranged to total the features of calls that have been sampled and present the data in a usable form. As an example, the average holding time of calls can be obtained, because the times of the answer signal and the release signal of every call sampled will be recorded on the tape. The computer can total these periods for every call and divide this total by the number of calls sampled. The average holding time can also be obtained for a particular period of the day by programming specially for it.

In addition, the total number of calls that took a particular route can be found by counting the number with that particular route code that were contained in the sample and applying the arithmetic of normal statistical methods. The differing values of n at different times of the day can also be taken into account by programming the computer to put a particular significance on a given set of samples.

Additional Statistics Obtainable from the Equipment

The equipment is primarily designed to measure, by sampling methods, the traffic flow through G.S.C.s,

*Price, C. K. A Line-Signal Monitoring Unit Using Transistors. *P.O.E.E.J.*, Vol. 53, p. 121, July 1960.

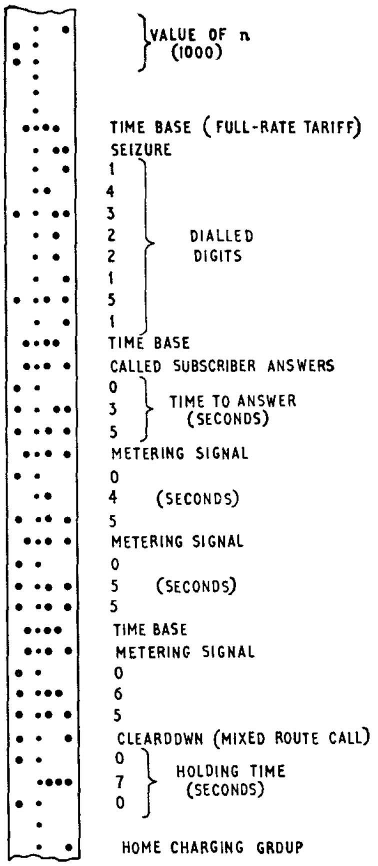


FIG. 7—PART OF PUNCHED TAPE PRODUCED BY EQUIPMENT

giving details of routes and variations with time. Further information about trunk traffic can also be obtained if the computer is programmed to give it; e.g. the meter-pulse rate can be checked against the code dialled, or a record can be made of the number of calls that failed in the sample. Such information can be of use to help improve the quality of the service because it gives averages relating to the behaviour of trunk equipment, and this information is not so easily available from other sources.

APPENDIX

The principle of current starvation depends on the characteristic of an s.c.r. which requires a minimum current to be flowing between anode and cathode to maintain the s.c.r. conducting. The elements of a circuit in which this feature is used are shown in Fig. 8. In the normal condition the s.c.r. is not conducting and

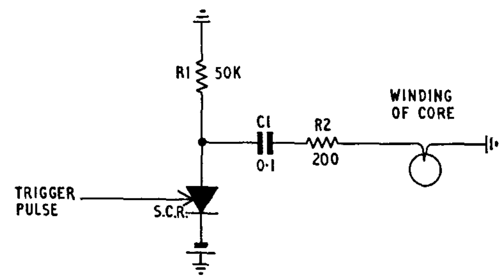


FIG. 8—BASIC CIRCUIT PRODUCING DRIVE PULSE

both plates of capacitor C1 are at earth potential. A trigger pulse, positive with respect to the cathode, will fire the s.c.r. and send a negative-going pulse through resistor R2 and the core winding. The current in the anode of the s.c.r. is the current required to charge capacitor C1 and will, therefore, decay exponentially towards a steady value of 1 mA (the value controlled by resistor R1). When the decaying current in the s.c.r. has fallen to a value below 5 mA the s.c.r. will cease to conduct because the design of the s.c.r. requires a current of about 5 mA to maintain conduction. When the s.c.r. ceases to conduct capacitor C1 discharges slowly through resistor R1 until both plates are at earth potential. After a recovery time, dependent on the values of resistor R1 and capacitor C1, the s.c.r. may be fired again.

Book Review

"A.C. Carrier Control Systems." K. A. Ivey, Ph.D. John Wiley and Sons, Ltd. xiv + 349 pp. 244 ill. 90s.

This book deals with the analysis and design of servo systems and their components for precision positional control as employed in such fields as machine-tool control, gun control and radar. The descriptive treatment serves mainly to introduce the mathematical analyses, and practical applications are mentioned only in a few illustrative examples.

The reader is assumed to be conversant with basic control-circuit theory, and a brief introduction concludes with a dozen problems which test the reader's ability to appreciate the remaining 312 pages. On p. 163 it is explained that the book should be regarded as an addendum to others covering such design procedures as: Laplace transform methods; classical stability criteria; root locus; compensating network design; rate feedback techniques; Bode plot design methods; analogue simulation; minimum least-square and minimum mean-square error; and time-domain synthesis.

The main text is supported by a literature review giving summaries of the relevant contents of 69 books and by a bibliography of 209 other references.

The eight sections of the book cover: introduction; modulation theory, including the operation of various devices for modulation and demodulation; components, including the operating principles and applications of potentiometers, transformers, synchros, tachometers and servo-motors; analysis of systems; overall design of systems including use of such component parts as phase-shifting networks, bridged-T filters and parallel-T filters; detailed network design including *RLC* and *RC* networks and negative-impedance converters applied in passive or in active compensator circuits, electromechanical compensating networks; and the general classification of systems. Each section, except the last, concludes with problems to test the reader's grasp of the subject.

The descriptive and mathematical treatments are adequately illustrated by simplified circuit diagrams, block schematics and by performance graphs, but some 60 half-tone blocks of electromechanical components will contribute little useful information—especially to the reader who is already familiar with servo systems and for whom the book is intended.

F.H.

An Automatic Analyser for Recorder Charts

J. A. DAVIES†

U.D.C. 621.3.087.4:621.317.341

The analysis of data relating to the performance of transmission systems is essential for both design and maintenance purposes. To economize in the effort needed for such analysis, a device is described that can automatically examine recorder charts and present the results in a readily usable form.

INTRODUCTION

INVESTIGATIONS of the transmission performance of the inland trunk network have long revealed a need for statistical analysis of data gained from circuits and systems in service. This need has been only partially met by "manual" methods of analysis, which are so laborious that their use is inevitably limited. In the design of equipment and systems for use on long international submarine cables statistically derived limits of variability have been applied, and the maintenance of these systems has necessarily involved a considerable amount of analysis. Accordingly, investigations have been proceeding for some years into the possibility of mechanizing the process.

Statistical information on circuit performance may be obtained directly by a number of methods, but all suffer from one or more of the following disadvantages.

(*a*) The cumulative effect of a number of changes in performance may be clearly shown, but details of individual changes and the times at which they occur are not.

(*b*) The existence of a fault condition may be shown, but no indication given of its nature.

(*c*) Short complete breaks in transmission do not affect the analysis nearly to the extent that they affect performance as experienced by the users of the circuit.

(*d*) The information is in a form not easily assimilated by staff involved in day-to-day maintenance; their need is for a broad overall picture rather than for detailed information on a limited number of parameters.

The continuous, timed record provided by the trace of a recording decibelmeter has served for many years, both as a direct maintenance aid and as a source of information for analysis. Its ready availability and operational simplicity make this a most attractive choice as a means of data collection.

In 1956 a semi-automatic machine was made in which the trace on a moving chart was followed by manual movement of a cursor whose position was automatically recorded at regular time intervals in the form of a histogram of 25 classes. Though the speed of operation was considerably higher than wholly manual methods, the degree of concentration needed to ensure accurate trace-following, and the fact that the same calculations as for manual methods were subsequently required, made it clear that a much greater degree of automation was desirable. The machine here described has been designed to rapidly examine a chart with the minimum of supervision and to present its findings as a series of numerical readings requiring only brief slide-rule calculations for derivation of the most frequently-needed statistical quantities.

The machine reads the instantaneous lateral position of the trace on a recorder chart at frequent discrete intervals, and expresses each reading in terms of displacement from a reference position. As in the earlier trace-follower, equal readings are grouped and counted to present a histogram of the distribution of sample values, but, since the work for which this machine was envisaged specifically requires the calculation of arithmetic mean and standard deviation from the mean, further processing is undertaken for this purpose. The results of the analysis are displayed on a number of electromechanical registers under the following headings:

(*a*) Total Scans (n)—the number of sample readings taken,

(*b*) Σx—the sum of all individual measurements, x, and

(*c*) Σx^2—the sum of the squares of individual measurements.

It will be seen that the mean value is equal to

$$\frac{\Sigma x}{n}$$

and that the standard deviation from mean is equal to

$$\sqrt{\frac{\Sigma x^2}{n} - \left(\frac{\Sigma x}{n}\right)^2}.$$

In addition, an indication is given of the number of samples, out of the possible maximum, which were faulty for any reason recognized by the machine. Since most of these are automatically excluded from the analysis this serves mainly as a check of confidence.

DESIGN

Optical Reading Head

The optical reading head has the function of sampling the chart-trace position and producing an electrical analogue of each sample. Two main design requirements have been set as follows.

(*i*) The reading head must be capable of accepting and reading any of the standard types of recorder chart generally in use in the Post Office. These are 3 in. in width and carry a printed graticule of calibration and timing lines in blue on white paper on which a red-ink trace is superimposed by the pen of a recording meter.

(*ii*) Since the recording pen in traversing the paper describes an arc about its pivot, correct association of instantaneous trace position with the linear time-scale of the chart requires that the optical reading of trace displacement be carried out along a corresponding arc.

The head consists basically of a mechanical-optical flying-spot scanner, the principle of whose operation is illustrated in Fig. 1.

Light from a projection lamp illuminates a small aperture whose image is focussed to a narrow beam that passes through a prism in which it is bent through a right angle. Rotation of the prism about an axis coincident with the entrant light beam causes the reflected

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

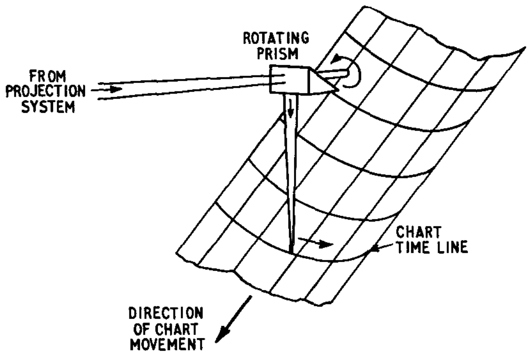


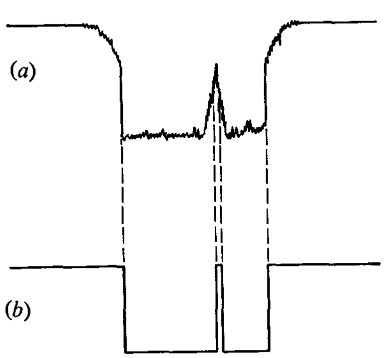
FIG. 1—PRINCIPLE OF OPERATION OF SCANNER

beam also to rotate. By means of suitably shaped and tilted guides the chart surface is made to occupy a 90° arc of the circle described by the light beam, with the curvature of the time lines lying wholly in its plane.

The projected light spot is thus made to traverse the width of the chart surface, during each revolution of the prism, on a path following that which would be traced by a recorder pen. The intensity of the light reflected from the chart surface at any instant serves to indicate the density of colour of the portion illuminated. At the surface of the paper both specular and diffuse reflection occur simultaneously, the former depending more on the surface glaze of the paper than on its colour. For this reason the detecting device has been positioned to avoid excitation except by diffuse reflection, and this requires extremely high sensitivity. Some indication of this is given by the fact that the photomultiplier used has an overall sensitivity of 200 amp/lumen, but passes a maximum anode current of only 0·3 mA.

To assist in colour discrimination a blue filter closely matched in colour with the printed chart-markings has been included in the optical system. White paper and blue lines, therefore, have high reflectivity, while the red trace appears relatively dark. The inside of the scanner housing is finished in matt black so that, in the period in which the chart is not being scanned, light reaching the photomultiplier cathode is at a minimum. The voltage waveform appearing across the anode load during each scan has the shape shown in Fig. 2(*a*). Amplitude variations in both the white and red parts of the signal are removed by limiting, to give the waveshape of Fig. 2(*b*).

During reading, the chart is moved steadily past the viewing point, successive scans examining narrow strips



(*a*) Photomultiplier Output Waveform
(*b*) Waveform after Limiting
FIG. 2—SCANNER OUTPUT-SIGNAL SHAPE

whose spacing is dependent on the speed of chart movement relative to the scanning frequency. At the slowest chart speed of 2 ft/min and at the fixed scanning frequency of 25 scans/s the scan pitch corresponds to an examination of a circuit under observation approximately once per minute (assuming the normal recording speed of 1 in./h). Chart-drive speeds of 4 ft/min and 8 ft/min are available to allow faster examination of charts where less frequent sampling is acceptable.

Since it is not uncommon for damage to the perforated edges of recorder charts to occur either during recording (as a result of dimensional changes) or during later handling, it was felt unsafe to rely on the sprocket-type drive used in recorders. Motive power is, therefore, supplied by a synchronous motor through a 3-speed gearbox to a hard-rubber-tyred drive-roller located below the guide assembly close to the viewing point, with a spring-loaded pressure roller acting on the face of the chart. This method provides adequate tractive force by the wedging action resulting from the disposition of the rollers, and release of the pressure-roller tension allows instantaneous stopping of the chart when required, without the need to overcome the inertia of the driving system.

Control and Calculating Circuits

Fig. 3 is a simplified block schematic diagram showing the relationships between the sections of the electronic equipment separately described below.

Differentiation of the waveform of Fig. 2(*b*) produces a train of four pulses alternately negative-going and positive-going, which correspond in time and sequence to the following events.

Pulse A—movement of the spot from a dark to a light area at the beginning of the scan.

Pulse B—transit of the spot from white paper to red trace.

Pulse C—transit from red to white.

Pulse D—transit from white to black at the end of the scan.

These pulses are applied either singly or in combination to control the timing of all the main electrical functions, as follows:

(*i*) scan counting and reset of logic circuits—pulse A,
(*ii*) faulty-scan detection—pulses A and C, and
(*iii*) trace-position measurement—pulses B, C and D.

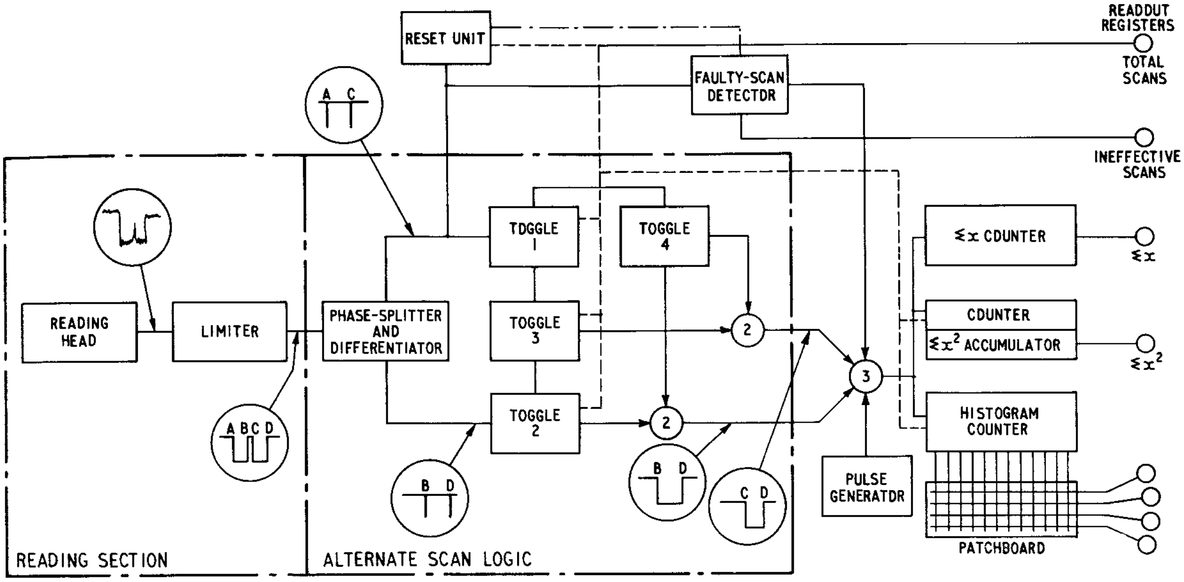
Scan Counting and Reset

The A pulse of each scan triggers a monostable delay-circuit to produce an output 18 ms later, i.e. 10 ms after completion of the scan. This is used directly to step the total-scans register and, if necessary, the ineffective-scans register, to reset the alternate scan logic, the histogram counter and the input counter of the sum-of-squares calculator. It is also used indirectly to reset the faulty-scan detector after a further 2 ms delay.

Choice of the A pulse as the main timing pulse of the train is dictated by its being the only one capable of detection without ambiguity in any scan whether faulty or good.

Faulty-Scan Detector

It will be seen that the waveform of Fig. 2(*b*) can result only from a scan of a correctly-recorded section of chart, i.e. having one, and only one, dark area between the



- - - - Main reset circuit
—·—· Delayed reset circuit

FIG. 3—SIMPLIFIED BLOCK SCHEMATIC DIAGRAM OF CHART ANALYSER

extremes of white paper. A break in the trace will result in the production of the A and D pulses only; extra marks in the path of the scan will add to the normal total of four pulses. Since in the differentiated waveform each dark area is represented by a pair of pulses of opposite polarity, a count of pulses of one polarity is also a count of the number of dark areas.

A 4-stage counter is stepped from zero in each scan by the A and succeeding negative-going pulses, an acceptable scan giving a count of two. At the end of any scan in which a count of other than two is recorded, input of data to the calculating circuits is suspended until the detection of the next correct scan, and a connexion is established to step the inneffective-scans register once for each scan in the intervening period. This system suffers from the disadvantage that it permits the inclusion in the analysis of the first in each series of faulty scans and excludes the first of the succeeding series of good ones. However, since confidence in the accuracy of any analysis necessarily depends on an overwhelming majority of good scans, the errors introduced are unlikely to be significant, and the extra complexity involved in eliminating them is felt to be unjustified.

Analogue to Digital Converter

In the electrical output from the scanning head time is analogous to distance, and trace displacement from a reference position may be assessed by measurement of time lapse between pulses in the differentiated waveform. Whilst any reference might be chosen it is convenient for various reasons to measure time lapse between detection of the trace and the end of the scan, both these events being clearly shown and all measurements being in the same sense.

Any trace is of finite width, and that produced by the running together of the successive alternations of the pen while recording a rapidly varying signal may be of very considerable width. Accurate measurement of displacement can only be made by determining the exact centre of the ink line, i.e. a point in time midway between the occurrence of the B and C pulses. This requires that both B and C pulses be recognized before measurement begins. To avoid this need, arrangements have been made to measure trace displacement as the time lapse between the B and D pulses on odd-numbered scans and between C and D pulses on even-numbered scans. The effect on the analysis of the introduction of two groups of small errors of equal weight but opposite sense is extremely small, but there is an alternative facility of sensing the B pulse or the C pulse exclusively, should this be preferred.

A train of 30 pulses beginning synchronously with the scan is fed to the calculating circuits through a gate opened by the B or C pulse and closed by the D pulse. The number of pulses received by the calculator for each scan is thus a measure of the distance between the trace and the rear edge of the chart. Using a train of equally-spaced pulses the readout from the machine is in terms of thirtieth parts of the chart-width, irrespective of its calibration. However, it will be apparent that the intervals of the pulse train can be arranged to correspond with those of any chart calibration law to allow direct reading, e.g. in decibels.

The gate pulse-train is fed in parallel to three units functioning independently as described below.

Histogram Unit

In the histogram unit samples are grouped according to size, the number in each group being separately recorded.

A 30-stage counter, employing p–n–p–n germanium diodes, in which not more than one stage may be energized at any time, is stepped from zero by each pulse train. Associated with each counter stage is a register-control circuit energized by the switch-on of the stage but having an operating time appreciably longer than the interval between pulses in the train. At the end of the scan the stage corresponding in number to the number of pulses received remains operated sufficiently long for the register-control circuit to add a count of one to the total in its register. The counter is then reset to zero in readiness for the next scan.

Although the analyser has been designed to be capable of producing a histogram of 30 equal classes, it was considered likely that this would seldom be required and that the facility of using a smaller number of classes whose individual limits could be varied at will offered considerable attraction. Full flexibility has been given by the provision of a patchboard which allows any one or more of the 30 counter outlets to be connected to each of the registers. Initially, only six registers have been provided, though space and wiring are available for up to 30.

Σx Counter

The Σx counter is a 10-stage counter of conventional design and is stepped by successive pulse trains without intermediate resetting. An output pulse steps the associated register once for each complete cycle of operation of the counter; this is arranged by local feed-back loops to occur for each 1,000 input pulses.

Σx^2 Calculator

In the Σx^2 calculator the input pulse train is counted and the square of the number of pulses added to the total existing in a 10-stage binary accumulator. An output is given to the register for each 1,000 pulses received by the accumulator. This unit has been fully described elsewhere.*

CONSTRUCTION

The analyser is housed in a console similar in size to an office desk, the scanning head and power supplies being incorporated in the left-hand pedestal; the electronic equipment is mounted on a rack which may be withdrawn on slides from the right-hand pedestal. Readout registers, patchboard and electrical controls are mounted in a turret above the rear of the desk surface. To the left of the turret is the chart-drive speed control giving choice of gear ratios for the three speeds, and near the front of the desk surface is a "pause" control which allows the operator temporarily to stop both chart movement and scan output at any time during a run and to resume the run without interference with the analysis.

In operation, the chart is drawn along an inspection trough in the desk surface from a storage box on the right of the desk to the reading head in the left pedestal, and, on emerging from the head guides, the chart is allowed to fall back into its original folds in a container beneath. The direction of movement from right to left was chosen on account of its equivalence to the natural eye movement (from left to right) used when examining a stationary chart.

Owing to the need to shield the photomultipliers from ambient light it is not, unfortunately, possible to make the reading point visible to the operator, and determination of the portion of chart being scanned can only be made by reference to some point a known distance away. A convenient distance for this purpose is 12 in., corresponding to 12 hours on the time scale of most charts, and a mark has been provided at this point.

The complete equipment is mains driven, a constant-voltage transformer at the input permitting operation without adjustment from supplies of from 200–250 volts.

*Ellen, L. W. A Simple Sum-of-Squares Electronic Calculator. *P.O.E.E.J.*, Vol. 56, p. 6, Apr. 1963.

A Pneumatic Cable Cutter

U.D.C. 621.937—85:621.315.23

When it is necessary to cut up large-diameter cables after they have been recovered, the existing method using an axe and chopping block is wasteful of time and effort. A pneumatic cable cutter that has been on trial is described.

INTRODUCTION

The recovery of main underground cables of large diameter is a slow process, and the existing method of cutting the cable into short lengths, using an axe and chopping block, is both time-wasting and fatiguing.

A Chance CA 1400 D.C. Pneumatic Cable Cutter (Fig. 1) has recently been purchased for trial purposes to establish whether a cutter of this type can be economically employed in the British Post Office. The appliance is of American design and manufacture, and is suitable for cutting lead, plastic or hessian covered cables up to 3 in. in diameter. It is not suitable for cutting armoured cable or self-supporting cable containing a steel suspension wire.

DESCRIPTION OF CABLE CUTTER

The appliance, which is powered by compressed air at 75–150 lb/in^2, is constructed mainly of aluminium alloy, with jaw blades of alloy steel. It has an overall length of 3 ft 7 in., and weighs 18 lb.

Dual operating triggers are fitted which, when operated together, allow compressed air to pass into the cutter driving-cylinder and on to the face of a piston, which is connected to an extended piston rod. This piston rod is, in turn, connected to and operates the alloy-steel blades via two cams. Spiral restoring springs within the driving cylinder return the piston to its former position on release of air from the cylinder.

Quick-release couplings are provided on the appliance and associated compressed-air hose.

Safety Precautions

To reduce the possibility of accidental operation the two operating triggers on the appliance are placed at 180° to each other, and both triggers must be operated to close the cutting blades.

COMPRESSED-AIR SUPPLY

Compressed air to operate the pneumatic cutter can either be obtained from a compressed-air cylinder or a compressor.

(*a*) *Compressed-Air Cylinder.* Cylinders of compressed air of 110 ft^3 capacity will give approximately 150 operations of the cutter at 150 lb/in^2 or 200 operations at 100 lb/in^2. Cylinders of compressed air of 165 ft^3 capacity will give approximately 200 operations at 150 lb/in^2 or 300 operations at 100 lb/in^2. A 2-stage regulator (0–150 lb/in^2) is required to obtain air at the correct pressure from the cylinder.

(*b*) *Compressor*. Compressed air at 100 lb/in^2 can be obtained from a Compressor, Air, No. 1 (trailer mounted); this pressure is adequate for cutting cables up to 2 in. in diameter. Compressed air up to 150 lb/in^2 can be obtained from a Compressor, Air, No. 3, as used with duct-rodding equipment.

USE OF CABLE CUTTER

Operation

The appliance is actuated, after connecting the compressed-air supply, by first operating the larger trigger at the centre of the cutter (see Fig. 2) and then operating the small trigger; the jaw blades do not close until the small trigger is operated. The blades automatically restore to the fully-open position when the small trigger is released.

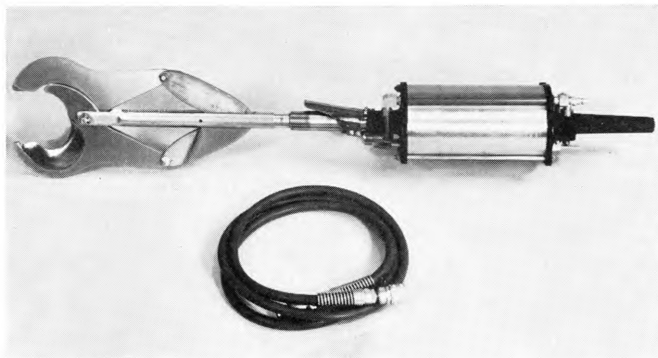
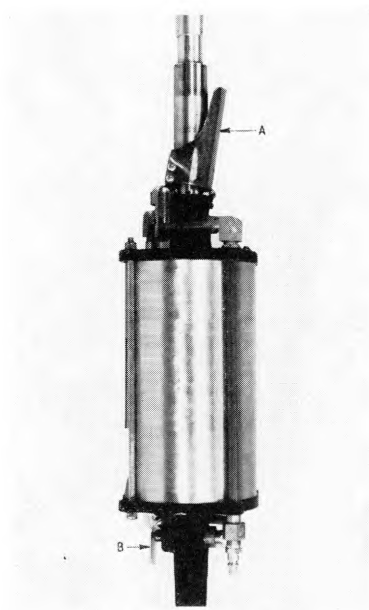


FIG. 1—PNEUMATIC CABLE-CUTTER

The cable to be cut must be raised about 2 in. from the ground by means of a small wooden block to allow it to be placed completely within the jaw blades of the cutter. The cutter must then be held firmly, with the jaws at right-angles to the cable to ensure a clean cut and to prevent twisting when the blades close.



A—Large trigger. B—Small trigger.
FIG. 2—POSITIONS OF LARGE AND SMALL TRIGGERS

Maintenance

The day-to-day maintenance required when the cutter is in use is small; it consists mainly of lubricating with a light machine oil the three pivot points of the jaw blades and the pivot points at the junction of the piston rod and jaw cams.

The cutter blades must be kept sharp by careful honing on the bevelled side.

When a task with the cutter has been completed, the driving cylinder should be lubricated. This is best done by removing the compressed-air hose from the cutter, injecting a few drops of oil into the driving-cylinder hose connexion, recoupling the hose and operating the cutter three or four times.

CONCLUSIONS

Trials carried out on 96 pr., 70 lb/mile and 54 pr., 70 lb/mile paper-core multiple-twin cable showed that the use of this machine to cut up cable can reduce the time taken to a quarter of that necessary when using manual methods.

E.W.C.

A Fault-Location Test Set for Repeatered Submarine Cables

R. J. EDWARDS†

U.D.C. 621.317.333.4:621.315.28

In recent years extensive use of submarine telephone repeaters has magnified the ever-present problem of locating cable faults. To meet changes in circumstances, a technique employed from the early days of submarine telegraphy has been adopted and further developed in the light of modern knowledge.

INTRODUCTION

In addition to its primary function of conveying high-frequency telephony signals, the inner coaxial conductor of a submarine cable also serves to carry the direct current necessary to energize the submerged repeaters. Usually, the energizing current is fed into the system from both terminals simultaneously but, occasionally, on relatively short systems, from one terminal only; with either method the effectively zero resistance of the earth itself is used to complete the circuit. Each repeater incorporates a filter to divert h.f. signals into the amplifier proper and allow the energizing current to flow through a resistive network including the amplifier valve-heaters, across which the h.t. voltage is developed. The bandwidth of this power-feeding path extends from zero to a few kilocycles per second.

In the event of a catastrophic failure of the cable insulant it is possible to energize the repeaters on at least one side of the fault via the fault resistance to earth, and, provided repeaters have not been damaged by the electrical surge that occurs at the instant of failure, tests made at normal transmission frequencies will indicate between which repeaters the fault has occurred.[1] More rarely, a broken inner conductor which remains insulated from earth precludes such tests, but in any eventuality it is desirable to take advantage of the low-frequency path available through unenergized repeaters by utilizing other location techniques which are, despite the greater testing-signal attenuation, potentially of greater precision.

UNDERLYING PRINCIPLES

It is well known that duplex-telegraph transmission is achieved by means of a bridge arrangement, one arm of which is the cable itself and the balance arm is a network designed to simulate cable end-impedance over the signal-frequency spectrum. For submarine d.c. telegraphy the simulating network consists of a ladder network, and it was long ago discovered that when the occurrence of a minor cable defect upset the bridge the balance could be restored by inserting a corresponding defect at a point along the ladder, found by trial, thus enabling duplex working to be resumed and, incidentally, crudely indicating the location of the actual defect. To appreciate the reasons for adopting this principle on modern telephone cables it is useful to examine the problem in more detail.

All alternating-current methods of fault location on transmission lines ultimately depend on an impedance irregularity due to the fault, which reflects back towards the testing end part of the energy contained in the testing signal. Various techniques may be employed to extract from the reflected energy the information it contains regarding the fault position; this information is in the form of distortion and delay suffered by the signal during its double journey. With a submarine telephone system, the repeaters, equalizers and abrupt changes of cable type also constitute points of reflection because each similarly disrupts the uniformity of distribution along the system of the four primary parameters (resistance, capacitance, inductance and leakance). The problem is to identify the fault reflection from the obscuring multitude of normal reflections and then in some manner to deduce its point of origin. Pulse-echo methods are impracticable because propagation characteristics of the unenergized system cause signals to be diffused rather than to be transmitted along the cable, with each harmonic component travelling at a different velocity. Conventional impedance/frequency measurements[2] are also of little value when the fault lies beyond five or six repeaters, because of the great signal attenuation encountered.

The unenergized system attenuates signals quite rapidly even at sub-audio frequencies, with the loss increasing in approximate proportion to the square root of frequency. For example, a typical transatlantic system has an attenuation coefficient of 1·57 db/100 nautical miles at 1 c/s, and, consequently, when the fault lies at a great distance only the extremely-low-frequency components of the testing-frequency spectrum will return to the testing end. In general, for cables longer than 100 miles, useful testing frequencies are restricted to the sub-audio range.

DESCRIPTION OF THE EQUIPMENT

The technique adopted in the present equipment utilizes an artificial-cable system* by means of which normal reflections are automatically neutralized in an impedance bridge, thus allowing abnormal reflections to be dealt with independently by inserting into the network at the correct position an artificial fault of the appropriate type and magnitude. Advantages of this arrangement are that both series-type and shunt-type faults can be located without changes in operating procedure, and the need for protracted calculations is eliminated. Either sine-waves or square-waves may be selected for the testing signal. Fig. 1 and 2 show the general arrangement and are largely self-explanatory, but a few of the more interesting features are described below. In general, the components of Fig. 1 are common to all systems in which the equipment is installed, whereas those of Fig. 2 are specifically designed for each terminal of a particular cable system.

Method of Indicating Bridge Balance at Sub-Audio Frequencies

The vertical deflector plates of a cathode-ray tube having a long after-glow are fed with an amplified and filtered version of the bridge unbalance voltage. When a

*An essential difference between the artificial cable and the duplex balance is that the former, in addition to possessing the correct impedance/frequency characteristic, must also simulate both attenuation and phase shift occurring in the actual system.

†Test and Inspection Branch, E.-in-C.'s Office.

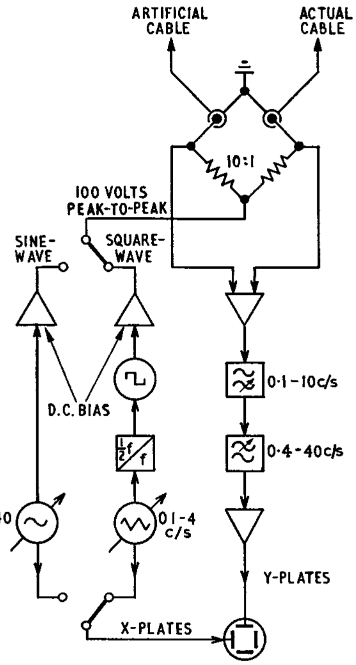


FIG. 1—SIMPLIFIED BLOCK SCHEMATIC DIAGRAM OF BRIDGE, SIGNAL GENERATOR AND INDICATOR UNITS

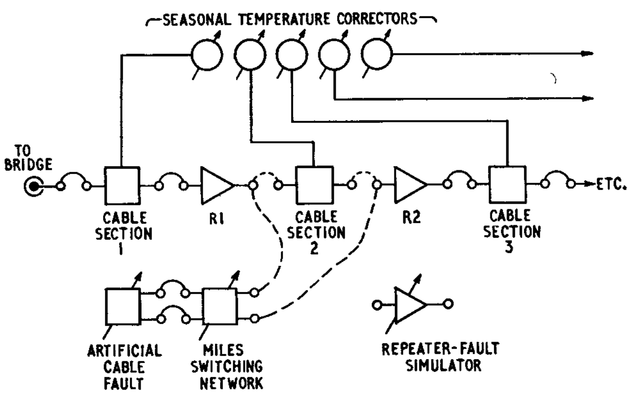


FIG. 2—BLOCK SCHEMATIC DIAGRAM OF ARTIFICIAL-CABLE SYSTEM

square-wave testing signal is selected the time base is linear and of twice the signal frequency, with a rapid flyback occurring whenever the square-wave reverses polarity; therefore, the cathode-ray-tube spot traces out a graph of unbalance voltage versus time with successive traces being mirror images of each other, as shown in Fig. 3. As balance condition is approached the picture collapses upon itself and, ideally, balance is indicated by a straight horizontal line across the tube face. In practice, the bridge is adjusted for minimum area enclosed between successive traces. When sine-waves are in use the time base is also of sine-wave form, being fed directly from the signal generator. This causes the cathode-ray-tube spot to trace out an ellipse whose axes are rotated in proportion to the phase shift occurring in the bridge, and, as before, ideal balance is indicated by a horizontal line. Overall sensitivity for both test signals is sufficient to detect 0·1 per cent bridge unbalance.

Interference Filters

Sudden local variations in the earth's magnetic field, electrical storms, and tidal and wave action induce random voltages in the cable with amplitudes roughly inversely proportional to frequency. An adjustable, active, high-pass filter minimizes the effects of these disturbances and, simultaneously, blocks erratic e.m.f.s generated by electrolytic action at the fault itself. At the higher end of the usable spectrum lies man-made interference at power frequencies, and the effects are more severe when the cable terminates in an industrial area or in the vicinity of electrified railways; hence the provision of a low-pass filter.

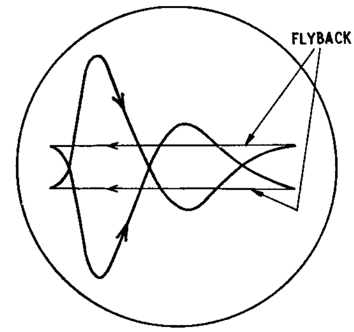


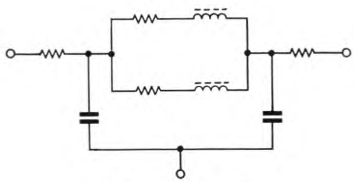
FIG. 3—CATHODE-RAY-TUBE DISPLAY OF A TYPICAL UNBALANCE PATTERN WHEN USING SQUARE-WAVES

The Artificial Cable

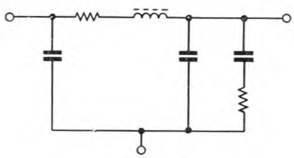
To effect a reduction in cost and size, all elements have 10 times the impedance of their counterparts in the actual system, but this artifice is easily allowed for by using identically-proportioned bridge ratio arms. Propagation characteristics remain unchanged because attenuation and phase shift depend only on the ratio of series to shunt elements. Individual networks representing repeater sections of cable, repeaters and equalizers have their terminals brought out to front-panel sockets and are connected in correct sequence by means of U-links. A special circuit is available to replace the network that normally represents the repeater section of cable in which the actual fault is situated, so enabling the artificial fault to be varied in 1-mile steps between adjacent repeater simulators.

Small imperfections in the artificial cable are inevitable, but simulation errors in the near-end sections must be reduced to an absolute minimum, otherwise nearby residual reflections will swamp those received from a remote fault because of the smaller attenuation involved. Individual networks (Fig. 4(*a*)) are designed to match impedance and propagation characteristics to within 0·1 per cent of the target values over the frequency range 0–40 c/s. These target values are derived by correcting the factory measurements made on the actual cable sections for the appropriate temperature and water pressure, which depend on predetermined positions along the route. Corrections are based on mean values of sea temperature, but only at depths greater than 1,500 fathoms does this factor remain sufficiently stable for seasonal variations to be neglected. For this reason networks which simulate cable sections laid over continental shelves are fitted with subsidiary elements that must be pre-set according to predicted sea temperature, although, under favourable circumstances, adjustments may be made as part of the fault-location process without prior information on sea temperature.

For each new cable type it is essential to derive



(*a*) Repeater Section of Cable



(*b*) Repeater

FIG. 4—TYPICAL SIMULATING NETWORKS

additional corrections from measurements on experimental lengths laid on the sea bed. This is because return currents prefer to flow in the sea at low frequencies rather than via the coaxial outer conductor, and skin effect occurs by virtue of the enormous cross-sectional area available. The effect on resistance and inductance on this account is frequency dependent from d.c. up to several hundred cycles per second. Additionally, when a terminal station is sited inland, measurements must be made on site to ascertain changes in effective cable parameters due to peculiarities in local earth conductivity, the presence of armouring wires, etc.

Artificial Repeaters and Equalizers

The design of the artificial-repeater and equalizer networks (Fig. 4(*b*)) presents fewer difficulties since it is necessary to consider only those components associated with the d.c. path, such as power-separating filters, thermionic-valve heaters and moisture detectors. Again, basic design information is obtained from factory measurements on individual units; it is then corrected for sea-bottom temperature and also for a small increase in resistance due to the heating effect of testing currents flowing through valve heaters.

One complication is the presence in an actual repeater of an automatic device[3] which, when any one of the valves fails, operates irreversibly to enable the amplifier still to function. Unfortunately, from the point of view of fault location, once the device has operated the unenergized repeater resistance is approximately doubled in value and, since this constitutes a source of reflection unaccounted for in the artificial system, the equipment operator may have two or even more simultaneous faults with which to contend.

The Artificial Fault

A cable conductor exposed to sea water behaves in a complex manner and is difficult to simulate. Fortunately, the problem is eased by allowing a few milliamperes of polarizing direct current to flow during a.c. tests; the fault impedance then becomes rather more predictable, and it may be represented by a resistor and capacitor in parallel. Representation may be made exact at any single frequency, but the resistor-capacitor combination is only a fair approximation over a band of frequencies, a condition which obtains when the testing signal consists of a square-wave. As a guide to the order of magnitude involved, an earth fault having a d.c. resistance of 25 ohms may have an equivalent shunt capacitance of 500 μF at 1 c/s, although its ability to store a charge depends on electrochemical action (polarization) rather than on the presence of such a large capacitor.

OPERATION OF THE EQUIPMENT

Since both the fault magnitude and its position effect the system end-impedance, the key to successful operation of the equipment resides in a detailed investigation of the manner in which the fault impedance responds to changes in testing frequency and to the polarity and value of the super-imposed direct current, with the object of separating the two basic causes of bridge unbalance. Classical Wheatstone-bridge measurements are also valuable in this respect, and the equipment incorporates facilities for carrying out such tests.

In practice, both fault position and impedance are arrived at simultaneously via a succession of closer approximations, with the operator, when adjusting the artificial fault, taking into consideration any pattern of behaviour discovered during his initial investigation. Since faults do not behave identically it is not possible to prescribe an exact set of operating rules and, indeed,

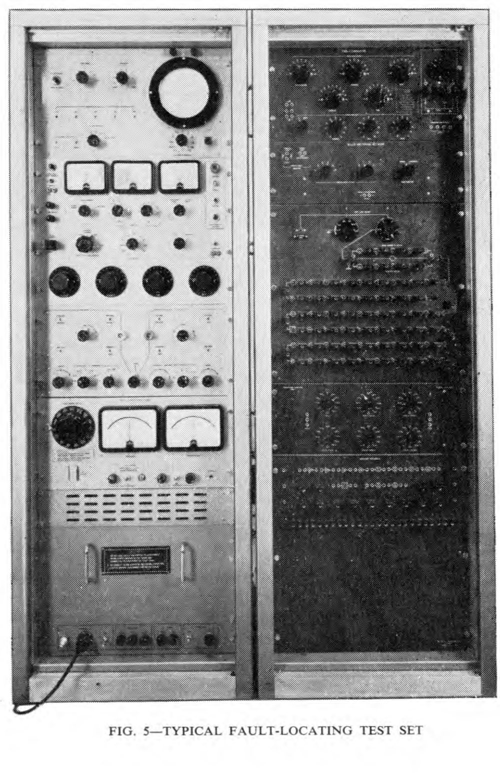


FIG. 5—TYPICAL FAULT-LOCATING TEST SET

location of cable faults in the sea is so far removed from mere adherence to a fixed set of rules that it might be considered an acquired art.

Only in the case of a broken but highly-insulated cable conductor is it relatively easy to deduce and prove the conditions existing at the fault, thereby allowing its location to be stated with confidence. Under such circumstances the erroı is not likely to be greater than 0·3 per cent of the distance from the nearer testing end of the system. Similar accuracy may be expected when an unbroken inner conductor becomes in contact with the sea, because tests from each end of the system will be concerned with a common fault impedance and, provided precautions are taken, ambiguities can be resolved. More serious difficulties are encountered when the cable is completely severed, with both ends having an unstable impedance to the sea; it is then essential to attach full weight to both a.c. and d.c. tests, including voltage/current measurements taken before power is removed from the system. Occasionally, many hours application of an appropriate direct current beneficially results in one of the end-impedances becoming low and stable, or, alternatively, an exposed end may become insulated by an electrochemically deposited film. Either of these extreme conditions allows the fault to be more closely simulated in the artificial system and is conducive to accurate fault location.

CONCLUSIONS

The prototype equipment was installed at both terminals of the Anglo-Swedish cable. During 1961 a fault 300 miles from Middlesbrough was located to within 0·6 miles, and following this demonstration of their capabilities, similar sets (Fig 5) have been installed at terminal stations of the Commonwealth cable and other oceanic systems.

The consequencies of a large location error on such systems could be serious; it is highly impıobable that any one method of fault location will ever be relied upon exclusively, but it is expected that, as experience is accumulated, the equipment described will have an important part to play.

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The International System of Units—SI Units

K. W. MORRIS, B.Sc.(Eng.), A.M.I.E.E.†

U.D.C. 53.081

SI Units form a comprehensive international system of units that will have increasing application in the United Kingdom as the metric system of weights and measures is more generally adopted here. The development of SI Units is described and the basic units are defined.

INTRODUCTION

About 12 years ago the British Post Office, along with other public and educational bodies, decided to actively encourage the use of the Rationalized M.K.S. system of units. This system was adopted internationally by the International Electrotechnical Commission (I.E.C.) in 1950, and was intended to provide a system of electrical units that could be used generally and which eliminated the shortcomings of the various existing systems of units.

The Rationalized M.K.S. system is now known as the M.K.S.A. or Giorgi system of units, and it forms part of a wider system of units covering more fields than electrical technology. This wider system of units was adopted by the General Conference on Weights and Measures (C.G.P.M.) in 1954, and in 1960 it was formally given the name "Système International d'Unités" (the International System of Units) and the abbreviation SI Units.

SI Units is a metric system of units which will have increasing importance in this country in the future: it is almost certain to be the system that will be adopted when, as a result of the recently announced Government policy, metric units become the primary system of weights and measures in this country.

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

DEVELOPMENT OF SI UNITS

The various systems of units that are in use have been developed over the years to meet the needs of commerce, industry, and the many branches of science and technology. These systems meet present-day needs with varying degrees of success, but one field where they caused difficulties, prior to the introduction of M.K.S.A. units, was that of electrical technology. Here three main systems of units had developed:

(*i*) the C.G.S. electromagnetic system,
(*ii*) the C.G.S. electrostatic system, and
(*iii*) the practical units.

Conversion between systems (*i*) and (*ii*) involved the constant c, which is the free-space velocity of light in cm/s, while conversion between the practical and the C.G.S. systems involved various powers of 10. These complicated formulae made calculations more laborious and rendered teaching and understanding more difficult.

Professor Giorgi suggested in 1901 that if the metre were used as the unit of length (instead of the centimetre), the kilogramme as the unit of mass (instead of the gramme) and the second as the unit of time then, with one of the practical electrical units as the fourth unit, a coherent system of units could be built up which would be suitable for all uses and would solve the difficulties that existed.

The ampere was eventually selected as the fourth unit, and the system based on these four units became known as the M.K.S.A. or Giorgi system, which covers the field of electrical technology.

The first three (metre, kilogramme and second) of the four units together with the radian (as the unit of plane angle) and the steradian (as the unit of solid angle) give the M.K.S. system used in mechanics. By adding as a fifth unit the degree Kelvin (°K) this system of units was extended to cover the field of thermodynamics. To cover the field of illumination a sixth unit was considered necessary, and the candela (cd) was selected as this unit. These six basic units form the SI Units, which thus provides a comprehensive system of units covering weights and measures, mechanics, electricity, thermodynamics and illumination.

In order to include chemistry in this system of units a further unit has been considered necessary, and the International Organization for Standardization (I.S.O.) has recommended the mole (symbol mol), corresponding to the basic quantity "amount of substance," for this purpose. If this is agreed it will become the seventh basic unit.

UNITS AND DEFINITIONS OF THE SYSTEM

Basic SI Units

The present six basic units of the SI Units, and the corresponding unit symbols, are shown in Table 1.

TABLE 1
Basic SI Units

Quantity	Name of Unit	Unit Symbol
Length	Metre	m
Mass	Kilogramme	kg
Time	Second	s
Electric current	Ampere	A
Thermodynamic temperature	Degree Kelvin*	°K
Luminous intensity	Candela	cd

*Temperature difference is commonly expressed in degrees Celsius (or Centigrade) instead of degrees Kelvin. But the unit for the Celsius and Kelvin scales is the same: 1 degree C = 1 degree K.

Definitions of Basic SI Units

Length. The unit of length called the "metre" is 1,650,763·73 wavelengths in vacuo of the radiation corresponding to the transition between the energy levels $2p_{10}$ and $5d_5$ of the krypton-86 atom (11th C.G.P.M., 1960).

Mass. The unit of mass called the "kilogramme" is the mass of the international prototype which is in the custody of the International Bureau of Weights and Measures (B.I.P.M.) at Sèvres, near Paris, France (3rd C.G.P.M., 1901).

Time. The unit of time called the "second" is defined by the fraction 1/31,556,925·9747 of the tropical year for 1900 January 0 at 12 h ephemeris time (11th C.G.P.M., 1960). The tropical year is the time interval between consecutive passages, in the same direction, of the Sun through the Earth's equatorial plane.

Electric current. The unit of electric current called the "ampere" is that constant current which, if maintained in two parallel rectilinear conductors of infinite length, of negligible circular cross-section, and placed at a distance of one metre apart in a vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre length (9th C.G.P.M., 1948).

Thermodynamic Temperature. The unit of thermodynamic temperature called the "degree Kelvin" is the degree interval of the thermodynamic scale on which the temperature of the triple point of water is 273·16 degrees exactly (10th C.G.P.M., 1954). Note: the corresponding temperature of the ice point (the freezing point of water at 1 atmosphere pressure) is 273·15 °K.

Luminous Intensity. The unit of luminous intensity called the "candela" is such that the luminance of a full radiator at the temperature of solidification of platinum is 60 units of luminous intensity per square centimetre (9th C.G.P.M., 1948).

Some Derived SI Units Having Special Names

Some derived SI Units having special names, and the corresponding unit symbols, are shown in Table 2.

TABLE 2
Specially Named Derived SI Units

Physical Quantity	SI Units	Unit Symbol
Force	Newton	N = kg m/s²
Work, energy, quantity of heat	Joule	J = N m
Power	Watt	W = J/s
Electric charge	Coulomb	C = A s
Electrical potential	Volt	V = W/A
Electric capacitance	Farad	F = A s/V
Electric resistance	Ohm	Ω = V/A
Magnetic flux	Weber	Wb = V s
Inductance	Henry	H = V s/A
Luminous flux	Lumen	lm = cd sr
Illumination	Lux	lx = lm/m²

Some Derived SI Units Having Complex Names

Some derived SI Units having complex names, and the corresponding unit symbols, are shown in Table 3.

PARTICULAR ASPECTS OF SI UNITS

SI Units form a coherent system of units, that is, a system in which the product or quotient of any two quantities leads directly to the resultant quantity. For example, unit force (newton) moving through unit distance (metre) does unit work (joule); and, as 1 joule/second equals 1 watt, a direct and simple link between mechanical and electrical systems results.

The same fundamental standards are used in SI Units as in the C.G.S. system, namely the metre, kilogramme and the mean solar second, and therefore there is no disagreement between a result obtained with SI Units and one obtained with C.G.S. Units.

One important change in concepts is that in SI Units the kilogramme is regarded as the unit of mass and not as the unit of weight, and the concept of weight is replaced by that of force for which the unit is the newton.

USE OF SI UNITS

SI Units resulted from long deliberation by a number of important international bodies, among whom are the I.E.C., the I.S.O., the C.G.P.M., and the International Union of Pure and Applied Physics (I.U.P.A.P.) and its Commission for Symbols, Units and Nomenclature

TABLE 3
Some Derived SI Units Having Complex Names

Physical Quantity	SI Units	Unit Symbol
Area	Square metre	m^2
Volume	Cubic metre	m^3
Frequency	Cycle per second*	s^{-1}
Density (mass density)	Kilogramme per cubic metre	kg/m^3
Velocity	Metre per second	m/s
Angular velocity	Radian per second	rad/s
Acceleration	Metre per second squared	m/s^2
Angular acceleration	Radian per second squared	rad/s^2
Pressure	Newton per square metre	N/m^2
Surface tension	Newton per metre	N/m
Dynamic viscosity	Newton second per metre squared	$N\ s/m^2$
Kinematic viscosity } Diffusion coefficient }	Metre squared per second	m^2/s
Thermal conductivity	Watt per metre degree Kelvin	W/(m °K)
Electric field strength	Volt per metre	V/m
Magnetic flux density	Weber per square metre†	Wb/m^2
Magnetic field strength	Ampere per metre	A/m
Luminance	Candela per square metre	cd/m^2

*The hertz (symbol Hz) is used as the name of this unit in Continental literature in accordance with the recommendations of the C.G.P.M., the I.E.C. and the I.S.O. In British Standards, the symbol "c/s" is used for this unit.

†The tesla (symbol T) is the name given to this unit in Continental literature in accordance with the recommendations of the C.G.P.M., the I.E.C. and the I.S.O.

(S.U.N.). It is, of course, the desire of these bodies that SI Units should be adopted as widely as possible, and the various national representatives are working to this end. The International Telecommunications Union (I.T.U.), of which the British Post Office is a member; has adopted this system of units and has recommended its use by its members. In France, SI Units have been adopted as a legal system. In this country the British Standards Institution is the national body perhaps most concerned with preparation for wide implementation; the first step towards this, in which the Post Office actively participated, was taken a few years ago when the various electrical interests adopted the M.K.S.A. system which, as stated earlier, is part of SI Units.

Further steps will undoubtedly follow as the country gradually adopts the metric system.

CONCLUSION

SI Units provide a modern international system of units, suitable for general and scientific use, which reduces or eliminates the difficulties caused by the older systems of units. It will have increasing use here as this country moves over to the metric system of weights and measures. Part of SI Units is familiar to Post Office engineers as the M.K.S.A. system that was introduced some 12 years ago; wider use of SI Units does not introduce any change to the M.K.S.A. system, and as far as the Post Office is concerned the repercussions are likely to be more in the field of physical dimensions than of electrical theory and measurements.

ACKNOWLEDGEMENT

Extracts from B.S. 3763 : 1964, The International System (SI) Units, are reproduced by permission of The British Standards Institution, 2 Park Street, London, W.1., from whom copies of the complete standard may be obtained.

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Book Review

"The Electronics Book List." Edited by G. W. A. Dummer and J. Mackenzie Robertson. United Trade Press, Ltd. 152 pp. 20s.

This is a list in book form of a selection of some 1,100 books on electronics, arranged under 50 different subject headings. Most of the books shown have been published since 1945, although a number are pre-war and some are as early as 1927. Details are given in columns showing title, author, publisher, year of publication, number of pages and price. In addition, a list of British publishers and their addresses is included.

One has the impression that the material for this book has been most hastily compiled. The editors admit that this first selection cannot be regarded as complete, and there are indeed many other books on electronics worthy of inclusion. Generally, the books in each section are listed in order of publication date, but this is not always the case: in some sections titles have been added at the end as though as an afterthought. Many cases occur where the bibliographical details are not complete. "An Introduction to the Theory and Practice of Transistors" by Tillman and Roberts (Pitman) appears twice in the same section with differing bibliographical details. "Television Receiver Servicing Vol. 2" by Spreadbury (Iliffe) is listed under the section "Repairs and Maintenance," but Vol. 1 has been omitted. "Masers" by Troup (Methuen) appears under both "Microwaves" and "Masers," although it is not apparent why this book and none of the others under "Masers" also appears under "Microwaves."

It is to be hoped that the general untidiness and the obvious omissions will receive attention before a second edition appears. A future edition could, with advantage, include an author index.

R.C.G.

Soft-Soldering to Gold-Plated Surfaces

E. V. WALKER, B.Sc., A.R.S.M., F.I.M., and F. A. WALDIE†

U.D.C. 621.791.3: 669.218.68

Following published accounts which claim that soft-soldered joints on gold-plated surfaces are embrittled by the gold, an investigation was carried out to test these findings. The investigation showed that soldered joints are not embrittled by gold provided the thickness of the gold plating does not exceed about 50 microinches. Moreover, even when the thickness of gold plating exceeds 200 microinches, the tensile strength of joints is not adversely affected.

INTRODUCTION

IN June 1962 two papers concerned with the embrittlement of soft-soldered joints by gold from plated surfaces were read before the American Society for Testing Materials. The first[1] was by F. Gordon Foster of Bell Telephone Laboratories and the second[2] by J. D. Keller of the Martin-Orlando Co., Florida. Both authors reported that gold dissolves very readily in 60:40 tin-lead solder and causes deterioration in its strength and ductility if the gold content exceeds about 5 per cent. It was also shown that, when soldered joints are made to thick gold plating, wetting and flow are impaired. This, the authors say, is due to the formation of tin-gold and lead-gold compounds. The publication of these two papers caused much anxiety to those concerned with equipment incorporating joints soft-soldered to gold plating.

In June 1963 a paper on soldering to gold plating was read by W. B. Harding and H. B. Pressly (Bendix Corporation, Missouri) to the American Electroplaters' Society.[3] In a survey of the literature they say that very little information has been published on the solderability of gold plating. The authors investigated the effect of gold-plating processes, thickness of gold plating, soldering time and temperature on the properties of joints using 63:37 tin-lead solder. Their results, in general, support the conclusions of Foster and Keller, but because their experiments covered a wider field, they were able to make some additional observations. Their conclusions are:

(*a*) for a given thickness, pure-gold plating permits stronger and more ductile soldered joints to be made than an alloy-gold plating, and the quality of a soldered joint is unaffected by the type of pure-gold plating bath used, i.e. acid cyanide or alkali cyanide,

(*b*) no detrimental effects on the microstructure and strength of soldered joints occur provided the thickness of the gold plating is not greater than 50 microinches,

(*c*) soldering time and temperature should be kept to a minimum, and

(*d*) a gold thickness of 10 microinches is a definite aid to soldering.

In January 1965 J. Whitfield and A. J. Cubbin reported in the *A.T.E. Journal*[4] results of an investigation on soldering to gold plating 200 microinches thick. The authors found that the strength of joints was not impaired by the presence of gold in the solder, a finding that was supported by field reliability trials.

Soldering to gold plating in British Post Office equipment is done at present on components for submerged repeaters and on plugs and sockets used with printed circuits for 62-type equipment. For the former the thickness is specified at not less than 20 microinches (actual thickness might be 30 or possibly 50 microinches in places) which, according to Harding and Pressly, would cause no weakening of a soldered joint. For the plugs and sockets, however, the thickness of gold is specified at 200 microinches which, according to these workers, would definitely produce an unsatisfactory soldered joint, although the more recent publication of Whitfield and Cubbin contradicts this.

Post Office experience over the past 10 years has been that there is no difficulty in soldering to gold plating on components for submerged repeaters, nor has the very careful inspection at all stages in the manufacture of submerged repeaters given any cause to suspect the quality of soft-soldered joints made to gold plating.

To obtain first-hand information on the effect of gold on the quality of soldered joints, the work described in this article was undertaken during 1963–64.

EXPERIMENTAL WORK

Some preliminary experiments showed that (*a*) gold very readily dissolves in 60:40 tin-lead solder, (*b*) solder does not flow on gold plating so well as it does on clean copper, the difference being more marked with 200-microinch plating than when the gold is 20 microinches thick, and (*c*) a joint soldered to gold plating shows acicular and other shaped constituents in its microstructure (for example, compare Fig. 1 and 2).

FIG. 1—SOLDER ON PLAIN COPPER

Tests for Embrittlement of Solder by Gold

The effect of gold on the ductility of solder was determined in the following way. Copper strips, 3 in. × ⅜ in. and 0·029 in. thick, were electroplated on one side with gold from an acid cyanide bath to thicknesses in the range 30–330 microinches. The plated strips (gold face

†Post Office Research Station.

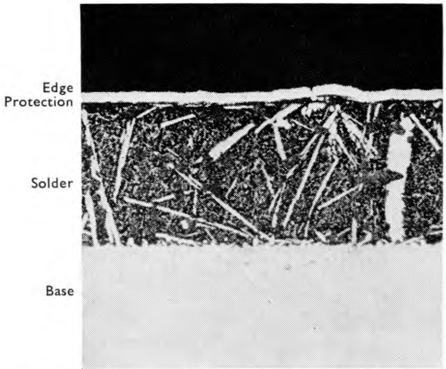

FIG. 2—ACICULAR CRYSTALS IN SOLDER ON 130-MICROINCH GOLD PLATE

upwards) were placed, one at a time, on a freshly "tinned" flat face of a soldering iron kept at a temperature of 350°C and held horizontally in a clamp. A $\frac{1}{4}$ in. length of 18 s.w.g. rosin-cored 60:40 tin-lead solder* was placed in the centre of the plated strip, which was removed from the soldering iron 5 seconds after the solder had melted. After cooling to room temperature, the strip was bent around a steel mandrel of $\frac{7}{32}$ in. diameter, with the solder drop placed on the outside of the bend. Observations for cracking were made with a low-power microscope: the results are set out in Table 1, the criterion of ductility being the absence of cracks in the solder. The appearance of a cracked specimen is

TABLE 1
Relation between Thickness of Gold Plating and Ductility of Solder

Thickness of Gold Plating (microinches)	Mechanical Condition of the Solder
30	Ductile
40	Ductile
50	Ductile
80	Ductile
100	Brittle
130	Brittle
330	Brittle

shown in Fig. 3; the cracks that were visible in the microstructure are shown in Fig. 4.

The change from the ductile to brittle condition takes place in the thickness range 80–100 microinches, but it is not sharp. Although the 80-microinch specimen was ductile in the centre of the solder zone, it was brittle towards the edges where the solder was thinner and, thus, the concentration of gold was greater.

Tests for Strength

The question arises as to whether the embrittlement of solder joined to thick gold plating has any practical significance, e.g. in jointing to tags plated with gold to a thickness of 200 microinches. In an attempt to answer this, the following tests were carried out.

*To British Standard 441 (60:40 solder with activated flux). This solder was used in all experiments.

FIG. 3—CRACKS IN SOLDER ON 200-MICROINCH GOLD PLATE

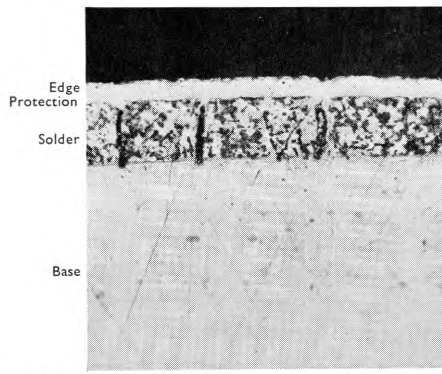

FIG. 4—CRACKS AND INDETERMINATE-SHAPED CRYSTALS IN SOLDER ON 100-MICROINCH GOLD PLATE

(*a*) Lap joints ($\frac{1}{8}$ in. overlap) were made between strips of copper $\frac{3}{8}$ in. wide and 0·029 in. thick which had been plated with various thicknesses of gold from an acid cyanide bath. The specimens were given a tensile test: the results are given in Table 2. They show that the strength of a joint is not related to the thickness of the gold plating.

TABLE 2
Relation between Thickness of Gold Plating and Strength of a Soldered Lap Joint

Thickness of Gold Plating (microinches)	Shear Strength (tons/in^2)	
	Minimum	Average
Nil	3·24	3·39
40	2·68	2·98
50	2·94	3·38
100	2·34	2·42
160	2·88	3·07
200	2·51	3·28

(*b*) Tinned-copper wires (20 and 25 s.w.g.) were soldered to 1 in. long 16 s.w.g. copper pins which had been gold-plated to a thickness of 280 microinches from an acid cyanide bath. The wire was wrapped one and a half turns around the pins. As a control, plain copper pins were also employed.

To simulate the kind of treatment the joints might receive during the maintenance of equipment, the following operation was carried out on them before performing the tensile test. The gold-plated pins and the free end of the tinned-copper wire were clamped in a horizontal position, the distance between the soldered joint and the clamp at the free end of the wire being 4½ in. The wire was sufficiently slack to permit 12 half-circle reverse bends to be given to it (as in the movement of a skipping rope—see Fig. 5), the deflexion about the

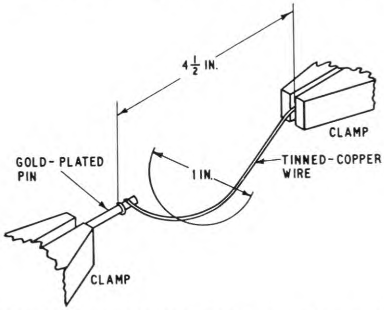

FIG. 5—SIMULATION OF TREATMENT THAT A JOINT MIGHT RECEIVE DURING MAINTENANCE OF EQUIPMENT

centre line being $\pm$ 0·5 in. The results are given in Table 3. They show that soldered joints made to heavily gold-plated pins are just as strong as those made to pins of plain copper.

TABLE 3

Strength of a Soldered Joint between Tinned Copper Wire and Pins Gold-Plated to a Thickness of 280 microinches, and between Tinned-Copper Wire and Plain Copper Pins

Pin Material	Breaking Load (lb)			
	20 S.W.G.		25 S.W.G.	
	Minimum	Average	Minimum	Average
Gold-plated copper	17·5	24	6	8
Plain copper	16·5	18	6·5	8

Microstructures

Gold-tin and gold-lead form eutectic alloys and intermetallic compounds. By preparing a selection of these alloys and examining their microstructures, Foster[1] was able to identify the additional constituents formed in a 60:40 tin-lead alloy when it is soldered to gold plating. His observations are given in Table 4. Foster found all these constituents hard. If present in sufficient quantity, they could, therefore, cause embrittlement of solder.

Fig. 1 shows the microstructure of 60:40 tin-lead solder, and Fig. 2 that of the same alloy after soldering to gold plating. The acicular crystals of the gold-tin constituent are evident in the latter photomicrograph. Fig. 4, 6 and 7 show, respectively, the indeterminate-shaped crystals of gold-tin, the feathery acicular crystals of gold-tin and the black dendritic crystals of gold-lead.

TABLE 4

Additional Constituents found in Solder to which Gold has been added

Shape of Constituent	Identity of Constituent
White acicular crystals	Gold-tin compound
White crystals of indeterminate shape	Gold-tin compound
Feathery acicular crystals	Gold-tin compound
Black dendritic crystals	Gold-lead compound

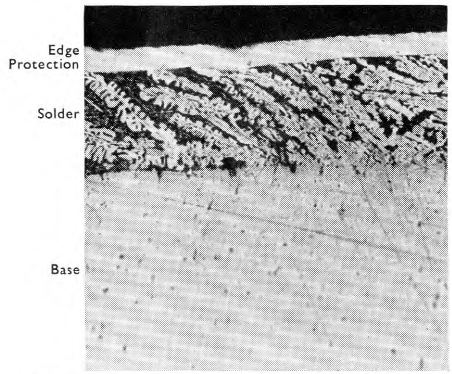

FIG. 6—CRACKS AND FEATHERY ACICULAR CRYSTALS IN SOLDER ON 80-MICROINCH GOLD PLATE

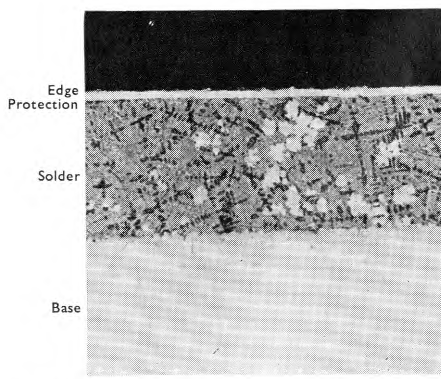

FIG. 7—DENDRITIC AND INDETERMINATE-SHAPED CRYSTALS IN SOLDER ON 130-MICROINCH GOLD PLATE

The conditions governing which of these constituents is likely to form in a joint soldered to gold plating are not known.

CONCLUSIONS

The bend-tests show that gold will not embrittle 60:40 tin-lead solder provided the thickness of the gold plating does not exceed about 50 microinches. Thus, there is no cause to doubt the reliability of the soft-soldered joints made to gold-plated components used in submerged repeaters.

Tensile tests show that even when the thickness of gold plating exceeds 200 microinches, and is thus sufficient to cause embrittlement of solder, the strength of joints is not adversely affected.

Where the gold plating is sufficiently thick to cause the embrittlement of a soldered joint, this takes place immediately the joint is made, i.e. it is not a phenomenon brought about by "aging," so that if a joint is satisfactory initially, it will remain so indefinitely.

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Installation of Letter-Sorting Machines at Preston

U.D.C. 681.187

The use of a mobile crane to assist the installation of large letter-sorting machines resulted in a large saving in manhours and greatly simplified the task.

WHEN a request was received to install three letter-sorting machines on the second floor of the West Cliff sorting office, Preston, special consideration had to be given to the means of access available. Previously, at similar offices where no provision for machinery installation has been made, the machines, which are 17 ft long, 4 ft 6 in. wide and weigh 3½ tons, were lifted in pieces to the required floor via the lift shaft. At Preston this would have necessitated splitting two of the machines into three sections and re-assembling them within the building; the third machine had already been split when it had been recovered from Belfast, and had been stored in three sections. Re-assembling the machines at Preston would have occupied two men for at least 12 weeks, and the introduction of the machines into service would have been correspondingly delayed. Also, it would have taken a gang of men a full day to lift the parts of each machine up the lift shaft, with the consequent problem of releasing the lift from normal service and subsequently re-roping it. Transport posed a further problem, as two low-loading vehicles are required to carry a machine split into sections, whereas one suffices for a complete machine.

These problems had previously been encountered when one machine had been installed in sections in Birmingham in 1959, one in Belfast in 1960, and 10 in Norwich between 1958 and 1961.

The possibility was examined of lifting the machines into the Preston office by mobile crane, and the Ministry of Public Building and Works (M.P.B.W.) agreed to provide an apparatus entrance at a suitable position in an external wall. Holes were, in fact, made on both first and second floor levels, that on the first floor being intended for subsequent use, and temporary screens were fitted. Permanent apparatus-entrance doors with adequate safety arrangements were provided later.

The machine from Belfast was re-assembled by Engineering Department's Power Branch staff in the Branch workshop at Mount Pleasant, London, before being conveyed to Preston. The second and third machines were transported from Liverpool and Leeds, respectively. The Post Office Supplies Department's Movements Branch, Birmingham, and the Leeds Telephone Area co-operated with the Preston Telephone Area and the Engineering Department's Power Branch to ensure that all machines arrived on site at the scheduled time. The Preston Telephone Area provided a 5-man external party to assist in the installation operation, and also arranged for the local police to keep the area clear. Messrs. Miller, Ltd., of Preston, provided a crane for lifting the machines from the Post Office transport up to the second floor of the sorting office.

The crane was erected on site ready to commence work and the temporary screen was removed from the wall opening by 9 a.m. Two baulks of timber 20 ft long were arranged to project 6 ft through the opening on the second floor; the machines were lowered on to these and a wire-rope tackle, secured to an internal pillar, was used to winch them into the building.

Due to the preparatory work needed before a machine could be lifted, the operation took about 2 hours for each machine; on any future occasion this could be reduced to less than 1 hour. The whole of the operation was completed by 3.30 p.m., at a cost of 50 manhours. This compares with about 1,500 manhours which would have been required to split the machines, lift them via the lift shaft, and re-assemble them on the sorting-office floor.

The M.P.B.W. has now agreed to provide standard apparatus entrances on each floor of new sorting-office buildings, with provision for anchoring temporary loading joists. The normal method of installing machines above the ground floor will in future be by mobile crane.

R.G.M.

Using a Computer for Main-Line Planning and Circuit Provision

B. CROSS†

U.D.C. 681.142:621.395.74

The planning of the Post Office main-line network and the efficient utilization of the plant forming the network entail much time-consuming effort. Methods of using a computer to carry out part of this work and at the same time provide additional information for planning purposes are described.

INTRODUCTION

THE circuit-provision groups of the Main Lines Planning and Provision (LMP) Branch of the Post Office Engineering Department do not physically provide the circuits under their control; their responsibility is to decide which pairs in main underground (MU) cables, or which channels in high-frequency (h.f.) carrier groups, should be connected to form each working circuit.

The cable pairs or h.f. carrier channels allocated by the circuit-provision groups, are listed, together with any necessary items of transmission equipment such as amplifiers, on special forms known as circuit advices. Copies of these forms are then sent to the appropriate Telephone Areas, so that the actual work involved in connecting the circuit components can be carried out.

Prior to 1959, proposals had been made to convert the information recorded on MU cable diagrams to a form suitable for transferring to punched cards. When the Post Office Accountant General's Department's (LEAPS) computers[1] were installed they were only lightly loaded, and all Branches of the Engineering Department were asked if they had any work suitable for mechanization. Proposals by LMP Branch for a punched-card MU cable record were considered, to see if the more complex operations practicable with a computer would bring added benefit. The result of this study was a recommendation that the LEAPS machines be used for a trial mechanization of the new circuit-provision procedure, which used circuit schedules and routing records instead of the circuit-advice forms referred to above.

The trial showed that a computer of the LEAPS type (i.e. a National-Elliott 405 computer) that processed records sequentially on magnetic film, was unsuited to circuit-provision work: this requires the time for access to a cable record to be virtually independent of that record's position in the computer's storage system. Although the records for public circuits could be processed in bulk reasonably efficiently using sorting techniques to permit sequential operation, the need to be able to deal at short notice with orders for private circuits made other methods essential. The small LMP-Branch team that organized and programmed the LEAPS trial in the period 1960–62 continued to study the ways in which computers might aid the Branch, and produced many programs for the Elliott 803 computer (Engineering Department Computer No. 1)[2] installed at the Post Office Research Station. In January 1965 this unit was absorbed into one of the project teams set up in the Organization and Efficiency (Maintenance and Computers) (OMC) Branch to study the feasibility of mechanizing the greater part of the planning, estimating and utilization of the trunk, junction and local networks.

The first part of this article describes in general terms the programs developed for use on the Elliott 803 computer in the period 1961–65. Many of the programs are in regular use but give only limited assistance to the effort involved in the present tremendous expansion of the main-line network. The second part details the stages in the production of one of these programs—that used to assist in planning the h.f. network. The method described is not put forward as the only, or the best, approach to this type of problem, but it is the method used by the author for the majority of the work done so far.

LMP BRANCH PROGRAMS FOR THE ELLIOTT 803 COMPUTER, 1961–1965

The basic data for many of the programs written by the LMP Branch team are the Annual Schedules of Circuit Estimates (A.S.C.E.s). These A.S.C.E.s show (Fig. 1) the circuits existing on each public-circuit route, those authorized for the current year, and the estimates

†Organization and Efficiency (Maintenance and Computers) Branch, E.-in-C.'s Office.

EXCHANGE			EXCHANGE			PRIORITY	LENGTH	TRAFFIC OPERATING CONDITIONS		CIRCUITS EXISTING AT 1.1.65				CIRCUITS REQUIRED DURING YEAR COMMENCING 1.4.65 (Authorised)				1.4.66 (Estimated)				1.4.69 (Estimated)				NOTES
NAME	TERMINATIONS O/G	I/C	NAME	TERMINATIONS O/G	I/C			O/G from (Exch. in 1)	I/C to	O/G from (Exch. in 1)	I/C to	B/W	Total	O/G from (Exch. in 1)	I/C to	B/W	Total	O/G from (Exch. in 1)	I/C to	B/W	Total	O/G from (Exch. in 1)	I/C to	B/W	Total	
1	1a		2	2a		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Montrose	CB10		Edinburgh Woodcroft	TKNO	RT	-	56	R	R	-	-	-	-	10	12	-	22	12	14	-	26	-	-	-	-	New route EH TK/MECH 6/65 Ceases Montrose NDAM 5/68 M.R. 14:16:- - 30 Amend Cols. 11 and 12
MONTROSE	ND		LAURENCEKIRK	U13		-	9	D	D/P	-	-	-	-	-	-	-	-	-	-	-	-	12	11	-	23	Amend Cols. 20 and 22
PERTH	ND		Kirkcaldy	NO		00	22	O/DC	D/DC	-	-	-	-	(11)	(12)	(-)	(23)	11	12	-	23	13	14	-	27	New route Kirkcaldy Standard ND 9/66 Amend Cols. 20 and 22
	TKO CIRCUITS																									
PERTH	AM	-	BRIDGE OF EARN	-	ND	-	4	D	-	-	-	-	-	1	-	-	1	1	-	-	1	1	-	-	1	Amend Cols. 11 and 14

FIG. 1—TYPICAL PAGE FROM THE ANNUAL SCHEDULE OF CIRCUIT ESTIMATES (A.S.C.E.s)

for the second and fifth years. The circuit-provision duties in LMP Branch are responsible for issuing the setting-up instructions for circuits whose radial length is (with some exceptions) in excess of 25 miles, and the A.S.C.E. entry for the coming year is taken as the authority for the provision of the circuits. The network planners, on the other hand, are normally interested only in the fifth-year estimates, which are used as a basis for deciding what additional line plant will be needed to meet forecast growth.

The output from an Elliott 803 computer is provided by either a high-speed paper-tape punch (100 characters/second) or an on-line teleprinter (10 characters/second). As the latter operates at a very low speed it is only used for extremely short outputs or to give instructions to the operator. The paper tape produced from the punches may be converted to legible form on a standard Creed teleprinter that prints 69 characters on a line; alternatively, a modified Flexowriter is available that incorporates tabulation facilities and has a wide carriage allowing 156 characters to be printed on a line. Since April 1965 the computer has been modified to work with 5-track or 8-track tape, but the LMP Branch programs were written before these changes were made, and the output is restricted to the limited range of characters available with the 5-track code.

Programs 4 *and* 11—*A.S.C.E. Analysis*

A large number of useful statistics may be obtained from the A.S.C.E.s but, until Programs 4 and 11 were produced, only the most important statistics were derived, and to obtain these involved considerable clerical effort. Every year a list of public-circuit routes with a radial length of 15 miles or over is compiled manually, in alphabetical order, showing,

(*i*) the two terminal towns;

(*ii*) the radial length of the route, and

(*iii*) the total numbers of circuits existing, authorized and estimated for the second and fifth years.

This information is punched on to paper tape in Elliott 5-track Telecode, each town name being converted to a 6-digit numerical code which specifies the Region, Telephone Area, district switching centre and group switching centre for that town. This tape is read by the computer together with another tape that lists those routes which use h.f. plant, and the output consists of tables analysing the entries in terms of

(*i*) radial length of circuit,

(*ii*) terminal Regions (see Fig. 2), and

(*iii*) terminal districts,

and showing the audio and h.f. circuits separately in addition to the total. The running time for the program (Program 11), which produces the three tables for circuits in each of the length categories 15 to 24 miles, over 24 miles and over 14 miles, totals 3 hours on the Elliott 803 computer. It is worth noting that the majority of this time is spent punching tape at 100 characters/second, so that no great reduction in processing time would result from running this program, unmodified, on an Elliott 503 computer, as the output-punch speeds are identical; however, a drastic reduction in running time, probably to 5 minutes, would be possible if the program were modified so that the line printer, operating at 1,000 lines/minute, could be used for output. Program 4 uses the same alphabetical-list tape as Program 11, but analyses the contents into milage and route-size blocks, i.e. the number of routes in particular size and distance ranges are shown in tabular form. In practice, this program has been used more to analyse other data (specially prepared to have a format similar to the normal input) than for the purpose for which it was written.

A.S.C.E. ANALYSIS A=EXISTING 1.10.64 B=AUTHORIZED 1.4.65 C=ESTIMATED 1.4.66 D=ESTIMATED 1.4.69

65 / 66 - 69 / 70 OVER 24 MILES

REGION		NUMBER OF CCTS(A)			NUMBER OF CCTS(B)			NUMBER OF CCTS(C)			NUMBER OF CCTS(D)			MEAN CCT. MILES(D)		
FROM	TO	AUDIO	H.F.	TOTAL	AUDIO	H.F.	TOTAL	AUDIO	H.F.	TOTAL	AUDIO	H.F.	TOTAL	AUDIO	H.F.	TOTAL
EIRE	HCR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	LTR	0	151	151	0	206	206	0	297	297	0	389	389	0	288	288
	MID	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NI	8	76	84	8	43	51	8	51	59	8	69	77	35	80	75
	NWR	0	61	61	0	72	72	0	77	77	0	79	79	0	136	136
	SCOT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SWR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	WBC	0	44	44	0	91	91	0	110	110	0	159	159	0	141	141
TOTAL		8	332	340	8	412	420	8	535	543	8	696	704	35	216	214
HCR	EIRE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	HCR	578	1739	2317	732	3195	3927	924	4338	5262	1222	8430	9652	39	45	45
	LTR	778	7586	8364	989	8948	9937	1286	11478	12764	1611	17273	18884	31	41	40
	MID	76	1050	1126	84	1402	1486	102	1735	1837	141	3046	3187	41	79	78
	NER	6	381	387	5	548	553	6	728	734	11	1205	1216	76	162	161
	NI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NWR	0	229	229	0	372	372	0	494	494	0	1025	1025	0	154	154
	SCOT	0	98	98	0	182	182	0	257	257	0	543	543	0	332	332
	SWR	46	593	639	88	1148	1236	114	1592	1706	171	2660	2831	29	69	67
	WBC	0	38	38	0	203	203	0	320	320	0	610	610	0	133	133
TOTAL		1484	11714	13198	1898	15998	17896	2432	20942	23374	3156	34792	37948	35	61	59
LTR	EIRE	0	151	151	0	206	206	0	297	297	0	389	389	0	288	288
	HCR	778	7586	8364	989	8948	9937	1286	11478	12764	1611	17273	18884	31	41	40
	LTR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	MID	0	3032	3032	0	3227	3227	21	3815	3836	30	5160	5190	85	97	97
	NER	0	1811	1811	27	2111	2138	62	2416	2478	88	3221	3309	207	181	182
	NI	0	141	141	0	147	147	0	213	213	0	308	308	0	322	322
	NWR	0	2184	2184	0	2337	2337	0	2732	2732	26	3797	3823	211	172	172
	SCOT	0	978	978	0	1155	1155	0	1406	1406	0	1896	1896	0	347	347
	SWR	28	2024	2052	26	2233	2259	17	2616	2633	0	3558	3558	0	106	106
	WBC	0	784	784	0	825	825	0	963	963	0	1253	1253	0	143	143
TOTAL		806	18691	19497	1042	21189	22231	1386	25936	27322	1755	36855	38610	44	105	102
MID	EIRE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	HCR	76	1050	1126	84	1402	1486	102	1735	1837	141	3046	3187	41	79	78
	LTR	0	3032	3032	0	3227	3227	21	3815	3836	30	5160	5190	85	97	97
	MID	183	1503	1686	245	1804	2049	306	2280	2586	387	3156	3543	35	39	38
	NER	63	1156	1219	102	1530	1632	186	1792	1978	348	2332	2680	65	82	80
	NI	0	15	15	0	27	27	0	31	31	0	43	43	0	221	221
	NWR	54	1218	1272	76	1573	1649	107	1789	1896	155	2600	2755	36	68	66
	SCOT	0	291	291	0	358	358	0	449	449	0	654	654	0	248	248
	SWR	0	661	661	0	840	840	0	1025	1025	0	1461	1461	0	85	85
	WBC	93	723	816	116	892	1008	108	1085	1193	157	1566	1723	40	64	62
TDTAL		469	9649	10118	623	11653	12276	830	14001	14831	1218	20018	21236	46	81	79

FIG. 2—TABLE, PRODUCED BY COMPUTER, SHOWING ANALYSIS OF A.S.C E.s INTO TERMINAL REGIONS

Program 2—General Analysis

Program 2 accepts groups of numbers, interspersed with control characters, and prints out the arithmetic mean, standard deviation and other similar properties of the groups. It has, for example, been used to find that the average cable distance, unweighted,* of local exchanges from their group switching centres is 9·1 miles.

Program 3—Cable Prices

As the name implies, Program 3 is used to calculate the prices of a large range of audio cables. It has a high mathematical content with a small amount of input data, and is an ideal application for an Elliott 803 computer—particularly one with a floating-point unit, which speeds up the addition, subtraction, multiplication and division of floating-point numbers.†

There are two input tapes: one specifies the basic costs of lead, copper, paper, hessian and steel-tape armouring, with two other figures for the variations in lay, joint and test costs, and wages; the other gives the basic factors under which the prices of various cable sizes were previously computed under the Bulk Cable Agreement. Although this agreement has now been replaced by competitive tendering, the factors are still able to give a fair idea of how the prices of cable will alter with fluctuation in the costs of raw materials. The program is run once a month with the currently-valid basic costs, and the output tables are filed in chronological sequence. The figures are only published when prices have changed significantly since the last publication.

Program 12—High-Frequency-Network Planning

Program 12—the subject of the second half of this article—was one of the more ambitious projects, as the amount of information to be handled was in excess of that normally processed by the Elliott 803 computer.

General

All the above programs are written fundamentally in Elliott 803 Autocode,[3] but consist largely of machine-code blocks within the Autocode framework. The main advantages over pure machine-language programs are:

(*i*) output of titles and operator instructions are simplified by the use of the TITLE instruction,

(*ii*) standard Autocode routines are available, e.g. READ, SORT, PRINT, etc.,

(*iii*) triggers (entries on input tapes to change the sequence in which the program is carried out) on Autocode data tapes are accepted without modification—there is no equivalent facility available in current machine-code routines, and

(*iv*) the tedious method of referring to storage locations in machine code (relative addressing) is avoided, as the alphabetical addresses used in Autocode (A, B3, C(D + 4), etc.) may be used in the machine-code blocks.

As paper tapes are very easily damaged it is vital to have a means whereby the validity of a tape may be checked quickly before use. One of the facilities offered by the general-purpose program (Program 1) is a routine that produces a copy of any 5-track tape, whether program or data, and places at the head of the copy the sum of the values of every character on the tape: the value of a character varies from zero to 31—the range of values possible with five binary digits. The resulting tape may be checked by a routine in Program 1 at any time before use to discover if any mutilation has occurred. The check is carried out at maximum speed (500 characters/second, or nearly 3 miles/hour), so that little time is lost in taking this precaution.

One limitation of the Elliott 803 computer is that although the potential speed of the tape readers is 500 characters/second this ideal is not realized when reading a number on a tape punched in 5-track code and forming the value in binary-coded form in the working register or accumulator. The speed for this type of operation is about 60 characters/second, which slows appreciably any program with a large amount of input. Program 1 contains a routine that recodes tapes that have to be used many times. The method consists of forming the value required in the accumulator, punching out the 39 binary digits (bits) of the accumulator as eight consecutive 5-bit characters on paper tape, then punching as a ninth character the five least-significant bits of the binary sum of the eight preceding characters. The resulting code has been named word-checked binary (w.c.b.). This code may be read at 350 characters/second without losing the facility of checking each number as it is input. Another advantage of w.c.b. code is that, in the computer, a storage location containing several numbers (i.e. packed—see later part of article), may be output on to paper tape and later re-input without the need for unpacking and repacking. The advantages of w.c.b. code diminish when a computer with a high internal operating speed is available, and it is unlikely that this code will be used with the Engineering Department Computer No. 2 (Elliott 503 computer).[4]

X AND U PROGRAMS

In addition to the programs already mentioned, many experimental or "one-off" programs have been written: these are usually given a number in the X (experimental) or U (unpublished) series. When an X program has been developed to a point where it may usefully handle live work it is renumbered in the main series and full documentation effected. There are normally about 10 to 20 programs added to the U series each year; these are documented simply—just the program name and a short general description of its operation. If these programs are destined for wider application they are renumbered in the main series in the same way as for X programs. A selection of the programs in these series is given below.

Program X1—Circuit Provision

Program X1 was a trial program for circuit-provision work, written for operation on the LEAPS computers. It is now being superseded by a more ambitious project in course of preparation by the OMC Branch project team with the assistance of the Regional Offices and other Headquarters Branches.

Programs X3 and X4—Shortest-Link Connexions

Programs X3 and X4 apply the method detailed in the November 1957 issue of the *Bell System Technical Journal* ("Shortest Connexion Networks and Some

*Average unweighted cable distance—average cable distance not adjusted to take account of the number of circuits on the route concerned.

†Floating-point numbers—numbers held by the computer, with a limited accuracy, in a mantissa and exponent form.

Generalizations" by R. C. Prim) to select those parts of a network which are necessary to connect all the nodes of the network. The network selected is the one of minimum length. Program X4 differs from Program X3 only in that some weighting is applied to individual arcs to give some indication of their importance in the network. This method shows promise of offering a solution to the problem of finding the most economic routing for an omnibus circuit.

Program X2—Automatic Routing

Using Program X2 a network may be coded and input to the computer, and various routings between stated nodes may then be found according to the requirements of the user. Although currently used to find routings through the British Post Office h.f. network, it could equally well be used to find the shortest routes from, say, London to any continental city, provided the European road network was suitably coded for computer input. This program has been developed progressively in the last two years, and the latest version is able to assess the costs of valid routings found and list the various solutions in order of economic preference.

At present the time taken to find all the practical alternatives between two nodes is approximately 1 minute, but this time should be reduced to 1 second or less when the new Elliott 503 computer is used.

There are other approaches to this problem, involving the use of matrix algebra, but so far all these appear to offer a "blunderbuss" solution in that they always find the *n* best routings for every possible route in the network from one or all nodes to all other nodes, and the programs take several hours to run. In the American New Jersey Bell Telephone Company, where a major circuit-provision computer scheme is being developed, a program of this type is used. Every 6 months it produces in 6 hours all likely routings from the current network; these are stored on disk files for possible future use. The author's view so far has been that, although the X2 program method takes longer per routing, two main advantages stem from the concept of finding one routing at a time:

(*i*) expensive storage space is not required to hold routing information that has a very low usage factor, and

(*ii*) if a new routing is required it may be found almost instantaneously, i.e. in plenty of time for "computer interrogation during customer's inquiry," if required.

Selected U Programs

The list below gives a selection of the U programs currently on the register, with comment restricted to a brief mention of each program's function.

*Program U*5 calculates the theoretical ratio of spare to working plant, expressed as a percentage, for given rates of growth and planning periods.

*Program U*13 accepts 5-track tapes showing the utilization of h.f. cables, translates the alphabetical names found on the tapes to numerical codes, compiles a decoding list as the input data are processed, and punches out a packed, numerical version in 8-track word-checked binary.

*Program U*14—Using the output from Program U13 as input, an analysis is made showing the manner in which groups in the network are routed. The analysis also provides statistics on the "fill" and usage of super-groups and 24-circuit links.

*Program U*17 automatically amends the 6-digit numerical exchange codes used on the A.S.C.E. data tape in accordance with amendments listed on a separate tape.

*Program U*19 calculates the sum of the products of the number of circuits and their routing distances for each h.f. route. The total h.f. circuit-route-miles figure so obtained is then divided by the h.f. circuit-radial-miles figure obtained from Program 11 to give the route-miles/radial-miles factor for the year in question.

PREPARATION OF A LARGE-SCALE ELLIOTT 803 COMPUTER PROJECT

The program selected as the subject of this part of the article—h.f. network planning—was chosen because it shows what can be done on a small computer if necessary. The many intermediate paper-tape stages in this program would normally be avoided so that the program could proceed at maximum speed, but, if no other computing facilities are readily available, the variety of work that can be carried out, albeit rather inefficiently, on a small computer of the Elliott 803 type is almost limitless. However, some processes would quickly become so inefficient that it would not be worth the effort to program them, and thus a practical limit is reached fairly early for most applications. The program described below could not be conveniently amended to deal with a network with more than 500 nodes and 1,000 arcs, and further expansion of the h.f. network will be catered for by transferring the work, with some reprogramming, to the new Elliott 503 computer; the running time of 3 hours 45 minutes should then be reduced drastically to about 5–6 minutes.

Choice of Computer

For large projects it is usual to study the system requirements to determine the type of computer best suited for the work, but for the smaller application it is generally a question of choosing (if there is a choice) from the computers readily available to the user. For the work on h.f. network planning, the only computer available was the Elliott 803 computer at the Post Office Research Station.

General System Requirements

The next step is to decide very broadly what the program is required to do. The h.f. network planning job can be broken down into the following discrete steps.

(*i*) Obtain a record of the fifth-year circuit estimates foı every h.f. public-circuit route.

(*ii*) Allocate the fifth-year circuits according to predetermined routings, in a given proportion to the capacity of the appropriate parts of the h.f. network.

(*iii*) Add in the group requirements for private circuits and overseas circuits.

(*iv*) Provide an indication of those parts of the network where there is insufficient capacity to carry the fifth-year circuits.

(*v*) Provide general tabular output showing: (*a*) the allocation of circuits to routings and details of those routings, (*b*) the "fill," i.e. the contents of each part of the network, and (*c*) the channel-equipment requirements at each repeater station.

Storage Pattern

The storage pattern is, perhaps, the most important stage in the development of a program, because the method of data storage will probably determine the general speed and complexity of the program logic. With the Engineering Department's Elliott 803 computer there are only two ways in which information may be stored: in the main core-store, or on paper tape. The second method is normally used only if there is insufficient room in the main store for additional data. This information is then punched on to tape for re-input at a later stage when the main store is able to accept it.

Information in the main store may be held in two formats: either as a floating-point number in the range $1{\cdot}73\times10^{-77}$ to $5{\cdot}8\times10^{-76}$ with an accuracy of 29 binary (9 decimal) digits, or as a collection of 39 bits which may hold a single number or several at the same time, each of reduced potential maximum size. The system of storing several numbers in one location is generally referred to as "packing" and may be best explained using decimal instead of binary notation, which may not be familiar to all readers.

An 8-decimal-digit register may be used to hold a single number, e.g.

19,701,975,

but it is more than likely that such a large capacity would not be needed and, if it is imagined that a division in the middle of the register separates it into two halves, it can be used to store two dates, e.g.

1970 1975.

It is possible by means of suitable machine instructions to separate numbers such as these and carry out arithmetic operations on them individually, but, provided "spill-over" is avoided, numbers of this type may be added and subtracted without separation, e.g.

3190	4812
+0031	2004
=3221	6816

The result is the same whether the above is interpreted as the sum of two 8-digit numbers or two separate sums of two 4-digit numbers. Spill-over from one number to another packed into the same register is unlikely to occur if the likely maximum content of each imaginary division has been correctly estimated. This method is often used on simple office adding machines when two sets of numbers have to be totalled. To sum up, it would be possible to hold one 8-digit number in the register, or two 4-digit numbers, or one 3-digit and one 5-digit number, or any combination down to eight 1-digit numbers.

When data requirements are large enough to exceed the computer storage available on a single-location-per-number basis, packing has to be used, although this necessitates the use of machine-code instructions in the program. Also, storage and retrieval times for the data are appreciably increased in some instances. For example, to add together two numbers each held in a single location and store the result in another location will take 1,728 μs on the Elliott 803 computer, whereas to do the same with two numbers in the range 0 to 8191 and held in a packed form, each at the most-significant end of a location, and store the result in the least-significant position in another location will take 10,368 μs, an increase of 500 per cent.

Storage Requirements for H.F. Network Planning Program

Although the potential size of the network with which this program operates has now been increased to take advantage of the additional 4,096-word core store installed in the Elliott 803 computer in 1965, the description below is appropriate to the computer storage capacity available when the program was written in 1963. When the main sub-routines of the Autocode program have been allowed for, there are only about 3,400 locations (or words) of storage available for the main program and data.

The number of arcs in the h.f. network (see Fig. 3) is limited to 511, and for each of these the following information has to be stored.

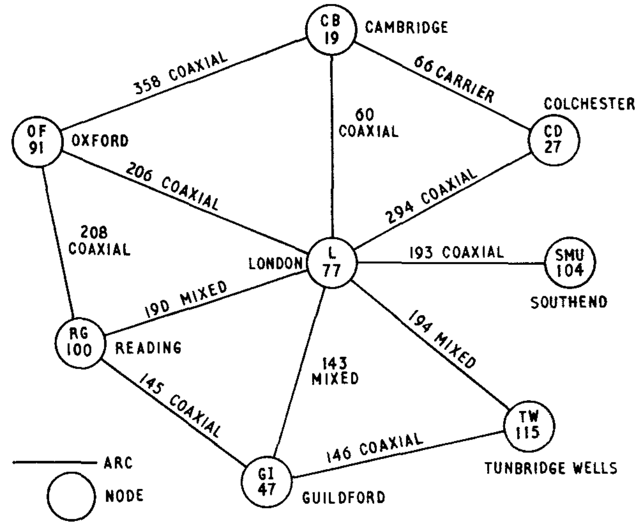


FIG. 3—DIAGRAM OF PART OF THE H.F. NETWORK WITH WHICH THE PLANNING PROGRAM WILL OPERATE

(*i*) Arc code number (for identification).
(*ii*) Capacity, in 12-circuit groups.
(*iii*) Fill, in groups, for public circuits.
(*iv*) Fill, in groups, for private circuits and overseas circuits.

The latter three items are unlikely to exceed 8,191 in value, so they are packed into one location. The arc code number itself is not recorded, but the locations used for arc data are sequential, so that

if arc 1 be stored in location 901,
then arc 2 will be stored in location 902,
arc 270 will be stored in location 1170, and
arc 511 will be stored in location 1411.

All the programmer has to arrange is for 900 to be added to the code number of an arc if he wishes to obtain the address of the location in which the information pertinent to that arc is stored. In practice, absolute numbers are not used in autocode addresses, but the reader will appreciate there is no fundamental difference if the locations are called B1 to B511 instead of 900 to 1411.

Details of each h.f. public-circuit route are also required, and, as the computer has to cope with up to 1,500 of these, only one location can be spared for each route because only 2,889 locations are available. The code number for each route is implicit in the addres of each location, as explained above for the arc list, but there are still two items for each public-circuit route that have to be recorded: the name and the number of circuits estimated for the fifth year. It is obvious that, at six alphabetical characters per location, a single location per route is not enough to store the full name, e.g. Birmingham–Tunbridge Wells. The name is, therefore, simplified by using the engineering codes, e.g. BM–TW, and, since for the routes concerned the two codes would not exceed three characters each, the entire route name may be stored in one location. There is, however, still no room for the number of circuits, and so it is necessary to input one set of route data first, then, when that has been processed, input the other.

The fundamental pattern of data storage has now been set; packing is imperative, and it is also necessary to delay the input of some data until earlier information has been processed. This pattern is repeated for the 15 separate data tapes that are required for this program, the last being input about 3½ hours after the first. Of the 15 tapes, three tapes contain intermediate results produced by the computer for input at a later stage.

Program Requirements

Within the computer, the program also has to be stored, and it requires one location to store two machine instructions, e.g.

30 247:20 7611,

which instruct the machine to extract the content of location 247 and store it in location 7611. The large amount of data required for this program reduces drastically the storage available for the program, while the complications of packing and time-sequencing of input increase the number of instructions required. To solve this dilemma the Autocode program is written in three parts, the second and third parts being input at appropriate points in the program, replacing the old instructions with new but maintaining the current data in the store.

Detailed System

It is now appropriate to produce the detailed program. This is normally carried out in two separate stages:

(*i*) flow-charting, and

(*ii*) coding or instruction writing,

although experienced programmers tend to merge these activities. One big advantage of a flow chart is the help it gives a programmer trying to correct or amend another programmer's work and, for this reason alone, one should always be prepared. Fig. 4 shows part of the flow chart detailing the input of the h.f. circuit data stored in location A1–A1500. A print-up of part of these data would appear as

271	67
272	93
273	13
4(	1965

The first three lines each consist of the h.f. public-circuit route code (e.g. 271) followed by the fifth year estimate of circuits (e.g. 67). The 4(symbol is a "trigger" for use with Autocode programs. The computer, when reading 4(instead of a number, interprets this as an instruction to go to that part of the program headed with 4)—it might be termed a paragraph number. Following the trigger is the year in which the data tape was produced so that the program may check that the correct data is being

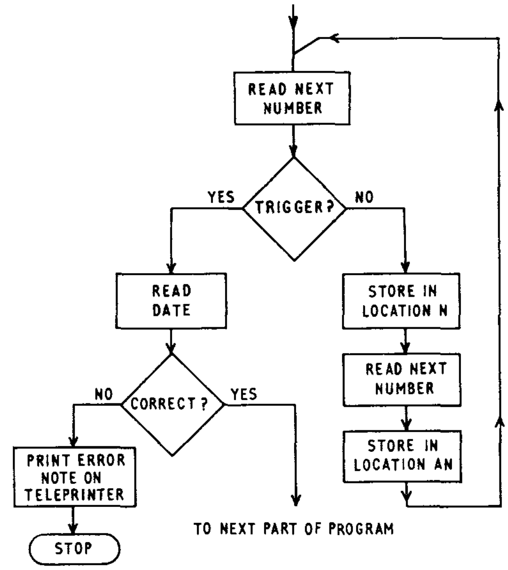


FIG. 4—FLOW CHART SHOWING INPUT OF H.F. CIRCUIT DATA

processed. The operations shown in the flow chart should now be clear. The first number, 271, is read and, as it is not a trigger, it is stored in location N. The number of circuits, 67, is read and stored in AN, i.e. A271. This process is then repeated twice more, storing 93 in A272 and 13 in A273. On the fourth cycle the trigger is read, then the date is read and checked, and the computer passes to the next part of the program. In this next stage the arc details have to be input and packed in a suitable manner into locations B1–B511. As the computer has only two tape readers it is now necessary to print instructions on the teleprinter to tell the operator which tapes are required next.

Output

Casual users of computing facilities do not often bother too much with the layout of the final computer output. It is certainly tedious to work out the appropriate titles and tabulation that are required, but it is worthwhile, even for simple outputs, because, if results are to published, a well-produced table may be duplicated directly by a photographic or similar process, thus avoiding the expense and delay of stencil cutting.

The h.f. planning output has to replace and, if possible, improve upon manual records. These consist of three foolscap-size schedules with the entries in pencil; pencil is used to permit corrections to be inserted easily when amendments to the circuit estimates are made from time to time throughout the year. In the computer system, one printed output is produced initially with the program being re-run whenever sufficient amendments have been received to make such action worthwhile. One of the advantages of mechanization is, therefore, that a neat, printed schedule is produced that is as up to date as is necessary.

It is desirable for the computer output for h.f. planning to be similar to the manually prepared schedules in style, and so use is made of the Flexowriter with the 156-character/line carriage. This permits a foolscap-size schedule to be produced, with the printed lines parallel to the longest dimension, as in the original schedule

SCHEDULE 1 ESTIMATED REQUIREMENTS OF PUBLIC TRAFFIC CIRCUITS PROVIDED ON H.F. GROUPS SHOWING ALTERNATIVE ROUTINGS SHEET NO. 1/64

TRAFFIC CODE	ROUTE NAME	H.F. CIRCUITS PERCENT.	H.F. CIRCUITS NUMBER	ROUTING NUMBER	CIRCUITS CARRIED	DETAILS OF ROUTING SHOWING SECTION TYPE (AUDIO *CARRIER -COAXIAL =RADIO +MIXED)
1	AB-DE	100	3[illegible]	1	[illegible]1	AB*DE
				[illegible]	1	AB=DE
2	AB-EH	100	143	1	70	AB*DE*EH
				2	3	AB=DE=EH
3	AB-EN	100	56	1	6	AB*HPJ*XAC*EN
				2	0	AB*DE*PH*IV*EN
4	AB-GW	100	104	1	44	AB*DE*PH+SXR+GW
				2	40	AB=DE=GW
				3	20	AB*HPJ*XAC*EN*IV-FW-OB-IN-GW
5	AB-HPJ	67	47	1	30	AB*HPJ
				2	17	AB*DE*PH*IV*EN*XAC*HPJ
6	AB-IV	100	45	1	[illegible]	AB*HPJ*XAC*EN*IV
				2	[illegible]0	AB=DE*PH*IV
7	AB-KFX	100	[illegible]	1	1	AB*DE*PH*IV-WRO-KFX
				[illegible]	10	AB*HPJ*XAC=WRO=KFX
8	AB-LRM	100	[illegible]	1	1[illegible]	AB*HPJ*XAC=WRO=KFX=LRM
				[illegible]	10	AB*DE*PH*IV-WRO-KFX-LRM
9	AB-L	100	84	1	44	AB*DE*EH-NT-LS-L
				2	0	AB=DE=EH=CE-MP=L
				3	1	AB=DE=EH=NT=LS=L
10	AB-NT	100	18	1	1[illegible]	AB*DE*EH-NT
					0	AB=DE=EH=NT

Schedule 1

SCHEDULE 2 ESTIMATED H.F. GROUP REQUIREMENTS FOR PUBLIC TRAFFIC CIRCUITS SHEET NO. 6/64

H.F. SECTION DETAILS CODE	TERMINALS	TYPE OF EQUIPMENT	REQUIREMENTS CIRCUITS	REQUIREMENTS GROUPS	DEFERRED GROUPS	CAPACITY GROUPS	TRAFFIC ROUTE	NUMBER OF CCTS.	TRAFFIC ROUTE	NUMBER OF CCTS.	TRAFFIC ROUTE	NUMBER OF CCTS.	TRAFFIC ROUTE	NUMBER OF CCTS.	TRAFFIC ROUTE	NUMBER OF CCTS.
341	BM-BS	C.E.L. 1005	[illegible]38	91	[illegible]	80	HR-PY	[illegible]	HR-SA	30	HP SX	18				
							BM-B[illegible]	1	BM-DY	30	BM-NG	50	BM-SF	20	BT-CV	12
							BT-L	2[illegible]	BT-MP	[illegible]	BT-STK	14	CF-NG	[illegible]5	CF-SF	20
[illegible]3	BM*BT	[illegible] CCT. CARRIER	[illegible]9[illegible]	34	[illegible]	48	CV-NG	17	DY-STK	7	LE TH	[illegible]0	NG-SA	10	NG-WR	11
							BM-CS	[illegible]	BM-CLF	5	BM-LV	40	BS-CS	70	BS-LV	20
							CB-CS	[illegible]6	CF-CS	19	CS-LE	22	CS-L	70	CS-RG	28
							CS-SA	17	CS-STK	[illegible]	CS-SX	1[illegible]	CS-TW	23	CLF-L	10
34[illegible]	BM-CS	[illegible]E.L. [illegible]A	56[illegible]	61	0	8[illegible]	DN-L	84	LE-PR	4	LV-RG	[illegible]	LV-SA	10	LV-WV	20
							AHE-BM		BB-CV	1[illegible]	BF-BM	29	BF-MR	10	BM-KZ	20
							BM-LOL	[illegible]0	BM-NH	3	BT-CV	1[illegible]	CB-CV	30	CV-GR	10
							CV-LV	[illegible]0	CV-L	7[illegible]	CV-MR	39	LV-NH	27	CV-NG	17
[illegible]4	BM*CV	[illegible] CCT. CARRIER	438	47		70	CV-OF	[illegible]1	CV-WV	[illegible]8	CV-WR	5	L-RY	10	MP-NH	10
							BB-BM	[illegible]0	BF-BM	[illegible]	BM-LB	7[illegible]	BM-LG	1[illegible]5	BM-NC	20
							BM-RY	[illegible]8	CV-NG	1[illegible]	CV-RG	30	LV-WR	[illegible]0	EV-LG	16
[illegible]43	BM-CV	C.E.L. [illegible]	4[illegible]9	45	[illegible]	80	LG-WV	1[illegible]	LG-WR		LOL-MR	10				
							BM-OY	[illegible]1	BM-DY	9	BM-GY	[illegible]	BM-HU	[illegible]0	BM-LS	60
							BM LE	8	BM-MI	10	BM-SF	70	BS-NG	[illegible]2	BS-SF	8
							CS-SF	[illegible]	DY-L	[illegible]	DY-MR	[illegible]	DY-STK	30	GY-RG	15
							LE-LV	1	LE-L	7[illegible]	LE-STK	9	LV-NG	[illegible]0	LV-SF	20
							[illegible]-NG	[illegible]00	L-SF	30	NG-OF	11	NG-PG	0	NG-SA	16
							NG-STK	10	NG-TW	20	NG-WL	11	NG-WV	2[illegible]	RG-SF	[illegible]
19	BM-DY	C.E.L. [illegible]A	9[illegible]	101	0	[illegible]	SF-STK	10	S[illegible]-TW	15						
							BM-EV	100	BM-GP	[illegible]1	BM-HP	[illegible]	BM-NE	3[illegible]	BM-SX	26
							BM-WR	[illegible]0	BS-CS	15	BS-EV	1[illegible]	CV-WR	[illegible]0	EV-LG	16
							[illegible]-L	1[illegible]	HR-L	[illegible]3	HR-SY	1[illegible]	LG-WR	10	L-WR	50

Schedule 2

SCHEDULE 3 ESTIMATED 5TH YEAR CHANNEL EQUIPMENT REQUIREMENTS SHEET NO. [illegible]/64

EXCHANGE/REPEATER STATION	NUMBER	EXCHANGE/REPEATER STATION	NUMBER	EXCHANGE/REPEATER STATION	NUMBER	EXCHANGE/REPEATER STATION	NUMBER
NEFYN	[illegible]	NEWARK	20	NEWBURY	[illegible]	NEWCASTLE	[illegible]8
NEWMARKET	7	NEWPORT, MONMOUTH		NEWRY	7	NEWTOWN	8
NORTHAMPTON	[illegible]8	NORWICH	94	NOTTINGHAM	[illegible]5	NUNEHAM COURTENAY	
OBAN	26	OLD BOSTON	[illegible]	ORPINGTON	4	OXFORD	1[illegible]
PERTH	[illegible]2	PETERBOROUGH	88	PETERHEAD	1	PLUMPTON, PENRITH	0
PLYMOUTH	9[illegible]	PORTADOWN	[illegible]	PORT ELLEN RADIO	[illegible]	PORTMADOC	1[illegible]
PORTPATRICK	1	PORTSMOUTH	[illegible]	POTTERS BAR	1	PRESTON	9
READING	614	REDHILL	[illegible]	ROMFORD	26	ROTHESAY	[illegible]
RUGBY	1	RYDE	1	ST. ALBANS	1[illegible]	ST. AUSTELL	[illegible]
ST. JUST RADIO	[illegible]	ST. MARGARET'S BAY		ST. MARY'S, SCILLY	0	SALISBURY	18[illegible]
SARKBANK	[illegible]	SCARBOROUGH	[illegible]1	SCUNTHORPE	4	SHEFFIELD	[illegible]
SHREWSBURY	[illegible]	SKEGNESS		SKYREBURN BRIDGE		SLOUGH	1[illegible]
SOUTHAMPTON	06	SOUTHEND	[illegible]	SPALDING	[illegible]	STAINES	
STEVENAGE	1	STIRLING		STOKE-ON-TRENT	9[illegible]	STORNOWAY	1
STORNOWAY RADIO	C	STRANRAER	[illegible]	STROOD	4	SWANDEAN	[illegible]
SWANSEA	[illegible]	SWINDON	[illegible]	TAUNTON	4[illegible]	TAVISTOCK	
TETSWORTH	0	THANET	[illegible]	TOBERMORY	[illegible]	TORQUAY	[illegible]2
TRURO	43	TUCKTON BRIDGE		TUNBRIDGE WELLS	8	UXBRIDGE	[illegible]1
WAKEFIELD	17	WALTHAM CROSS		WARRINGTON		WATFORD	[illegible]
WEYBRIDGE	[illegible]	WHITBURN	[illegible]	WHITEHAVEN	1[illegible]	WICK, CAITHNESS	9
WIDEMOUTH BAY	8	WIGAN	1	WINCH STEP	19	WINTERTON-ON-SEA	3
WISBECH	[illegible]2	WOLVERHAMPTON	[illegible]	WORCESTER	[illegible]	WREXHAM	11
YEOVIL	29	YORK	[illegible]				

Schedule 3

FIG 5—H.F. PLANNING SCHEDULES PRODUCED BY COMPUTER

(see Fig. 5). A line of hyphens is printed above and below the schedule to outline the correct depth of the paper, and it is possible to tear off the schedules accurately at these lines with the aid of a straight-edge. Having settled the size, the actual contents now have to be decided. Two of the original schedules, showing the number of h.f. circuits on a route and the routings followed, have been condensed into a new schedule, Schedule 1. A third schedule, showing the fill of each arc, is printed as Schedule 2, and, finally, a Schedule 3 is produced that has no counterpart in the manual system. This shows all the repeater stations in the country with the number of channel translating equipments required at the fifth year.

Operation

Manual preparation of the schedules fully occupies an engineer for 3 months of the year and, to maintain an up-to-date picture as amendments to estimates are received, for quite a large proportion of the other 9 months. A large part of this work can be carried out on the Elliott 803 computer in three or four sessions of $3\frac{1}{2}$ hours each, thus freeing the engineer concerned from tedious repetitive work and enabling him to use his engineering ability to better purpose. There is the disadvantage that the output is only up to date for a short time, but this disadvantage will disappear when the program is rewritten for the Elliott 503 computer. On that machine a running time of 5–6 minutes means that, if required, weekly or daily up-dating runs are feasible.

CONCLUSION

So far, the applications described give only limited assistance to LMP Branch, but when the large project now being studied is implemented, the Branch (and the Regional Offices) should benefit greatly from the improved planning, utilization and record-keeping, and from the detailed statistics that will be possible.

References

[1]McGrath, H. T. The London Payroll Computers. *P.O.E.E.J.*, Vol. 52, p. 142, July 1959.

[2]Allery, G. D. The Post Office Engineering Department's Computer. *P.O.E.E.J.*, Vol. 55, p. 199, Oct. 1962.

[3]Laver, F. J. M. On Programming Computers. *P.O.E.E.J.*, Vol. 55, p. 125, July 1962.

[4]McGrath, H. T. New Computing Facilities for the Post Office Engineering Department. *P.O.E.E.J.*, Vol. 58, p. 38, Apr. 1965.

Notes and Comments

L. K. Wheeler, B.Sc.(Eng.), A.M.I.E.E.

Mr. L. K. Wheeler, who was recently appointed Staff Engineer of the Transmission Systems Division of Research Branch, began his engineering career in the Hendon factory of Standard Telephones and Cables, Ltd., and in 1933 entered the Post Office Engineering Department as a Probationary Inspector by Open Competition. After training at Swansea, Birmingham and Shrewsbury, with an intervening period in the Telegraph Branch of the Engineer-in-Chief's Office, his

first substantive post was a mixed internal and external duty at Stafford. An opportunity to return to London in 1935 was accepted by Mr. Wheeler, who wished to pursue his studies; he joined the Telephone Branch of the Engineer-in-Chief's Office, where he was employed on trunking and grading development.

In 1937 he obtained his London B.Sc.(Eng.) degree and passed the Limited Competition examination for Probationary Assistant Engineer (old style) after studying at Northampton Polytechnic in the evenings. He then joined the Telegraph Group in Research Branch, where he became concerned with investigations and developments in v.f. telegraphy, several of these finding application during the war period. Another interesting project in which he was intimately involved was the development of phototelegraph equipment for use on the radio network of Cable and Wireless, Ltd.

The war hastened developments in electronic switching circuits, and Mr. Wheeler applied them to apparatus and testers for the telegraph service. In 1947 he was promoted to Senior Executive Engineer of the same group, which carried out very successful work on code-converters, regenerative repeaters, and test-sets for start-stop telegraphy. Major projects directed by him as group-leader were the development of off-shore submerged repeaters to be used in some long-distance telegraph cables operated by Cable and Wireless, Ltd., error-correcting multiplex apparatus for use on radio circuits, and the telegraph distortion analyser.

In 1956 Mr. Wheeler was promoted Assistant Staff Engineer in charge of telegraph research, and two years later his section was merged with the radio-telegraphy group of the former WE Branch. Under his guidance, valuable work in the study of comparative performance of radio-telegraph systems has been done. More recently another group was transferred to his section, concerned with filter design and the Lincompex radio-telephony system.

It is noteworthy and a credit to Mr. Wheeler that many of the investigations with which he has been concerned have led directly to useful practical applications. He has also been the author, or co-author, of several articles and papers, and has contributed considerably to C.C.I.T.T. studies.

Rather quiet by nature and with a pleasant sense of humour, he can nevertheless be quite forceful in technical discussion. His many years of experience in the telegraph field have brought him into contact with all forms of transmission technique and so should provide a sound basis for success in his new post.

G.N.D.

Board of Editors

Mr. B. Cross has resigned from the post of Advertisement Manager and Mr. R. P. Myhill has been appointed to take his place. The Board of Editors takes this opportunity of thanking Mr. Cross for his services.

Notes for Authors

Authors are reminded that some notes are available to help them prepare the manuscripts of the Journal articles in a way that will assist in securing uniformity of presentation, simplify the work of the Journal's printer and draughtsmen, and help ensure that the authors' wishes are easily interpreted. Any author preparing an article for the Journal who is not already in possession of the notes is asked to write to the Managing Editor to obtain a copy.

It is emphasized that all contributions to the Journal, including those for Regional Notes and Associate Section Notes, must be typed, with double spacing between lines, on one side only of each sheet of paper.

Each circuit diagram or sketch should be drawn on a separate sheet of paper; neat sketches are all that are required. Photographs should be clear and sharply focused. Prints should preferably be glossy and should be unmounted, any notes or captions being written on a separate sheet of paper. Negatives or plates are not needed and should not be supplied.

Supplement and Model Answer Books

Students studying for City and Guilds of London Institute examinations in telecommunications are reminded that the Supplement to the Journal includes model answers to examination questions set in all the subjects of the Telecommunication Technicians' Course. Back numbers of the Journal are available in limited quantities only and students are urged to place a regular order for the Journal to ensure that they keep informed of current developments in telecommunications and receive all copies of the Supplement.

Books of model answers are available for some telecommunication subjects, and details of these books are given at the end of each Supplement.

Journal Binding

This issue completes Vol. 58, and readers wishing to have this volume bound should refer to page 293 for details.

Institution of Post Office Electrical Engineers

Annual Awards for Associate Section Papers—Session 1964–65

The Judging Committee having adjudicated on the papers submitted by the Local Centre Committees, prizes and Institution certificates have been awarded to the following in respect of the papers named:

First Prize of £7 7*s*.

J. M. Hogg, Technical Officer, Aberdeen Centre—"Recent Changes in Automatic Exchange Apparatus."

Prizes of £4 4*s each*

R. W. Winn, Technical Officer, Tunbridge Wells Centre—"Tunbridge Wells Zone Centre—Power Plant."

A. J. Christie, Technical Officer, Inverness Centre—"Some Developments in Subscribers' Apparatus."

The Council of the Institution is indebted to Messrs. A. H. C. Knox, E. Hoare and J. H. Pearce for kindly undertaking the adjudication of the papers.

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.

2821 *An Introduction to Counting Techniques and Transistor Circuit Logic.* K. J. Dean (Brit. 1964).
Explains the design and use of circuit modules—the building bricks of transistor-type counting equipment, static switching systems and simple logical machines.

2822 *The Challenge of Space.* G. K. C. Pardoe (Brit. 1964).
Covers the range of activities associated with contemporary space flight; the simple basic mathematics of the entry into space; the types of satellites and vehicles now reaching into space; and the organizations set up to manage the projects.

2823 *A Journey Through Space and The Atom.* S. T. Butler and H. Messell (Brit. 1963).
Material presented in the fifth annual Nuclear Research Foundation Summer Science School at the University of Sydney, 1962.

2824 *T.V. and Radio Line Distribution.* H. E. Penrose (Brit. 1964).
Devoted to the techniques whereby television and radio signals are received at suitably sited main receiving stations and relayed to individual receivers over transmission lines.

2825 *The Digital Computer.* K. C. Parton (Brit. 1964).
Describes concisely how to use a modern computer, the sort of work being done, how the computer works, and the considerations necessary to ensure a ready acceptance of computer help in an existing organization.

2826 *Masers and Lasers.* M. Brotherton (Amer. 1964).
Explains, in simple non-mathematical language, the key ideas and principles behind masers and lasers, and discusses the origin, significance and role played by these electronic devices today in science and technology.

2827 *Introduction to Microwave Theory and Measurements.* A. L. Lance (Amer. 1964).
A compact, logical description of physical concepts, mathematical formulations and measurement systems, with illustrative examples of ideas and measurement procedures.

2828 *The Story of Jodrell Bank.* R. Piper (Brit. 1965).
A clear, readable account of the work of the telescope together with the story of how it came to be built.

2829 *Practical Transistor Servicing.* W. C. Caldwell (Amer. 1960).
A simple explanation of how transistors work, followed by the best methods of testing transistor radios and actual trouble experience.

2830 *Planning by Network.* H. S. Woodgate (Brit. 1964).
Sets out simply the basic principles of the main network techniques and explains how they are applied.

2831 *The Age of Automation.* L. Bagrit (Brit. 1965).
The B.B.C. Reith Lectures, 1964. Presents a fascinating new world with man saved from the drudgery of routine work, rich enough to help the underdeveloped areas, with leisure to cultivate cultural and sporting interests and with the prospect of a comfortable retirement from an industrial to a rural area at 55.

2832 *A Long Way from Euclid.* C. Reid (Brit. 1963).
Concentrates on the part played by the "Elements" of Euclid during the last two thousand years, and takes the reader from ideas familiar since childhood to some of the most exciting outposts of contemporary mathematics. No mathematical background beyond elementary algebra and plane geometry is assumed.

2833 *Radio Wave Propagation, VHF and Above.* P. A. Matthews (Brit. 1965).
Describes the basic mechanisms of propagation and reviews the different means of propagation at v.h.f. and above, and the limitations which the medium imposes on a system.

2834 *The Goonhilly Project.* Edited by F. J. D. Taylor (Brit. 1964).
Describes the British P.O. Earth Station System and explains the solutions found to the problems of communication between Earth Stations, via a distant and rapidly moving satellite.

2835 *Radio Servicing*—Radio Valves (Brit. 1964).
2836 *Radio Servicing*—D.C. and Magnetism (Brit. 1964).
2837 *Radio Servicing*—A.C. and Acoustics (Brit. 1964).
A series designed to give the necessary theoretical knowledge of radio servicing.

W. D. FLORENCE,
Librarian.

Regional Notes

London Telecommunications Region

IN-SITU CABINET REMOVAL

Road improvements frequently involve cutting back the kerb line on the corners of road intersections to improve traffic flow. On rare occasions this can be achieved without alteration to our plant, but often a large footway box has to be demolished and rebuilt, with the consequent relaying of ducts and cables from suitable points either side, to conform to the new kerb line. Such alterations are costly to the promoting Authority, and involve Post Office staff in work which seldom brings any improvement to the plant. This is particularly so where a cross-connexion cabinet and its associated footway box have to be shifted.

Recently at the junction of Western Avenue and Oldfield Lane, Greenford, Middlesex, the kerb had to be set back a maximum of 18 in. at a point where a cross-connexion cabinet No. 2 existed, served from a joint-box already on the backline of the footway.

To erect a new cabinet and change over its serving cables would have cost several hundred pounds—almost as much as the road improvement on the corner concerned—and would have delayed the contractors' program. Luckily the movement required was small and was towards the serving cables. A preliminary survey beneath the footway revealed that if the cabinet could be bodily shifted, the ducts could be re-accommodated in a slightly different position with no harm to the cables or joints.

Arrangements were made with the Mechanical-Aids Depot to supply a Jumbo Crane on a given day when a Works Supervisor would be on site with our own contractors, together with a jointing team to ensure no damage occurred to the cables.

MOVING THE CABINET WITH THE HELP OF A JUMBO CRANE

The ground from the footway box to the cabinet was fully excavated, exposing completely the self-aligning ducts and the concrete foundation of the cabinet. Channels were cut in the soil beneath the foundation, and through these sling chains were passed from the crane and the cabinet gently lifted clear, there being ample slack on the cables to permit this.

The underside of the concrete base was then cleaned with a stiff brush and water, and coated with a cement slurry to assist bonding. The new concrete foundation was then cast and the cabinet gently slung and lowered on to it, as shown in the accompanying photograph, being finally plumbed level and upright with suitable supports and left to set.

In re-aligning the ducts it was only necessary to fit split ducts in place of two whose collars were damaged. No damage was suffered by the cables, which were replaced on the bearers in the box from which they had been moved to give greater flexibility.

The whole operation occupied six men for approximately two hours, excluding time spent on reinstating the ground around the cabinet.

This type of movement is seldom possible due to the position of other undertakers' plant in the ground, but in this instance it was entirely successful and resulted in a very large reduction in the labour resources that would otherwise have had to be employed on the work. At the same time only a small charge was incurred by the promoting Authority.

B.S.T.

Home Counties Region

EARLY TRANSMISSION EQUIPMENT

A link with the very early days of long-distance telephony was broken a few weeks ago by the recovery of the remaining "black" transmission equipment at Marks Tey repeater station.

The double-stage repeaters recovered were of two types: the 4202 which was a simple two-stage amplifier and equalizer, and the 4252, a similar repeater associated with an echo suppressor. A number of two-wire repeaters also remained, and the drawings for these (which bear the names of Standard Telephones and Cables, Ltd., and the Western Electric Co., Ltd.) were prepared between 1923 and 1925. In this equipment a C battery was used for grid bias, and the battery, with an arrangement to charge it from the B battery, survived until recent years.

A few double-stage repeaters remained in service up to about 5 years ago when the last 4-wire circuits were shifted to more modern plant. Features of this equipment, which would hardly commend it to Transmission Efficiency Officers, were break jacks in the input and output of each direction, and a 10-stud rheostat in the input circuit of the second stage to facilitate gain adjustments. The repeaters did, however, use auto-bias and incorporated a small pad which could be switched to give final adjustment to within $\frac{1}{3}$ db.

Supervisory arrangements on all this equipment included anode-current failure alarms and arrangements by which keys could switch ammeters into the filament and h.t. circuits of each repeater. The original valves had bright-emitter filaments taking currents of one ampere, but these were later replaced by $\frac{1}{4}$ amp versions.

The first transmission equipment at Marks Tey was installed in 1927, when the repeater station was temporarily housed in a wooden hut while the permanent building was being constructed. The hut is still to be seen next door, serving as a workshop for a local garage. Two Ruston and

Hornsby single-cylinder diesel engines supplied the station power. One of these still remains, and is used in the event of a prolonged mains failure. In the early days the station lighting was supplied from the B battery, as also was the lighting in the flat occupied by the resident engineer—a feature of some note in a village when oil lighting in the house was the general rule.

Some of the earliest circuits which passed through Marks Tey repeater station were to the Continent, and others were to Norwich via Halesworth, which closed many years ago. Today a good many audio circuits are still amplified there, although the station is expected to close in about 1968. Current intention is that the building should house the proposed Marks Tey non-director telephone exchange, but before that time its use for transmission purposes will have extended over a span of more than 40 years.

R.A.M.L.

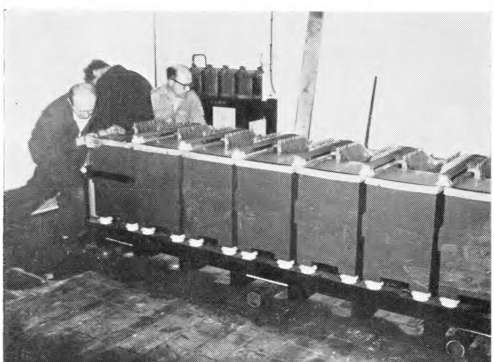
Northern Ireland

A NOVEL METHOD FOR SHIFTING BATTERIES

A re-arrangement of accommodation at Bangor (Co. Down) telephone exchange required the exchange batteries to be shifted within the battery room to a new position some 12 ft down the room from their existing position. The batteries consist of Cells, Secondary, Stationary No. 12/1400 plated to 700 ampere-hour capacity, and the normal method of shifting them would have been to completely dismantle all of the cells, shift the empty boxes, and then rebuild the batteries in the new position—a job which would have taken about six weeks. It was decided, however, to ask the D.P. Battery Co., Ltd., to shift the batteries on rollers without dismantling them.

The standard timber frames which support the cells on the floor were in two sections for each row of cells, so that, by removing the inter-row connexions and two of the inter-cell connexions, each battery could be broken down into four sections: three of six cells and one of seven cells.

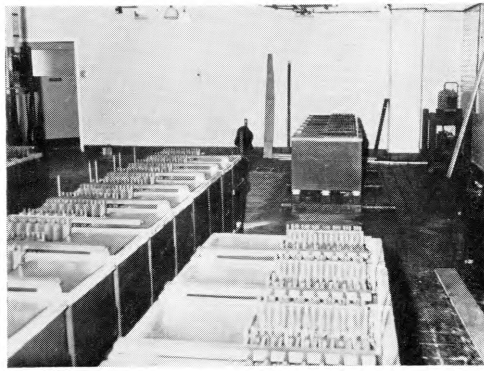
Three pieces of 3-in. steel pipe were used as rollers to shift each of these sections, one at a time. The rollers were slipped under the longitudinal bearers of the frame beside the transverse bearers, there being a resultant clearance of about $\frac{1}{4}$ in. Six pieces of flat mild steel, $\frac{1}{2}$ in. thick, 2 in. wide and the length of the transverse-bearer spacing, were then placed one at a time between the underside of the longitudinal bearers and the rollers by levering up the bearers at each point. The battery section, weighing about $1\frac{1}{2}$ tons, was now sitting on the rollers with the transverse bearers $\frac{1}{4}$ in. clear of the floor. It was then possible to push the battery section along for about 12 in. until the rollers were stopped by the transverse bearers, as shown in the first photograph. Next the rollers were slid along by hammering



ROLLING THE BATTERY TO ITS NEW POSITION

with baulks of timber and the section rolled a further 12 in.

This process was repeated until the new position was reached, as shown in the second photograph, the pieces of steel strip were knocked out, and the rollers removed. The



A SECTION OF THE BATTERY IN ITS NEW POSITION

other three sections of the battery were then moved and the interconnexions were re-made. The fuse post was shifted and the battery was connected to the power board by temporary cables pending extension of the bus-bars. The second battery was then shifted in a similar manner.

The whole job, including preparation and clearing up, was completed in less than four days thanks to the willingness of the contractors and the Telephone Manager's staff to tackle the unusual. The result was a substantial saving in time and money.

A.N.

North-Western Region

RECOVERY OF BRAMHALL MANUAL EXCHANGE

Bramhall manual-to-automatic exchange transfer took place on 29 September 1965 when the first of two units, comprising a 4,900-line multiple, was brought into use. To clear the waiting list and the contract, completion of a further 1,500-line multiple on the second unit is required before 31 March 1966.

The major portion of the second unit was to be installed in the space occupied by the existing manual-exchange test room and, therefore, it was essential that its recovery should proceed as quickly as possible.

The larger banks of cables were cut using an experimental pneumatic cable cutter. A lino knife was used to cut the cable stitching, and the cutter was used to cut half a dozen switchboard cables at a time. This enabled the recovery to proceed at a tremendous pace. The M.D.F. was cut down to floor level by an oxy-acetylene torch on the second day, the footing being removed on the third day by an external gang using a road breaker; a joiner sanded the floor area required for the subscriber's I.D.F. on the fourth day, and the accommodation was ready for installation to commence.

Saving in time on the whole operation, including the recovery of the manual suite, is expected to be in the neighbourhood of 3,000 manhours.

G.F.P.

RODDING AND ROPING A 500-YARD DUCT SECTION

The proposed duct route intended for a new Colchester–West Mersea junction cable included 1,000 yards of $3\frac{1}{2}$ in. p.v.c. conduit across the Mersea Strood. This is the road joining the island with the mainland and is subject to flooding at high tide. The p.v.c. duct, with duct seals at the jointing chambers and with the carriage-way frames and covers sealed to prevent the ingress of water, was expected to keep free of salt water. However, before this duct was laid it became possible to buy 1,500 yd of a recently replaced 4-in. cast-iron water main in the road.

The 1,500 yd will be divided into three sections of approximately 500 yd between jointing points, but, to enable the Engineering Department to test an experimental duct motor on long-length rodding, the present two sections consist of approximately 500 yd and 1,000 yd, respectively.

The 467 yd section from Mersea Island to the mainland was roped using the improved Ductmotor No. 1 with 500 yd of nylon hose. This section presented no difficulty and, with the ductmotor connected to a compressor delivery of 85 lb/in^2, it was rodded and roped within the hour, with synthetic draw rope.

An attempt was then made, using two ductmotors with marrying attachments, to rod the 1,000 yd pipe from each end and to marry at the 480 yd point, where the track was to be broken down and a joint-box built for balancing purposes. The ductmotor from the "Peldon Rose" end travelled freely along the pipe for 562 yd before the motor stopped, while the ductmotor from the "Strood" end travelled 350 yd before stopping; the marrying attempt had not been successful.

The track was broken down at the 480 yd point, a section of the pipe being removed with a pneumatic pipe cutter. The "Peldon Rose" end ductmotor was drawn back and removed, and a draw-rope attached to the nylon hose was drawn in. Rodding re-commenced with the ductmotor working from this point towards the Strood end and this time marrying was achieved. The two ductmotors were then drawn towards the 480 yd point, but after 50 yd they jammed, and in attempting to move them the nylon hose was severed. A section of the pipe was then removed and the two jammed ductmotors were recovered. On inspection it was found that a bag was inverted on one motor causing it to jam. Duct rodding from this point in both directions was completed and the final section of the 1,500-yd pipe was roped with Draw-Rope No. 1, without joins.

The conclusions drawn from this experiment were that the improved Ductmotor No. 1 can successfully rod a clean, free duct up to 500 yd in length. Providing the ductmotors are cleaned and oiled after each section is rodded, they should be trouble-free. A draw rope should be attached to the ductmotor, thus roping at the same time as rodding as well as providing a means of freeing or recovering the ductmotor if an obstruction in the track is encountered. In new ducts, designed for long-length cabling, it is practicable to build large jointing chambers at the ends of 498 yd sections, and so utilize the whole 500 yd and 1,000 yd standard lengths of polythene-sheathed cables. The jointing chamber must be fitted with anchor irons, and be long enough to insert and remove the ductmotor easily, and to support and restrain the polythene cables in line with the expanding-plug joints. The draw-rope should be in 660 yd lengths on a reel fitted with a light brake, and have a breaking strength of not less than 600 lb to draw in a 2 in. steel-cored rope.

S.A., C.J. and H.L.

Midland Region

GAS EXPLOSION AT WORCESTER

On the evening of 6 July 1965 the main road near Worcester Cathedral was shaken by a violent explosion. The covers of six Post Office manholes were blown off and for some hours gas burnt in the opening of two of them. Two weeks previously one of these covers had defied all attempts at opening by normal means. Gas was leaking from a nearby main and entering a 15-way duct track containing six local cables, two audio junction cables, two pairs of carrier cables and one coaxial cable.

The coaxial cable went out of service due to a full earth on a centre conductor. In the audio cables 166 circuits also failed and the air pressure on one carrier cable failed. Early the next morning, when the gas leak was under control and the plant had cooled down, work on fault clearance began. On the coaxial system the power-separating chokes in the adjacent repeater station had burned out, and by the time these were replaced the fault had cleared as a result of the cable cooling. The system was then restored to temporary service.

On one of the carrier cable lengths the sheath had melted away and the paper insulation was badly charred for a length of about 18 in. Eventually all the cable lengths were replaced and found to be similarly damaged. One polythene-sheathed cable was found to have the sheath melted over a distance of 6 ft with the paper insulation badly charred.

Surprisingly enough there was no other damage in the manholes and no other faults reported except later when dampness crept into the damaged local cables during the repair work.

E.W.A. and D.A.P.

London Postal Region

THE NEW WESTERN DISTRICT SORTING OFFICE

On the 3 August 1965 the Postmaster-General opened the new Western District Office, which is one of the largest and most mechanized sorting offices in the world, costing altogether about £4,500,000. It is situated in Rathbone Place, a turning off Oxford Street, and will deal with 9,000,000 letters and 250,000 parcels each week.

Underneath is one of the Post Office railway stations, some 60 ft below ground. It is equipped with its own 11,000-volt substation, 450-volt and 150-volt rectifiers and relay equipment for automatic-train control.

In the sub-basement there is a garage to accommodate 100 vehicles. The basement is used for the mechanized storage of parcels, mail-bag cleaning, and the storage of empty bags as well as accommodating folding and tying machines, together with the associated electric fork-lift and pallet trucks. There is also an extensive network of distributing conveyors.

An island loading platform with overhead mechanized mail-bag storage devices occupies the ground floor.

The first, second and third floors accommodate the operational staff, the parcel-sorting machines, letter and packet segregator, automatic letter-facing machines, letter tray distribution, packet-sorting machinery, and the associated chain and band conveyors and storage devices. These floors are linked with the Post Office railway and ground-floor loading platform by vertical and horizontal conveyors, chutes and seven passenger and goods lifts.

Administrative offices, a restaurant capable of serving 500 meals at once, a lounge, and a cloakroom occupy the fourth floor while on the fifth floor are situated the lift-motor rooms, and the plenum heating fans and filter rooms.

The building is heated by three 4,000,000 B.t.u./h boilers. The heat is distributed by a hot-air plenum system supplemented by hot-water radiators around the periphery of the floors to make good the fabric heat losses.

The garage, which requires a high rate of air change, has a ventilation system with fan room in the sub-basement. There is a similar ventilation system to serve the Post Office railway station.

The building has its own sub-station, and continuity of supply is reasonably assured by four separate supply cables, two at 11,000 volts and two at 415/240 volts. The installed power load is 1,000 kVA and the lighting load is 500 kVA, making a total of 1,500 kVA.

The planning and installation of the lighting and power has been closely integrated with the mechanization. The control switchboard has been divided into six sections, and the electrical distribution arranged to minimize the effect of circuit failure on the postal equipment.

The letter-sorting office has yet to be put into operation. Although it has a considerable amount of mechanization, letter sorting will at first be done manually, provision being made for the inclusion of letter-sorting machinery at some future date.

Meanwhile, the parcel-sorting office, with its 12 parcel-sorting machines, its distributing machinery and storage devices, is in service with a capacity for handling 10,000 parcels an hour.

L.W.O.

Associate Section Notes

Bournemouth Centre

The activities of the Bournemouth Centre have been somewhat limited this summer.

At the annual general meeting in April it was decided to introduce the scheme for payment of the annual subscription by deduction from pay. This has now been successfully achieved, and our membership now stands at just over 70 and continues to rise slowly.

In July some of our members visited Poole power station where our guides described the working of the boilers both when using oil-firing and coal-firing methods. The working of high, medium, and low pressure turbines was explained, as well as the control and distribution of the electricity produced.

In October we made a very successful trip to the Royal Aircraft Establishment at Farnborough. We were taken round the establishment by coach and shown the huge tanks that were used to find the cause of the Comet disasters, and are now employed to test new aircraft for structural weaknesses and metal fatigue. After this we visited the hangar where the recovered parts of crashed aircraft are laid out and examined for the reasons for the accident. Lastly, we visited a display of models of rockets of various types, together with some of the components that go towards making one of these complex devices. This was a most interesting visit, but it was unfortunately limited by shortage of time.

R.A.W.

Exeter Centre

The Centre's summer program ended with an evening visit to the Norman Lockyer Observatory at Sidmouth. The work in progress at this observatory includes studies of the movement of the ionosphere, research into the micro-pulsations of the earth's magnetic field and investigation of the phenomenon of night glow, that faint illumination of the sky which exists even on a moonless night. The party had hoped to use the observatory's 10 in. telescope, but the sky was too cloudy for making observations.

The winter program started with the following talks:

30 November: "Subscriber Trunk Dialling for U.A.X.s," by Mr. M. W. Bayley, Wales and Border Counties Region.

16 December: "Matters of Local History," by Mr. Cloe.

The remainder of the winter program is as follows:

18 January: A visit to the biological laboratory of the Marine Biological Association of the United Kingdom at Plymouth.

25 February: Quiz—Plymouth *v.* Exeter. This event will be held in the Royal Seven Stars Hotel, Totnes.

30 March: "Delays in the Completion of Exchange Equipment Works Orders—Who is to Blame? What are the remedies?," by Mr. M. J. Thurlow.

T.F.K.

Plymouth Centre

The previous secretary, Mr. D. H. Scoble, has left on promotion to Assistant Executive Engineer. The Section wishes to congratulate him and thank him for the work he has put in whilst with us. The new secretary is Mr. H. J. Hambly.

The Section has been dormant during the summer but the winter program starts with a visit to the B.B.C. Transmitting Station at North Hessary Tor.

H.J.H.

Swindon Centre

An evening visit was made to the diesel testing station and engine workshops of British Railways (Western Region) at Swindon on 6 August by 28 members, and a very good insight into the problems experienced by British Railways with the introduction of diesel trains was given. Following this, in September, the final visit of the summer was made by 25 members to London Airport for a conducted tour by B.O.A.C.

W.H.B.

Reading Centre

The committee arranged the following program for the Centre's winter session.

19 October: "Medical Electrical Equipment," by Dr. Mason of the Radcliffe Infirmary, Oxford.

30 November: "Location of Faults in Cables," by Messrs. R. A. M. Light and H. P. Brooks.

14 December: "High-Speed Gas Production," by a member of the Southern Gas Board staff.

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

22 February: "Future Developments of Subscribers' Telephone Instruments," by Mr. T. C. Harding, Subscribers' Apparatus and Miscellaneous Services Branch, Engineering Department.

We are also hoping to be able to present an illustrated talk on "Wankel Engines" during March.

We will have made our eagerly awaited visit to the Road Research Track at Crowthorne by the time these notes are published. The response from members was such that some applicants had to be refused, but those who were unable to go on the visit will be given first consideration in the event of a second visit to the Track.

P.L.C.

Norwich Centre

The first lecture of the 1965–66 session was quite well attended despite clashing with other events. The lecture was given by Mr. W. D. Lewis, a Senior Meteorological Officer, and was entitled "Weather Service"—a service in which Post Office communications play a considerable part. Questions after the talk ranged from the use of statistics in forecasting, to the reliability of folklore and seaweed.

Other items on the program for this session include:

"Pulse-Code Modulation," by Mr. Jarvis of the Post Office Research Station.

"The North Sea Search," for oil and gas, by Mr. Lacey of Shell Mex and BP.

"Electronics at the University of East Anglia," by Mr. P. Lefevre, an ex-Post Office Engineer, now on the staff of the University after varied work on electronics in the United States.

Another item is to be a talk on "Radio Astronomy" by a speaker from the Cavendish Laboratory, Cambridge.

T.H.C.

Inverness Centre

Prior to the commencement of the new session, and the more serious side of the Centre's activities, a golf outing was held at Fortrose. Seventeen members took part and, at the end of an enjoyable outing, the Centre's "Pewter Mug" was won by Mr. C. F. Tulloch.

A film show was held on 22 September when the following films were shown: "A Question of Springing," "Mille Miglia" and "The Captive River."

W.C.

Dundee Centre

Our program for the coming session, though slightly shorter than usual, should provide something to satisfy all tastes.

Visits will be made to Pye Communications, Airdrie, and to the Art Galleries and Museum at Dundee. Talks will be given on "Space Communication," by Mr. S. C. Gordon, Post Office Research Station; "New Telephone Instruments," by Mr. T. C. Harding, Subscribers' Apparatus and Miscellaneous Services Branch, Engineering Department; "Hi-Fi," by Pye, Ltd., Cambridge; and "S.T.D. at U.A.X.s," by Messrs. L. E. Pinner and D. L. Miller, Dundee.

A film show was arranged for our December meeting.

Congratulations and thanks are given to Mr. George Deuchars, now promoted to Assistant Executive Engineer, for his loyal support and assistance during his many years as a member of the Associate Section.

R.T.L.

Glasgow Centre

The annual general meeting was held on Friday, 23 April, and the following officers and committee were elected: *Chairman:* Mr. S. T. Marsh; *Vice-Chairman:* Mr. J. McCallum; *Secretary:* Mr. R. M. Fraser; *Treasurer:* Mr. H. Gordon; *Committee:* Messrs. W. Bolton, J. Campbell, J. Fleming, N. Cochrane, R. A. Dick, A. McIntosh, W. Fotheringham, S. Johnstone, A. Kerr, W. Leitch, H. McNamara, J. Murray, I. Steel, R. T. Shanks, I. Thomlinson, B. Wright and J. Newlands.

It was felt by those attending this meeting that due to the increase in membership of the Centre, now at 450, the number of committee members should be increased, the notification of meetings to the members, by personal contact, having proved the most effective method of ensuring good attendances at our meetings and visits.

During the second half of the program for the 1964–65 session our members enjoyed talks and visits as follows:

January: "Space Communications," Dr. Hugh Dalgleish, Post Office Research Station.

February: "The New Engineering Training College at Harlow," Mr. R. W. Palmer, Principal, C.T.S. Stone.

March: Visit to Rolls Royce Factory at East Kilbride.

March: "Hi-Fi," Lecture and Demonstration by Wharfdale, Wireless Works, Yorkshire.

May: Visit to Colvilles, Ltd., Ravenscraig Steel Works.

With an interesting program for the 1965–66 session now under way we are hopeful of even better support from our members.

J.McC.

Ayr Centre

The February meeting of this Centre heard a talk on the subject "Ford Engines and Electrical Equipment" given by Mr. R. Stuart of the Ford Motor Co., Ltd. This talk, amply illustrated with slides and a film, was very interesting and well attended.

The annual general meeting was held on 16 June, the following office bearers being elected: *President:* Mr. A. E. Edgar; *Chairman:* Mr. W. F. Leith; *Vice-Chairman:* Mr. L. R. L. Parry; *Secretary:* Mr. A. Bagnall; *Committee Members:* Messrs. Halliday, Claymore, Telfer, Scott, McIntyre and Whyte.

An interesting program of five lectures and two visits is now under way for the 1965–66 session.

A.B.

Belfast Centre

Our 1964–65 session opened with a lecture entitled "Modern Maintenance—Serving the Subscriber," by Mr. T. F. A. Urben, Telephone Exchange Standards and Maintenance Branch, Engineering Department, on 28 October, 1964.

Other talks and lectures throughout the remainder of the session were as follows:

25 November: "Microwaves and Satellites," by Mr. T. S. Wylie, Deputy Telephone Manager, Belfast.

27 January: "Psychology and the P.O. Engineer," by Mr. G. D. Cumming, one of our own members.

4 March: "Gas Pressurization of Cables," by Messrs. J. D. McDonnell and L. A. Johnston, two members of the Belfast Senior section.

14 April: "Some Electronic Telephone Exchange Developments," by Mr. D. L. Benson, Telephone Electronic Exchange Systems Development Branch, Engineering Department.

We got off to a flying start, and our first two meetings were very well supported. Those members whose interest and attendance waned during the season will have realized the value of the meetings they missed, as all the lectures and talks were very enthusiastically received.

We were very pleased that one of our members, namely Mr. G. D. Cumming, had been successful in gaining a monetary award and an Institution Certificate in the 1964–65 Essay Competition for his essay entitled "Protection of the P.O. Plant from Electrical Power Systems," and hope that this, his second success, will encourage other budding authors to enter for the next competition.

The committee have catered for all interests during the 1965–66 session, the program for which is now under way, and we look forward to increased support.

S.M.

London Centre

The session opened well with a very interesting talk on the "Duties of an Airline Pilot," by Capt. F. Walton of B.O.A.C. (Can we now complain of our daily routines after hearing of all the routine checks a pilot has to carry out before take-off?)

Our October lecture on "Colour Television," by Mr. C. E. Clinch of the Main Lines Planning and Provision Branch, Engineering Department, was most enlightening. Our thanks to A.B.C. television studios at Teddington for their co-operation.

4 November saw the quiz final between London and Home Counties Regions at Canterbury. South-West Area represented London, and Canterbury Centre the Home Counties Region. From a very mixed bag of questions the London team finally won the trophy (a fine model of the Post Office Tower) by half a point. We congratulate the S.W. Area team of Messrs. R. Hammond (Capt.), S. Cook, J. T. Featherstone, D. Burgess, K. Monahan and J. Palmer. We wish to thank Mr. E. Hoare (Chairman and Question Master) and the other officials of the meeting for giving up their time to help us, and also our hosts, Canterbury Centre, for the satisfying meal which preceded a very enjoyable evening's entertainment. I'm sure everybody went home feeling just that little bit wiser.

Is there a team in the Midland Region who would like to join us in a friendly "battle of wits"?

"New Space Communication Satellite Projects" by Mr. D. Wray was the subject of our November lecture. The demonstration with a portable satellite to reflect the beamed signal, facts and figures about Goonhilly Downs, and several film shots, made the evening a very enjoyable one.

R.W.H.

Staff Changes

Promotions

Name	Region, etc.	Date
Assistant Staff Engineer to Staff Engineer		
Wheeler, L. K.	E.-in-C.O.	13.9.65
Senior Executive Engineer to Assistant Staff Engineer		
Mitchell, G. (*In absentia*)	T.S.U.	22.7.65
Rutterford, L. F.	T.S.U.	22.7.65
Thwaite, H.	E.-in-C.O.	11.8.65
Masters, D. C.	E.-in-C.O.	6.8.65
Senior Executive Engineer to Chief Factories Engineer		
Smith, D. C.	Factories Department	29.9.65
Senior Executive Engineer to Telephone Manager		
W. N. Lang	E.-in-C.O. to H.C. Reg.	5.4.65
Area Engineer to Regional Engineer		
Masters, E. J.	H.C. Reg.	26.7.65
Day, J. V.	N.E. Reg.	6.8.65
Senior Executive Engineer to Regional Engineer		
McGrath, H. T.	E.-in-C.O. to L.T. Reg.	6.8.65
Executive Engineer to Area Engineer		
Bramham, C. E. H.	N.I. to N.E. Reg.	4.6.65
Houldsworth, G. R.	N.W. Reg.	4.6.65
Weedon, N. W.	H.C. Reg.	12.7.65
Porter, D. J.	Scot. to N.W. Reg.	2.8.65
Bish, T. A.	Mid. Reg.	8.7.65
Executive Engineer to Senior Executive Engineer		
Ritchie, W. R.	E.-in-C.O.	22.7.65
Wickens, R. F.	T.S.U.	22.7.65
Cox, D. S.	T.S.U.	22.7.65
Fiddes, R. G.	T.S.U.	22.7.65
Eccles, J.	E.-in-C.O.	22.7.65
Roche, D. J.	E.-in-C.O.	22.7.65
Burling, K. G.	H.C. Reg. to E.-in-C.O.	22.7.65
Dowling, A. G.	E.-in-C.O.	28.7.65
Boag, J. F.	E.-in-C.O.	22.7.65
Brown, H.	E.-in-C.O.	9.8.65
Meads, E. F.	E.-in-C.O.	3.8.65
Bluett, R. J.	E.-in-C.O.	2.8.65
Howarth, J. E.	E.-in-C.O.	2.8.65
Durrant, R. F.	Mid. Reg. to T.S.U.	31.8.65
Jennings, J. C.	S.W. Reg. to N.E. Reg.	13.9.65
Lomas, T.	E.-in-C.O.	20.9.65
Cross, B.	E.-in-C.O.	20.9.65
Wherry, A. B.	E.-in-C.O.	20.9.65
Longmore, D. S.	E.-in-C.O.	20.9.65
Harris, T.	L.T. Reg to E.-in-C.O.	27.9.65
Paxton, C.	E.-in-C.O.	29.9.65
Executive Engineer (Open Competition)		
Miller, M. R.	E.-in-C.O.	5.7.65
Bennett, M.	L.T. Reg.	6.7.65
Hackett, E. A.	E.-in-C.O.	19.7.65
Berry, J. C.	E.-in-C.O.	23.7.65
Adams, G. W.	E.-in-C.O.	2.8.65
Knappett, J. J.	E.-in-C.O.	11.8.65
Hill, M. W.	E.-in-C.O.	24.8.65
Duff, I. F.	E.-in-C.O.	1.9.65
Haigh, G. R.	E.-in-C.O.	1.9.65
King, A. D.	E.-in-C.O.	1.9.65
Lacey, N.	E.-in-C.O.	1.9.65
Nuttall, B. L.	E.-in-C.O.	1.9.65
Oliver, G. P.	E.-in-C.O.	1.9.65
Probert, C. C.	E.-in-C.O.	1.9.65
Seymour, C. A.	E.-in-C.O.	1.9.65
Jones, W. G. T.	E.-in-C.O.	9.9.65
White, R. L.	E.-in-C.O.	6.9.65
Wedlake, J. O.	E.-in-C.O.	6.9.65
Rayner, R. C.	E.-in-C.O.	13.9.65

Name	Region, etc.	Date
Executive Engineer (Limited Competition)		
Hill, S. J.	E.-in-C.O.	2.8.65
Holland, D.	N.W. Reg.	8.6.65
Monoghan, D.	N.E. Reg.	31.5.65
Taylor, R. G.	L.T. Reg. to E.-in-C.O.	8.6.65
Morse, G. E.	E.-in-C.O.	12.8.65
Fretton, K. G.	E.-in-C.O.	10.5.65
Ward, K. E.	L.T. Reg.	14.6.65
Bartlett, B. B.	H.C. Reg. to Mid. Reg.	21.6.65
Jones, J. B.	N.W. Reg.	9.6.65
Assistant Executive Engineer to Executive Engineer		
Murfitt, R.	E.-in-C.O.	7.7.65
Palmer, D.	E.-in-C.O.	7.7.65
Pritchard, D. A.	E.-in-C.O.	7.7.65
Rigby, D. F.	E.-in-C.O.	7.7.65
Taylor, F. C.	E.-in-C.O.	7.7.65
Angell, F. W.	E.-in-C.O.	12.7.65
Bridgwood, J. L.	E.-in-C.O.	12.7.65
Jones, A. W.	E.-in-C.O.	12.7.65
Matthew, J. D.	E.-in-C.O.	12.7.65
Parrott, R.	E.-in-C.O.	12.7.65
Price, D.	E.-in-C.O.	12.7.65
Hubbard, D.	Mid. Reg.	21.6.65
Williams, J.	H.C. Reg.	28.6.65
Ramsey, W. A. R.	S.W. Reg.	21.6.54
Keat, T. D.	S.W. Reg.	20.7.65
Mead, R. H.	S.W. Reg. to H.C. Reg.	26.7.65
Scott, A.	Scot.	6.7.65
Collins, K. P. O.	W.B.C.	8.7.65
Whitlock, A. A.	Mid. Reg. to L.T. Reg.	9.8.65
Clark, L.	E.-in-C.O.	16.8.65
Maitland, F. A.	L.T. Reg.	12 8.65
Castle, A. G.	L.T. Reg.	12.8.65
Farmer, W. H.	N.I.	16.8.65
Whitehead, H. J.	Scot.	1.9.65
Smith, N. A.	L.T. Reg. to E.-in-C.O.	13.9.65
Peel, A. B.	N.E. Reg.	20.9.65
Greaves, D. A.	L.T. Reg.	12.8.65
Lanfear, J. S.	S.W. Reg.	27.9.65
Tilbrook, F. H.	H.C. Reg.	29.9.65
Heasman, L. A.	H.C. Reg.	29.9.65
Vernon, R.	S.W. Reg.	27.9.65
South, V. G.	H.C. Reg.	29.9.65
Fowler, R. H. Q.	H.C. Reg.	29.9.65
Snow, H. G.	H.C. Reg.	29.9.65
Triplow, L. E.	H.C. Reg.	29.9.65
Assistant Executive Engineer (Open Competition)		
Corley, D. C.	E.-in-C.O.	16.8.65
Armstrong, J. C.	E.-in-C.O.	17.8.65
Adcock, R. C.	E.-in-C.O.	6.9.65
Terrell, T. J.	E.-in-C.O.	17.8.65
Sanders, P. W.	E.-in-C.O.	17.8.65
Busby, J. L.	E.-in-C.O.	20.7.65
Memory, D. M.	E.-in-C.O.	20.7.65
Pugh, A. R.	E.-in-C.O.	17.8.65
Colles, J. M.	E.-in-C.O.	14.9.65
McMillan, A. M.	Scot.	22.10.65
Symons, W. M.	E.-in-C.O.	17.8.65
Keith, A. F.	E.-in-C.O.	20.7.65
Strank, J. T.	E.-in-C.O.	20.7.65
Stephen, J.	E.-in-C.O.	20.7.65
Tierney, C. J.	E.-in-C.O.	14.9.65
Assistant Executive Engineer (Limited Competition)		
Curry, J.	N.E. Reg.	5.4.65
Cathcart, O.	N.I.	5.4.65
Robson, D. C.	E.-in-C.O.	5.4.65
Cheesman, P. R.	E.-in-C.O.	5.4.65
Dubery, R. G.	E.-in-C.O.	5.4.65
Marchant, R.	E.-in-C.O.	5.4.65
Huggins, M. E.	E.-in-C.O.	5.4.65
Ansell, M. J.	E.-in-C.O.	5.4.65

Name	Region, etc.	Date
Assistant Executive Engineer (Limited Competition)—continued		
Wheddon, C.	E.-in-C.O.	29.3.65
Francis, P. V.	N.E. Reg.	5.4.65
Clegg, R.	W.B.C.	5.4.65
Brown, L. M.	N.W. Reg.	5.4.65
Smith, R. A.	E.-in-C.O.	20.4.65
Gubbay, D. M.	E.-in-C.O.	20.4.65
Cook, R. E. E.	E.-in-C.O.	21.6.65
Legg, K. W.	S.W. Reg.	14.6.65
Giles, T.	S.W. Reg.	20.4.65
Wyatt, B. J.	S.W. Reg.	20.4.65
Jelly, C.	E.-in-C.O.	20.4.65
Champion, J. T. C.	H.C. Reg.	20.4.65
Bennett, H. A. J.	E.-in-C.O.	29.3.65
Saunders, W. A.	N.W. Reg.	20.4.65
Longhorn, P. F.	N.W. Reg.	20.4.65
Wilson, J. W.	E.-in-C.O.	20.4.65
Chorlton, H.	N.W. Reg.	20.4.65
Cawthorne, V. C.	L.T. Reg.	20.4.65
Pass, G.	Mid. Reg.	20.4.65
Jones, D. C.	S.W. Reg.	20.4.65
Clark, B.	H.C. Reg.	20.4.65
O'Neill, A. J.	E.T.E.	10.5.65
Scoble, D. H.	Mid. Reg.	10.5.65
Perry, M.	L.T. Reg.	10.5.65
McFadden, J. J.	N.I.	24.5.65
Sills, R. I.	Mid. Reg.	8.6.65
Sale, D. W.	H.C. Reg.	10.5.65
Church, E. J.	L.T. Reg.	10.5.65
Dutton, R.	Mid. Reg.	20.4.65
Harrington, M. C.	L.T. Reg.	10.5.65
Baxter, G.	N.E. Reg.	10.5.65
Daniels, M. G.	E.-in-C.O.	10.5.65
Wadsworth, C. A.	E.-in-C.O.	29.3.65
Stevenson, G. J.	E.-in-C.O.	10.5.65
Allsworth, M. D.	H.C. Reg.	24.5.65
Reid, A. W.	L.T. Reg.	20.4.65
Hayes, B.	N.E. Reg.	6.9.65
Smith, M. L.	N.E. Reg.	24.5.65
Yule, W. J.	N.E. Reg.	23.8.65
Courtis, C. H. M.	Mid. Reg.	24.5.65
Chapman, J. P.	E.-in-C.O.	24.5.65
Bradley, A. G.	Mid. Reg.	24.5.65
Wiles, J. R.	E.-in-C.O.	24.5.65
York, J. E.	Mid. Reg.	24.5.65
Cook, M. J.	E.-in-C.O.	24.5.65
Nokes, L. A.	Mid. Reg.	24.5.65
Misra, S. K.	E.-in-C.O.	24.5.65
Clarke, M. J.	E.-in-C.O.	8.3.65
Smith, R. L.	E.-in-C.O.	26.4.65
Brown, W. D.	E.-in-C.O.	8.6.65
Chamberlin, R. S.	E.-in-C.O.	30.3.65
Vickers, J. R.	E.T.E.	8.6.65
Roberts, M. P.	E.-in-C.O.	8.6.65
Munro, J. E.	Mid. Reg.	8.6.65
McKenna, J. J.	E.-in-C.O.	8.6.65
Clougher, J. M.	Mid. Reg.	8.6.65
Thomson, F. S.	Scot.	8.6.65
Gardner, T. G.	E.-in-C.O.	20.4.65
Broomfield, C. F.	E.-in-C.O.	26.4.65
Mullan, P.	Mid. Reg.	8.6.65
Smith, A.	E.-in-C.O.	26.4.65
Inspector to Assistant Executive Engineer		
Morris, A.	W.B.C.	23.6.65
Mayor, S.	N.W. Reg.	8.7.65
Harris, V. F.	Mid. Reg.	15.7.65
Smith, W. E.	Mid. Reg.	15.7.65
Bradley, R. G.	Mid. Reg.	15.7.65
Thompson, D. H. C.	Mid. Reg.	15.7.65
Grant, A.	Scot.	5.4.65
Cameron, P.	Scot.	3.8.65
Clubb, S. H. R.	L.T. Reg.	17.8.65
Bayly, F. J.	L.T. Reg.	10.8.65
Brookes, R. F. A.	L.T. Reg.	10.8.65
Watkins, C. D.	H.C. Reg.	6.9.65
King, E. W.	L.T. Reg.	6.9.65
Inspector to Assistant Executive Engineer—continued		
Dawkes, H. E.	L.T. Reg.	21.9.65
Rea, A. T.	Scot.	2.9.65
Lees, J. L.	N.W. Reg.	14.9.65
Roberts, J.	N.W. Reg.	27.9.65
Simpson, A.	N.W. Reg.	14.9.65
Parker, L. P.	S.W. Reg.	15.9.65
Godfrey, W. S.	S.W. Reg.	17.9.65
Technical Officer to Assistant Executive Engineer		
Daggett, H.	N.E. Reg.	29.6.65
Dewar, A. J.	Scot.	23.6.65
Richardson, I. K. E.	W.B.C.	19.7.65
Cryer, E. W. G.	L.T. Reg.	6.7.65
Johnston, J.	L.T. Reg.	6.7.65
Hewitt, J. P.	L.T. Reg.	6.7.65
Kell, T. J.	L.T. Reg.	6.7.65
Walker, R. W.	L.T. Reg.	6.7.65
Sawyer, R. S.	L.T. Reg.	6.7.65
Williams, W. A.	L.T. Reg.	6.7.65
Rance, D. G. W.	L.T. Reg.	6.7.65
Parker, J. A.	L.T. Reg.	6.7.65
Blaxall, G. L.	L.T. Reg.	6.7.65
Blessington, A. R.	L.T. Reg.	6.7.65
Cock, P. C.	L.T. Reg.	6.7.65
O'Shea, L. D.	L.T. Reg.	6.7.65
O' Brien, P. F.	L.T. Reg.	6.7.65
Daly, D. J.	L.T. Reg.	6.7.65
Horsnell, J. D.	L.T. Reg.	6.7.65
Hewitt, E. G.	L.T. Reg.	6.7.65
Horn, D. T.	L.T. Reg.	6.7.65
Price, A. L.	L.T. Reg.	6.7.65
Jupp, D. C.	L.T. Reg.	6.7.65
Woodhouse, F. C.	L.T. Reg.	6.7.65
Howe, R. C.	L.T. Reg.	6.7.65
Spencer, R. K.	H.C. Reg.	5.7.65
Pyne, R. J.	S.W. Reg.	14.7.65
Tolley, P. V. J.	H.C. Reg.	8.7.65
Evans, D.	H.C. Reg.	8.7.65
Cowgill, H. R.	N.E. Reg. to H.C. Reg.	29.6.65
Magee, W. T. J.	N.I.	28.5.65
Rowsby, M.	N.E. Reg.	29.6.65
Wood, S. J.	N.W. Reg.	8.7.65
Ferguson, R. E.	N.W. Reg.	8.7.65
Kendrick, V. J.	N.W. Reg.	8.7.65
Lovett, E. F.	N.W. Reg.	8.7.65
High, A.	N.W. Reg.	8.7.65
Turner, E. W.	N.W. Reg.	8.7.65
Peterson, N.	N.W. Reg.	22.7.65
Stott, R.	N.W. Reg.	8.7.65
Wood, W. E.	N.W. Reg.	8.7.65
Williams, J. F.	N.W. Reg.	12.7.65
Stephenson, J. H.	N.W. Reg.	8.7.65
Kenworthy, R. J.	N.W. Reg.	8.7.65
Walton, H. F.	N.W. Reg.	19.7.65
Andrews, I. D.	N.W. Reg.	8.7.65
Ireland, J. M.	N.W. Reg.	8.7.65
Fenton, W. A.	N.W. Reg.	8.7.65
Morvan, C. A.	Mid. Reg.	15.7.65
Collins, S. H.	Mid. Reg.	15.7.65
Bennion, C.	Mid. Reg.	15.7.65
Barratt, D. D. W.	Mid. Reg.	15.7.65
Richardson, N. A.	H.C. Reg.	28.7.65
Salmon, D. J.	Mid. Reg.	15.7.65
Matthews, D. G.	Mid. Reg.	15.7.65
Parkes, L. C.	Mid. Reg.	15.7.65
Pritchard, G. E.	Mid. Reg.	15.7.65
Phillips, R.	Mid. Reg.	15.7.65
Ferneyhough, G.	Mid. Reg.	15.7.65
Williams, R. J.	Mid. Reg.	15.7.65
Ayton, T. F.	N.I.	16.6.65
Kent, G. L.	L.T. Reg.	6.7.65
Stevenson, D. A. G.	L.T. Reg.	6.7.65
Kiely, P.	L.T. Reg.	6.7.65
Symonds, D.	W.B.C.	19.7.65
Wood, T. C.	W.B.C.	26.7.65
Chapman, D.	N.W. Reg.	29.7.65

Retirements and Resignations—*continued*

Name	Region, etc.	Date
Assistant Executive Engineer—continued		
Baxter, A.	N.W. Reg.	29.8.65
Wilks, G. A.	L.T. Reg.	30.8.65
Staniforth, C. (*Resigned*)	E.-in-C.O.	2.8.65
Byfield, G. G. (*Resigned*)	E.-in-C.O.	4.8.65
Cadman, J. L. (*Resigned*)	E.-in-C.O.	20.8.65
Reeves, S. (*Resigned*)	N.W. Reg.	31.8.65
Turner, C. D. (*Resigned*)	E.-in-C.O.	31.8.65
Aldridge, K. W. (*Resigned*)	Mid. Reg.	31.8.65
Rainey, J. T. (*Resigned*)	E.-in-C.O.	31.8.65
McStravick, W.	Scot.	14.9.65
Chapman, W. J.	S.W. Reg.	24.9.65
O'Neill, E. P.	Scot.	25.9.65
Smith, E.	L.T. Reg.	26.9.65
Caple, H. W.	E.-in-C.O.	27.9.65
MacCallum, A.	Scot.	29.9.65
Ireland, W. R.	L.T. Reg.	30.9.65
Hester, W. F. T.	H.C. Reg.	30.9.65
Howard, J. H.	N.W. Reg.	30.9.65
Coales, G. E. W.	L.T. Reg.	30.9.65
Inspector		
Talmadge, A. C. W.	H.C. Reg.	1.7.65
Gibbs, E.	L.T. Reg.	1.7.65
Webb, E.	S.W. Reg.	6.7.65
Piper, E.	L.T. Reg.	20.7.65
Rowson, T. H.	N.E. Reg.	23.7.65
Johnson, R. R.	N.E. Reg.	30.7.65
Shambrook, C. H.	Mid. Reg.	7.8.65
Barratt, E. V.	S.W. Reg.	8.8.65
Inspector—continued		
Walker, K. W. A. (*Resigned*)	L.T. Reg.	31.8.65
Taylor, J.	N.W. Reg.	9.9.65
Hickox, E. P.	L.T. Reg.	30.9.65
Senior Experimental Officer		
Paul, W. A. J.	E.-in-C.O.	5.7.65
Experimental Officer		
Bryan, I. E. (*Resigned*)	E.-in-C.O.	31.8.65
Assistant Experimental Officer		
Taylor, J. M.	E.-in-C.O.	16.9.65
Samuels, P. M. H.	E.-in-C.O.	17.9.65
Leading Draughtsman		
Kirkham, A. C. J. (*Resigned*)	E.-in-C.O.	31.8.65
Draughtsman		
Oseman, R. H. (*Resigned*)	E.-in-C.O.	30.9.65
Senior Executive Officer		
Bourne, H. T. B.	E.-in-C.O.	7.9.65
Higher Executive Officer		
Priestley R. E	E.-in-C.O.	30.9.65
Executive Officer		
Thurogood, G. J. (Miss)	E.-in-C.O.	20.7.65
Cutts, W.*	E.-in-C.O.	21.8.65
Brown, G. B.	E.-in-C.O.	22.8.56

*Mr. W. Cutts is continuing as a disestablished officer in E.-in-C.O.

Transfers

Name	Region, etc.	Date
Staff Engineer		
Rhodes, J.	Home Office to E.-in-C.O.	14.6.65
Assistant Staff Engineer		
Croisdale, A. C.	Factories Department to E.-in-C.O.	27.9.65
Area Engineer		
Baxter, E. C.	H.C. Reg. to Hong Kong	21.4.65
Senior Executive Engineer		
Baker, H.	E.-in-C.O. to H.C. Reg.	20.8.65
Baker, D.	E.-in-C.O. to L.T. Reg.	31.8.65
Executive Engineer		
Blanchard, C. N.	E.-in-C.O. to Ministry of Aviation	2.8.65
Lock, D. C. A.	L.T. Reg. to E.-in-C.O.	1.7.65
Black, C. W.	E.-in-C.O. to L.T. Reg.	12.7.65
Endersby, J. C.	E.-in-C.O. to East Africa	12.7.65
East, D. W.	E.-in-C.O. to Ministry of Defence	26.7.65
Williams, N. R.	N.E. Reg. to H.C. Reg.	1.9.65
Warburton, D.	E.-in-C.O. to L.T. Reg.	27.9.65
Howley, A. E.	L.T. Reg. to Ministry of Aviation	1.7.65
Assistant Executive Engineer		
Bickerdike, C. P.	E.-in-C.O. to N.E. Reg.	1.5.65
Wotherspoon, R. R.	E.-in-C.O. to Scot.	3.5.65
Assistant Executive Engineer—continued		
Honneyman, J. G.	E.-in-C.O. to H.C. Reg.	3.5.65
Young, R. C.	E.-in-C.O. to H.C. Reg.	8.6.65
Adams, G. W.	E.-in-C.O. to H.C. Reg.	14.6.65
Nimmo, J.	E.-in-C.O. to Scot.	14.6.65
Aviss, H. S.	E.-in-C.O. to H.C. Reg.	14.6.65
Austin, G. P.	Mid. Reg. to E.-in-C.O.	21.6.65
White, G. A.	Singapore to L.T. Reg.	18.8.64
Butterworth, G.	E.-in-C.O. to H.C. Reg.	5.7.65
Robinson, W. H.	L.T. Reg. to E.T.E.	5.7.65
Barber, T. H.	L.T. Reg. to East Africa	19.7.65
Beeston, B.	Nigeria to L.T. Reg.	26.7.65
Strachan, W. G.	Ghana to E.-in-C.O.	27.7.65
Dengel, R. J.	Nigeria to L.T. Reg.	2.8.65
Barber, W. A. F.	E.-in-C.O.	9.8.65
Stebbing, L. K.	E.-in-C.O.	9.8.65
Harrison, J. C.	E.-in-C.O. to East Africa	10.8.65
Kitsell, J. H.	S.H.A.P.E. to E.-in-C.O.	1.9.65
Ashton, E. G.	L.T. Reg. to H.C. Reg.	13.9.65
Owen, G. G.	E.-in-C.O. to East Africa	14.9.65
Whitewick, H. E.	E.-in-C.O. to C.O.S.D.	15.9.65
Pearson, L. H.	E.-in-C.O. to W.B.C.	27.9.65
Groves, J. G.	E.-in-C.O. to East Africa	28.9.65
Senior Experimental Officer		
Simmons, J. A.	Ministry of Defence to E.-in-C.O.	31.8.65
Experimental Officer		
Jones, M. J. D.	Ministry of Defence to E.-in-C.O.	2.8.65

The Post Office Electrical Engineers' Journal

Volume 58, April 1965—January 1966

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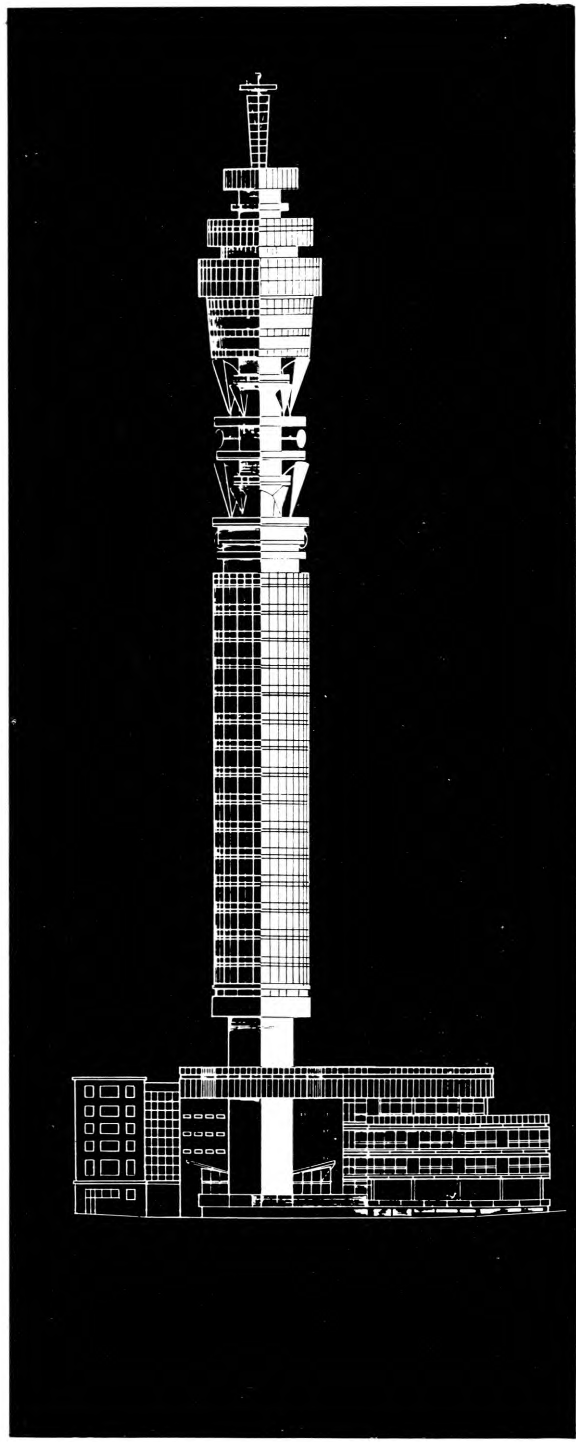
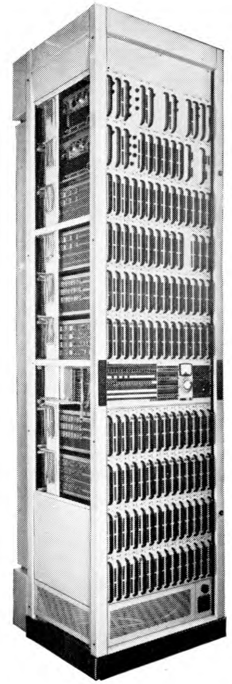
Model Answer Books

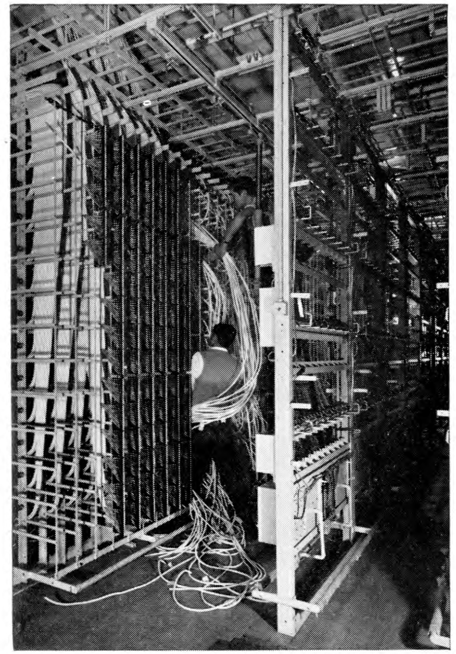
Books of model answers to certain of the City and Guilds of London Institute examinations in telecommunications are published by the Board of Editors. Details of the books available are given at the end of the Supplement to the Journal.





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 approximately one sixth of the floor area of an electromechanical equivalent. In addition it offers potentially much greater reliability and flexibility in use.



Cabling in progress

Mercury exchange utilises nearly 1,000 racks which provide accommodation for 11,000 relay sets and more than 10,500 selectors together with ancillary equipment and covers a floor area of nearly one acre. Over 15,000 incoming trunks and outgoing junctions are terminated at the Main Distribution Frames. From here calls go out to the exchanges in the London Director Network. Also part of this mammoth enterprise is a local tandem exchange which replaces one installed by the company well over twenty years ago.

Floor Pattern Lamp Signalling PMBX

The first of its type to go into service, this compact switchboard now being installed in the Howland Street building incorporates many new features among which are automatic ringing and automatic holding of exchange calls, 'jack-in' relay sets and individually removable jacks. This design will form the basis of the new standard B.P.O. PMBX.

MERCURY

the largest exchange order of its type ever awarded by the B.P.O. to a single manufacturer

A further E.T.L. contribution to Britain's S.T.D. network is the recent installation of Mercury Trunk Exchange in the Tower Building, Howland Street, London. Developed in conjunction with the B.P.O. and now operational, this exchange will serve as a master switching centre for the increasing volume of trunk telephone traffic entering London via the massive micro-wave tower. As the largest installation of its kind in the world, this undertaking represents further evidence of E.T.L.'s leading position in the field of telecommunications.

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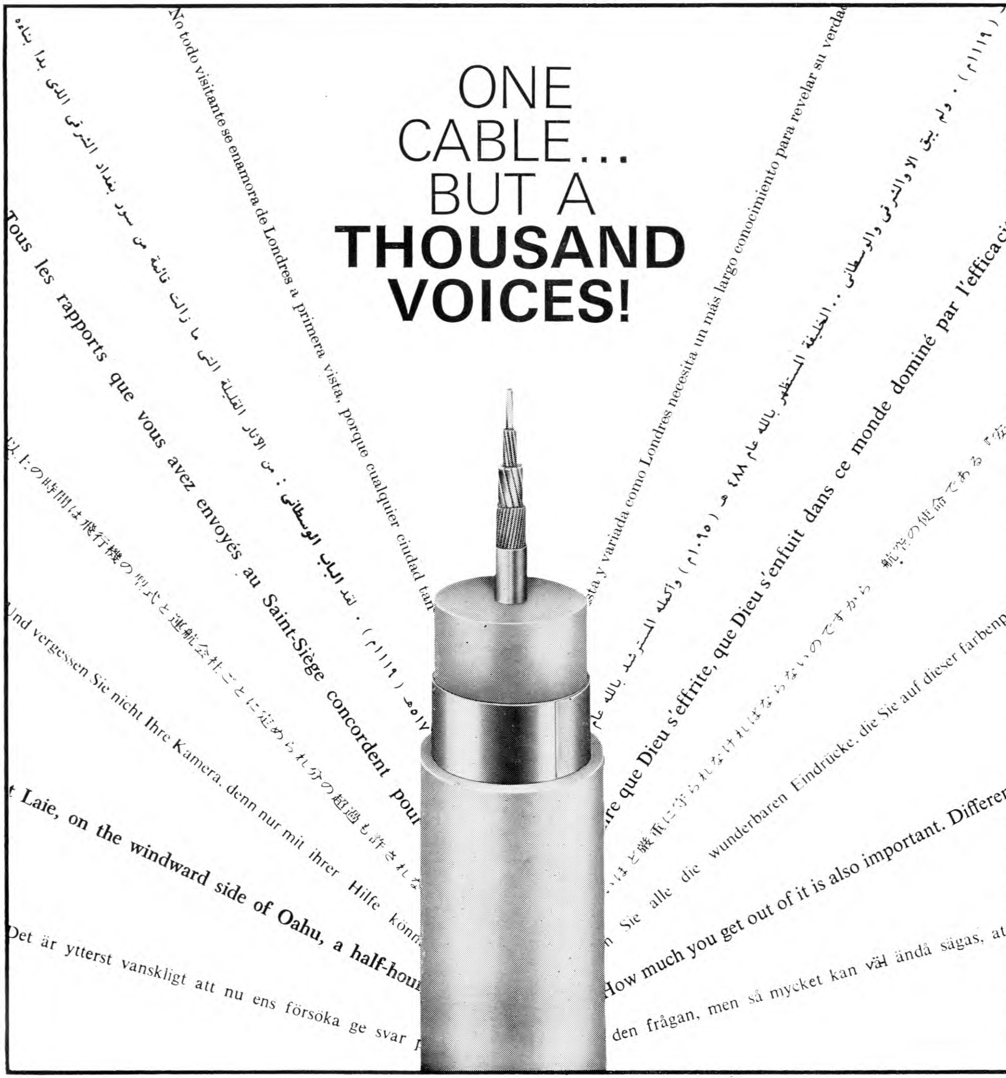
PTE 125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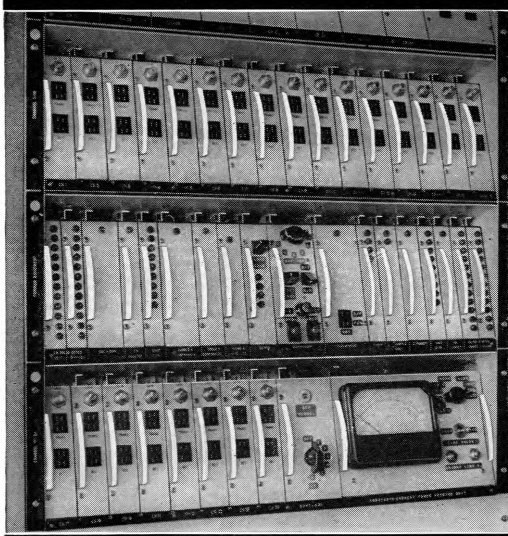
INCREASE CAPACITY OF EXISTING JUNCTION CABLE ROUTES ECONOMICALLY WITH



The new G.E.C. 24-circuit Pulse Code Modulation Equipment, Type SPO 1800, provides a new and economic means of increasing the capacity of existing junction cable routes.

The equipment provides 24 high-quality 300c/s-3400c/s speech circuits, with signalling facilities, over two pairs of an audio cable.

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For further information write for Standard Specification SPO 1800.

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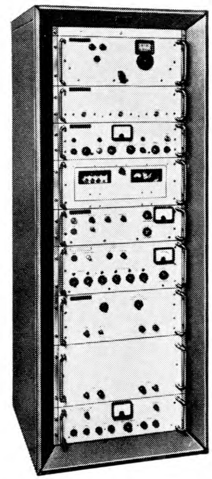
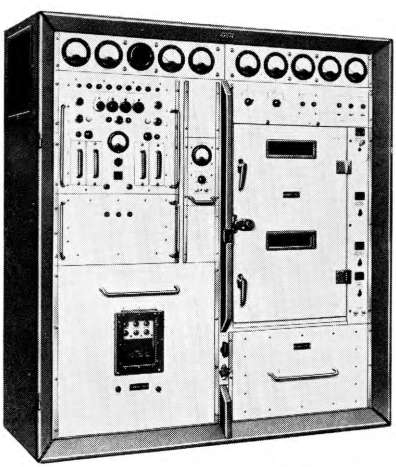
3 **change mode or operational state RAPIDLY**

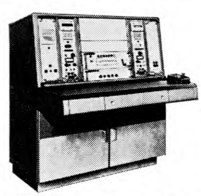
4 **adapt to new requirements RAPIDLY**



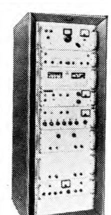
RTA. 191 Receiver te-minal



TA. 184 10 kW linear amplifier



LA 304 Remote Control Console



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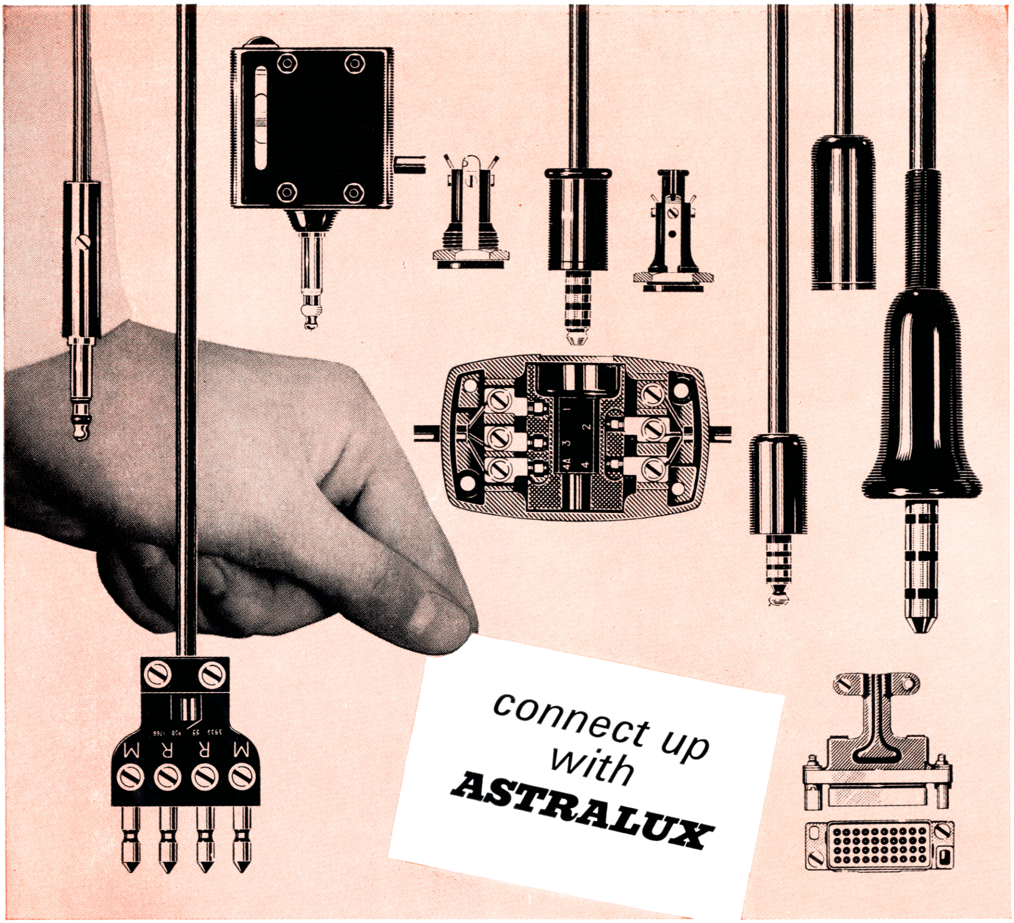

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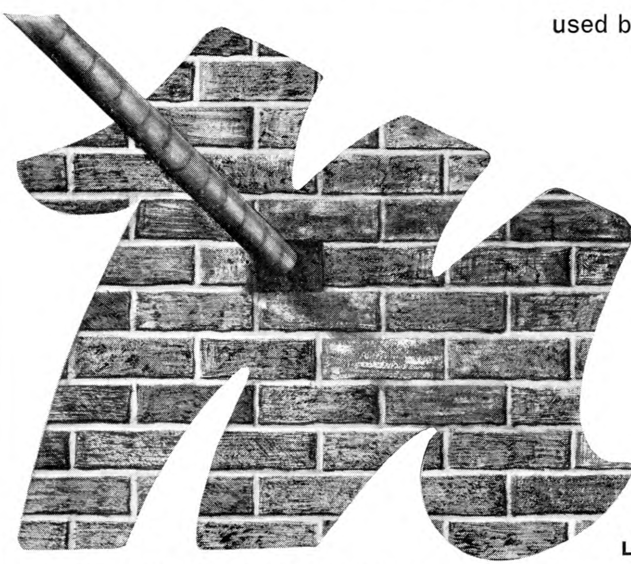

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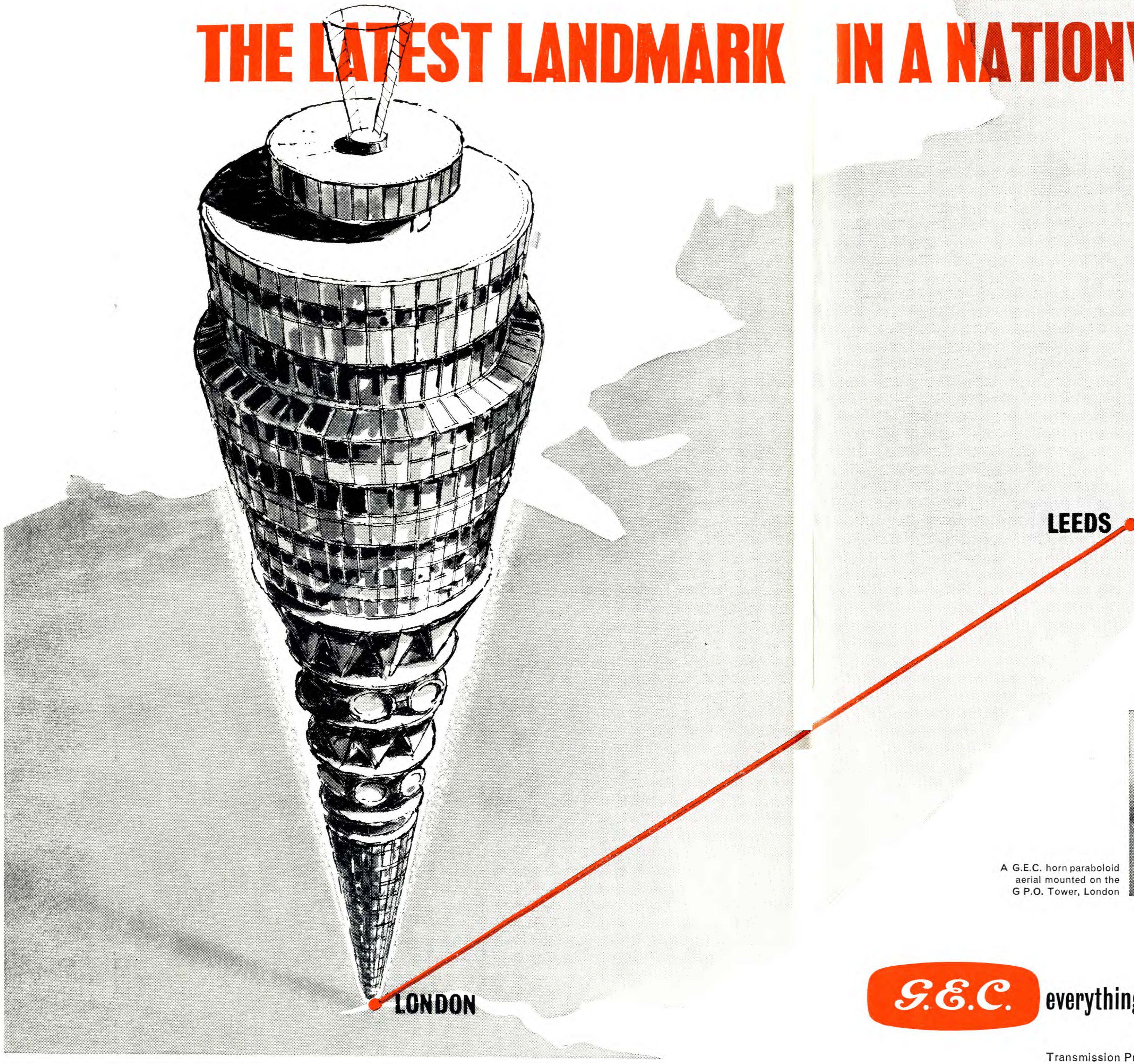
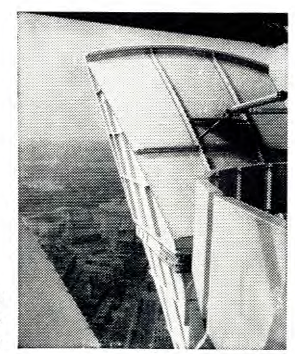


LONDON–LEEDS MICROWAVE SYSTEM

Rising to 620 feet above the streets of London, the Post Office Tower is an imposing landmark of the new micro-wave radio network in the United Kingdom. From this slender building, which houses one of the most comprehensive telecommunication installations in the world, high capacity RF channels will radiate to all parts of the country. To the range of G.E.C. transmission equipment already providing a substantial contribution to this network is now added the latest 6000 'M'c/s radio equipment, which has been chosen by the General Post Office for the London-Leeds system.

The equipment, type SPO 5558, makes maximum use of semiconductors. Two working RF channels, each with a capacity of 1800 speech circuits, and one standby channel will be provided, with automatic changeover from either working channel to standby in the event of degradation of the signal below a preset level. The standby channel is also equipped to provide an occasional television service. All the equipment is battery operated.

For futher information write for standard specification SPO 5558.



A G.E.C. horn paraboloid aerial mounted on the G P.O. Tower, London

G.E.C. everything for telecommunications

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S.P.35

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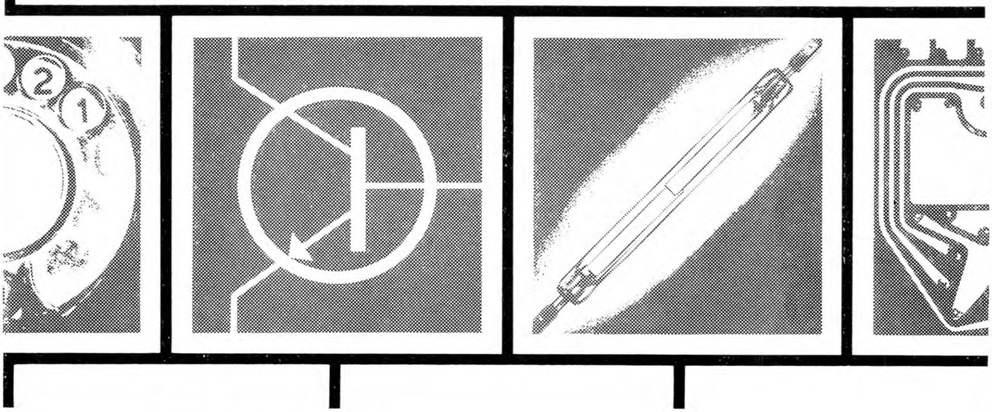

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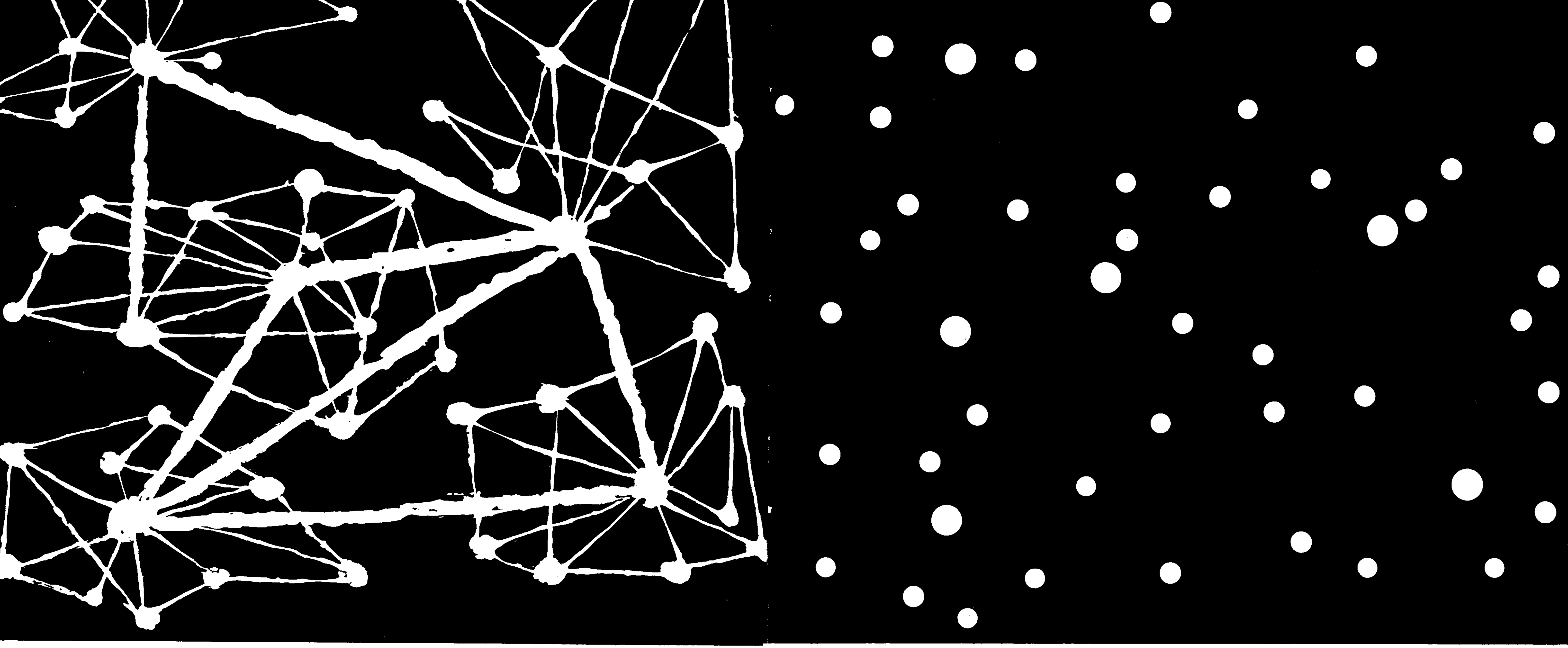
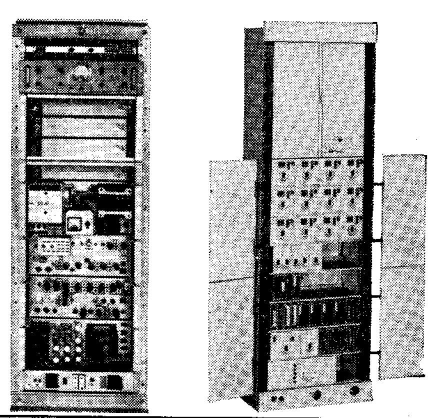


when stringing wires is hard— putting in ATE radio telephones is easy

It's just not economic or practical in many parts of the world to have normal wire and cable operating telephones. That's where ATE Radio Telephone Systems come in. In areas where difficulties of terrain would make the cost of installation and maintenance of telephone wires unrealistic, ATE — the pioneers of line-integrated radio telephones — can provide fully automatic systems which offer three important benefits: LOWER INSTALLATION COSTS: LOWER MAINTENANCE COSTS: GREATER RELIABILITY.

ATE Radio Telephones cut out the costly business of constant line-checking and repair. They are designed for unattended operation under arduous conditions and they give absolute reliability in all climates.



Normal telephone facilities
In remote areas, ATE Radio Telephone Systems provide vital links between wire-telephone exchanges, as well as connecting remote subscribers and creating self-contained, non-public systems. Users will find that there is absolutely no difference in the use of radio telephones compared with normal wire systems. They provide the same supervisory and metering facilities that are used on manual and automatic, public or private-wire metallic circuit networks.

Wide range of ATE equipment
The range of ATE Radio Telephone Equipment covers needs from those of the remote subscriber on a battery-operated single-channel system, to a 12-channel system which is ideal for spur routes from main routes, economical relief of open-wire and cable routes, open-wire replacement, emergency service and military applications, order wire and alarm circuits for microwave applications, and short-term seasonal traffic.

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ATE Radio Telephone Equipment can also provide many remote control and telegraph facilities. The equipment, which operates completely unattended, transmits speech and enables pressures to be monitored, data telemetered, and a great variety of electronic signals transmitted in clear or in code. In combination with appropriate ATE electronic signalling units, it can activate alarms and switch power circuits on or off.

World-wide organisation
ATE has a comprehensive systems planning and surveying service. Associated companies, representatives and agents are located in 75 countries throughout the world.

Rural Radio Catalogue
For complete technical details of ATE Radio Telephone Systems and ancillary equipment, send for the fully illustrated Rural Radio Catalogue from AT&E (Bridgnorth) Limited, Bridgnorth, Shropshire, England. Telex: 33373

PLESSEY
Electronics

INDEX TO ADVERTISERS

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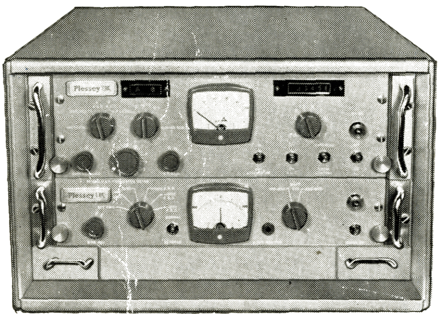
PLESSEY PVR 525

transistorised dual diversity HF radio teleprinter receiving terminal



The PVR 525 represents a major breakthrough in radio teleprinter receivers. For the first time, a really high-quality FSK terminal is available at a price low enough to make it viable in situations where this type of equipment has never before been considered.

Complete reliability

The unit is fully transistorised and of exceptionally robust construction. It is designed to operate in severe environmental conditions with a minimum of servicing and requires no forced-air ventilation. Dual-diversity design ensures good reception under all atmospheric conditions.

Multi-purpose

The equipment is designed to receive press and meteorological information or point-to-point communications. It can also be of invaluable service in civil engineering projects, oilfields and similar undertakings where long-distance and accurate teleprinter communication is essential. Local, extended and remote control are available.

Simple Installation and Operation

The equipment is housed in a small cabinet (21″ x 15″ x 18″) and poses no installation problems. It is designed to be used by non-technical personnel, and will operate for long periods with no adjustment. Tuning is assisted by the meter on the front panel which also monitors audio output and local-oscillator voltage.

Brief Specifications

Frequency range: 2-30 Mc/s. Six crystal-controlled channels. Input impedance: 75 ohms nominal, unbalanced. Converter output: 80-0-80V at 45 mA for two double-current teleprinters or 80V at 60 mA for one single-current teleprinter. Power Supply 105-135V A.C. or 200-250V A.C.

For full details of this equipment please write to:

The Plessey Company Limited
Electronics Group
Ilford, Essex, England
Telephone: Ilford 3040 Telex: 23166

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