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The Mechanization of Leeds Parcel-Sorting Office

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The growth of parcels traffic in Leeds demanded a parcel-sorting office capable of handling more than 240,000 parcels per week. A new office was therefore designed and installed in a converted factory building, and was formally opened by the Postmaster General in December 1959. Sorting of parcels is completed in two stages, primary and secondary, and this office is the first in the United Kingdom to be provided with fully-mechanized primary-sorting equipment; secondary sorting is completed by hand. Distribution of parcels in the sorting office—from reception to discharge—is completed mechanically.

INTRODUCTION

THE Leeds parcel-sorting office was designed to make maximum use of machinery for sorting the mail and distributing it in the sorting office. Parcels are delivered to the sorting office in vans and are unloaded on to a special platform beneath which conveyors have been installed. These conveyors take the mail to one of 12 primary-sorting operators. Here parcels are fed into primary-sorting machines by means of which the operators send mail to 24 secondary-sorting points. The operator reads the address on a parcel, loads it into the machine, presses one of 24 code keys on the keyboard, and automatically causes the parcel to be delivered to one of 24 secondary-sorting points. At this stage parcels are sorted by hand into bags which are subsequently carried by conveyor to the loading bay for dispatch by van.

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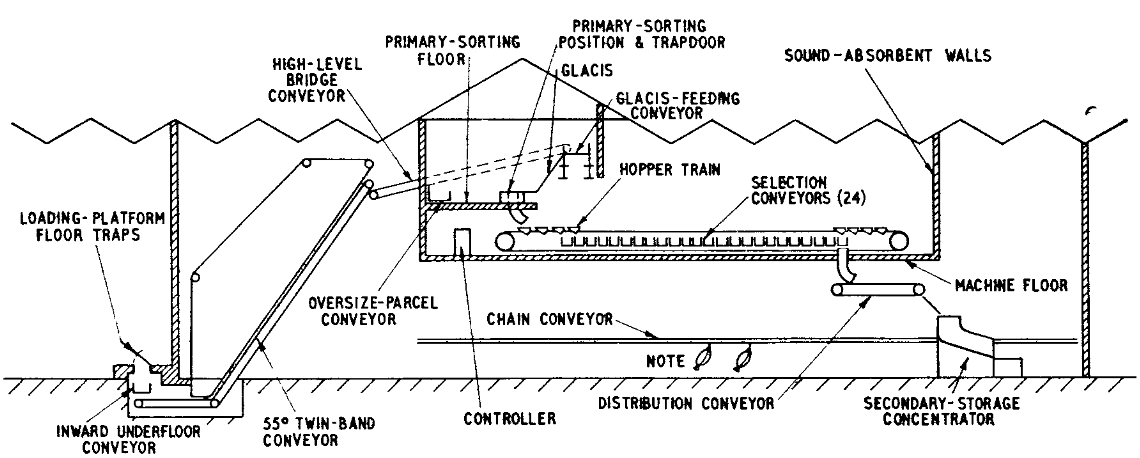
LAYOUT OF OFFICE

Theoretical studies of the layout for the new sorting office at Leeds resulted in a basic requirement of a four-storey building with a floor area of approximately 140 ft × 120 ft.

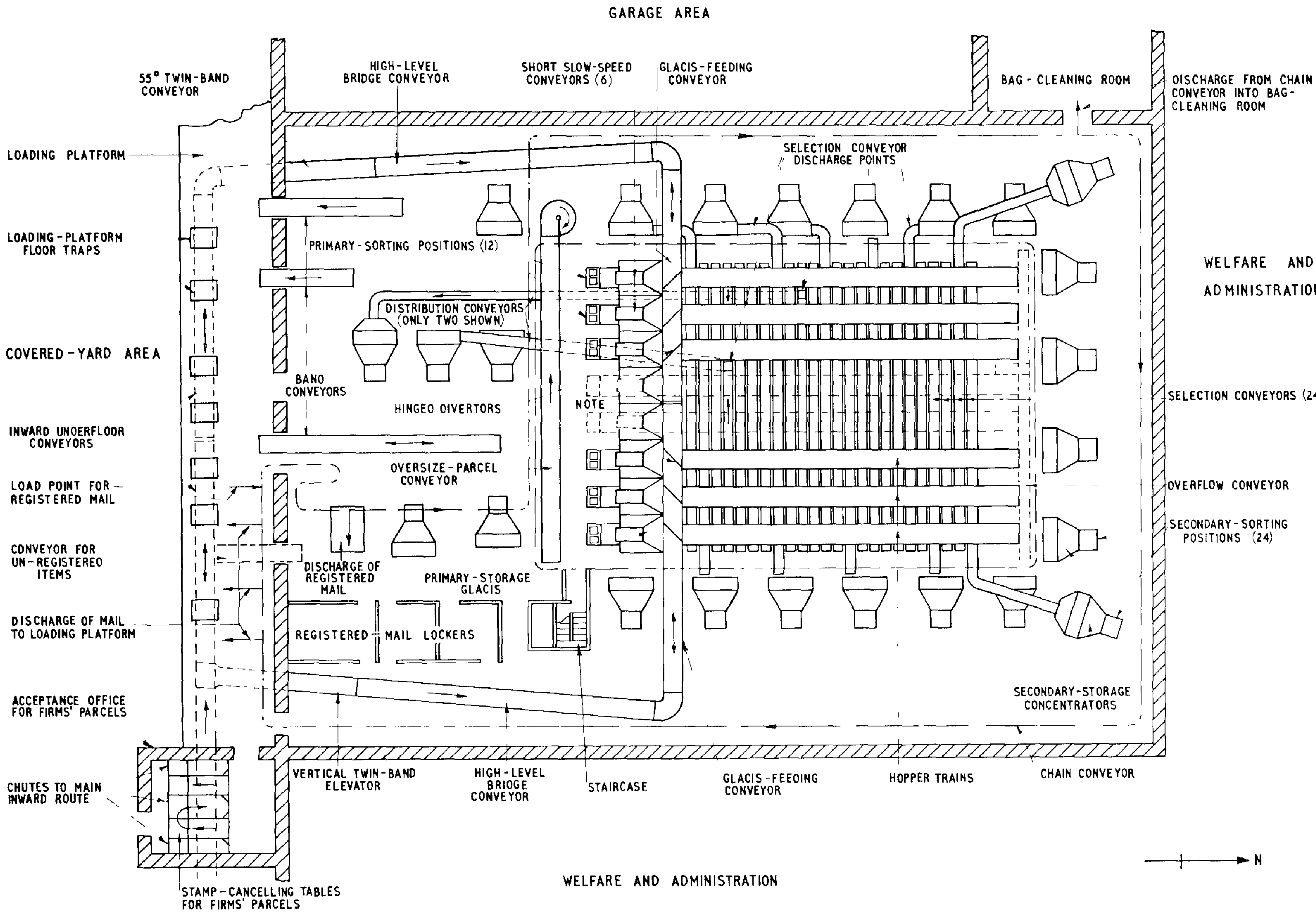
In 1956 a factory building which could be adapted to meet the requirements became available. Modifying the existing structure of the building saved both time and money by comparison with demolishing the old structure and building a new office on the site. The factory was a single-storey building with a north-light roof. The floor area was approximately 260 ft × 320 ft with 32 ft of clear height under the roof trusses. To adapt it for postal purposes two internal brick walls were built, dividing the building into three main sections, i.e. a garage, covered yard and sorting office. Rooms were built for stores, welfare and administrative purposes around the perimeter of the building.

A sectional elevation and the general layout of the sorting office are shown in Fig. 1 and 2. A 180 ft long loading platform was built at one end of the sorting office and underneath it the inward conveyors were installed. At the east end of this platform is an office for receiving firms' parcels, i.e. parcels in bulk from local business



Note: Mail bags are shown in transit to loading platform.

FIG. 1—SECTIONAL ELEVATION OF THE SORTING OFFICE



Note: While ultimately there will be 16 primary-sorting positions and eight hopper trains, only 12 and six, respectively, are at present installed

FIG. 2—LAYOUT OF SORTING OFFICE

houses. Inside the sorting office two floors were built. The top floor, known as the primary-sorting floor, is approximately 85 ft × 25 ft and houses the primary-sorting operators' positions. The first floor is approximately 85 ft × 125 ft and accommodates the parcel-sorting machinery. Both of these floors are island floors supported on stanchions from the ground floor. The machinery floor is an open steel grid on which the parcel-sorting machines are supported by bonded-rubber anti-vibration mountings. Both floors are surrounded by sound-absorbent walls of aluminium and glass-wool sandwich construction. The underside of the machinery floor is covered with an asbestos and wood sound-absorbent cladding. Two bays of the roof were raised to provide adequate headroom above the primary-sorting positions.

FIG. 3—LOADING PLATFORM SHOWING THE CHAIN CONVEYOR AND THE FLOOR LOADING TRAPS

INWARD CONVEYORS

Incoming parcels are emptied via floor traps in the loading platform on to one of two reversible conveyors in the trench below (see Fig. 2 and 3). These can be arranged to feed either or both of a pair of rising conveyors, one at each end of the trench.

At the western end the conveyor is a twin-band type, rising at an angle of 55°, in which the parcels are carried between a pair of bands (see Fig. 1). The upper or cover band is friction driven from a further band and is fitted with a number of transverse steel-bar weights. Parcels are held in contact with the lower or carrying band by the pressure of this weighted band which, by wrapping around the parcels, prevents them slipping back down the conveyor.

At the eastern end of the trench the rising conveyor is a vertical twin-band elevator.[1] Here the parcels are again carried between a pair of bands but the lateral pressure between the bands is provided by means of a flexible air bag which is fitted behind the cover band. As parcels are taken up the riser, the air bag deforms. The pressure in the bag is maintained at approximately 10 lb/ft^2 by means of a constantly-running blower.

At the top of each riser the parcels are fed on to a high-level bridge conveyor. These conveyors are self-supporting structures between the top of the rising conveyors and the ends of the conveyors feeding the inclined banks, or glacis, leading down to the primary-sorting positions.

The glacis-feeding conveyors are reversible and each normally feeds one half of the primary-storage glacis. By reversing one of the conveyors it is possible to feed all the primary-storage glacis from either the east or west routes.

Parcels are pushed from the glacis-feeding conveyors on to the storage glacis by means of hinged divertors. The storage glacis is divided into eight sections by wooden cheeks, each section holding about 150 parcels. The divertors are powered by hydraulic jacks which can be operated by the sorting-office staff to control the flow of parcels to each section. By reversing the hinge-pin clamps the divertors can also be opened in either direction to plough off parcels arriving by either the east or west route.

PARCEL-SORTING MACHINERY

To meet the peak traffic needs of the office six primary-sorting machines are provided, giving 12 primary sorters' positions. Each machine has access to the 24 secondary-sorting positions.

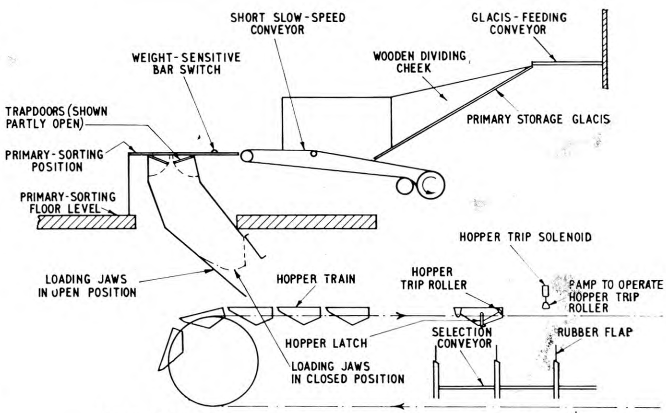


FIG. 4—GENERAL ARRANGEMENT OF PRIMARY-SORTING MACHINE

[1] LANGTON, H. J. The Vertical Conveyance of Mail. *P.O.E.E.J.*, Vol. 51, p. 112, July, 1958.

The average sorting rate is in the region of 15 parcels/minute/sorter.

The parcel-sorting machine comprises an endless chain of double hoppers arranged side by side, driven at a rate of about 30 hoppers/minute (see Fig. 4). Running transversely below the upper track of the hopper trains are 24 selection conveyors which extend across the full width of the six sorting machines. The hopper trains return below the selection conveyors.

As each parcel is sorted it is fed into one of the hoppers and a code, representing the destination of the parcel, is fed into a controller. The parcel travels in the hopper until it is above the selection conveyor which feeds the secondary-sorting position appropriate to the parcel destination. The controller then operates a tripping device on the machine which causes the base of the hopper to open and release the parcel on to the selection conveyor. The parcel is then delivered to its secondary-sorting position for final hand sorting into bags. The opened hopper re-closes as it passes round the tail wheel of the machine.

Provision is made for the future installation of two further machines to meet the estimated thirty-year requirement of eight.

Primary-Sorters' Equipment

The parcels are drawn from the primary-storage glacis by a short slow-speed conveyor and deposited on a table adjacent to the sorter (Fig. 5). This conveyor is under the control of a weight-sensitive bar switch which ensures an even flow of parcels to the sorters.

The sorter slides a parcel on to a pair of trapdoors set in the top of the table, at the same time turning the parcel to such a position that he can read the address. He then presses the appropriate key on the keyboard, which records the required secondary-sorting position in the controller, operates the drive to the trapdoors, and prepares the loading head for the delivery of the parcel into the first available hopper.

The sorting positions are arranged in pairs, each pair using one train of double hoppers. Each position has access to the hoppers on one half of the train and is able to work independently of the other.

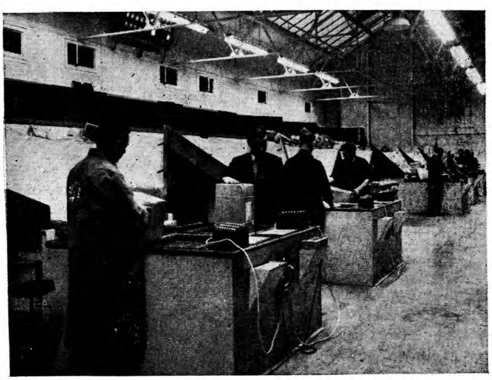


FIG. 5—VIEW OF PRIMARY-SORTING FLOOR

Loading Head

The loading head consists of the trapdoors, their operating gear and the loading jaws. When the sorter presses a route-selection key, the trapdoors are opened by means of a link mechanism which is driven via a one-revolution clutch-and-brake device from the main driving shaft of the sorting machine. The parcel falls through the trapdoors into the loading jaws where it is held by a canvas sling immediately above the hopper train. As soon as the next hopper is in the correct position for loading, the sling straightens to form a chute and the parcel slides into the hopper. The sling then returns to its initial position ready to receive the next parcel.

The function of this equipment is to provide short-term storage for the parcel between the trapdoors and the hopper train. In this way the regular rhythm of the hopper train is isolated from the sorter who can work at his own speed. The sorter is aware of machine-imposed rhythm only if his speed of sorting rises to the machine hopper speed.

Hopper Train

Each hopper train (Fig. 6) consists of 88 pairs of hoppers carried by two heavy-duty roller chains which run on steel guides. The train is driven via a pair of 48 in. diameter sprocket wheels by means of an electric motor and worm reduction gear. A fluid coupling is incorporated in the drive gear to give smooth starting. The hoppers consist of wooden panels fitted on a steel framework, and each hopper is approximately 2 ft square and 1 ft deep.

FIG. 6—VIEW FROM TENSION END OF ONE DOUBLE-HOPPER TRAIN

The bottom of each hopper is formed by two hinged flaps which are normally held in the closed position by a latching device. When this latch is released by a ramp pressing down on a trip roller, the hinged flaps fall open.

At the end of the hopper train the hoppers pass around a pair of sprockets similar to the drive sprockets. These serve to tension the carrying chains. As the hoppers pass round these tension wheels the open hopper flaps are closed and latched by rubber rollers and cams. If a parcel cannot be discharged into its intended selection conveyor, perhaps because of a blockage in the selection conveyor or chute, it is tipped from the hopper as it passes round the tension wheels. The parcel falls on to an overflow conveyor which discharges it via a chute into a wheeled container on the ground floor for manual sorting.

Selection Conveyors

The selection conveyors, 24 in number, run transversely between the sorting and return runs of the hopper trains and collect the output from all six hopper trains. The side plates are of pressed-steel construction and incorporate 10 in. rubber flaps at the top to minimize damage if a parcel fouls the top of the side plate or an open hopper flap. The idler rollers of these conveyors are spaced so that parcels fall on to the band between adjacent rollers, the flexible band thus serving to cushion the fall from the hoppers. These conveyors feed into secondary-storage concentrators, either directly or via distribution conveyors slung beneath the machinery floor. Some of the selection conveyors are split into two sections which together feed a single distribution conveyor.

Secondary Storage

Sheet-steel concentrators hold parcels awaiting secondary sorting. These are basically sections of an inclined cone which discharge on to a table, around which the bag frames are arranged, as shown in Fig. 7.

Each controller (Fig. 8) comprises twenty-four 8 in. diameter pin-wheels (one per selection). In the rim of each wheel is located a ring of steel pins; these are capable of an axial movement of approximately $\frac{1}{4}$ in. from their normal position. The wheels are driven from the main hopper train and rotate in synchronism with it at the rate of one pin pitch of travel to one hopper pitch.

The sorting destination keyed by the sorter is stored momentarily by one of 24 relays. At the instant of operation of the loading jaws this information is transferred to the pin-wheel corresponding to the selection made, by the displacement of one of the pins around its periphery. When the hopper containing the parcel reaches the selection conveyor to which it is to be discharged, the protruding pin in the controller pin-wheel engages with a micro-switch and energizes the trip solenoid situated on the side of the machine above the appropriate selection conveyor. The solenoid moves the trip ramp into a position where it can exert the necessary downward thrust on the hopper trip roller to release the latch and permit the parcel to fall through to the selection conveyor below. The pin in the controller is then reset to its normal position.

The controllers are made up in pairs, each pair serving one double-hopper train. The complete assembly is housed in a glass-fronted case which also holds the associated relays.

A number of timing pulses required for the controller operation are obtained from cams mounted on the driving head of the machine.

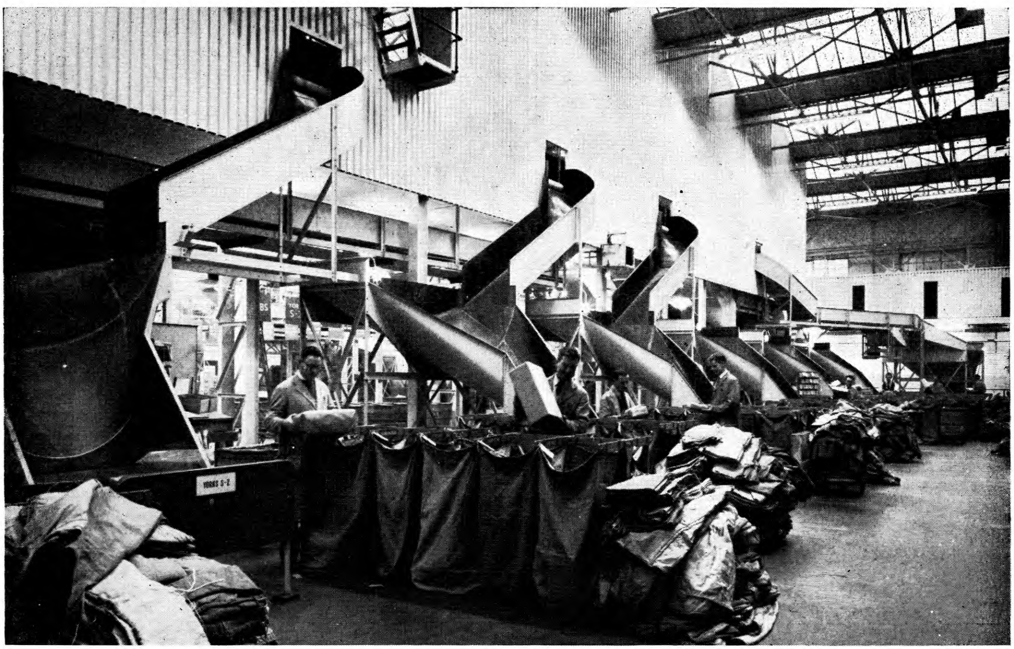


FIG. 7—SECONDARY-SORTING FLOOR

CONTROLLERS

The controllers, one for each primary-sorting position, are mechanical memory devices in which the destination of the parcel in a particular hopper is recorded by the operation of the keys. This information is used to discharge each parcel at the appropriate position.

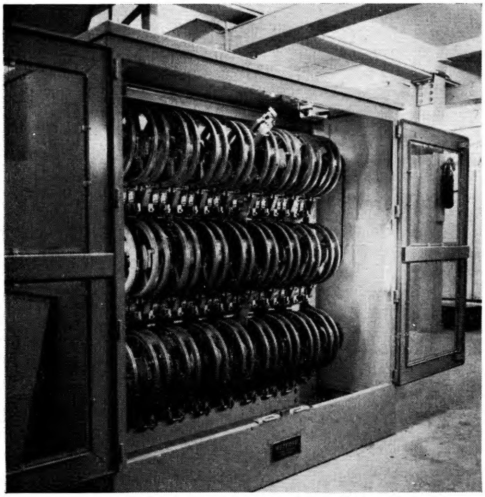


FIG. 8—COMPLETE CONTROLLER ASSEMBLY

PROTECTIVE DEVICES

To guard against damage either to the machines or the parcels, equipment is provided to detect fault conditions and, where necessary, shut down all or part of the plant affected. These conditions include:

(*a*) Selection or distribution conveyor failing to start or stalling.

(*b*) Chutes blocked by parcels.

(*c*) Band breaking on a selection or distribution conveyor.

(*d*) Hopper door not re-closing or latching properly.

Alarm and fault indication lamps are provided to inform both the engineering and postal staff of the condition of the plant.

POWER SUPPLIES AND CONTROL GEAR

The total installed load of approximately 280 kVA is taken via an auxiliary medium-voltage switchboard. This, in addition to the fused switches controlling the power supplies to the main conveyors and sorting machines, incorporates 50 contactor starters controlling the selection-conveyor and distribution-conveyor motors.

The bulk of the equipment is controlled from a central panel on the machinery floor. Interlocks in the control gear prevent the main inward conveyors being started in the wrong sequence, and also prevent the starting of sorting machines unless the selection and distribution conveyors are running.

Duplicate 50-volt rectifier units provide power for the controllers and alarm and indication lamps. These are used alternately and are changed over weekly. The polarity of the d.c. supply is reversed with each change-over to reduce contact migration troubles on the controller switches.

CHAIN CONVEYOR

The chain conveyor is located on the perimeter walls on three sides of the sorting office. Its main function is to transport bags of mail from the secondary-sorting position to the loading platform for dispatch (see Fig. 3), but it also serves to take incoming registered mail from the loading platform to the registered-mail lockers and take empty bags from the loading platform to the bag-cleaning room at the north-west corner of the building. The conveyor is 820 ft long and carries bags at 4 ft spacing at 60 ft/minute. It is driven by a 5 h.p. motor via a fluid coupling and gear box. The bags are suspended from carriers of Post Office design,[2] modified to give the required release facilities.

MISCELLANEOUS CONVEYORS

On the primary-sorting floor a flat-band conveyor is provided behind the sorters to take parcels which, because of their length or shape, are unsuitable for the machines. This discharges via a spiral chute to the ground floor.

Three band conveyors are provided at the south end of the office to take parcels to the loading platform for delivery in Leeds. One of these is reversible and can serve as an emergency inward conveyor in the event of a complete breakdown of the sorting machines; a temporary manual primary-sorting position would be set up in the centre of the ground floor in these circumstances.

A further small conveyor takes unregistered items, received in bags of registered mail, from the registered lockers and feeds them into the main inward conveyors.

At the east end of the loading platform two small conveyors are provided for firms' parcels requiring stamp cancellation. These feed on to stamping tables from which the parcels are dispatched via chutes to join the main inward traffic stream.

CONCLUSION

The plant, which was manufactured and installed by Sovex, Ltd., of Erith, Kent, has been in operation since December 1959. Some difficulty has been experienced with the vertical riser and alterations have had to be made to this part of the installation. Otherwise the performance of the equipment has been satisfactory.

[2] SMITH, W. J., and ROGERS, J. D. Chain Conveyors in Postal Engineering. *P.O.E.E.J.*, Vol. 51, p. 53, Apr. 1958.

Recent Developments in Automatic Telephone Exchange Trunking

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Due to the introduction of new facilities and techniques, and because of changes of practice, there have been a number of significant developments in automatic telephone exchange trunking in the last few years. The more important changes that have taken place and, in particular, the effects of group charging and subscriber trunk dialling are described.

INTRODUCTION

THERE have been a number of significant developments in automatic telephone exchange trunking in recent years. These changes have largely been made necessary by progress towards the conversion of the United Kingdom telephone system to a fully automatic service. The mechanization of trunk switching, the continued extension of facilities for subscribers to dial calls beyond their own exchanges, and, in particular, the introduction of group charging and subscriber trunk dialling have made many changes necessary in the trunking of automatic exchanges. The more important of these changes are described in the following paragraphs.

TANDEM DIALLING BY SUBSCRIBERS AND OPERATORS

Multi-Metering

After the 1939–45 war the facilities for subscribers connected to automatic exchanges to dial calls via other exchanges (i.e. to have access to other exchanges for tandem dialling) were increased by the extension of multi-metering to non-director exchanges,[1] the first exchange with such facilities being Enniskillen, in 1946. Prior to this, multi-metering had been available only at some U.A.X.s and director exchanges, the first installation being in the early 1930s. Subscribers connected to non-director exchanges were thus able to dial their own calls to most exchanges within 15 miles radial distance of their own exchange; such calls were untimed. In general, subscribers were charged one unit fee for calls between exchanges situated within 5 miles radial distance of one another. For calls between exchanges 5 to 7½ miles apart the charge was two unit fees, from 7½ to 12½ miles three units, and from 12½ to 15 miles four units. As an exception, for calls to exchanges in linked-numbering-scheme areas a common fee was charged according to the radial distance from the originating exchange to an arbitrary point in the linked-numbering-scheme area.

The need to provide extended tandem dialling access at non-director exchanges as quickly as possible led to the adoption of the "fixed-fee principle" of multi-metering. This permitted the use of a simple auto–auto relay-set giving metering at a fixed rate, but made it necessary for subscriber-dialled traffic to terminate at directly-connected exchanges; this rule was applied even when calls to an indirectly-connected exchange (i.e. one to which calls could have been routed via an intermediate exchange) had the same fee charge as calls to a directly-connected exchange.

Normally, level 8 was used as the multi-metering level in non-director exchanges and this level was trunked to 2nd and 3rd selectors to give access to the directly-connected exchanges in the multi-fee area. To economize in the number of fixed-fee multi-metering auto–auto relay-sets, exchanges in a particular fee area were served wherever possible from one or more individual groups of 3rd selectors: this permitted the auto–auto relay-sets to be connected between 2nd and 3rd selectors.

Tandem dialling was also available to operators and, where access was required by them to manual exchanges trunked from level 8, an additional group of junctions had to be provided so that standard supervisory conditions could be given. The component used by subscribers of such a route to a manual exchange gave guarded metering conditions, i.e. metering took place only when a called subscriber answered. To give access to such a divided route the groups of 2nd and 3rd selectors concerned had to be split, and therefore, apart from the need for more circuits, additional selectors were required. To reduce the number of these groups of selectors to a minimum the routes to manual exchanges were, as far as possible, allocated to levels of the level 8 2nd selectors.

Trunk Mechanization

One of the objects of multi-metering was to reduce the amount of traffic routed via operators, so as to reduce costs as well as to give a more rapid service. To extend this policy it was decided in 1946 to plan for "single-operator control" of the majority of trunk calls.[2] Single-operator control implied that the operator who answered the calling subscriber should be able to reach the required number by automatic means, i.e. without the assistance of any other operator.

The implementation of this plan required the installation at zone centres of automatic trunk switching units (operating on a non-director basis) and the provision of Signalling System A.C. No. 1 (S.S.A.C.1)[3] and Signalling System D.C. No. 2 (S.S.D.C.2)[4] dialling equipment for outgoing traffic dialled by operators within the area served by the zone centre, and also for the incoming operator-dialled traffic from distant zone centres. The first of these units was installed in London in 1954, and since then most of the other zone centres have been similarly mechanized. It should be noted that some measure of dialling over trunk circuits (using a 2 v.f. signalling system[3]) was introduced at the larger automatic zone centres in 1938 to relieve the manual boards, but access by dialling was limited to the subscribers at the distant zone centre.

At group centres, in addition to providing outgoing dialling equipment (S.S.A.C.1, S.S.D.C.2 or loop/disconnect) it was necessary to install selectors and relay-sets to terminate the incoming dialling circuits (S.S.A.C.1 or S.S.D.C.2) from the zone centre trunk unit and also to rearrange the trunking to allow incoming trunk calls to be routed, via auto–auto relay-sets with regenerators, to dependent automatic exchanges.

GROUP CHARGING AND SUBSCRIBER TRUNK DIALLING

To speed the extension of automatic working and as a step towards the eventual introduction of subscriber trunk dialling (S.T.D.),[5] group charging was introduced

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in 1958. With group charging the charges for telephone calls are based on the radial distances between charging points common to groups of about 10 exchanges and not on the radial distance between one exchange and another, as hitherto. Each of these groups of exchanges is known as a charging group. Furthermore, subscribers are charged one unit fee for calls from exchanges in one charging group to exchanges in all adjacent charging groups.

One of the immediate advantages of group charging was the increased tandem dialling facilities (on a local-code-dialling basis) which could be made available to subscribers connected to some of the older discriminating-type satellite exchanges. These exchanges would have required extensive modification to give increased tandem dialling access if multi-metering had been necessary. In addition, group charging enables the trunking of the selectors used for tandem dialling in non-director exchanges to be simplified, since the trunking is no longer influenced by the need to use fixed-fee multi-metering relay-sets.

Facilities for subscribers to dial their own calls are now being further extended by S.T.D., which enables subscribers to dial their own trunk calls.

With the introduction of S.T.D., all calls both local and trunk are timed. On S.T.D. calls the register-translator equipment that sets up the call also controls all the charging and timing operations. On calls to a local number or a number on another exchange in the home or adjacent charging group (prefixed by the appropriate local dialling code) the timing and charging requirements are given by local-call timing equipment.

A subscriber's private meter facility (S.P.M.) has also been introduced with S.T.D. to indicate to the subscriber (if required) the total chargeable units and the units chargeable to the last call or series of calls made. These meters may be associated with the telephones on direct lines or associated with switchboards on P.B.X. lines.

TRUNKING AT GROUP SWITCHING CENTRES

In order to deal with S.T.D. traffic incoming to a group of exchanges within a charging group, one of the exchanges acts as a tandem switching centre and is directly connected to all the other exchanges in the group. This exchange is known as the group switching centre (G.S.C.) and each charging group is identified by a unique numbering-group code, e.g. AB2. In some instances, however, one charging group may be divided into two or more numbering groups, each with its own unique code. The numbering group in which the G.S.C. is located is then known as the home numbering group; the remaining numbering group or groups within the charging group are termed "dependent." For some charging groups, however, an exchange in an adjacent charging group acts as the G.S.C; such charging groups are termed "dependent."

The S.T.D. traffic originating within the charging group is handled by register-translator equipment which is usually installed at the G.S.C.

Fig. 1 is a trunking diagram of a typical G.S.C. where S.T.D. is available to the G.S.C. local-exchange subscribers. In this example the assistance manual board is associated with the automatic exchange. S.T.D. traffic incoming from distant subscribers is routed by the originating register-translator equipment to the S.T.D. group of 1st selectors. Of the digits dialled by a calling subscriber, e.g. 0 AB2 842234, the code AB2 enables the controlling register-translator equipment to recognize the required numbering group, to translate this information and to send out the digits necessary for routing the call to the S.T.D. selectors in the G.S.C. serving that numbering group. The maximum number of digits in the national number is 10, and hence the number of digits available for routing the call onwards from the point reached by the translation is six. This imposes certain restrictions on the trunking of the G.S.C. and in the allocation of exchanges to selector levels. Briefly, 6-digit subscribers' numbers can only be used at the G.S.C. local or satellite exchange, 5-digit exchanges must be served from 1st selector levels, 4-digit exchanges can be connected to 2nd selector levels, and although 3-digit exchanges could be connected to 3rd selector levels, it is necessary to allow for their eventual growth and they are allocated to 2nd selector levels.

Allocation of Selector Levels

When considering the allocation to selector levels of exchanges in the home and dependent numbering groups, allowances for growth in the size of individual exchanges and in the number of exchanges are important because the levels allocated determine part of the subscribers' national numbers, and therefore subsequent changes are very difficult to arrange.

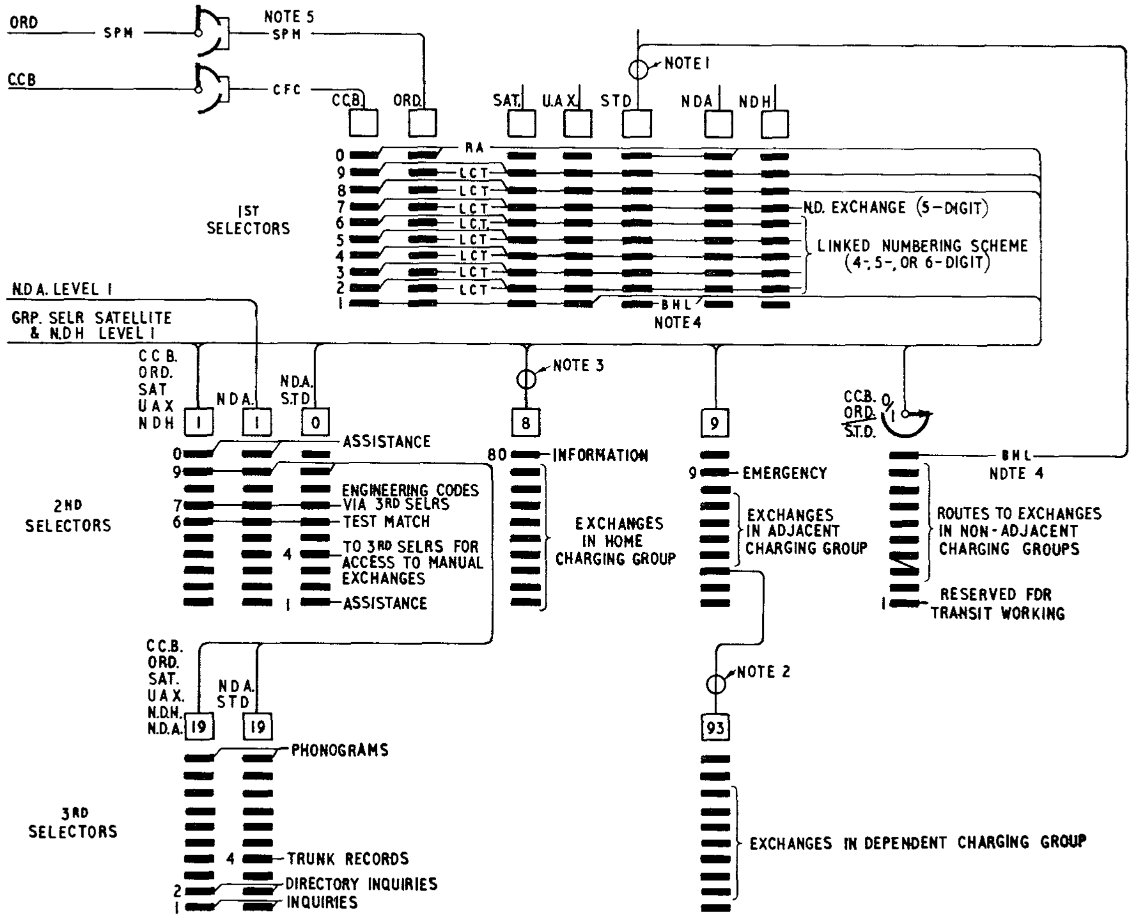
Level 8 (as shown in Fig. 1) is used to give access to 3-digit and 4-digit exchanges in the same charging group as the G.S.C.

Some charging groups contain more exchanges than can be served on the basis just described and it may then become necessary to split a particular charging group into more than one numbering group, as has already been mentioned. In these circumstances the translated digits for a numbering group other than the home numbering group route the call to level 8 2nd selectors, the levels of which give access to the required exchanges, as shown in Fig. 1.

Level 80 is used on a metering basis for access to information services, including the speaking clock. This level has been chosen so that S.T.D. access can be given, if required, to these services. Ultimately, special final selectors will be connected to level 80 so that 4-digit codes in the series 80XX can be used.

Level 9. The introduction of a national numbering scheme provided a suitable opportunity to re-examine the selector levels used in non-director exchanges for giving access to special services, i.e. to manual board and engineering services. By trunking these services from level 1 instead of level 9, level 9 becomes available for tandem dialling purposes. At one time it was considered that level 1 might be used for access to exchanges in adjacent charging groups[5] and level 9 for access to special services, but because of the possibility of false traffic to subscribers this was not acceptable. Levels 91–90 (except 99) are therefore used for tandem dialling to exchanges in adjacent charging groups. The segregation of circuits to these exchanges on a single level enables a controlling register to bar irregular access by recognition of the digit 9 following a 3-digit non-director numbering-group code.

If a dependent numbering group is in an adjacent charging group it is the usual practice to allocate all the exchanges concerned to a particular 3rd selector group (or to 4th selectors if there are to be more than seven such exchanges). Fig. 1 shows a typical instance where level 93 is used for this purpose, and in such circum-



C.F.C.—Coin-checking and fee-checking equipment. S.P.M.—Subscribers' private meter equipment. N.D.A.—Non-director exchanges in adjacent charging group. N.D.H.—Non-director exchanges in home charging group. B.H.L.—Backward-holding link. L.C.T.—Local-call timing equipment. R.A.—Register-access equipment.

Notes:

1. Point reached by translation of numbering-group-code for home numbering group.
2. Point reached by translation of numbering-group-code for dependent numbering group in adjacent charging group.
3. Point reached by translation of numbering-group-code for dependent numbering group in home charging group.
4. Link circuit between 2-motion group selectors and motor-uniselector group selectors.
5. Alternative position for subscribers' private meter equipment.

FIG. 1—TRUNKING OF TYPICAL GROUP SWITCHING CENTRE

stances the point reached by the numbering-group-code translation is between 2nd and 3rd selectors. The allocation of exchanges to the levels of these selectors is governed by normal trunking considerations within the limits, already mentioned, imposed by S.T.D. These S.T.D. limits do not apply, however, to those routes trunked from level 9 2nd selectors and subsequent selector groups to exchanges in adjacent, but not dependent, charging groups.

Level 99 is used for access to the emergency service via a single group of circuits serving all directly-connected exchanges dependent on the G.S.C. Hitherto, it has been necessary to provide three groups of 999 circuits to provide the facilities required, and although the adoption of a single group means a loss of the manual-hold facility on 999 calls from U.A.X.s, it enables savings to be made in group-selector banks and relay-sets.

Access to Manual Exchanges. Mention has already been made of the method of splitting selector groups in order to give subscribers and operators separate access to manual exchanges. To avoid the uneconomic provision of separate selector groups on both levels 8 and 9, all the groups of junctions to manual exchanges for use by operators (and thus requiring full supervisory facilities) are generally connected to a group of level 04 3rd selectors. These selectors give operator access to manual exchanges in both the home and adjacent charging groups. This change in the method of access to these routes has been made possible by the reduction in the number of manual exchanges which has taken place in recent years. Subscribers gain access to the guarded-metering component of those routes via levels 8 and 9 in the usual manner.

Levels 2–7. Where, because of the restrictions of the fixed-fee multi-metering scheme, levels 2–7 were previously available only for subscribers within a non-director linked numbering scheme, these levels can now also be used to give access to exchanges in the home charging group. Fig. 1 shows a G.S.C. where levels 2–6 are in use for access to the linked-numbering scheme and level 7 is in use for direct access to a 5-digit non-director exchange in the home numbering group.

In some instances the S.T.D. requirement of allocating 5-digit exchanges to 1st selector levels would result in uneconomic trunking arrangements at either the main or at some satellite exchange. If this is likely to occur consideration is given to the division of the charging group into two numbering groups.

Level 1. Regarding the trunking arrangements on level 1, the number of selector groups required is influenced by the need to maintain standard codes and also by the facilities necessary, e.g. manual hold and metering.

Level 0, which has in the past been used for access to the assistance operator will, under S.T.D., be used for access to the controlling register-translator equipment. The register-access relay-sets are connected to a group of 2nd selectors (and these in turn are sometimes connected to 3rd selectors) to give access to exchanges in non-adjacent charging groups. Such selectors may be of a two-motion or motor-uniselector type. The latter are used if the line plant and equipment savings resulting from their 40 availability feature are sufficient to offset their greater cost. Level 1 of these 2nd selectors is reserved for use when access to the transit trunk network[6] is required. One level of this group is trunked back into the S.T.D. group of 1st selectors (Fig. 1) and caters for calls for which the subscriber dials the national number instead of the appropriate local code.

TRUNKING AT MINOR EXCHANGES

Three classes of minor automatic exchanges—minor non-director exchanges, satellite exchanges and U.A.X.s—will normally be dependent upon the G.S.C. for the distribution of outgoing and incoming S.T.D. traffic.

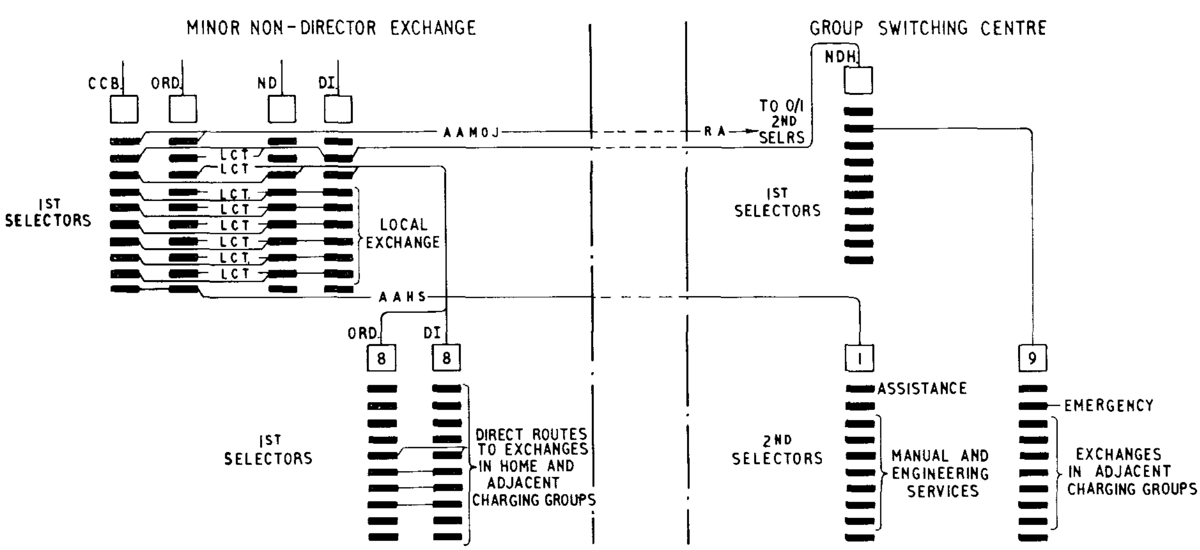
Minor Non-director Exchanges

Fig. 2 shows the typical trunking for a minor non-director exchange. Level 0 is trunked via an auto–auto relay-set and a junction to a register-access relay-set at the G.S.C. and is used for all outgoing S.T.D. traffic. Hitherto, this level has been used for direct access to the assistance operator. The auto–auto relay-set caters for periodic metering returned over the junction from the G.S.C. It also passes the coin-checking and fee-checking conditions needed for pay-on-answer coin boxes. Level 9 is connected to the 1st selectors at the G.S.C. and gives access to the local-code-dialled routes trunked from levels at the G.S.C. and also to the emergency service. Level 1 is connected to the G.S.C. for access to the assistance operator (100) and to manual board and engineering services. This method of access to service points via a single group of junctions from the minor non-director exchange was adopted prior to S.T.D. and avoided the need for individual circuits from the non-director exchange to individual service points. Some of the larger minor non-director exchanges justify direct auxiliary routes to other exchanges in both the home and adjacent charging groups, and such routes are normally connected to level 8 2nd selectors. The allocation of routes to these levels is not influenced by the S.T.D. conditions as it would be at the G.S.C. but only by normal trunking considerations. The local subscribers at the non-director exchange are allocated to the remaining 1st selector levels.

Satellite Exchanges

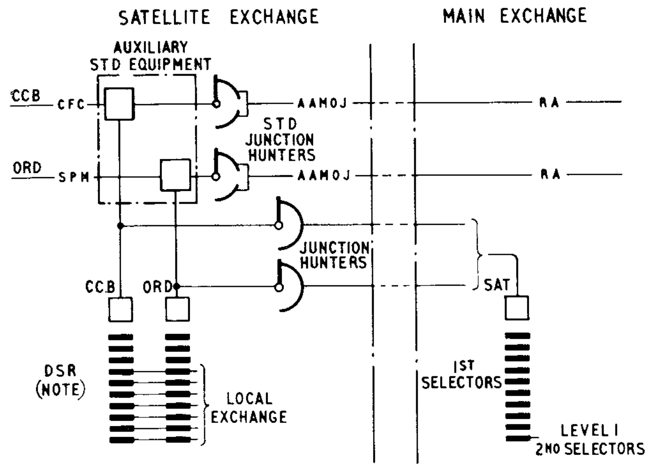
S.T.D. at group-selector-satellite exchanges is introduced in a manner similar to that already described for minor non-director exchanges except that levels 8 and 9 are connected to 2nd selectors at the G.S.C. giving access to the local-code-dialled routes connected to the G.S.C. and to the emergency service. Routes to other satellite exchanges are trunked from selector levels at the satellite exchange. Direct routes are required from the group-selector-satellite levels to any 5-digit minor non-director exchanges allocated to 1st selector levels at the G.S.C., and it therefore follows that in some instances it would be desirable to include such non-director exchanges within the linked numbering scheme.

At discriminating-type satellites, use is made of auxiliary junction-hunters to provide S.T.D. facilities. The trunking arrangements are shown in Fig. 3 and 4. Both the discriminating-selector-repeater (D.S.R.) type satellite and the satellite 1st selector type function in the usual manner unless 0 is dialled as the first digit. When this occurs, a change-over circuit disconnects the 1st selector and switches the calling subscriber through to an S.T.D. junction-hunter which searches for a free S.T.D. junction to the register-translator equipment at the G.S.C. Access to the junctions is given via metering-over-junction (M.O.J.) type auto–auto relay-sets. Local-call timing is incorporated in the auxiliary circuit and is operative on all except S.T.D. calls.



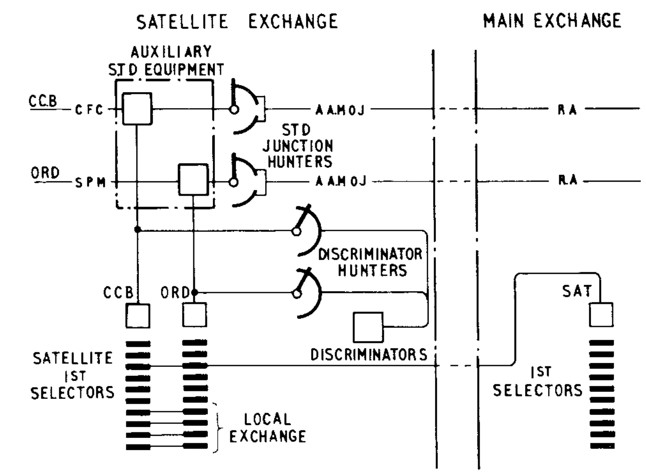
D.I.—Selectors terminating direct circuits from manual or automanual exchanges. N.D.—Selectors terminating circuits from non-director exchanges R.A.—Register-access equipment A.A.M.O.J.—Auto-auto relay-set with metering over junction. A.A.H.S.—Auto-auto relay-set with coin-checking and fee-checking facility. N.D.H.—Non-director exchanges in home charging group

FIG. 2—MINOR NON-DIRECTOR EXCHANGE TRUNKING



A A M O J —Auto-auto relay-set with metering over junction. R A —Register-access equipment D S R —Discriminating-selector-repeater.
Note Modified to provide coin-checking and fee-checking facility.

FIG. 3—DISCRIMINATING-SELECTOR-REPEATER SATELLITE EXCHANGE TRUNKING



A.A M O J —Auto-auto relay-set with metering over junction. R A —Register-access equipment

FIG 4—SATELLITE 1ST SELECTOR AND DISCRIMINATOR TRUNKING

U.A.X.s

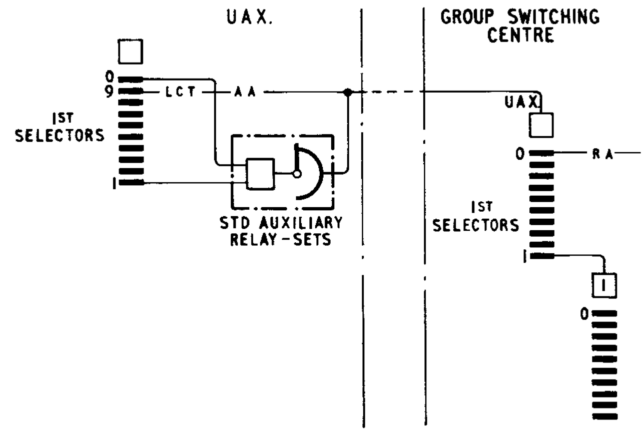
To extend S.T.D. to U.A.X.s the form of trunking indicated in Fig. 5 is likely to be adopted.

When a subscriber dials 0 for an S.T.D. call, an auxiliary relay-set is brought into use and seizes a junction to the U.A.X. group of 1st selectors at the G.S.C. The auxiliary relay-set repeats the digit 0 to route the call to the register-translator equipment at the G.S.C. Calls to "100" and to the manual and engineering services are routed in the same manner, but for these the digit 1 is repeated by the auxiliary relay-set. This relay-set also gives the appropriate facilities, e.g. manual hold and coin and fee checking.

Level 9 is connected to the G.S.C. via local-call timing equipment and auto–auto relay-sets for local code-dialling through the G.S.C.

Whilst in some existing U.A.X.s it may be necessary to change the telephone numbers of some subscribers in order to free levels 1 and 0, levels 2–8 will be available for access to local subscribers and to direct auxiliary routes provided from the U.A.X.

Although Fig. 1 has not been drawn to cater for S.T.D. at U.A.X.s, the changes involved are likely to be



R A.—Register-access equipment L C T —Local-call timing equipment A A —Auto–auto relay-set

FIG 5—U A X. TRUNKING WITH SUBSCRIBER TRUNK DIALLING

small. The problem will, of course, be complicated during the interim stages when only some U.A.X.s will have S.T.D. For those U.A.X.s which have S.T.D. a group of circuits will be necessary from level 0 of the U.A.X. group of 1st selectors to the register-access relay-sets. Further, a separate U.A.X. level 1 group of 2nd selectors may, in some instances, become necessary.

CALL-TIMING AND METERING AT NON-DIRECTOR EXCHANGES

In non-director exchanges (G.S.C.s and minor non-director exchanges), local-call timing equipment is connected in the 1st selector-level outlets serving local numbers or junctions to other exchanges in the home and adjacent charging groups, as indicated in Fig. 1.

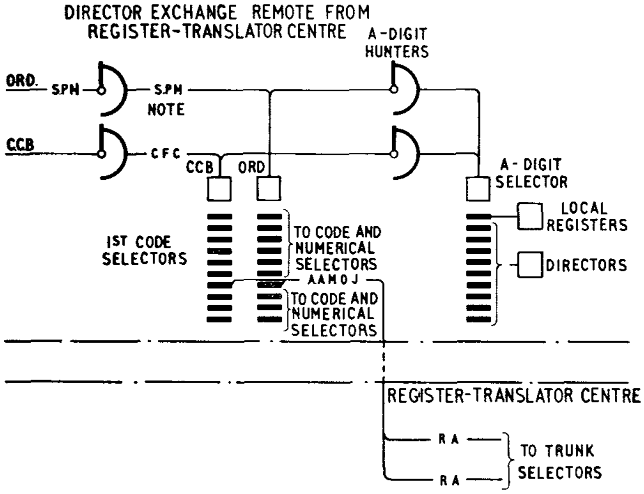
The manual board and engineering services on level 1 do not require metering except for level 16, which is to be used for the test-match score information service. However, this service gives rise to heavy traffic on certain occasions and, to avoid congestion, calls to this service are terminated by forced release after a pre-determined maximum time. Such calls are metered at one unit on being established; the timing and forced release is controlled by equipment similar to that used for the speaking-clock service. Local-call timing equipment is not therefore necessary on level 1.

The charging and timing of S.T.D. calls is controlled by the register-translator, as mentioned earlier. The equipment needed to control the operation of the subscribers' private meters has been arranged so that it can be connected either on an individual basis in the line termination of each subscriber requiring the facility or on a common basis in the circuits between the outlets of the subscribers' uniselectors and 1st selectors.

TRUNKING IN DIRECTOR AREAS

In director areas outgoing S.T.D. traffic can be catered for most economically by installing one central group of originating register-translator equipment to serve all the director exchanges in the area. To provide access to this equipment from individual director exchanges, level 0 of the A-digit selectors is connected to a form of local register. This local register causes the 1st code selector to step to the level required to give access, via a junction relay-set, to the central register-translator equipment.

The local-call timing arrangements are incorporated in the 1st code selector, and the coin-checking and fee-



S.P.M.—Subscribers' private meter equipment. C.F.C.—Coin-checking and fee-checking equipment. A.A.M.O.J.—Auto-auto relay-set with metering over junction R.A.—Register-access equipment.
Note: Alternative position for subscribers' private meter equipment.

FIG. 6—DIRECTOR EXCHANGE TRUNKING

checking and subscribers' private meter facilities are provided in the same manner as in non-director exchanges (see Fig. 6).

GROUP-SELECTOR AND FINAL-SELECTOR EQUIPMENT

A type of group-selector rack with grading facilities incorporated within the rack was introduced in 1945 for use in all group-selector ranks in both director and non-director exchanges.[7] After some years of experience it has been decided that for penultimate selectors economies can be achieved if the interconnecting circuits are taken direct from the penultimate group-selector racks to the appropriate final selectors. This avoids routing the interconnecting circuits via the equipment I.D.F. and has been adopted because, in practice, the consequent loss of flexibility is unlikely to prove an embarrassment. However, to reduce the amount of cross-jumpering required on the graded-type penultimate racks it is necessary to pair selector levels 1 and 2, 3 and 4 and so on, instead of 0 and 1, 2 and 3 as hitherto. In order to maintain these new level-pairing arrangements when only one 11-and-over P.B.X. final selector unit is required, the other level of the pair is reserved for allocation to another 11-and-over P.B.X. final selector unit at a later date.

In order to determine the bank and selector requirements for ordinary and 2–10 P.B.X. final selectors, it was the practice for many years to use fixed loading figures, e.g. ordinary final-selector bank multiples were provided (in multiples of 10 banks with a minimum of 20 banks) on the basis of 188 connexions being allocated to a 200-line unit, and 2–10 P.B.X. final-selector bank multiples were provided on the basis of 132 ordinary connexions and 56 2–10 P.B.X. connexions per 200-line unit. The use of this fixed method of loading, especially where the incoming calling rate to ordinary subscribers was low, led in some instances to some over-provision of final-selector banks. To avoid this, the loading of the final-selector units is now calculated for each exchange so that the ordinary and 2–10 P.B.X. final-selector bank sets are provided on the most economical basis. This may mean an increase in the number of 2–10 units, but their greater cost will be more than offset by the overall savings in final-selector banks.

In recent years the minimum bank multiple for any final-selector unit has, as mentioned above, been set at 20 banks. Such a minimum figure was considered necessary because of the following factors:

(*a*) The difficulty of manufacturing bank sets which are not a multiple of the shelf capacity.

(*b*) The impracticability of extending a final-selector bank set when it has once been installed.

(*c*) Possible future increases in traffic incoming to the final-selector unit.

(*d*) The final-selector unit is provided on the basis of the ultimate loading.

It has, however, now been decided that in some instances economies could be obtained without seriously prejudicing the long-term requirements by using a 15-bank multiple for final selectors serving ordinary subscribers.

SUBSCRIBERS' 50-POINT LINEFINDER SYSTEM

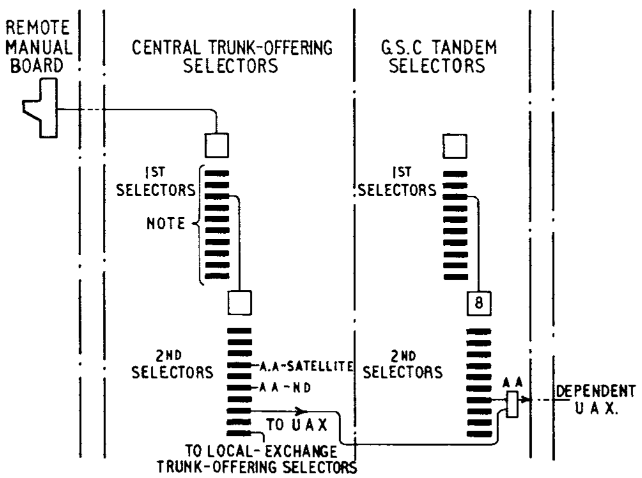
For many years it was the general practice at non-director and director exchanges to provide uniselector-type calling equipments on the basis of one uniselector per incoming connexion. Such a basis had some advantages from the point of view of accommodating changes in the ratio of shared service to exclusive connexions, but was generous in exchanges where the originating calling rate of the subscribers was low. The 50-point linefinder system[8] was introduced in 1957 to allow for the more economic provision of calling equipments to serve subscribers with a low originating calling rate.

In the 50-point linefinder system the subscribers are grouped in units of 49 terminating on the banks of 5 × 50-point non-homing rotary-type linefinders (P.O. Type 2 uniselectors), each of which is connected to a subscriber's uniselector circuit of the normal type functioning as a selector hunter. The 50th point of the linefinder bank is used for testing purposes. The system incorporates facilities for shared service by means of a single calling equipment per pair of sharing subscribers, and hence each group can accommodate either 49 exclusive subscribers or up to 98 shared-service subscribers. A fully-equipped rack caters for 10 groups each of 49 terminations, but the actual number of connexions depends upon the proportion of shared-service lines, e.g. a typical rack might accommodate 600 connexions on 490 terminations. By way of comparison the same size rack would accommodate a maximum of 300 connexions on 2-home-position uniselectors.

At new exchanges subscribers' calling equipments are provided on a composite installation of uniselector racks and 50-point linefinder racks, the actual proportion of each type being dependent on the ratio of high-calling-rate to low-calling-rate subscribers. Existing exchanges with uniselector calling equipments are generally extended so that as far as possible residential subscribers can be accommodated on 50-point linefinders, the remainder being allocated to existing uniselectors.

TRUNK OFFERING

The facility of trunk offering has in the past been provided via direct circuits from the assistance operator to the associated non-director, minor non-director and director exchanges and also to satellite exchanges. Trunk offering at directly-connected U.A.X.s was normally provided via routes from the G.S.C. to the U.A.X. which were accessible both to operators and subscribers. With the introduction of remote assistance centres (trunk-control centres) in director and non-director areas, each manual board required facilities for trunk offering to all subscribers within the director or non-director area even though the operator might not have been the parent operator for the subscriber's local exchange. To cater for this requirement in the most economical manner, circuits were provided from each trunk-control centre to a central group of selectors. The levels of these selectors gave access to the trunk-offering selectors at the dependent director, non-director and satellite exchanges. This scheme required the operator to dial an arbitrary 2-digit or 3-digit code prior to the number of the wanted subscriber.



Note: To non-director exchanges, satellite exchanges and U.A.X.s in group switching area (via 2nd selectors where necessary). Direct trunk-offering circuits are provided to non-director and satellite exchanges. Ordinary traffic-carrying junctions are used to U.A.X.s.

FIG. 7—TRUNK-OFFERING SCHEME WITH CENTRAL TRUNK-OFFERING SELECTORS AT GROUP SWITCHING CENTRE

It is expected that with the introduction of S.T.D. the number of assistance operators will decrease, with a consequent effect on the number of assistance centres. Where an assistance centre is to be remote from the G.S.C. it is proposed to adopt the centralized-trunk-offering principle with the selectors situated at the group switching centre. The relay-sets used will permit trunk offering to U.A.X. subscribers via normal traffic circuits between the G.S.C. and each U.A.X. The essential features of the trunking scheme are shown in Fig. 7.

FUTURE PLANS

The introduction of S.T.D. has brought about significant changes in the trunking and grading arrangements of group switching centres and minor exchanges. It is expected that more changes will be necessary to cater for the introduction of the new transit switching plan and the design of exchanges on a unit basis.[9]

References

[1] WATERS, H. S. Multi-Fee Metering at Non-Director Exchanges. *P.O.E.E.J.*, Vol. 39, p. 17, Apr. 1946.
[2] THOMPSON, A. J., and BROADHURST, J. H. Trunk Mechanization. *I.P.O.E.E. Paper No.* 201, 1951.
[3] SMITH, D. C. Signalling System A.C. No. 1 (2 V.F.). *P.O.E.E.J.*, Vol. 44, pp. 66 and 114, July and Oct. 1951.
[4] HORSFIELD, B. R., and WELCH, S. The Single Commutation Direct Current Signalling and Impulsing System. *P.O.E.E.J.*, Vol. 44, p. 18, Apr. 1951.
[5] Subscriber Trunk Dialling. *P.O.E.E.J.*, Vol. 51, Jan. 1959.
[6] TOBIN, W. J. E., and STRATTON, J. A New Switching and Transmission Plan for the Inland Trunk Network. *P.O.E.E.J.*, Vol. 53, p. 75, July 1960.
[7] FRANCIS, H. E. Post-War Exchange Design. *I.P.O.E.E. Paper No.* 181, 1943.
[8] FOX, W. H., ASHWELL, J. L. K., and WEAVER, A. L. Subscribers' 50-point Linefinder System. *P.O.E.E.J.*, Vol. 51, p. 81, July 1958.
[9] LAWRENCE, J. P. The Unit Method of Automatic Telephone Exchange Design. *P.O.E.E.J.*, Vol. 53, p. 14, Apr. 1961.

Book Review

"Telecommunication Dictionary." A. Visser. Elsevier Publishing Co., Amsterdam. Distributed by D. Van Nostrand Company, Ltd., N.Y. and London. 1011 pp. 147s.

This is a six-language dictionary in English, French, Spanish, Italian, German and Dutch, and is one of a group of 22 multi-lingual dictionaries, covering separate fields of technology and commerce, published by Elsevier. It contains nearly 10,000 terms and is a rearranged and augmented edition of one produced in 1955 by Mr. Visser, then Head of Documentation Services of the Netherlands P.T.T., for use by officers of the P.T.T. The new edition has been produced under Mr. Visser's direction, and comprises a "basic table" in which terms are given in English in alphabetical order with the equivalents in the other languages listed below each, and five subsidiary sections, one for each of the other languages, in which the terms are in alphabetical order in those languages, with numerical references to the basic table.

The publishers say that in the basic table can be found "all terms used in the telecommunication world" but this statement needs some qualification. Certainly a wide range of engineering and traffic terms is covered, including whole phrases such as "split trunk group available for use only on certain outward positions," but whereas "pointed mason's chisel" appears, "cathode follower," "magnetic drum," "flip-flop," "mismatch," "backward-wave tube" and "vestigial sideband" do not. It is possible to compile quite rapidly a list of 50 or more terms which one can reasonably expect to encounter in present-day papers on telecommunications subjects but which do not appear in this dictionary; however, many of them do appear in the other Elsevier dictionaries, particularly in those devoted to "Amplification, Modulation, Transmission and Reception," "Electronics and Waveguides" and "Television, Radar and Antennae."

Probably no dictionary is perfect, and the translation of technical terms is quite often a difficult matter. Often the meaning conveyed by a single word in one language can be rendered in another only by a phrase of several words. In a multi-lingual dictionary the several versions of a term can be seen at once, so that if there is doubt about the applicability to a given set of circumstances of the version given for one language, it can to some extent be checked by examining the versions given in the other languages. In this respect a multi-lingual dictionary may be more convenient than a collection of two-language dictionaries.

This dictionary is an excellent piece of book production, and the paper and binding have been chosen to stand up to extensive use.

H. D. B.

A New Frame and Cover for Carriageway Manholes and Joint-boxes

S. W. JENNINGS, A.M.I.E.E., and A. F. L. HEARN†

U.D.C. 624.027.8:621.315.233

A brief history is given of the use by the Post Office of frames and covers for manholes and joint-boxes in carriageways. Investigations made into the loads that these covers must be capable of withstanding are outlined, the requirements for a new frame and cover are examined, and the development of a new unit-type frame and cover is described.

INTRODUCTION

VARIOUS types of manhole frames and covers have been used satisfactorily in the past by the Post Office but the weight and speed of modern road traffic have shown them to have some disadvantages. The situation required a careful study of the shortcomings of existing frames and covers and this led to the development of a better type, which is also easier to install.

TYPES OF FRAMES AND COVERS USED BY THE POST OFFICE

Early frames and covers for manholes and joint-boxes built for telephone and telegraph purposes were adaptations of types already in use for gaining access to drainage systems. The covers were, in general, of two basic types:

(*i*) A cast-iron "tray" divided into compartments which were filled with some hard-wearing material, e.g. wood blocks, concrete.

(*ii*) A cast-iron upper plate, which formed the wearing surface, having an arrangement of supporting ribs below it.

The cover rested in a massive frame of inverted "tee" section. The load-bearing surfaces consisted of "chipping blocks" of relatively small cross-sectional area, the levels of which were modified by the manufacturer to permit initial adjustment and prevent the cover "rocking" when new.

Round Type (*Frame and Cover, Manhole, No. 3*)

This was the first type of frame and cover to be used by the Post Office and is shown in Fig. 1. Whilst exceedingly heavy, it was easy to install due to the rigidity of the massive frame casting. The cover usually developed rock soon after installation due to unequal wear of the chipping blocks. It was necessary to lift the cover vertically some six inches when access to the plant was required.

Oval Type (*Frame and Cover, Jointing-Pit, No. 2*)

The oval frame and cover was similar in design to the round type and possessed the same characteristics. Due to its shape, however, it was possible for the cover to fall through the frame aperture and cause damage to the plant in the jointing chamber.

Wood's Type (*Frame and Cover, Joint-Box, Carriageway*)

The Wood's type frame and cover (Fig. 2), which superseded the oval type, was provided with serrated seatings in an endeavour to increase the area of contact between the cover and the frame and thereby reduce the rate of wear. In practice the increase in life was not realized due to slight casting inaccuracies causing small-area contact surfaces to wear rapidly, resulting in rocking covers. Its installation and handling characteristics were similar to those of Frame and Cover, Manhole, No. 3.

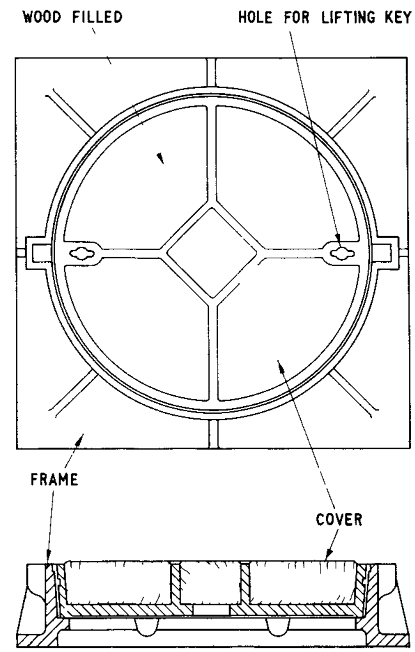


FIG. 1—PLAN AND SECTION OF ROUND COVER

"*Slide-out*" *Type* (*Frame and Cover, Manhole, No. 3E*)

This type was introduced in 1948 in both square and rectangular form (Fig. 3). It will be seen that the frame, which was assembled from separate cast units, had a hollow section which was filled with concrete on site. As shown, the cover was also filled with concrete. The seating areas were fully machined in order to provide a large area of contact to reduce the rate of wear. The lack of rigidity of the frames made their installation, to the standard of accuracy required to take full advantage of the large seating areas, extremely difficult under field conditions. As a result, rocking developed early in the life of the unit and the lightness of the frame sections proved inadequate to withstand the consequent stresses. The removal of the covers for access to the plant was made easy by the "slide-out" facility provided.

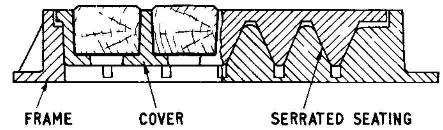


FIG. 2—WOOD'S TYPE COVER SHOWING SERRATED SEATING

† Mr. Jennings was formerly in the External Plant and Protection Branch, E.-in-C.'s Office, but is now with the Ministry of Transport. Mr. Hearn is in the External Plant and Protection Branch, E.-in-C.'s Office.

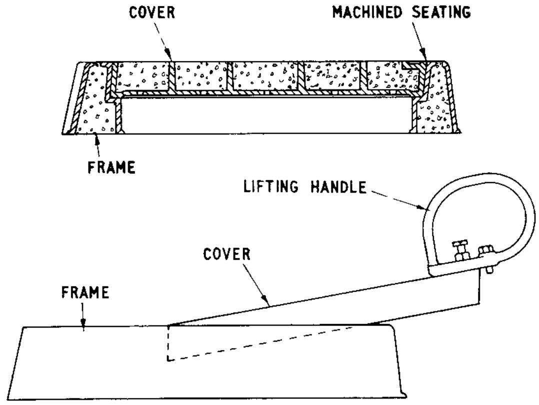


FIG 3—SLIDE-OUT TYPE OF FRAME AND COVER

Multi-Cover Type (Frame and Cover, Joint-Box, No. 10)

The increased use of coaxial cables necessitated a review of jointing-chamber designs. In 1951 longer joint boxes were introduced to reduce cabling difficulties and to provide improved jointing facilities at a lower cost than that of an equivalent manhole. The frame and cover chosen consisted of four individual covers, with their associated frame sections, assembled into one continuous unit. In the field, the difficulties of replacing cross bars into accurately machined recesses dictated the use of covers supported on two opposite sides only.

BEHAVIOUR OF MANHOLE AND JOINT-BOX COVERS UNDER TRAFFIC CONDITIONS

In view of the short life and breakage of some covers, the stresses to which a manhole cover is subjected when installed in a road carrying fast-moving heavy traffic were investigated.

The preliminary investigations were made using a mechanical indicating device, despite the known inaccuracies of this type of instrument that result from inertia and possible resonance of the moving parts. The indicator was mounted under the edge of the second cover of a Frame and Cover, Joint-Box, No. 10, and an artificial surface irregularity provided at the end from which vehicles approached the cover. The provision of this irregularity was necessary to simulate impact conditions. A fully-laden stores-carrying vehicle was driven over the cover at different speeds and the indicator readings taken. These tests revealed that the downward deflexion at the centre of the cover was followed by a rebound in the upward direction to 80 per cent of the downward deflexion, due to the release of stored energy when the load was removed.

The magnitude of this upward deflexion was of such vital importance that it demanded further and more accurate investigation, and arrangements were made for tests to be carried out with an improved indicating unit. The basis of this indicator was the strain gauge. This consisted of a resistance element mounted on a very thin sheet of paper, which was rigidly cemented to the face of the metal at the position where the measurement of strain was required. Any dimensional change in the metal was transmitted through the cement to the resistance element which therefore suffered a change in resistance proportional to its change in length. To counteract the effect of temperature changes a second similar element was cemented to the metal, close to the first, but at a position where no strain occurred. These two elements formed two arms of a bridge network, the normal galvanometer being replaced by a cathode-ray oscilloscope with a "long-persistence" screen. The bridge was balanced under static conditions and any subsequent changes in the resistance of the "working" element were indicated on the oscilloscope.

These tests confirmed the results obtained using the mechanical indicator, and showed that the error in the magnitude of deflexion indicated by the mechanical indicator was of the order of 10 per cent.

THEORETICAL EXAMINATION OF COVER DESIGN

Stresses in the Cover

A study of the configuration of a typical manhole-cover casting of the No. 10 type indicated that the failures were, in all probability, due to its lack of strength when subjected to stresses in the reverse direction from those imposed when supporting the weight of traffic.

A part section of a typical casting is shown in Fig. 4.

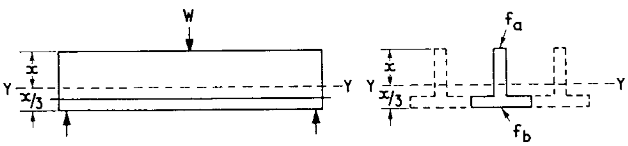


FIG. 4—NORMAL LOADING OF TYPICAL CAST BEAM

Consider that the portion within the solid lines is supported and loaded as shown, and that:

W = the applied load,
Y-Y = the position of the neutral axis,
f_a = the stress in the upper face of the web,
f_b = the stress in the lower face of the plate.

The cast-iron of which the cover is made is assumed to have an ultimate tensile stress (U.T.S.) of 12 tons/in^2 and an ultimate compressive stress (U.C.S.) of 26 tons/in^2. The compressive stress, f_a, in the upper face is proportional to Wx and the tensile stress, f_b, in the lower face is proportional to $Wx/3$. The load, W, which the cover will resist without fracture is limited by the U.C.S. of the cast-iron, although even under these conditions the tensile stress in the lower face is nearing the U.T.S. of the material. The concrete filling adds to the strength of the cover when new, but when shrinkage and subsequent loosening of the concrete occurs this increase in strength is lost.

Instantaneous removal of the load releases the stored potential energy, causes the cover to restore to its original position and, due to the kinetic energy when it reaches this point, causes a deflexion of 80 per cent of the loaded deflexion in the upward direction. As the deflexion is proportional to load, this condition could be simulated by reversing the cover and applying a load W_r (Fig. 5).

If the load W_r is increased sufficiently the cover will fail due to the stress f_a in the cast-iron reaching the U.T.S. of the material. This stress is proportional to xW_r.

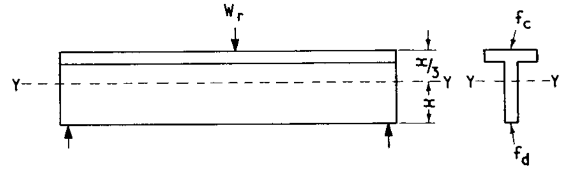


FIG. 5—LOADING OF REVERSED BEAM

$\therefore \quad xW_r = Wx/3$
and $\quad W_r = W/3.$

Thus, the reverse load that the cover will withstand is only 1/3 of the limiting dead load. As the stress reaches 80 per cent of this load, the cover can only be relied upon to withstand 5/12 or 0·42 of the dead load for which it is designed. A cover which fractures under dead-load conditions at 35 tons can therefore only be loaded to 35 × 0·42 tons or 14·7 tons, approximately, if that load is liable to be removed instantaneously. It is not possible to remove the load instantaneously, but this condition is approached when the cover is loaded by fast-moving vehicles. This is due to the relatively slow rate of recovery of the cover under simple harmonic motion, compared with the speed of removal of the load due to the forward velocity of the vehicle.

Reduction of Seating Wear

Further examination of existing frames and covers also led to the belief that, under rebound conditions, the cover lost contact with the frame seating during part of its period of oscillation, causing excessive wear. To prevent this, it was necessary to reduce the maximum value of the upward acceleration of the edge of the cover immediately over the frame seating to a value less than that due to gravity. This was effected by an increase in the stiffness of the cover to reduce the amplitude of the deflexion. This reduction in the deflexion also reduced the sliding movement at the seating areas, further reducing wear of the seatings.

DEVELOPMENT OF UNIT-TYPE FRAME AND COVER

In view of the results of the tests and theoretical considerations outlined above, the fitting of multiple carriageway covers was discontinued and additional support provided to those already installed, until a better design could be developed and proved to be satisfactory by extensive and prolonged field trial.

The new design for multiple-access covers was developed to fulfil, as far as possible, the following requirements:

(*i*) Be capable of carrying fast-moving heavy loads with a reasonable factor of safety. In view of the doubts regarding the degree of impact likely to be experienced, e.g. due to bad reinstatement, and the possible double-impact of twin rear-axle vehicles, the ultimate dead load for design purposes was taken to be 45 tons applied over a 12 in. diameter circle placed anywhere on a multiple-cover assembly.

(*ii*) Be capable of being slid out by two men, each lifting a weight of less than 130 lb.

(*iii*) Have a longer useful life than previous types.

(*iv*) Need no filling on site.

(*v*) Provide a non-skid surface for traffic.

(*vi*) Be easy to install to a standard of accuracy which would ensure contact between the cover and frame over the full seating area.

(*vii*) Be assembled from toleranced parts to provide interchangeability and versatility.

A study of the above requirements suggested that the same cover unit could be used for all Post Office carriageway covers (1, 2 or 3 unit), thus offering further versatility.

Practical Design Considerations

In order to achieve a high strength/weight ratio, the weight of the filling had to be reduced to a minimum. Experiments carried out with various types of filling proved that a high-grade flooring asphalt was superior to any other type of filler. This material can be used in slabs 1 in. thick and 4 in. square. It was, therefore, necessary to provide a supporting plate approximately 1 in. below the upper surface of the cover and ribs spaced 4 in. apart in both directions.

Two methods of manufacture of the cover were possible, i.e. casting or fabrication. The fabrication method was rejected owing to the difficulty of quality control of welding and the relatively high rate of corrosion of structural-steel sections. The materials available for casting included various grades of cast-iron to British Standard (B.S.) 1452, steel, spheroidal-graphited iron and light-weight alloy. Using any of these materials the minimum practical casting thickness is of the order of $\frac{5}{16}$ in. With this limitation little advantage can be taken of the increased U.T.S. of the higher-grade materials as the considerable increase in cost is not accompanied by a material decrease in weight. The use of light-weight alloys was rejected due to their lack of stiffness and low resistance to wear and corrosion of the seating surfaces. The material finally chosen was cast-iron to B.S. 1452, grade 12.

The relative values of the maximum bending moment on a line at right-angles to the supporting edges, due to a load placed anywhere on the cover, are shown in Fig. 6.

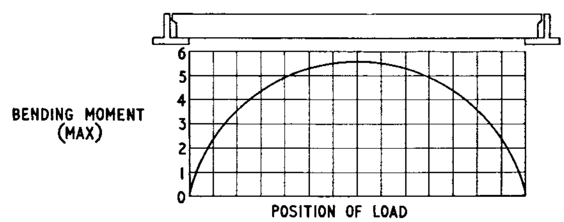


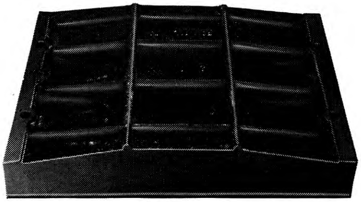
FIG. 6—RELATIVE VALUES OF BENDING MOMENT DUE TO LOAD PLACED ON COVER

Previous designs had taken little, if any, advantage of the reduction in bending moment at the supporting edges, but by designing a casting in which the moment of resistance followed, more or less, the bending moment curve a considerable reduction in weight and cost was obtained. To increase the stiffness of the casting, without a corresponding increase in weight, the depth of the casting was increased. The amount of this increase was, however, limited by the increased height to which the leading edge of the cover must be raised to clear the edge of the frame. A depth of $5\frac{1}{2}$ in., 1 in. more than its immediate predecessor, was eventually chosen as giving the best compromise.

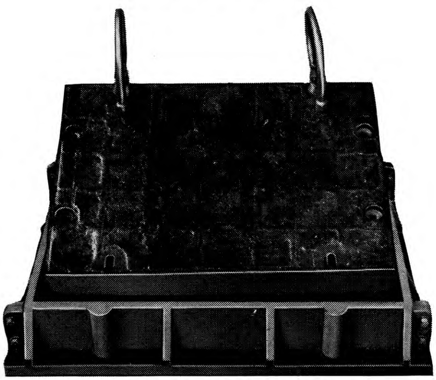
Design of the Cover

The design of cover* ultimately adopted (Fig. 7(*a*) and 7(*b*)) consisted of a series of beams to span the aperture, cast integrally with each other and covered by a plate for supporting the filling material. Above this plate projections were provided to retain the filling. To allow satisfactory core positioning when casting, five beams were chosen. The possible advantage to be obtained by linking these beams with webs spanning the cover at right-angles to the centre line of the beams

* The new design is the subject of Patent Application No. 23009/58.



(a) Underside of Cover



(b) Frame and Cover, Showing how Cover Slides Out

FIG. 7—UNIT-TYPE FRAME AND COVER

was rejected due to the poor resulting strength/weight ratio. Webs were, however, necessary to give support to the semi-circular ribs on which the cover slides when removed. These webs were made as light as practicable. To support a load of 45 tons anywhere on a multi-cover unit, the edges of the covers were strengthened by spacing the beams closer together at the edges and providing an end beam of ample proportions. The neutral axis of the cover falls a little below the centre of the depth to provide adequate strength to resist the upward deflexion experienced when the load is instantaneously withdrawn. Provision was made for bolting the cover to the side members during installation to ensure intimate contact between the machined surfaces.

Design of the Frame

The frame is made in sections which are bolted together, and follows conventional inverted "T" section design. It is of ample proportions to resist the hammering effect of fast-moving heavy traffic.

Packaging

The covers and frame sections (Fig. 8) are supplied

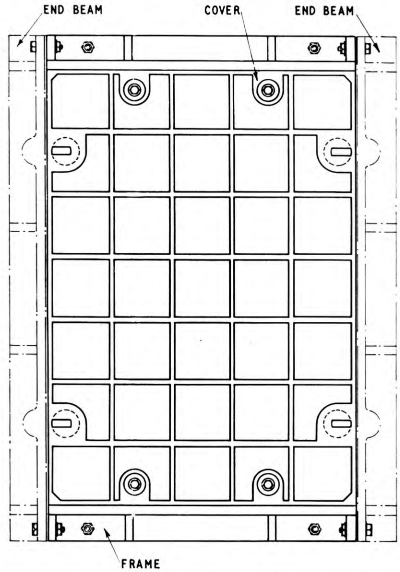


FIG. 8—PLAN OF NEW COVER SHOWING END BEAMS

in "packaged" units, "Frames and Covers, Units A, B and C," thus permitting one or more cover units to be assembled on site as required. The covers and frame sections are machined to $\pm 0{\cdot}015$ in. to allow reasonably cheap machining yet permit full interchangeability. When more than one cover section is required the end beams, shown chain-dotted in Fig. 8, are provided at each end of the manhole and the intermediate edges of the side-frames are bolted together to make a single frame which will take two or three covers.

CONCLUSIONS

Experience, so far, indicates that the life of these units far exceeds that of earlier types, and only in a very few instances has rocking been reported. Investigations of those covers that have developed rock has indicated that insufficient care had been taken when they were installed, allowing subsequent settlement of the frame sections.

ACKNOWLEDGEMENTS

The authors wish to thank their colleagues in the Home Counties Region for assistance in arranging experimental installations, and also the Laystall Engineering Co., Ltd., who were responsible for the machining of the prototype frames and covers.

New Methods of Meter-Pulse Registration

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U.D.C. 621.395.36

The registration of meter pulses on electromechanical meters at existing-type automatic telephone exchanges results in considerable labour costs by the time a subscriber's account has been produced. It is apparent that meter-pulse registration by suitable electronic methods could lead to the complete automation of all processes from registration to the production of the subscriber's account. This article outlines the requirements of a metering system and, after briefly referring to existing arrangements, describes two basically different electronic methods of registration which are being investigated.

INTRODUCTION

As a revenue-earning department of the Civil Service the Post Office is expected to, and in fact does, make a profit.[1] Much of this profit comes from the telephone service. The telephone service revenue comes mainly from three sources: rental and installation charges, charges for ticketed calls, and charges for metered calls. The revenue received from metered calls is roughly 20 per cent of the total telephone revenue, or about £45,000,000 per annum. At the present time this sum consists almost entirely of charges for local calls and would, therefore, be expected to rise slowly over the years with the growth in the number of subscribers. However, this tendency is considerably affected by the introduction of subscriber trunk dialling (S.T.D.).

As described elsewhere,[2] subscribers having S.T.D. facilities are able to complete, by dialling, a high proportion of calls previously obtainable only with the assistance of an operator; further, the charges for all calls dialled by an S.T.D. subscriber, including local calls, are recorded on his meter. The number of meter pulses recorded on his meter for each call will vary according to the duration of the call and the distance over which it is made.[3]

Thus, as S.T.D. is extended throughout the country, the proportion of the total telephone revenue obtained from metered calls will increase rapidly; at the same time the reduction in the number of manual and automanual exchanges will increase the cost of meter reading, which is at present normally performed visually by operators during periods of light traffic. The need for cheap and accurate methods of bringing to account subscribers' meter readings will concurrently increase in importance. Two factors are involved in this process: firstly, the form in which the meter record is stored, and secondly, the method by which it is read when the total is desired. These are, to a large extent, interdependent.

REQUIREMENTS OF A METERING SYSTEM

To be acceptable to an operating administration a metering system must:

(*a*) be accurate, both in recording and during reading,

(*b*) be cheap in capital costs and in annual charges,

(*c*) be economical in power needed and space occupied,

(*d*) provide ready access for reading any or all of the metered totals stored, and

(*e*) be compatible with whatever automatic accounting and billing system it has to interwork.

In the design of all-electronic exchanges, under the guidance of the Joint Electronic Research Committee, all these points are being considered; this article deals primarily with some electronic methods which might prove suitable for use in existing electromechanical exchanges.

EXISTING METERING AND ACCOUNTING SYSTEM

Meter-Pulse Registration

In all the automatic exchanges now in operation in this country each subscriber's line has an electromechanical meter associated with it for the registration of meter pulses; in the case of a shared-service line, one or two meters may be fitted according to whether separate metering is provided or not. Three basic types of meter exist today: the large No. 1 Type, and the smaller No. 100 Type and No. 150 Type. Fig. 1 shows a section of the racks of 100-type meters at Fulham telephone exchange.

Fig. 2 shows in schematic form the relationship between subscribers' lines, subscribers' line circuits with their associated meters, and the remainder of the exchange. The actual type of exchange does not need to be specified; it is sufficient to accept that meter pulses are generated within the switching network and appear as voltage changes on leads, each one of which is individual to a

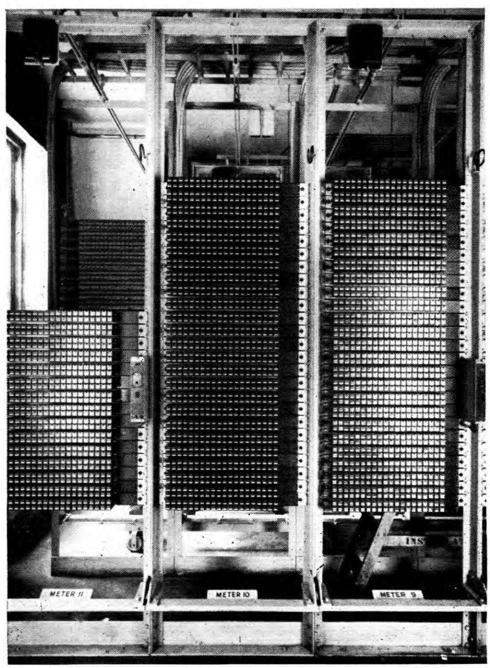


FIG. 1—METER RACKS AT FULHAM TELEPHONE EXCHANGE

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

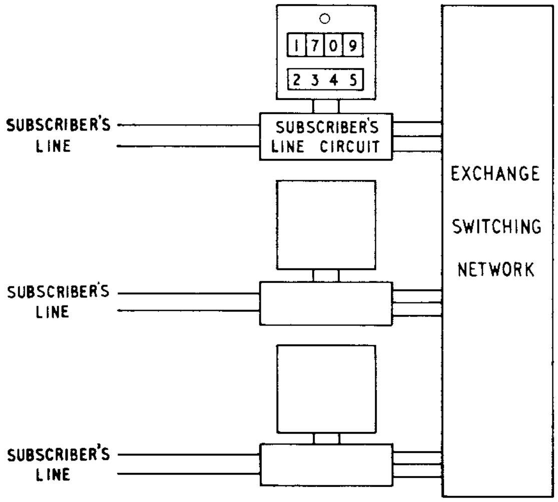


FIG. 2—BLOCK SCHEMATIC DIAGRAM OF EXISTING METERING SYSTEM

subscriber. The subscriber's meter steps once for each meter pulse received.

Meter Reading

All existing meters are designed to be read visually; Fig. 3 shows the stages involved in the processing of a

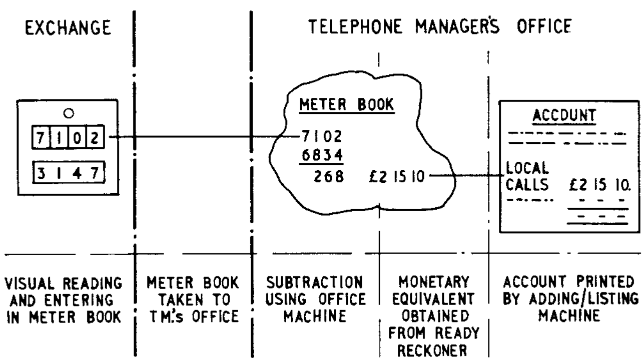


FIG. 3—PROCESSING A METER READING UNDER THE EXISTING METHODS

meter reading to form part of a subscriber's bill. This diagram is typical only—the details vary from Telephone Area to Telephone Area.

Where punched-card accounting systems are in operation as many as possible of the arithmetical processes are performed automatically; Fig. 4 shows the stages involved.

Fig. 5 shows a further refinement of the system, at present on trial in the Edinburgh Telephone Area. Here the subscribers' meters are photographed in blocks of 100; the film is then sent to the Telephone Manager's office where it is processed. The resulting negatives are fed into a reader and the meter readings are projected, one by one, on to a screen in front of a key-punch machine operator. From the stage where the punched card is prepared all further manipulation is done by automatic machinery.

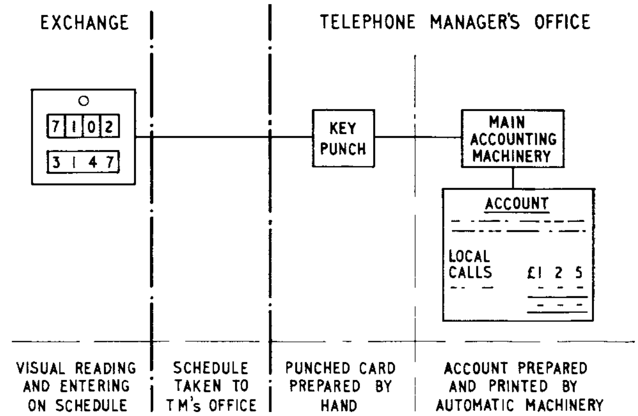


FIG. 4—PROCESSING A METER READING USING A PUNCHED-CARD SYSTEM

The system shown in Fig. 5 is an obvious improvement over that in Fig. 3 in that all the purely arithmetical processes have been mechanized; there is still, however, room for further improvement.

POSSIBLE METHODS OF IMPROVEMENT

The input to the system shown in Fig. 5 is the meter itself, an electromechanical device recording information in what may be called machine language. The punched-card accounting equipment at the Telephone Manager's office uses a different machine language. In other words, requirement (*e*) is not met. To transfer from one language to another entails subsidiary processes of photography, dispatch, chemical developing, projecting, reading and card punching. All these processes cost money, and some of them are liable to introduce errors which can only be minimized by additional cost. For example, to reduce human error at the punching stage, each card is punched with the same information by two separate operators, the card being slightly displaced for the second punching. Thus, provided that the same information has been punched by both operators, all the holes on the card are slightly oval. The subsequent automatic machinery rejects any card containing a round hole.

Punched-card accounting is being installed throughout the country; any improvement in compatibility must come, therefore, from replacing the electromechanical meter by some new device capable of giving an output

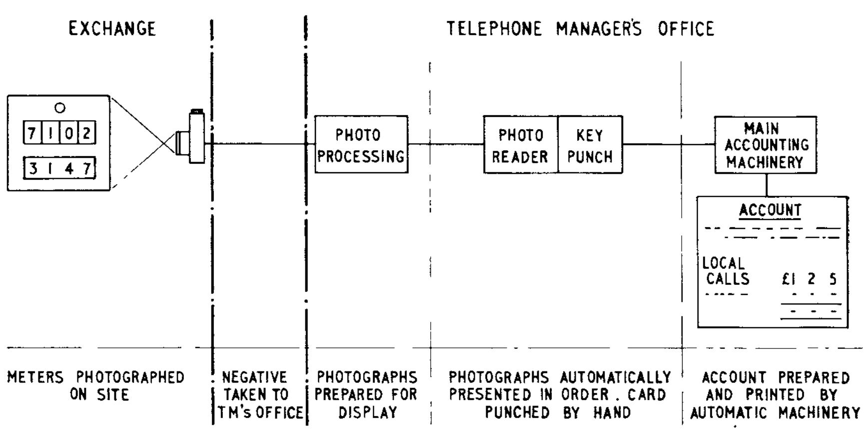


FIG. 5—PROCESSING A METER READING USING A PHOTOGRAPHIC AND PUNCHED-CARD SYSTEM

which can be fed as directly as possible into the punched-card machinery. In the course of time the punched-card equipment will itself be superseded and replaced by computer-type data-processing equipment. Any new meter-pulse registration device must, therefore, cater for both types of accounting equipment; it is evident that the output must be electrical in form, and that the contents of each meter store must be made available for reading on receipt of a signal, also electrical in form. Requirements (*d*) and (*e*) will then be met.

Punched-card accounting machinery is partly electro-mechanical, partly electronic: computers are fully electronic. There is, therefore, a strong argument for any new meter-pulse registration device being electronic in character, since, as shown above, it can be considered as a remote part of the accounting machinery. Much research has been done in recent years on electronic storage devices since these are widely used in computers, data-processing equipment, and electronic telephone exchanges. The main devices from which a choice can be made are as follows:

(*a*) The magnetic or ferrite core.
(*b*) The delay line.
(*c*) Magnetic or paper tape.
(*d*) The magnetic drum.

The remainder of this article consists of descriptions of two proposed systems using magnetic drums, one of which also uses ferrite cores for temporary storage, and of one system using tape.

MAGNETIC-DRUM METERING SCHEMES

Meter-Pulse Registration

The surface of a magnetic drum consists of a large number of tracks, each track providing an information storage area; with each track are associated read and write heads. Fig. 6 is a sketch of a magnetic drum, with one track and its two heads shown. A positive pulse of

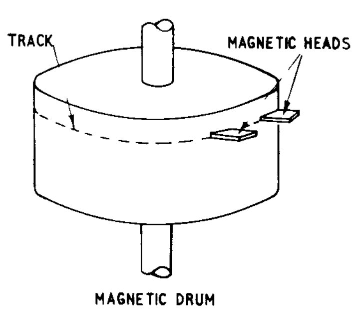


FIG 6—SCHEMATIC DIAGRAM OF A MAGNETIC-DRUM STORE

current flowing through the write head magnetically saturates, in one direction, the small length of track passing under the head at that instant; a negative pulse saturates it in the opposite direction. These two states of saturation can be used to represent the binary digits 0 and 1. In practice, more complicated methods of modulation are used, but these do not affect the argument. Once a digit 0 or a digit 1 is stored in one of the elementary areas it will remain until it is deliberately altered. What is more, each time it passes under the read head the information can be read and used, if required, without affecting it in any way.

The length of the elementary area is typically 0·01 in. and tracks can be spaced about 0·05 in. apart. A drum of 9 in. diameter and 5 in. axial length can accommodate about a quarter of a million binary digits. This is a greater storage capacity than 10,000 Meters No. 150, and a drum of this size would thus be sufficient to record all the metering information of a full-sized telephone exchange.

Each subscriber's meter store on the magnetic drum comprises a register, which is a portion of one track; the Appendix describes a scheme of allocation of registers over a magnetic drum and also a preferred information coding system.

Fig. 7 shows in schematic form the relationship between subscribers' lines, subscribers' line circuits, the remainder of the exchange and the magnetic drum; it can be directly contrasted with Fig. 2. Meter pulses,

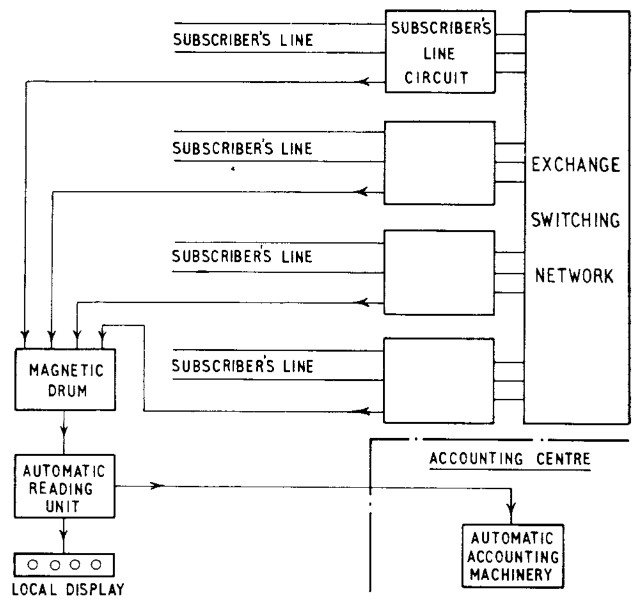


FIG. 7—EXPLANATORY DIAGRAM OF METERING SYSTEM USING A MAGNETIC-DRUM STORE

appearing as voltage changes on the leads individual to each subscriber, are in this case caused to modify the total meter pulses already stored in the appropriate subscriber's register.

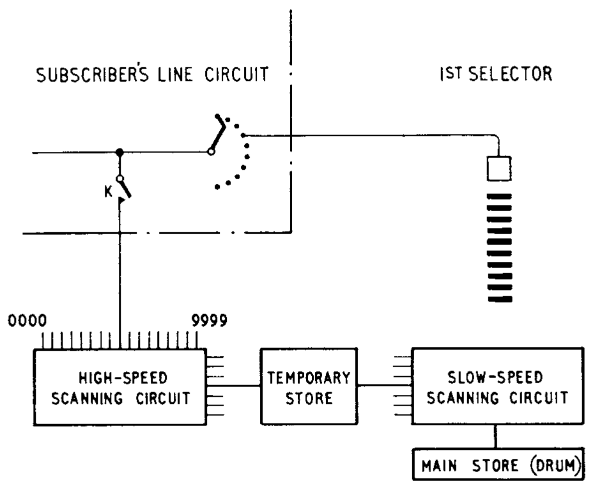
Meter Reading

The automatic reading unit shown in Fig. 7 can be designed to produce whatever output is required for the type of accounting machinery to which the information is passed. It could, for example, be arranged to produce a punched card for each subscriber, a magnetic tape containing all the meter totals in the exchange in some pre-determined order, or a printed record on a teleprinter or electric typewriter. Typical of the other facilities that could be incorporated is that of collecting together the meter readings for all the lines of a subscriber with a private branch exchange.

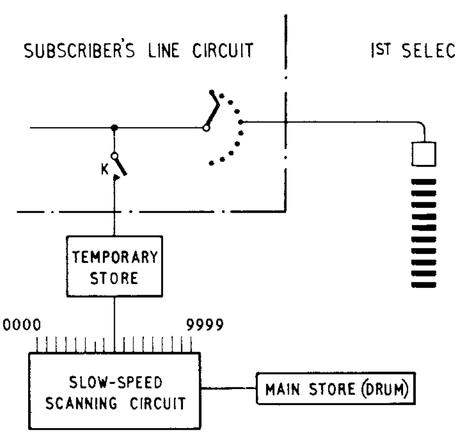
Facilities can be included for reading an individual meter, typically by setting the subscriber's number on rotary switches which then initiate a display of the corresponding meter total. An attractive facility which can be provided is that of reading an individual meter from some remote point; for example, the Telephone Manager's office. This can be done by dialling a special access code followed by the required subscriber's number, after which the appropriate meter total is pulsed back serially over the pair of wires, using v.f. signals if necessary.

Detection of Meter Pulses

As mentioned above, each meter total relating to a particular subscriber is stored in a register individual to that subscriber; access to a register, in order to add to the total stored in it, can only be obtained during the time it is passing under the read head. Meter pulses, however, arrive at random, and for each subscriber a temporary memory must be included to remember, until the appropriate register is accessible, that a meter pulse has arrived. Fig. 8(*a*) and (*b*) are diagrams of two basically similar magnetic-drum metering schemes; alternative positions for the temporary store are shown. The conditions which govern the position in which it is fitted are discussed below.



(*a*) With Two Scanning Circuits



(*b*) With One Scanning Circuit

FIG. 8—BLOCK SCHEMATIC DIAGRAMS OF MAGNETIC-DRUM METERING SYSTEMS

One of the major advantages of electronic equipment is its high speed of operation. This can often be exploited by enabling one piece of equipment to be time-shared between a large number of inputs. In the particular case of meter-pulse detection, for instance, it is not necessary to maintain a continuous monitor on every meter lead (which is one of the functions of individual electromechanical meters) provided that a common detection circuit can be connected to each lead so frequently that every pulse is recorded. This is the function of the scanning circuits shown in Fig. 8.

The minimum duration of a meter pulse is about 150 ms and, provided that every meter lead in the exchange is scanned at least once during this time, any meter pulse can be detected and recorded in the appropriate temporary store. In these circumstances the position of the store would be as shown in Fig. 8(*a*).

Since the most frequent rate of repetitive metering which is contemplated is about one per second, the apparatus for transferring information from the temporary store to the main store can be time-shared over a greater number of subscribers than can the high-speed scanning circuit. The only criterion is that each temporary store must be emptied and reset once per second.

By scanning more frequently than once every 150 ms and increasing the capacity of the temporary store, it is possible to incorporate some desirable check features. For example, if each line is scanned once every drum revolution, say every 30 ms, a simple persistence check on the presence of the 150 ms meter pulse can be carried out. A store of two binary digits would enable a persistence check of 90–120 ms to be carried out on the presence of any meter pulse before a single unit was added to the appropriate subscriber's register in the main store. The contents of this store during the four drum revolutions would be as shown in Table 1.

TABLE 1

Sequence of Simple Check of Meter-Pulse Persistence

Scan Number	State of 2-Digit Store: Before Scanning	State of 2-Digit Store: After Scanning	Limits of Meter-Pulse Persistence (ms)	Action Taken
1	00	01	0–30	1 added to 2-digit store
2	01	10	30–60	1 added to 2-digit store
3	10	11	60–90	1 added to 2-digit store
4	11	00	90–120	2-digit store restored to normal and add-1 instruction sent to main store.

The facilities which can be incorporated in this part of the system allow scope for considerable ingenuity. For instance, a further increase in the size of the temporary store would permit not only the persistence of a meter pulse to be checked but would permit the "add-1" instruction to be delayed until the meter pulse had disappeared for a predetermined time. This would act as a check if a permanent positive battery appeared on a P-wire in a positive-battery-metering exchange: it would also ensure that double registration of a split meter pulse could not occur.

By providing the temporary store before the scanning circuit, as shown in Fig. 8(*b*), only one scanner, operating at a rate of once per second, is needed. The temporary store must be of such a nature that, having sensed the arrival of a meter pulse, it retains the information until reset by the scanning circuit; split meter pulses are thus ignored. The temporary store must, however, incorporate an operating lag as a persistence check to distinguish true meter pulses from noise which might be present on the meter lead.

Addition of Meter Pulses

When a genuine meter pulse has been detected a single unit must be added to the total of meter pulses already stored in the subscriber's register in the main store. The addition circuit which carries out this function is used with either of the configurations shown in Fig. 8(*a*) and (*b*) and is included in the main store. Fig. 9 shows the addition circuit in schematic form; its operation is as follows.

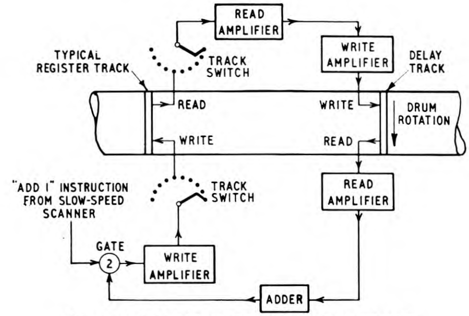


FIG. 9—SCHEMATIC DIAGRAM OF ADD-1 CIRCUIT

Assume that the track switch, which is an electronic uniselector-type circuit taking one step per drum revolution and which is used to connect different tracks to the common equipment, is on track 1, and register 1 of that track is approaching the read head. The stored information in register 1 is read and immediately re-written on a delay track, where it circulates for a few milliseconds before being read and passed to the adder. Here the stored total is increased by one and the result passed forward to the gate. If no add-1 instruction signal is present on the other input to the gate no signal reaches the write amplifier and no change is made to the information stored on the drum surface. If, however, an add-1 instruction is present, the pulse pattern representing the new total is passed to the write amplifier and is written on the drum in the register 1 position which, by this time, is under the write head.

The contents of later registers are already circulating through the system; each is similarly presented, having been augmented by one, to the gate at the time when the appropriate add-1 signal may be present.

When all registers in track 1 have been dealt with, the track switch steps to track 2, and so on. The delay track, the two read and two write amplifiers, the adder and the gate are shared between a large number of register tracks, the actual number being dependent upon the speed of the drum. The function of the delay track is to enable the read and write heads of the register tracks to be separated slightly. If they were too close, the high-energy writing pulses would directly affect the sensitive read amplifier. The length of delay track used is slightly less than the separation of the read and write heads of each track of registers, the small difference being equivalent to the time taken for the reading, writing and addition circuits to operate.

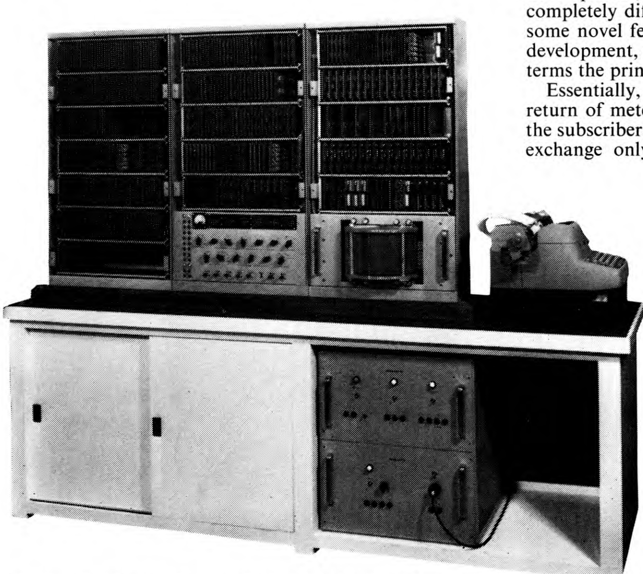


FIG. 10—DRUM-METERING EQUIPMENT AT READING TELEPHONE EXCHANGE

Experimental Installations of Drum-Metering Equipment

Two drum-metering equipments, each serving 1,000 lines, have been installed in telephone exchanges to demonstrate the principles and to obtain information on accuracy of recording, reliability, and facility requirements. The first, which was installed in Reading exchange in the middle of 1960, is in accordance with Fig. 8(*a*) and uses additional tracks on the drum as the temporary store. Fig. 10 shows a photograph of the equipment.

Early in 1961 the other equipment was installed in Chatham exchange. It is in accordance with Fig. 8(*b*) and uses ferrite cores, one per subscriber, as the temporary stores. A photograph of the equipment is shown in Fig. 11.

A TAPE-METERING SCHEME

The drum-metering schemes have been discussed above at some length since they are in an advanced stage of development; attention is, however, being given to a completely different type of metering scheme which has some novel features. Since this is at an earlier stage of development, it is proposed merely to describe in general terms the principles involved.

Essentially, the scheme consists in controlling the return of meter pulses from the switching equipment to the subscribers' line circuits so that throughout the whole exchange only one pulse is presented for registration at a time. The arrival of a meter pulse at a subscriber's line circuit causes a signal to be passed to an identification circuit, which in turn causes the directory number of the subscriber concerned to be recorded on a tape. Since true one-at-a-time arrival of meter pulses is an essential feature of the system, the identifying circuit, the recorder, and much of the control apparatus can be common to the whole exchange.

System Description

Fig. 12 shows a schematic diagram of the system. A meter pulse, arriving at random, is stored in a memory provided with each 1st selector and application is made from the selector to the one-at-a-time allotter, only one of which is provided for the exchange. If the printer is ready to operate, the

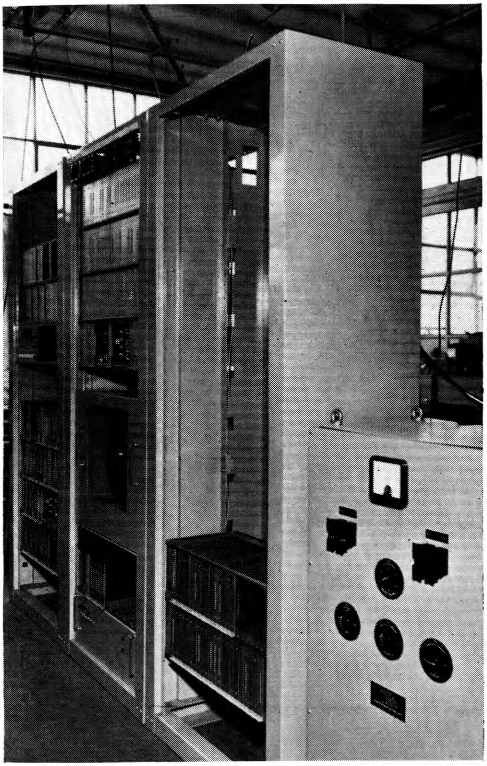
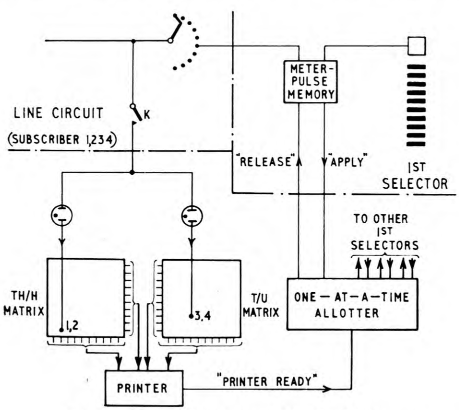


FIG. 11—DRUM-METERING EQUIPMENT AT CHATHAM TELEPHONE EXCHANGE

allotter selects one 1st selector from those applying at the time and causes release of the meter pulse over the normal P-wire, or M-wire, to the subscriber's line circuit.



TH/H = Thousands/Hundreds T/U = Tens/Units
FIG. 12—BLOCK SCHEMATIC DIAGRAM OF TAPE-METERING SYSTEM

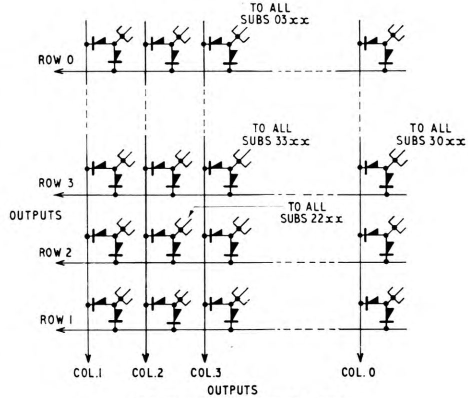


FIG. 13—A RECTIFIER MATRIX

The common identification circuit consists of two 10 × 10 matrices of, for example, rectifiers (see Fig. 13), one matrix representing all combinations of thousands and hundreds and the other matrix all combinations of tens and units. Each subscriber's line circuit is connected to the appropriate input of each matrix. For example, the subscriber's line circuit corresponding to the directory number 1234 would have a connexion to an input at the junction of row 1 and column 2 on the first matrix, and the junction of row 3 and column 4 on the second matrix; the arrival of a meter pulse at this subscriber's line circuit would thus cause outputs from these rows and columns only. Only four sets of ten reading circuits are required, and, for any meter pulse, only one reading circuit of each set will give an output, and these will correspond to the thousands, hundreds, tens and units digits of the directory number of the subscriber being metered.

When the identification and recording cycle is finished a signal is sent to the allotter to release one of the other meter pulses for which a release demand has been received.

Each subscriber's line circuit must be isolated from others having the same thousands/hundreds or tens/units combinations; a cold-cathode diode, as shown in Fig. 12, is suitable for this function. If a 50-volt negative battery potential is applied at the matrix outputs, the two tubes corresponding to a subscriber whose P-wire carries the positive metering potential will have approximately 100 volts across them, causing them, and them only, to strike.

Recording Devices

To avoid loss of revenue the identification and recording cycle must be fast enough to enable the memory circuits in each 1st selector in use to be allotted and restored to normal before another meter pulse arrives. For small low-traffic exchanges a paper-tape perforator would suffice but in exchanges with heavy peak traffic magnetic-tape equipment would be needed. Various forms of recorder are being examined to determine their suitability for this purpose.

Advantages and Disadvantages

The main attraction of the scheme is the extremely small amount of apparatus provided per subscriber's line circuit. A memory circuit is needed with each 1st selector, but only one set of the remainder of the apparatus is provided for each exchange. The overall cost should, therefore, compare very favourably with the costs of other methods.

The output, however, is in the form of a list of subscribers' directory numbers, and for each appearance of any one subscriber's number that subscriber must be charged one unit fee. Before this can be done the list must be sorted, and for this purpose magnetic-drum equipment provided on the basis of one per accounting centre would seem ideal. Its cost would then be shared among all the exchanges served by the centre.

One of the main disadvantages is that "on-demand" reading of a subscriber's meter total is not readily possible; the latest figure available would depend on the frequency with which tapes were sent to the accounting centre and sorted. The implications of this disadvantage are being considered.

CONCLUSIONS

One of the most promising places where electronic techniques may be exploited in electromechanical exchanges is in the process of bringing to account the charges for metered calls. Two basic approaches have been described above: the results of the tests now in progress will decide whether a standard scheme should be introduced.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the help given during the preparation of this article by colleagues in the Telephone Exchange Systems Developments Branch, especially Mr. C. F. J. Hillen.

The equipment shown in Fig. 10 was made and installed by British Telecommunications Research, Ltd., on behalf of the Automatic Telephone & Electric Co., Ltd., and the equipment shown in Fig. 11 was made and installed by Standard Telephones & Cables, Ltd. The photographs of these equipments are reproduced by permission of the respective manufacturers.

References

[1] Post Office Report and Commercial Accounts, 1959–1960 (H.M. Stationery Office).

[2] Francis, H. E. The General Plan for Subscriber Trunk Dialling. *P.O.E.E.J.*, Vol. 51, p. 258, Jan. 1959.

[3] Walker, N. Periodic Metering. *P.O.E.E.J.*, Vol. 51, p. 320, Jan. 1959.

APPENDIX

Allocation of Subscribers' Registers and Information-Coding System

The pure binary code is a very economical way of storing digital information. For example, a meter register of 14 binary digits would store up to 16,383, and 15 digits would store 32,767. Furthermore, the process of adding one to a number stored in pure binary code is extremely simple. On the other hand, the reading of pure binary information, whether for local display of a single total or for accounting purposes, requires quite complicated circuits, since a decimal representation is required. For this reason, binary-coded decimal is proposed for drum metering; with this method each decimal digit of the number is coded separately, in pure binary. Table 2 indicates the pure binary equivalent of the first 31 decimal digits and also their equivalent in binary-coded decimal.

A binary-coded decimal store of 9,999 would, therefore, require 16 binary digits, i.e. one set of four for each decimal digit. A store with the capacity equivalent to that of a 150-type meter, which can count to 99,999, would require 20 binary digits, instead of the 17 required when using the pure binary code. A subsidiary advantage of using the binary-coded decimal method is that the representation of a 4-digit or 5-digit number seen on

TABLE 2
Binary Coding of Decimal Digits

Decimal Digit	Pure Binary Equivalent	Binary-Coded Decimal Equivalent	
0	00000	0000	0000
1	00001	0000	0001
2	00010	0000	0010
..	..	..	..
9	01001	0000	1001
10	01010	0001	0000
11	01011	0001	0001
..	..	..	..
15	01111	0001	0101
16	10000	0001	0110
17	10001	0001	0111
18	10010	0001	1000
19	10011	0001	1001
20	10100	0010	0000
21	10101	0010	0001
..	..	..	..
29	11101	0010	1001
30	11110	0011	0000
31	11111	0011	0001

an oscilloscope is quite readable after a little practice, whereas to decipher a display of the same number in pure binary code would be very tedious.

Layout of Subscriber's Register

Each subscriber's register could be laid out as shown in Fig. 14, which shows that four spare binary cells have been allotted to each register. One or two of these additional binary cells could, for

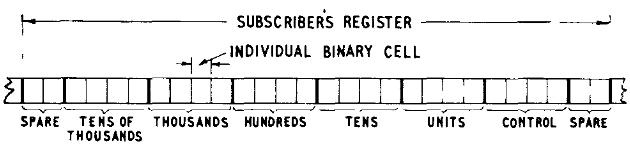


FIG. 14—LAYOUT OF INFORMATION IN SUBSCRIBER'S REGISTER

example, be used to indicate the class of service of the subscriber. Each subscriber's register, therefore, occupies 28 binary cells. Assuming a 9 in. diameter drum, the circumference of which is approximately 28·3 in., 100 subscribers' registers can be accommodated per track, and the length of each individual binary cell is $28{\cdot}3/(28 \times 100) \simeq 0{\cdot}01$ in.

Pulse-Repetition Frequency

The total number of binary cells per track is 2,800 and, therefore, assuming a speed of rotation of 2,000 rev/min, the pulse-repetition frequency (p.r.f.) $= 2{,}800 \times 2{,}000/60 \simeq 93{,}000$ pulses per second.

Layout of Drum Tracks

On the above assumption that 100 subscribers' registers can be accommodated per track, 100 tracks would suffice for a full-sized exchange of 10,000 subscribers. For a drum having a revolution time of 30 ms, each delay track could, theoretically, be shared between 33 tracks of registers. However, in order to keep well within the 1 sec scanning time a suitable figure would be 25 tracks of registers, or 2,500 subscribers. A full-sized exchange would then require four delay tracks. Assuming an additional six tracks are provided for clock timing and miscellaneous purposes, a total of 110 tracks is needed for a scheme of the type shown in Fig. 8(*b*), where an external memory is provided. These tracks could be accommodated on a drum having an axial length of 5 in., the track spacing being 0·045 in.

For the scheme shown in Fig. 8(*a*), assume a temporary store of six binary cells is required for each subscriber's line. This is equivalent to 400 subscriber's lines per track, or an extra 25 tracks for a 10,000-line exchange. The total number of tracks is therefore 135, made up of 100 tracks of subscribers' registers, 25 tracks for temporary stores, four delay tracks, and six tracks for clock timing and miscellaneous functions. These 135 tracks could be accommodated on a drum of 6 in. axial length, the track spacing being 0·044 in.

New Lower-half Wallboards for Pay-on-Answer Coin-Boxes in Public Call Offices

E. H. SEYMOUR, A.M.I.E.E.†

U.D.C. 621.395.721.7:725.16

Coincident with the change of coin-boxes in public call offices to the pay-on-answer type to give subscriber trunk dialling facilities, changes will be made to the directory holders and fitments. A brief description of the new fitments is given.

THE replacement of existing coin-boxes by the pay-on-answer type* in public call offices necessitates changing the present type of lower wallboard. Two new types of lower wallboard will be used, one in the provinces and the other in the London area, and as complete items both are directly interchangeable with existing lower wallboards.

On the two new wallboards the component layout is generally the same; the coin-box is fitted on the left and the directory shelf or holder on the right.

Provincial Wallboard

The type of wallboard required for provincial call offices is illustrated in Fig. 1.

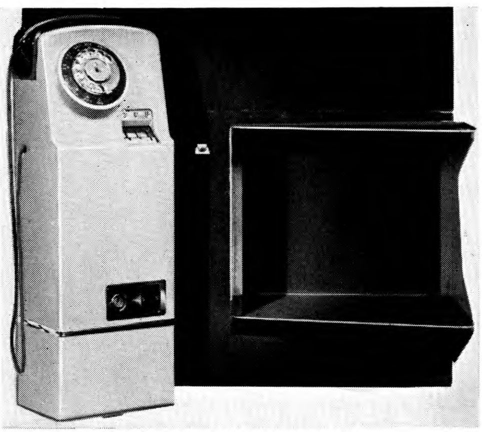


FIG. 1—PROVINCIAL WALLBOARD

The left-hand side of the lower wallboard is fitted with a wedge-shaped steel mounting bracket having its front surface at an angle of 30° to the plane of the wallboard. The coin-box is fixed to the front of the bracket and hence is also inclined at 30° to the wallboard.

A simple 2-shelf container is fitted on the right-hand side, the directories being accommodated on the lower shelf. Parcels, bags, etc., can be placed on the upper shelf and, if necessary, on top of the directories. The container is made of aluminium alloy and is enamelled light grey, but the two shelves have, in addition, sheets of black synthetic resin-bonded paper fixed with adhesive to their upper surfaces. A cigarette rest is fitted between the coin-box and the container.

London Wallboard

The wallboard for London call offices is shown in Fig. 2, the essential difference from the provincial type

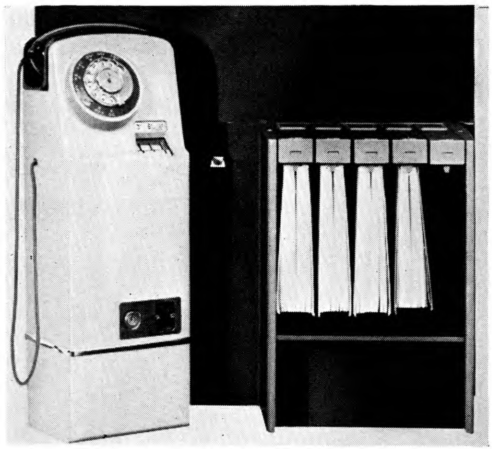


FIG. 2—LONDON WALLBOARD

being the provision of a more elaborate form of directory holder. The top of the holder supports five die-cast aluminimum-alloy directory carriers from each of which a directory is suspended. The carriers are pivoted at a near-centre point along their length so that, when a a carrier is lifted at its front end and rotated through 180°, the directory is in a position to be opened and read. After use the carriers are returned to their normal position (as shown in Fig. 2). The directories cannot be removed from the carriers by members of the public.

When the number of directories provided exceeds five, the additional directories are placed on the lower horizontal shelf. The four directory carriers, numbering from left to right, will always accommodate the four London Postal Area directories A–D, E–K, L–R and S–Z. The fifth carrier will contain the appropriate, or the most appropriate, county directory, depending on the geographical location of the call office. In some London call offices the four London Postal Area directories only are provided; at such call offices the fifth carrier will not be used and provision is made for locking it in position so that it cannot be moved.

The carriers have been made sufficiently wide to allow

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

*BASTOW, F. J., COLLINGWOOD, J. D., NEWELL, E., and PRICE, C. K. The Pay-on-Answer Coin-Box System. *P.O.E.E.J.*, Vol. 51, p. 343, Jan. 1959.

for the growth of each of the five directories to 1,000 pages.

For identification purposes 10 different types of labels are required; four for the London Postal Area directories, five for the county directories, and one designated "Not in Use." Because of this, labels will be supplied and stocked separately and fitted as necessary. Each label is an aluminium plate, printed in black characters with the necessary legend, and having a self-adhesive back normally protected with a pull-off paper cover. To fit the label, the paper back is pulled off, and the label is pressed into a recess on the carrier.

The sides of the holder are aluminium castings enamelled light grey; the directory carriers are natural aluminium and the lower shelf is black.

A cigarette rest is provided as for the provincial wallboard.

A Pay-on-Answer Coin-Box for Subscribers' Installations

E. H. SEYMOUR, A.M.I.E.E.†

U.D.C. 621.395.663.6:621.395.721.1

The pay-on-answer coin-box recently introduced was intended for both public and private installations. A cheaper version of the coin-box has now been designed for use at subscribers' installations.

THE pay-on-answer coin-box,[1] introduced to extend subscriber trunk dialling facilities to coin-box users, was originally intended to be used for both public call offices and subscribers' installations. However, because of the greatly increased cost of this type of coin-box, special attention has been given to providing a cheaper version for subscribers' use to avoid rental charges being uneconomic.

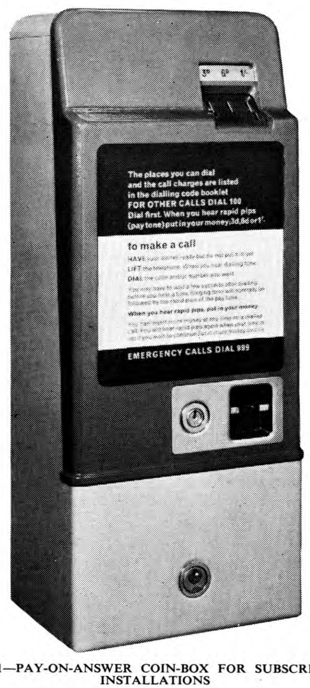


FIG. 1—PAY-ON-ANSWER COIN-BOX FOR SUBSCRIBERS' INSTALLATIONS

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

Many different possibilities were explored, including mechanisms that would accept 3d coins only or 3d and 6d coins only, but for operational and maintenance reasons it was finally decided to use the ordinary 3-coin mechanism developed for public call offices and to obtain economies by other means.

FEATURES OF THE NEW DESIGN

In the new design the mechanism and its outer casing are separate from the telephone instrument (as with the existing type coin-boxes); the notices have been simplified and reduced to one in number and, instead of being mounted separately, the single notice is fixed to the coin-box front cover. Finally, for new installations, a wallboard will not be provided.

Mechanism and Casing

A general view of the new coin-box (Box, Coin Collecting, No. 700) is shown in Fig. 1. Fig. 2 shows the interior of the new casing, with the covers to the mechanism and cash compartments removed. Externally, the appearance, which has been approved by the Council of Industrial Design, is similar to that of the coin-box used for public call offices, but the absence of the telephone handset and dial allows the overall height to be reduced.

The main casing and the cash-compartment cover are mild-steel pressings, whilst the mechanism cover is an aluminium die-casting. The large upper compartment houses the mechanism, and the lower compartment the open-top cash-box. With the covers removed, both the mechanism and the cash-box can be withdrawn from the front of the casing. The complete coin-box is in two-tone grey, the steel casing being in light grey and the mechanism cover in a darker grey, the colour shades being the same as those used for the two-tone grey Telephone No. 706[2].

The instructional notice is printed in black on an aluminium plate, and the surface of the plate is then anodized. The plate is fitted into a recess in the die-cast cover and fixed with an adhesive. The parts of the notice that appear white in Fig. 1 will actually be natural aluminium grey on production models.

The line and telephone-instrument cords and cables enter the coin-box through an aperture at the rear left-hand corner at the bottom of the casing and are taken via a protective chute behind the cash-box to a terminal strip in the mechanism compartment. A jack-and-plug-ended flexible cord from the terminal strip connects with

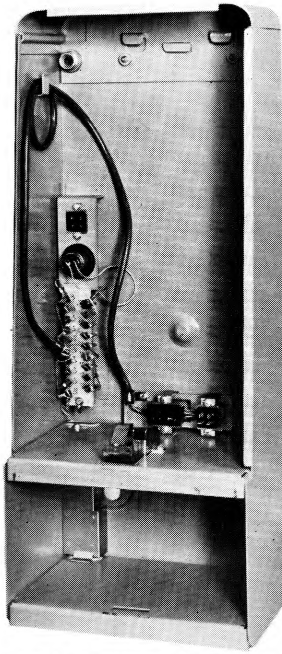


FIG. 2—INTERIOR OF COIN-BOX CASING

the plug and jack on the mechanism and allows the latter to be withdrawn from the case and placed on a table for maintenance attention whilst still in the working condition (Fig. 2 shows a prototype model; production models will have an improved method of terminating the cord on the terminal strip).

The mechanism (not shown) is identical with that used in the public call office type of coin-box, and the locks to both the mechanism and cash compartments are the same as those already in use on existing type subscribers' coin-boxes.

Telephone Instruments

The associated telephone instruments will be of the 700-type, and, because the coin-box is wall mounted, the telephone will normally also be a wall-mounted type. This arrangement may not, however, be desired at all installations, and customers can have a table telephone if they choose. The associated telephone can be supplied in any of the colours in the 700-type telephone range, but if a colour other than black is requested, the current extra connexion charge for a coloured telephone will apply.

Until the final design of the wall-mounted 700-type telephone is in production, the wall telephones used will be the interim type.[3]

Extension-Plan Working

Extension-plan working with coin-boxes is in general only applicable to subscribers' installations, and the separation of the telephone from the coin-box in the new design facilitates the provision of extension plans, since the necessary press-buttons can be provided as standard fitments on the telephones. Most types of extension plan can be used with the new coin-box.

The single-button and 4-button 700-type telephones,[4] of either the wall-mounted or table versions, will provide for all coin-box extension plans with the exception of Plans 5A and 7A. For these two extension plans, a Telephone No. 706 mounted on a plinth[5] will be used, and this combination will be available only as a table instrument.

Elimination of Wallboard

With the existing type coin-boxes, a subscriber's installation requires a coin-box, a wall-mounted table-telephone and either two or three notices and notice frames. To make a neat and tidy installation, this miscellany of components is mounted on a wallboard. With the new design the elimination of separately-mounted notices plus the fact that the telephone may be a table type makes the wallboard superfluous. Hence, for all new installations, the wallboard will be dispensed with, and the coin-box and the telephone, if a wall-type instrument, will be fixed directly to the wall. As the position of the telephone is not fixed in relation to the coin-box, with this arrangement the telephone may be placed to the left or right or below the coin-box to meet the customer's wishes.

ACKNOWLEDGEMENT

Appreciation is expressed to Associated Automation, Ltd., the development and liaison manufacturers for the new coin-box casing.

References

[1] BASTOW, F. J., COLLINGWOOD, J. D., NEWELL, E., and PRICE, C. K. The Pay-on-Answer Coin-Box System. *P.O.E.E.J.*, Vol. 51, p. 343, Jan. 1959.

[2] SPENCER, H. J. C., and WILSON, F. A. The New 700-Type Table Telephone—Telephone No. 706. *P.O.E.E.J.*, Vol. 52, p. 1, Apr. 1959.

[3] Trial of a New Type of Wall Telephone. *P.O.E.E.J.*, Vol. 53, p. 55, Apr. 1960.

[4] SPENCER, H. J. C. A Table Telephone with Four Push-Button Keys—Telephone No. 710. *P.O.E.E.J.*, Vol. 53, p. 190, Oct. 1960.

[5] 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 Experimental Electronic Director—Final Results of the Field Trial

U.D.C. 621.395.341.7:621.395.345

THE experimental electronic director[1] was built in 1950 and put into public service at Richmond (Surrey) exchange in 1952. The equipment consisted of a single translator serving six registers. The design was based on the use of cold-cathode tubes as storage devices with thermionic valves used as multivibrators, trigger circuits, etc. The equipment has now been recovered because the space it occupied was required for S.T.D. equipment.

The performance of the equipment during the first two years has been described in a previous article.[2] The final results of the trial are shown in Tables 1 and 2, which may be compared with the tables of the earlier article. Table 1 shows the fault liability of the different sections of the equipment, e.g. registers and translator, and indicates that, although the number of faults per year fluctuated as a result of thermionic-valve behaviour, a general trend towards a low failure rate is apparent. The failure rates of individual components are shown in Table 2; they are expressed as the number of faults/100 components/year, for each of the seven annual periods

[1] HERON, K. M., BAKER, H., and BENSON, D. L. An Experimental Electronic Director. *P.O.E.E.J.*, Vol. 44, p. 44, Oct. 1951.
[2] BAKER, H., and GEE, J. H. Experimental Electronic Director. *P.O.E.E.J.*, Vol. 47, p. 197, Jan. 1955.

TABLE 1
Faults on Each Item of Equipment During Successive Annual Periods

Item of Equipment	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Sixth Year	Seventh Year	Total for Trial
Translator	8	7	19	11	6	6	1	58
Register 1	25	2	4	5	1	1	0	38
Register 2	1	1	5	3	0	1	0	11
Register 3	18	2	1	3	0	1	2	27
Register 4	12	2	6	7	0	1	3	31
Register 5	15	2	4	2	0	0	0	23
Register 6	11	3	2	2	1	0	0	19
Power	3	6	12	7	3	3	1	35
Total Faults	93	25	53	40	11	13	7	242

TABLE 2
Component Faults/100 Components/Year

Item	Number of Components	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Sixth Year	Seventh Year
Thermionic Valves	282	3·9	2·8	5·3	7·8	1·42	1·42	1·06
Cold-Cathode Triodes	750	4·4	0·27	0·53	0·27	0	1·33	0
Cold-Cathode Diodes	932	1·2	0·11	0·32	0·43	0	0	0·18
Resistors	5,300	0·04	0·02	0·09	0·09	0	0	0
Capacitors	2,700	0·26	0·04	0·04	0·04	0	0	0·07
Rectifiers	342	1·8	0·9	0·58	0	0	0	0·29
Valveholders	1,050	0·29	0	0	0	0·09	0	0
Tags	15,000	0	0	0·007	0	0	0	0
Soldered Joints	35,000	0·02	0·011	0·009	0·0028	0·0086	0·0086	0·0086
All Components, Including Soldered Joints and Tags	61,356	0·15	0·041	0·032	0·065	0·018	0·021	0·0115
All Components, Excluding Soldered Joints and Tags	11,356	0·6	0·133	0·33	0·25	0·07	0·083	0 045

since the start of the trial. Where the number of components of a particular type was not sufficiently large to warrant separate analysis, a general classification of faults and components has been used, e.g. the thermionic-valve figures include twin-triode valves of two types and an r.f. pentode, CV138. There was no tendency for the fault rate of any component to increase as the trial proceeded although, at the end of the trial, many of the components were more than 12 years old. Furthermore, towards the end of the trial, many of the components were checked to determine whether their values had changed sufficiently to affect the performance of the equipment. It was found that component values had changed very little and all components checked were still within tolerance.

The experimental director was the first electronic switching equipment to be installed and used in an exchange anywhere in the world. Representatives of most of the countries of the world visited the installation during the field trial period and, because of the equipment's historical interest, the recovered translator and one register rack have been installed in the museum at the Central Training School at Stone.

The help and co-operation given by the Telephone Manager of South West Area, London Telecommunications Region, and his staff during the period that the equipment has been in service at Richmond are gratefully acknowledged.

F. J. E.

A Spectrum Analyser for the Frequency Range 25–140 Mc/s

U.D.C. 621.317.75.029.62

AN interesting item of measuring equipment developed at the Backwell Laboratory of the P.O. Research Branch is a spectrum analyser, or panoramic receiver, intended primarily for the examination of relatively broadband signals. The signals under examination are displayed on a cathode-ray tube, the horizontal axis being used for frequency and the vertical axis for amplitude

The spectrum scanned is continuously adjustable both as regards centre frequency and width, the former in the range 25–140 Mc/s and the latter up to at least ±25 per cent of the centre frequency. Thus, a broad frequency band can be monitored, or any desired part expanded for relatively detailed examination. Brilliance-modulated frequency-markers can be introduced on the trace at intervals of either 2 or 10 Mc/s.

Cover removed to show 450 kc/s i.f. amplifier and deflexion amplifiers

SPECTRUM ANALYSER FOR THE FREQUENCY RANGE 25–140 MC/S

Alternative nominal bandwidths of 7 kc/s or 35 kc/s are provided, and corresponding standards of resolution are realizable for scanning ranges up to about 250 kc/s and 6 Mc/s respectively. For still wider scans the available resolution gradually decreases, reaching about 100 kc/s effective bandwidth with a scan of 60 Mc/s.

For the examination of component amplitudes, a choice of linear or logarithmic scale is provided for the vertical deflexion. Using the logarithmic scale a range of just over 30 db can be displayed directly, but a switched attenuator can be used to extend this range. Provided that the input signal level is adequate and that the frequency spacings are not too small, sideband components can be displayed and measured down to some 60 db below the unmodulated carrier level. There are, however, some restrictions due to intermediate-frequency and image responses in narrow bands around 30 and 29·1 Mc/s.

The instrument, a photograph of which appears here, is housed in a transportable cabinet 19 in. high, 11 in. wide and 24 in. long. It is a.c. mains operated and weighs 68 lb.

Although this spectrum analyser was developed initially for the examination of signals in intermediate-frequency sections of broadband microwave radio links, it has many other applications. For example, it can be used to study the spectra of television transmissions or to search a wide frequency band for interfering or illicit signals. Its maximum frequency can readily be extended by the addition of suitable frequency-conversion units, and it has already been used in selective-fading and other investigation at frequencies around 900 and 4,000 Mc/s.

R. W. W.

Use of Phosphorescent Code Marks in Automatic Letter-Facing and Sorting Machines

C. F. FORSTER, B.Sc., A.R.I.C.†

U.D.C. 535.37:681.178

A range of new organic phosphors has been developed. These phosphors, which are cheap and efficient, make possible the use of phosphorescent code marks that can be printed on postage stamps and on envelopes or cards. Such code marks play an essential part in automatic letter-facing and automatic letter-sorting processes. By using phosphors sensitive to selected wavebands of ultra-violet light, interference between the code marks required for the two operations of facing and sorting can be avoided. The problems of applying phosphorescent code marks to envelopes are also discussed.

INTRODUCTION

AUTOMATIC letter-facing machines[1] and letter-sorting equipment[2,3] are now undergoing field trial. Both of these types of device depend for their operation on their ability to recognize a distinctive feature on each item of mail. For facing letters the postage stamp is the feature that the machine is required to recognize, while for automatic letter-sorting the machine has to determine the destination of the letter by translating a code that is marked on the envelope.

Many possible methods that would enable stamps to be recognized and the necessary code marks to be applied to envelopes have been investigated, but the most suitable method has been found to be the use of certain new phosphorescent materials. The considerations that lead to their adoption and the methods of applying them to stamps and envelopes are described in the following paragraphs.

AUTOMATIC LETTER-FACING

The automatic facing of envelopes and postcards can be carried out most easily if the machine can recognize the presence of the postage stamp, which in most instances is affixed in the top right-hand corner of the envelope. The automatic letter-facing machine installed at Southampton functions on this principle. Letters without a stamp of any kind are rejected by the machine and are dealt with later by manual methods.

In addition to being able to recognize the stamp so that all the letters can be automatically faced the right way round, it is also convenient at the same time to be able to separate second-class mail from first-class mail.* This requires some form of distinctive marking on the twopenny stamp that the machine can recognize.

Many foreign countries also have a cheaper rate for local letters, and in those countries such letters could also be advantageously separated at this stage.

In the machine installed at Southampton the envelopes are carried along by belts in single file and are examined along the bottom edge, back and front, for the presence of a stamp. If no stamp is detected the envelope is diverted along a "twist" path and inverted. It then rejoins the main stream and passes a further scanning stage to determine whether the envelope bears only a twopenny stamp or whether it carries stamps of other denominations. Electronic analysis of the resultant signals determines the collecting point to which the letter is conveyed. Stamps incorrectly positioned on the envelope could cause it to be mis-sorted, but fortunately this is not a common occurrence.

STAMP RECOGNITION

Five physical properties of matter that could be used to facilitate the recognition of stamps and also to distinguish between different denominations have been examined.

Colour Detection

It is possible to detect in several ways stamps printed in bold solid colours that make a good contrast with the envelope, e.g. by the use of suitable photocells and filters. Pale colours and neutral colours such as grey are difficult to detect,‡ and coloured envelopes that reduce the contrast with the stamp also cause failures.

If it is also desired to recognize, by colour, any particular denomination, such as the present brown twopenny stamp used for second-class mail, further difficulties arise. In addition, to avoid segregating mail bearing a twopenny stamp used together with other values to make up the first-class rate, the machine must be able to recognize other colours as well.

Simple photocell arrangements are much inferior to the eye in detecting colour differences and, unlike the eye, are hampered rather than assisted by the pattern on the stamp. Highly-selective filters must therefore be used, and these unfortunately absorb most of the incident light, so that the net amount reaching the photocell is quite small.

Conducting Materials

The disadvantages just described can be overcome by other methods of detection which depend on giving the stamp a unique property that makes it impossible to confuse the stamp with any other part of the envelope and also allows the signal to take the form of a simple code to facilitate the separation of one class of mail from another. This can be effected by printing one or more stripes of some sensitive material on the face or back of the stamp to form a code. One class of sensitive materials consists of electrical conductors. These can take the form of conducting salts, metallic strips or some such material as carbon black or graphite. Metallic strips such as are used in banknotes would be easy to detect, but they would not be suitable for use in postage stamps and are rather costly. Water-soluble salts would be liable to migrate throughout the paper and might affect the printing inks.

It was therefore decided to try out a coating of conducting graphite for the first trials with the experimental facing machine at Southampton. The coating consisted of one or two vertical stripes of colloidal graphite 1 mm

† Mr. Forster was at the Post Office Research Station at the time this article was written; he is now in the Test and Inspection Branch, E-in-C.'s Office.

* First-class mail consists of sealed letters, postcards and packets for which postage has been paid at the full rate; second-class mail consists of printed papers and secondary matter for which postage has been paid at a reduced rate.

‡ The West Berlin Postal Administration recently changed the colour of their 8-pfennig stamp from grey to deep orange-vermilion because of this difficulty.

wide and 1·5 cm apart, printed, partly for aesthetic reasons, on the backs of the stamps.* The conducting stripes would have been easier to detect on the face of the stamp but would have been more liable to damage. In fact it proved to be quite feasible to detect them through the paper by using high voltages.

Several technical problems in connexion with printing the conducting lines had to be overcome. Any normal oil-based ink medium would have the effect of an insulant sealing off each particle of graphite from its neighbour, so it was necessary to dispense with such media entirely and rely on the affinity of fine graphite particles for paper fibres. The lines were therefore printed from a dispersion of colloidal graphite in a volatile solvent only. Complete removal of the solvent was achieved by infra-red drying followed by calendering to ensure close packing of the particles. The subsequent application of gum served to protect the lines from damage by abrasion. However, paper shrinkage made accurate registration of the printed stamp image with the graphite lines a factor to be carefully watched, and some wastage was inevitable.

The detection of stamps having graphite lines was eventually very successful. Metallic enclosures such as pins could give false signals, and breaks in the graphite lines could cause failures in detection, but the main reasons for considering alternative methods were the high cost of printing due to the many extra operations involved and the aesthetic objections to black lines on the stamps.

Magnetic Materials

Inks containing magnetic materials such as magnetic oxide of iron are now on the market, and have proved to be satisfactory for coding such articles as bank cheques so that they can be automatically sorted by a suitable machine. The system would not be so satisfactory for mail because letters often consist of several layers of paper, and this makes them slightly curved, bulky and soft compared with a single uniform-sized sheet of paper such as a cheque, which sometimes makes detection uncertain.

Fluorescent Materials

Another method of detection, involving the use of fluorescent materials, has been investigated. Fluorescence is the phenomenon whereby a body irradiated by radiations of certain wavelengths absorbs these radiations and emits other radiations of longer wavelengths. An example of this could be a body which, when illuminated by blue light, emits a green fluorescence. A body illuminated by ultra-violet light that is invisible to the human eye but which causes the body to glow visibly by emitting light of wavelengths which lie within the visible region provides a more striking example. Fluorescent materials that emit a blue fluorescence are commonly added to washing powders to give an impression of brightness or whiteness to laundered articles.

The detection of fluorescent marks on postage stamps has been made more difficult owing to confusion with envelopes made from paper containing fluorescent brighteners.†

Phosphorescent Materials

Some materials possess the power to continue emitting radiations after the exciting "light" has been switched off. The duration of afterglow varies for different materials, ranging from minute fractions of a second to many hours. This phenomenon is known as phosphorescence and has many practical applications in everyday use. The screen of a television tube is coated with a phosphorescent material that glows when bombarded with electrons from the cathode. The afterglow must be of short duration in this instance because the screen is scanned many times a second; a long persistence would result in several succeeding images being superimposed.

The phosphors used in the electrical industry are inorganic hard crystalline substances of a particle size that makes them unsuitable for use in printing inks for normal printing methods. Their preparation requires considerable care and knowledge, and consequently they are too expensive to be used once only as required for postal purposes. Fortunately, certain organic substances have been developed to make phosphorescent materials that are eminently suitable for postal purposes.[4] These materials are made by a chemical combination of formaldehyde and certain decomposition products of urea, of which cyanuric acid is the most important. The product is non-radioactive, non-toxic, cheap and easy to manufacture. It is soft and friable and can be ground to a very fine powder, for incorporation in printing inks, without significant loss of phosphorescent power. It is translucent and thermoplastic so that when it is printed on postage stamps or envelopes it can only be seen with difficulty, if viewed in normal light, and cannot obscure written or printed information already on the envelope.

The material is not hygroscopic, but it is slightly soluble in water so that severe wetting could temporarily impair the phosphorescence and might eventually wash out the active material. This can be prevented by the use of suitable binding materials in the ink. Any temporary loss of phosphorescent power due to wetting is completely restored on drying.

It is possible to make an insoluble material resembling a commercial urea-formaldehyde resin by modifying the ingredients and the method of manufacture. This material, however, is a less efficient phosphor and is difficult to grind owing to its tough horny nature. The phosphorescent power of the cyanuric acid-formaldehyde phosphor is rather weak, but the material can be modified and the brightness of the phosphorescence considerably enhanced by the addition of small quantities of other substances during the course of manufacture. By this means, phosphors having different optical properties can be prepared. These differences can be in the colour of the emitted light, in the duration of the afterglow or in the wavelengths of the ultra-violet light used to excite the phosphorescence.

Selective Phosphors. Phosphors that emit light of different wavelengths can be selectively detected by a photocell with the aid of narrow-waveband filters, but such systems absorb so much of the total emission that the remainder may be insufficient to give a satisfactory response in the photocell. It has been found to be more practical to use phosphors that can only be excited by

* See Fig. 8 of "Mechanization of the Initial Stages of Processing Mail," Vol. 53, p. 16, Apr. 1960.

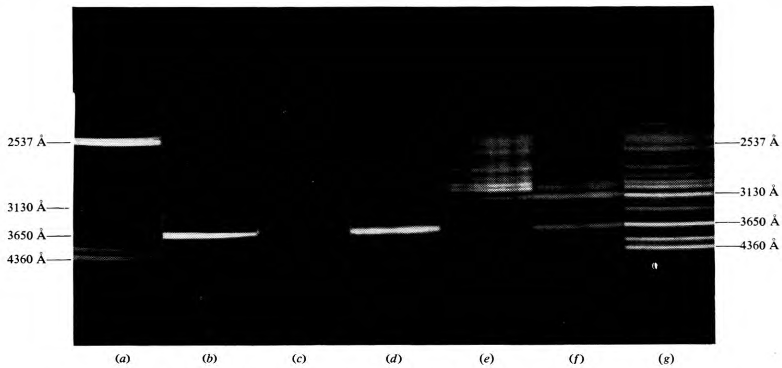
† The Federal German Post Office is still experimenting with this method of detection, and in 1960 issued a series of postage stamps printed on paper impregnated with a yellow-emitting fluorescent substance. No information is available on whether these stamps have been successful but it is assumed that the Federal German Post Office are relying on some kind of colour-filter technique to recognize the yellow fluorescence against a background of blue or violet fluorescence.

certain specific wavelengths of ultra-violet light. For example, most phosphors that emit yellow or green phosphorescence can be excited by near ultra-violet light of about 3650 ångström, whilst those that emit a violet-coloured light are often unaffected by this wavelength but can be excited by shorter wavelengths in the 2000–3000 ångström region.

This selective excitability can be utilized in postal sorting by using a violet-type phosphor on the stamp and a yellow-green type for the address-code marks. The code marks can then be excited by an ordinary black-bulb ultra-violet lamp* which does not excite the stamp phosphor.

Fig. 1 shows the spectra of several sources of ultra-violet radiation. Alongside are shown the actual mercury lines from these sources that caused e[illegible]ior of the different phosphors. These lines were o[illegible]ined by passing the light through a quartz prism and [illegible]rs system and casting the spectral image of the ultra-violet source on to a screen coated with the phosphorescent material that glowed wherever it was sensitive to a particular wavelength. The source was then extinguished and a piece of bromide paper rapidly placed face down on the glowing phosphorescent image. The lines shown on this photograph are therefore those of the source to which the phosphor is sensitive. The actual wavebands of the emitted light are shown in Fig. 2.

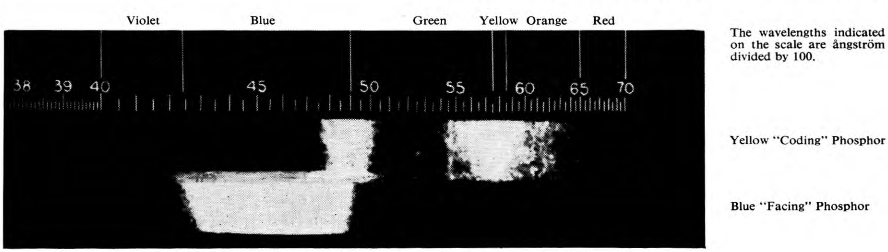
Fig. 3 shows an envelope bearing phosphorescent stamps and code marks photographed in darkness by the light emitted by the phosphor. The camera shutter was synchronized with the switch of the ultra-violet lamp so that as the lamp was switched off the camera shutter opened. This cycle was repeated until a sufficiently clear image had been built up on the photographic plate. A cold mercury-discharge tube emitting a wide range of ultra-violet radiations was used to excite both the stamp and code phosphors simultaneously. If a



(a) Emission spectrum of argon-filled low-pressure mercury lamp
(b) Emission spectrum of high-pressure mercury-vapour lamp with a Wood's glass filter.
(c) The spectral band of source (b) that excites the blue phosphor used for facing letters is too faint to register on the photograph.
(d) Spectral band of source (b) that excites the yellow phosphor used for address coding.
(e) Spectral band of source (g) that excites the blue phospor used for letter facing.
(f) Spectral band of source (g) that excites the yellow phosphor used for address coding.
(g) Emission spectrum of high-pressure mercury vapour lamp with Wood's glass removed.

FIG. 1—SPECTRA OF SOURCES OF ULTRA-VIOLET RADIATION SHOWING THE BANDS THAT EXCITE THE PHOSPHORS

* The normal black-bulb type of ultra-violet lamp comprises a quartz mercury-vapour discharge tube surrounded by an envelope made of "black glass" or Wood's glass, as used for ultra-violet filters. About 95 per cent of the ultra-violet radiation is emitted at 3650 ångström. Without the "black glass" filter the lamp gives a wide range of radiations including the very-short-wave ultra-violet emissions that are very harmful to the eyes.



The wavelengths indicated on the scale are ångström divided by 100.

FIG. 2—EMISSION SPECTRA OF BLUE AND YELLOW PHOSPHORS USED FOR FACING AND CODING

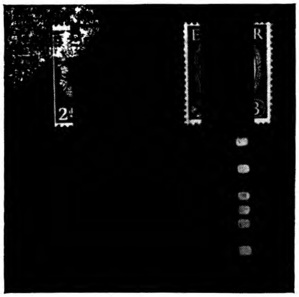


FIG. 3—ENVELOPE BEARING PHOSPHORESCENT STAMPS AND CODE MARKS PHOTOGRAPHED IN DARKNESS BY THE RADIATION EMITTED BY THE PHOSPHORS

"black lamp" emitting 3650 ångström ultra-violet radiation had been used, only the code marks would have been made to glow.

ADVANTAGES OF PHOSPHORESCENT MARKS FOR FACING

The use of phosphorescent marks as a means whereby stamps may be recognized with absolute certainty has the following advantages over other systems:

(*a*) The detection of phosphorescent marks is less difficult and more certain than optical detection of colours or methods of detection depending on the conductivity of graphite lines printed on the backs of stamps.

(*b*) Unlike fluorescent materials, phosphorescent marks can be read in total darkness, so that there is no background light to diminish the signal-to-noise ratio.

(*c*) Phosphorescent marks are not affected by the retention of organic solvents used in the ink or other media and so do not require infra-red drying.

(*d*) Phosphorescent marks are almost undetectable in normal lighting and so do not alter the appearance of the stamp in any way.

(*e*) Since they can be printed on the face of the stamp, phosphorescent marks can be applied in the same operation as the printing of the stamp itself using a 2-colour machine, so that the accuracy of printing (registration) is no problem.

(*f*) Owing to the greater ease of application, phosphorescent marks are cheaper to print than graphite lines.

(*g*) The use of phosphorescent marks (or graphite lines) has the advantage over the use of optical colour-detection methods that the signal is unmistakable and cannot be confused by coloured marks or labels on the envelope.

(*h*) Phosphorescent marks can readily be used in the form of a code to segregate first-class and second-class mail.

APPLICATION OF PHOSPHORESCENT MARKS TO STAMPS

There are several methods of treating stamps with the new material in order to make them phosphorescent.

(*i*) The paper can be impregnated during its manufacture by adding the phosphor powder or its raw ingredients to the paper pulp. With the latter method the material is cured during the drying out of the paper on hot rolls. This method is, however, extravagant, and much material is wasted by passing through the wire mesh on which the paper is formed.

(*ii*) The surface of the paper can be coated with the material by incorporating it with the size.

(*iii*) The phosphor can also be applied to paper by normal printing techniques such as typography, lithography or photogravure. These have the advantage that the phosphor can be applied to specific areas of the stamp, thus economizing in material, and can be arranged to form a code whereby stamps of different values can be distinguished from each other.

Little difficulty has been experienced in formulating a satisfactory ink medium for the phosphor. Certain oils and resins are absorbers of ultra-violet light, but the layer above the phosphor particles is so thin that no appreciable diminution of signal has been observed. In the normal course of events a large part of the medium soaks into the paper fibres, leaving only a thin film coating the phosphor particles.

A solution of polystyrene in toluene or xylene that freely passes ultra-violet radiations makes a satisfactory medium for the phosphor. An aqueous ink using polyvinyl alcohol as the binding agent is also quite suitable and can be used to overprint phosphorescent marks on stamps without causing the coloured ink of the stamp image to run or smudge.

Photogravure is the method at present used to print British postage stamps up to the 1s. 6d. denomination, and the same process is very suitable for applying phosphorescent marks to stamps. The two printing operations can be done consecutively on one printing press so that perfect registration of the two images is automatically achieved. Photogravure has another advantage over other printing techniques in that the amount of ink applied can be easily controlled. The fact that the printed image comprises a large number of discrete dots is of no consequence to a photocell, whereas with graphite lines it is essential that the printed area should be electrically conducting throughout its length.

Assuming that the optimum thickness of ink has been used, the two factors affecting the strength of the signal are the area of the ink surface and the reflectivity or absorptiveness of the layer underneath it. The signal is therefore strongest if the phosphor is printed on plain white paper and is diminished if it is printed over a coloured stamp image that absorbs ultra-violet light and considerably reduces the phosphorescence. The nature of the design of the stamp itself thus becomes a critical factor. Stamps printed in almost solid colour, such as the present ½d., 1d., 1½d., and 2d. stamps, absorb so much of the radiation that the strength of the phosphorescence is seriously diminished. On the other hand, stamps having a generally lightly-toned background such as the present 4½d. are unlikely to diminish the strength of the phosphor by more than 50 per cent. Apart from introducing new designs having specially sited white or lightly toned areas, the most satisfactory procedure is to utilize the uncoloured margins provided for the perforations. It occasionally happens that stamps are perforated off-centre, so that when the stamps are separated one margin is oversize and the other almost non-existent. However, except on rare occasions there will usually be enough margin left to give a signal that the photocell can recognize.

ADDRESS CODING

Before a machine can sort mail it must be able to read the address on each envelope or card. As no machine has yet been designed that is able to decipher all the varieties of human handwriting, the address must first be transcribed by an operator into some form of pattern that can be read mechanically. Such patterns usually take the form of arrangements of dots which are either punched out or printed by some suitable method. Punching-out would be quite unacceptable for mail, while if a printing technique is employed it must be of such a character as not to interfere with other information on the envelope. The printed code must also be so distinctive itself that other marks on the envelope cannot be mistaken by the detecting machine for part of the pattern or code.

The simplest solution is to use some kind of ink that has a distinctive property, such as fluorescence or phosphorescence. Phosphorescence is obviously preferable, since so many envelopes are themselves fluorescent. Any confusion with phosphorescent stamps can be avoided by using, for address-code purposes, a phosphor which can be excited by a selected waveband of ultra-violet light that does not excite the stamp phosphor significantly.

The present policy is to apply the coding to the address side of the envelope, folder, or postcard to avoid any risk of obscuring information on the reverse side of postcards. As the amount of space available on the face of an envelope is so variable it is desirable to keep the coding area as small as possible.

In the automatic letter-sorting equipment at Luton[2] a maximum of 14 code marks is used. Each mark is $\frac{1}{8}$ in. × $\frac{3}{32}$ in. and the marks are spaced at $\frac{1}{8}$ in. centres. The coded envelopes are fed into the automatic sorting machine where they pass under an ultra-violet lamp fitted with a Wood's glass filter, which causes the code marks to be excited to phosphorescence without affecting the stamp. The envelopes then pass to a photo-cell detector which reads the time intervals of the light and dark areas and operates the sorting machinery accordingly.

APPLICATION OF PHOSPHORESCENT CODE MARKS TO MAIL

The printing of phosphorescent marks on stamps is a simple matter compared with the complexity of code marking envelopes. An envelope enclosing a letter is an unsatisfactory object on which to print because of the resilience of the folded contents and the unevenness of the surface. Also, the thickness of the phosphor mark must be greater than that normally used in typographic printing with a carbon ink, if the brightness of phosphorescence is to be satisfactory. The chief marking techniques that have been considered are as follows.

Lithography

Lithography cannot be adapted to print a different code at each strike.

Recess Printing and Photogravure

Recess printing and photogravure permit the transfer of an adequate thickness of phosphor to the paper, but in order to ensure a good pick-up of ink from the recessed cells considerable pressure must be applied, and this cannot be done very satisfactorily with a soft resilient object such as a letter. Such a method is satisfactory for printing phosphorescent lines on stamps because the required pressure can be used and the printing of the phosphor can be done concurrently with the actual printing of the design in a 2-colour printing press.

Typography

Only thin films of ink can be applied by letterpress or typographic printing because the printing surface stands proud, and under the pressures used any surplus ink is squeezed out at the edges, leaving an irregular outline. A precise adjustment of the printing pressure is impossible owing to the variations in thickness and softness of envelopes. It is therefore necessary to use resilient material such as rubber for the printing heads. This places a drastic restriction on the type of ink which may be used. Hydrophilic media, such as glycerol, are generally used, but such inks would be useless for phosphorescent materials owing to their affinity for water.

A more practical approach might be to print the code on a separate paper tape which could afterwards be stuck on the envelope. Such a tape could be printed under ideal conditions and be of such a character that the ink could be rapidly absorbed, so that the marks would not smudge.

Spraying

Among the less orthodox methods considered, the spray-gun technique would overcome all difficulties with respect to the uneven surface receiving the ink, but there are considerable difficulties involved in maintaining very fine jets free from blockages if they are only operated intermittently.

Dry Scattering

In the powder-scattering technique used for printing coarse particles such as "glitter" on Christmas cards, the marks would be printed initially with a tacky varnish on which is scattered the phosphor powder. A useful amount of phosphor can be applied by this method, but otherwise it has no important advantages.

The Punched-Disk Process

The punched-disk process involves punching-out disks from a paper or plastic tape coated with the phosphor on the top and a contact adhesive on the under side. The mode of operation would be for the punches to cut the disks and press them against the envelope to which they would adhere. The problem of handling a tacky adhesive tape can be overcome by dusting the tacky side with chalk so that it does not adhere to surfaces until it is pressed against them to force the adhesive to flow through the particles and thereby cause adhesion.

Maintenance of the punching machinery would be a major problem, because the tolerances must be fairly fine and there is some risk of the adhesive material working its way up the punch until it jams in the channel. The cost of the tape is likely to be comparable to that used in the hot offset process described later and which, on balance, shows greater prospects of success.

Typewriter Ribbon

The amount of ink transferable from a fabric tape is insufficient for phosphorescent code marks, and replenishment of the relatively large denuded areas by an ink containing a solid pigment is not sufficiently satisfactory to make such a tape usable more than once.

Hot Offset

The hot offset method provides an answer to most of these problems and is used to mark soft materials such as leather, awkwardly shaped articles such as bottles, or materials like polythene that do not readily accept the conventional types of ink. The essential feature of this technique is that the marking material used is solid at normal temperatures, is applied molten, and sets almost instantaneously.

A backing of non-fibrous cellulose foil is coated with the material together with a low-melting-temperature release agent. The printing process consists of laying the foil face down on the object to be printed and applying the heated type or design to the back. The type is heated electrically and, when it touches the back of the foil, it melts the marking material, which adheres to the object to be printed. On removing the hot type and the foil, the marking material remains attached to the object in the shape of the type or design. Heavy pressure is not required in this method of printing, heat-softening of the marking material being all that is required to cause its transfer to the object.

Transfer of a design without heat can be achieved by the above means if a special pressure-sensitive formulation for the marking material is used, similar to those in the "carbon papers" used for making duplicate copies with a typewriter. However, for code marking envelopes the hot transfer method requiring only slight pressure to transfer a thick film to the paper is preferred.

In the automatic letter-sorting equipment in use at Luton, hot rods are brought into contact with the back of the foil by means of solenoids. The time of impact is only 100 ms, but sufficient heat is transferred in this time to cause the coating to be released from the foil and adhere to the envelope. A further effect of the heat is to cause the phosphorescent resin to soften, giving a more uniformly luminescent surface and also increasing the translucency of the transferred film, so that it does not obscure any writing or printing underneath it.

A great advantage of this method is the instantaneous hardening of the spots after removal of the hot rod, so that envelopes can be stacked immediately without smudging.

In the majority of code combinations not more than six or seven rods out of a total of 14 would be used at a time. This means that, where there are blank spaces in the code instead of spots, the material on the foil is not used and must be wasted. It is unlikely therefore that more than one-third of the available material will be utilized. The cost of the phosphor foil is sufficiently high to make this wastage a significant economic factor. Some form of re-coating technique may be possible but this has not been developed yet.

RE-CODING

Occasions will arise, because the operator has made a mistake or the envelope has been redirected or re-used, when it will be necessary to obliterate unwanted code marks in some way. Inhibition by chemicals is undesirable because those that would be most effective would probably damage the envelope or its contents, and unless they could be completely removed afterwards would also affect the new code if superimposed. Certain fluorescent materials can be volatilized by heat and so removed, but the amount of heat required to do this would be unsafe to use on mail.

A more practical method that might be adopted is physically to obscure the unwanted code by coating it with an ink or paint that will prevent the ultra-violet light from reaching the phosphor, or more simply to cover it with an adhesive paper label on which the new code can be printed. Such a paper label can be quite translucent so that ordinary printing or writing would not be obscured, and yet by impregnation with a suitable absorber of ultra-violet light the label would effectively prevent the exciting radiations from penetrating to the unwanted code marks beneath it.

CONCLUSION

The new phosphorescent materials described have been undergoing practical trials now for over a year under actual working conditions at Southampton and Luton.

The facing experiments at Southampton have been highly successful. However, there is still room for improvement in the brightness of the phosphor under damp atmospheric conditions. It is hoped that this can be achieved by the use of a newer and brighter phosphor that will permit the proportion of binding medium to be increased and so give greater protection to the phosphor pigment.

The coding experiments at Luton have also given complete satisfaction from a technical point of view. However, it does not seem that the hot offset method of applying the code marks will ever be cheap enough for general use, and the development of a satisfactory alternative method is now of immediate concern. One possibility that is being examined is the use of a phosphor-coated tissue that can be transferred by cold impact, like the familiar "carbon paper." Such tissues are relatively cheap to produce, and their use would obviate the need to use heated pins with their attendant problems of lubrication and maintenance.

[1] COPPING, G. P., GERARD, P. S., and ANDREWS, J. D. Mechanization of the Initial Stages of Processing Mail, Part 2—Automatic Facing and Stamp Cancellation. *P.O.E.E.J.*, Vol. 53, p. 12, Apr. 1960.

[2] PILLING, T., and GERARD, P. S. Automatic Letter Sorting—The Luton Experiment. *P.O.E.E.J.*, Vol. 54, p. 31, Apr. 1961.

[3] PILLING, T., and HORROCKS, P. Coding Desk and Code-Mark Reader for Use with Automatic Letter-Sorting Machines. *P.O.E.E.J.*, Vol. 54, p. 122, July 1961.

[4] British Patent No. 870504.

The Closing of the Central Telegraph Office

E. J. C. O'BRIEN†

U.D.C. 621.394.722:725.16

The Central Telegraph Office, once the largest telegraph office in the world, will be closed in 1962. The history of the building itself, which was opened in 1874, and the many technical and operational changes that have taken place within its walls are briefly reviewed.

AFTER nearly 90 years on its present site in St. Martin's-le-Grand in the City of London, the Central Telegraph Office (C.T.O.) is soon to be closed and the building demolished. Because of inevitable changes in techniques the building has now outlived its original purpose as a central office. Its closing will mark the end of an epoch during which the work of the C.T.O. not only contributed to the science of communications but also, because of the knowledge gained by the application of the principles of electricity to many and varied systems of telegraphy, exerted an influence in the wider sphere of electrical engineering.

The Institution of Electrical Engineers was founded in 1871 as the "Society of Telegraph Engineers," many of whose members had a technical interest in the C.T.O. This interest continued through the years spanning the period of the single-needle, the double-plate sounder and morse key, the many variants of machine telegraphy and finally the teleprinter and the voice-frequency (v.f.) channel.

This brief review recalls some of the many changes that have occurred during the life of a building that has dominated the telegraph scene for so many years.

Due to a variety of causes, including the effects of several severe winter storms on the overhead line networks, there was, in the late 1860s, considerable public dissatisfaction with the service being provided by the existing telegraph companies. The Government was pressed to place the telegraph service under the control of the Post Office and, in 1869, after exhaustive negotiations, Mr. Gladstone announced agreement with the telegraph companies for their purchase. The sum paid was £5½ million and the Postal Telegraph Department took over the head office of the Electric Telegraph Company in Little Bell Alley off Moorgate. The name of the alley was changed to Telegraph Street and the letters TS became the call sign of the Central Office. The rapid growth of business soon rendered the Telegraph Street premises inadequate and the Post Office decided to occupy part of a building then in course of construction in St. Martin's-le-Grand.

The building was completed in 1874; an additional storey was added in 1884 and the building was enlarged in 1901 and 1902. In 1930 a fifth storey was added, and further changes included the removal of the pneumatic-tube system from the central hall to another part of the building and the conversion of the hall to a lecture theatre, which was opened in 1935 as the King George V Hall. It seated 325 and was equipped for film projection and was also used for lectures and exhibitions. Fig. 1 shows the C.T.O. as it was in the early 1930s.

The transfer from Telegraph Street to St. Martins-le-Grand figures in the Postmaster-General's report to the Treasury in 1874, in the following terms:

> "At the end of the year the London Central Telegraph Office was removed to the new office in St. Martin's-le-Grand. So well had everything been arranged and so zealously and effectively were the arrangements carried out that no interruptions of any kind occurred; indeed, the provincial clerks were not aware of the change. The great telegraph business which had been conducted in Telegraph Street was on that night as the clock struck 10 taken up without the slightest hesitation or confusion in the new Post Office Building."

Telegraph business flourished in the new central office; traffic assumed definite patterns—metropolitan, provincial, overseas, and press. By far the greatest increase was in press telegrams, which in the year 1890 totalled 5,003,409. The press tariff, however, was so low (2d. per 100 words) that, although it operated only after 6.0 p.m., it virtually represented a form of subsidy to the press by the Post Office.

Cable companies, stock exchanges and branch telegraph offices originated most of the traffic, much of

FIG. 1—THE C.T.O. IN THE 1930s

† London Telecommunications Region.

which was received and re-transmitted through some 40 miles of pneumatic tubes, extending to the Great Tower Street branch office in the east and the House of Commons in the west.

During the period 1890 to 1900 development continued; overhead lines were being put underground and the "wires" (18 B.W.G.* copper insulated with gutta-percha to an overall diameter equivalent to 7½ B.W.G.) were routed into the C.T.O. in 3 in. cast-iron pipes, 80 wires per pipe. It is also noteworthy that at this time the main source of telegraph power in the C.T.O. was primary cells housed on 2¼ miles of teak shelving in the basement. Approximately 12,150 quart-size bichromate cells were used for heavily-worked and long-distance circuits together with 10,700 large Daniell cells for duplex circuits and for circuits up to 150 miles in length. About 900 Leclanché cells were also in use for lightly-worked circuits, while secondary cells were introduced during this period for the Hughes printing instruments used on Continental lines.

FIG. 2—A SCENE IN THE C.T.O. IN THE EARLY 1900s

Precise timing became increasingly important with the growth of inland and overseas traffic and the C.T.O. became the national and international time-distribution centre, transmitting Greenwich Mean Time which was checked daily by a signal from the Royal Observatory.

In 1889 the Post Office purchased the interests of the Submarine Telegraph Company and, using mainly the Hughes and Baudot systems, operated from the Cable Room 10 cables to the capitals and principal cities of Europe.

At the beginning of this century a multiplicity of systems were in operation: Baudot, Wheatstone, Murray, Hughes and various applications of Morse; in fact nearly all the innovations connected with these and many other famous telegraph names were in use in the galleries of the C.T.O. Short telegraph circuits in London itself, however, gradually gave place to phonogram and telephone-telegram circuits. There was also a trend towards central-battery working and, in the C.T.O., secondary-cell batteries of $\pm$ 40 volts, $\pm$ 80 volts and $\pm$ 120 volts replaced thousands of primary cells.

The C.T.O. had by this time achieved a status of international importance due to its size and world-wide ramifications. At a social function of the Post Office Engineering Department in 1908, the Engineer-in-Chief, Major O'Meara, claimed that the British telegraph service was acknowledged throughout the world to occupy the premier position.

This period and the ensuing few years were indeed the golden age of the C.T.O. The galleries were lofty, with good light from spacious windows. The instrument tables had none of the sleek anonymity of the modern hammer-grey metal cover; every set was individual and very impressive with a prodigious amount of lacquered brass. Sounders, keys, standard relays and indicating needles in elegant Gothic cases contributed to the variety of apparatus (Fig. 2). The whole place was alive with movement, and the hum and clatter created an atmosphere of urgency.

The operating staff included both men and women, in the ratio of about two to one, and a high standard of proficiency in keying morse, in using the keyboard perforator and in reading morse by sight and sound had to be attained. Considerable skill was necessary to operate the various systems at the required speed, especially the Baudot system, for which a 5-unit code had to be memorized in order to manipulate the five piano-type keys and to maintain cadence with the distributor.

The engineering staff were highly skilled mechanics rather than technicians, and had a specialized knowledge of telegraph instruments and the ability to make spare parts by hand. There was great pride of craft amongst them and they established a tradition of craftsmanship that came to be particularly associated with the C.T.O.

With the coming of the First World War, telegraph traffic increased. The Anglo-Russian cable between Peterhead and Alexandrovsk came into use and the Imperial Cable linking the C.T.O. to Halifax, Nova Scotia, was opened in 1917. In conjunction with Canadian land lines to the Pacific Cable it linked Great Britain more closely with Canada, Australia and New Zealand.

After the First World War further technical development took place, notably in the Baudot system, which gradually superseded the Hughes system on Continental circuits. Traffic at this time was approximately 45 million telegrams per year, and there were 4,500 telegraphists, of whom 2,000 were women. Including inspectors, tube attendants and messengers, the total staff was 5,700. The late twenties and the early thirties saw much change in the method of handling traffic. An 18-suit phonogram installation was brought into use and the telephone-telegram gallery, which had access to 680 telegraph offices, dealt with 50,000 messages a day.

The next development, the teleprinter, made the greatest impact of all, changing the appearance and the character of the C.T.O. completely. The Teleprinter No. 3A, a tape-printing instrument, came into use in 1928, while the year 1932 saw the introduction of a page-

* B.W.G.—Birmingham Wire Gauge: 18 B.W.G. = 0·049 in. diameter and 7½ B.W.G. = 0·172 in. diameter.

FIG. 3—THE C.T.O. AFTER REBUILDING

printing machine (the Teleprinter No. 7). The appearance of the galleries was changing; the array of brass and the impressive Morse and Baudot instruments gave way to the now familiar teleprinter on double-sided tables with a centre vee-band feeding direct to a common distribution area. The v.f. channel was also developed during this period and gradually became universal. The channel-ends were wired through jacks in the galleries to give flexibility and to facilitate the interconnexion of circuits. Picture transmission to newspaper offices was introduced and a printergram section was opened.

The gathering war clouds of 1938 put a stop to further changes and, when war came, the inside of the great building was completely destroyed by fire in one of the heavy air raids of 1940.

Rebuilding commenced, but it was considered unsafe to utilize the outside structure higher than the first floor (Fig. 3), although another storey was added later. The new equipment, installed on a teleprinter point-to-point basis with 210 bothway phonogram positions and five concentrator switchboards, was opened for service in June 1943 and escaped the hazards of the latter period of the war.

In 1945 a manually-switched system replaced the inland point-to-point network and in the following year two prototype switchboards were installed to re-open the telex service to Europe, using exclusively telegraph channels. By 1956 the manual switching of public telegraphs was replaced by an automatic system and 90 teleprinter positions connected to this system were installed in the C.T.O.

The new manual telex service expanded rapidly and plans were put in hand for this also to become completely automatic. In the interim period telex growth necessitated practically continuous installation of additional telex switchboard positions in the C.T.O., and the remarkable total of 242 positions dealing with approximately 2,300 subscribers and 1,200 trunks was reached. Telegraph test-desks were introduced and electronic distortion-measuring sets came into use. The peak 80 + 80-volt load had, by this time, reached 360 amp—a far cry from the output of the original primary-cell batteries.

In 1960 the running down of the historic building commenced; the Cable Room with its radio circuits, multi-destination press and European point-to-point circuits was transferred to Electra House. By December 1960 all London and Home Counties telex subscribers had been transferred to the new automatic telex exchange in Fleet Building‡ together with the major portion of the incoming continental traffic, thus enabling 82 inland telex switchboard positions in the C.T.O. to be closed. The international telex exchange, comprising 160 positions, remains to handle outgoing overseas traffic, but this exchange will also gradually close down as international subscriber-to-subscriber dialling is made available during 1961. Only a few positions will then be left in service to deal with assistance traffic and directory inquiries. These services and also the whole of the public telegraph instrument-room services will be removed to Fleet Building in 1962. When this is done the last link will be broken and a momentous chapter of telegraph history will come to an end.

‡ WILCOCK, A., and BAXTER, E. C. Fleet (London) Automatic Telex Exchange. *P.O.E.E.J.*, Vol. 54, p. 53, Apr. 1961.

Book Received

"Examples in Electrical Calculations." Published for the Admiralty by Her Majesty's Stationery Office. xvi + 471 pp. 264 ill. 20s.

This book was originally written to provide naval students of electrical technology with a collection of worked examples and carefully graded sets of exercises covering the scope of many electrical examinations in the Navy. In this new edition the text has been revised throughout and new examples have been added to bring the book up to date. The book also covers the requirements of the preliminary and intermediate grade examinations of the City and Guilds of London Institute in Electrical Engineering Practice, and of the Ordinary National Certificate in Electrical Engineering.

Each chapter contains basic theory interposed with fully-worked examples, and concludes with a number of exercises for the student (the numerical answers are supplied). It has been assumed that the student has only a knowledge of elementary mathematics, and some mathematical appendices, including mathematical tables, have been included at the end of the book.

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Pulse Code Modulation

Part 2—An Experimental 12-Channel Equipment

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U.D.C. 621.376.56:621.395.4

Part 1 of this article described in simple terms the basic principles of pulse code modulation (p.c.m.), and suggested applications in which p.c.m. might be useful. Part 2 describes an equipment which encodes 12 speech channels using a code of eight binary digits; it was developed to investigate the manner in which the subjective assessment of the transmission performance is related to the design parameters.

INTRODUCTION

THE ability of pulse code modulation (p.c.m.) to maintain a high signal-to-noise ratio in the message channel, even when the signal-to-noise ratio on the transmission path is low, suggests its application to multi-channel telephony using existing audio cables from which the loading has been removed. A practical p.c.m. system would have to be designed to operate satisfactorily as a link in a chain of telephone connexions in the public network, and as such must tolerate a relatively wide range of talker volume and speech circuit attenuation. Further, the possibility of a circuit being set up containing two p.c.m. links separated by a poor quality line must be considered, because the second p.c.m. system would then be operating below the optimum signal conditions.

An indication of the range of mean speech voltages to be expected at the input to inland trunk circuits may be obtained from measurements made in 1953–54,[1] in which a standard deviation of 4·4 db was quoted. Assuming that at least 99·7 per cent of all calls are to be encoded satisfactorily, and considering only the mean speech voltage, the p.c.m. equipment would experience a range of levels of 26·4 db at its input. To this must be added the normal variation of talker volume, so that the actual range would be much greater.

At this juncture it is as well to consider the special nature of the distortion suffered by a low-level speech signal in its passage through a p.c.m. transmission system. Consider, for example, an equipment using a 4-digit binary code, which would enable 16 quantizing steps to be described.

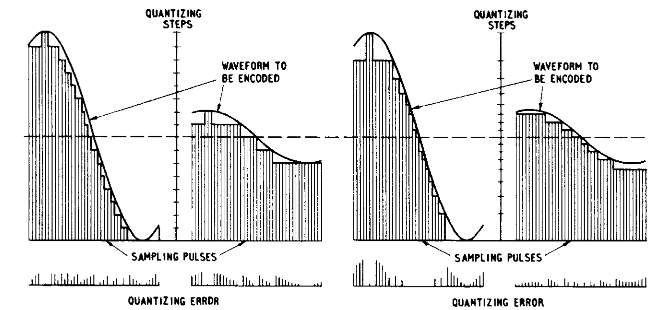
The maximum-amplitude signal which could be encoded would be that which fully occupied all 16 steps, and if this level were exceeded the excess amplitude would be subjected to severe limiting. In the simplest type of p.c.m. equipment the quantizing steps are all equally spaced, and when the incoming signal is attenuated by, say, 12 db only one-quarter of the available quantizing steps are used. This effect is illustrated by Fig. 12(*a*) for the pulse-amplitude-modulated (p.a.m.) signal obtained from a sine wave input, and it will be seen that the low-level signal is poorly defined by the relatively large step size. Taking this to the limit, an incoming signal attenuated by more than 24 db would not energize one step and so would not be transmitted in this example.

One method of improving the transmission of low-level signals would be to increase the number of digits in the code, but this would define the high-level signals in unnecessary detail and so use the bandwidth of the transmission path inefficiently. An alternative approach is indicated in Fig. 12(*b*), where the quantizing steps are spaced in a non-uniform manner, e.g. logarithmically, so that the definition of the low-level signals is considerably improved compared with linear quantizing. In Fig. 12(*a*) the low-level signal is quantized in five equal steps, whereas in Fig. 12(*b*) the same signal is defined by eight steps spaced in a logarithmic manner; this improvement has been obtained without any increase in the total number of quantizing steps. It will be seen that the design of a p.c.m. equipment for junction working must be based on a compromise involving the number of digits in the code and the law which relates the spacing of the quantizing steps to the incoming signal, in order to provide an acceptable quality of speech transmission.

The equipment described in this article was constructed as a laboratory tool for the assessment of the subjective effect of varying these two parameters and to investigate the effects of various types of interference. No provision was made for signalling as the equipment was not designed as a p.c.m. system to carry traffic, although many of its features would be applicable to a working system.

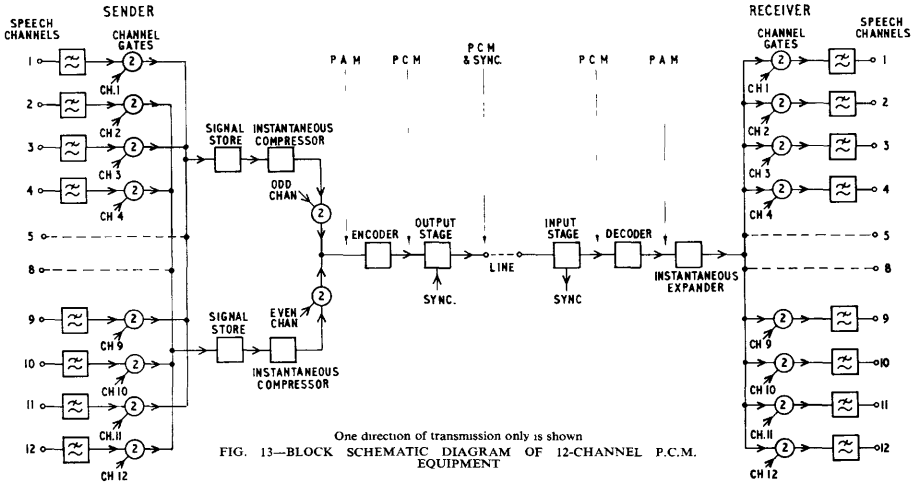
OUTLINE OF 12-CHANNEL P.C.M. EQUIPMENT

The basic arrangement of the 12-channel p.c.m. equipment is shown in Fig. 13. For reasons of design convenience the incoming channels are assembled in two groups, the odd numbered channels and the even. Simple low-pass filters restrict the frequency band of the channel signal and prevent the sampling frequency from reaching the incoming line. The signal present at each channel filter is sampled in turn by applying a narrow pulse to the channel gate, and the amplitude of the sample is



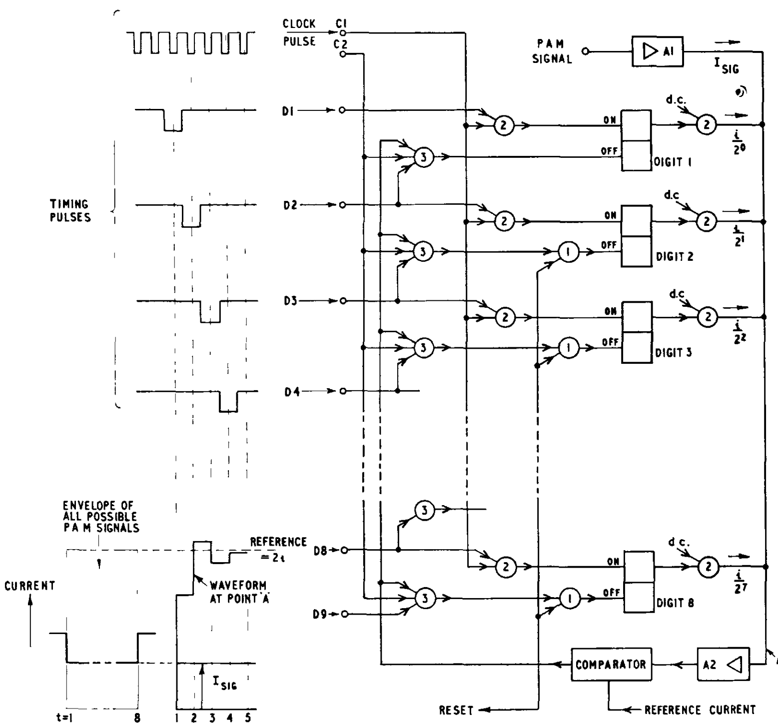
(*a*) Linear Quantizing (*b*) Logarithmic Quantizing
FIG 12—QUANTIZING OF P.A.M SIGNAL

† Post Office Research Station.



One direction of transmission only is shown

FIG. 13—BLOCK SCHEMATIC DIAGRAM OF 12-CHANNEL P.C.M. EQUIPMENT



$$\text{Current at A} = I_{SIG} - \sum_{n=8}^{n=1} \frac{i}{2^{n-1}}$$

FIG. 14—8-DIGIT ENCODER

maintained constant by the odd or even group signal stores while the encoder converts the signal sample from p.a.m. to p.c.m. Each of the two signal stores is followed by an instantaneous compressor the gain of which increases as the signal level falls, and so produces the effect of non-linear quantizing at the encoder. The output of each compressor is selected alternately and directed to the encoder, which is common to all 12 channels. The sender output stage adds to the eight binary digits of each encoded sample an additional digit which is used to synchronize the receiver to the sender. In the receiver this additional pulse is extracted and the eight digits of the code are directed to the decoder where they are converted back to a p.a.m. signal. An instantaneous expander, which has the inverse characteristic of the compressor, ensures that the overall amplitude response of compressor-encoder-decoder-expander is linear. The channel gates are opened in turn to direct the p.a.m. signals to the appropriate channel filter, where demodulation takes place.

METHOD OF ENCODING

An outline of the logical circuits used in the 8-digit encoder is given in Fig. 14, together with a chart showing the relative timing of the pulses which control the sequence of the encoding operation. The encoder includes eight current sources related in value by the series $i/2^0$, $i/2^1$, $i/2^2$ . . . $i/2^7$ which can be switched on and off as required, and one current source controlled by the magnitude of the incoming p.a.m. signal. All these currents are added together in the amplifier A2 and compared with a reference in the comparator stage; if the sum of the currents is equal to or greater than the reference a pulse is generated by the comparator, but if the reference is not exceeded then no pulse will be generated. This pulse is one of the signals which control the switching of the eight current sources.

Consider now the switching operations required to encode a p.a.m. signal which generates a current I_{SIG} at the input of amplifier A2:

(*a*) Digit pulse D1 gates clock pulse C1 to the ON input of the toggle* for the first digit of the code. This adds a current $i/2^0$ to the current I_{SIG}, but as the total does not exceed the reference no pulse is generated by the comparator. The first step on the waveform at point A in Fig. 14 illustrates this.

(*b*) Digit pulse D2 gates the next clock pulse to the ON input of the second toggle and so adds a current $i/2^1$ to those already flowing. As the total now exceeds the reference a pulse will be generated by the comparator.

(*c*) Digit pulse D3 now performs two gating operations: (*i*) it directs a clock pulse C1 to the ON input of the third digit toggle and so adds a current $i/2^2$ to the input of amplifier A2, and (*ii*) it directs a clock pulse C2 through a gate opened by the comparator pulse to the OFF input of the second digit toggle and so switches off the current $i/2^1$. The total current now flowing is $I_{SIG} + i/2^0 + i/2^2$, and the comparator will not operate.

(*d*) This sequence of switching continues until all eight digit toggles have been set according to the decisions reached by the comparator. Thus at the end of the encoding operation the sum of I_{SIG} and all the current sources which have remained switched on is now within the smallest current increment of the reference value.

(*e*) As the encoding operation is now complete, all digit toggles except the first are reset so as to be ready to encode the next p.a.m. sample. It is not necessary to reset the first toggle as it must always be switched on at the start of the encoding operation.

The binary code number for the difference between the reference and I_{SIG} is obtained by sending to line a pulse for every current source which has not been switched off during the encoding operation. Only unidirectional signals can be encoded by this technique, so it is necessary for the encoder to rest at its half-way value when there is no p.a.m. signal present. Thus the code number 255, i.e. $2^8 - 1$, is sent to line when the p.a.m. signal assumes its most negative value, and the code number is zero when the p.a.m. signal attains its most positive value.

Two clock pulses have been used to switch the toggles of the encoder; C1 switches on and C2 switches off. This is desirable because it enables the small difference between the switch-on and switch-off times to be equalized by introducing an equal delay in the path of the C1 pulse.

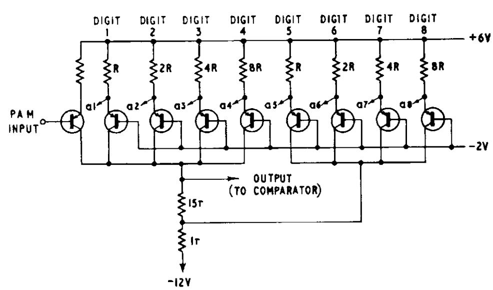
8-*Digit Encoder*

As many toggles and gates are required to perform logical functions throughout the p.c.m. equipment, the circuits have been arranged so that one design of each will serve for all purposes. In order to do this it is necessary to formulate certain rules to which all logical circuit elements must conform. For example:

(*a*) "1" state denoted by a potential of – 6 volts.
(*b*) "0" state denoted by earth potential.
(*c*) All gating performed by diodes.
(*d*) Each gate to be followed by an emitter follower.

The toggle circuit is of conventional design using p-n-p germanium transistors of the alloy-junction type. These are prevented from saturating by a low-dissipation clamp in order to allow operation at a clock frequency of 864 kc/s.

Fig. 15 shows in simplified form the manner in which the various currents are combined. Each digit current is determined by the resistor in the emitter circuit of a transistor and the potential difference between the emitter supply line and the base connexion of that transistor. The current from the collector is modified by the base–emitter voltage and the grounded-base current-gain of the transistor, but this can easily be corrected. Because the collector circuit presents a high source impedance, the value of the digit current is not varied



a_1 to a_8 are connected to the current switches

FIG 15—SIMPLIFIED CIRCUIT OF ENCODER CURRENT SOURCES

* A circuit which has two stable states.

when the switching of other digit currents causes the collector voltage to change. Digits 1 to 4 and the p.a.m. signal develop a voltage proportional to the total current across a load resistor of value $16r$, but the current from digits 5 to 8 is added at a tap[2] on the load resistor so that its contribution to the output is reduced by a factor of 16. In this way the ratio of highest to lowest emitter resistor is 8 : 1 and not 128 : 1, which would present difficulties due to excessively long time-constants.

Comparator

In principle the function of the comparator is quite straightforward; it is to generate a pulse at its output when the signal at its input is equal to or exceeds a given reference value. After each decision has been made the comparator is reset so as to avoid any hysteresis effects. This resetting pulse is timed to coincide with the switching of the digit toggles in order to allow as much time as possible for the comparison to be made. Bearing in mind that the output pulse of the comparator has to be of sufficient duration to effectively gate the "off" pulse to the digit toggles, the time available for the comparator to make its decision is fairly short and high-speed transistors are used.

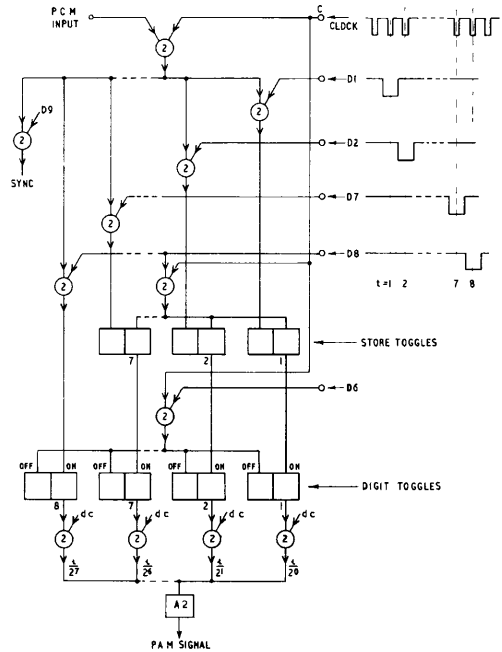
Sender Output Stage

The digits of the code word which is sent to line are obtained by reading the state of the digit toggles of the encoder. This read-out takes place one digit period after the toggle has been set, and a 1 is registered for each toggle which remains switched on. In the output stage of the sender an extra digit is added after the eight digits of the code word.This ninth digit is gated by a pulse pattern related to the channel numbering, so that synchronizing information is sent by this pulse to the receiver to enable it to identify (*a*) the position of a particular digit in the code word and (*b*) the particular channel being encoded.

8-*Digit Decoder*

A block diagram showing the logical stages which convert a p.c.m. signal to a p.a.m. signal is given in Fig. 16. In principle the decoder is similar to the encoder, but with the major difference that whereas the current sources of the encoder are switched by the comparator, those of the decoder are switched by the incoming p.c.m. signal. If the p.c.m. signal were applied directly to the digit toggles which control the current sources, the p.a.m. signal would be built up in steps as the code pulses arrived serially. It would be difficult to demodulate such a signal, so all incoming code pulses except the eighth are stored by toggles as they arrive. These are read as the eighth code pulse arrives so as to transfer the complete code word in parallel form to the digit toggles. Thus the same currents will be set up in the decoder as were set up by the switched current sources in the encoder, and one element of the p.a.m. signal is made available until the digit toggles are reset by the next sixth digit pulse.

While the digit toggles are holding their word, the store toggles are receiving the pulses of the next code word, which will be transferred to the digit toggles when the next eighth pulse arrives. The gap of two digit periods between successive p.a.m. signals allows sufficient time for the channel multiplex switch, which follows the



$$\text{Current at input of A2 amplifier} = \sum_{n=8}^{n=1} \frac{I}{2^{n-1}}$$

FIG. 16—8-DIGIT DECODER

decoder, to operate without introducing channel-to-channel crosstalk.

One of the main requirements of this p.c.m. equipment was that the number of digits in the code should be capable of being changed as required for speech assessment testing. This facility is provided by means of a switch which inhibits the gates associated with unwanted digits in the decoder. Thus, although the number of digits in the code sent to line is not varied, the effect of a reduced number is simulated by controlling the number of digits decoded. For example, when the switch is set to six digits the seventh and eighth digit toggles of the decoder are prevented from operating.

CHANNEL EQUIPMENT

Send-Channel Circuit

The basic send-channel circuit is shown in Fig. 17. The channel input filter restricts the incoming signal to the frequency band 300–3400 c/s and attenuates the channel sampling pulses, which would otherwise be fed back to the audio line. Two symmetrical n-p-n transistors are used as a gate with emitter coupled to emitter and base coupled to base, and the switching signal is applied between emitters and bases by a pulse transformer. This symmetrical arrangement confines the switching signal to the gate circuit and produces a minimum of spurious effects on the signal path. Each channel is sampled in turn 8,000 times/second by a 1 μs pulse which renders

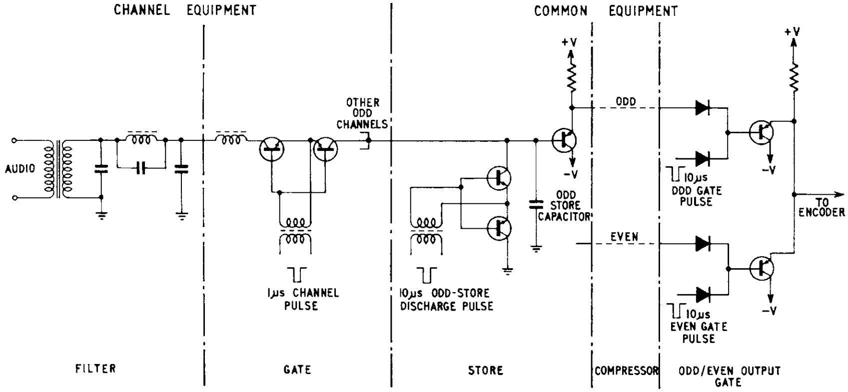


FIG. 17—SIMPLIFIED SEND-CHANNEL CIRCUIT

both transistors conducting and transfers the charge on the final capacitor of the filter to the store capacitor in a resonant manner.[3] After this transfer of charge the gate becomes high impedance so as not to discharge the store capacitor and also to provide a sufficiently low level of channel-to-channel crosstalk.

While an odd channel is being sampled the charge residing in the even signal-store capacitor is removed by the low impedance of another two-transistor gate. It is essential to remove the charge from this capacitor, for should any remain it would be added to the next even channel sample and would be apparent as crosstalk. For this reason it was considered desirable to arrange the channels in odd and even groups so as to provide more time in which to ensure that the discharge of the store is complete. This arrangement allows about 10 µs for the discharge of the signal store, whereas if the channels were selected sequentially considerably less than 1 µs would be available.

Emitter-follower stages are used to transfer the voltage on the store capacitor, which is in the form of a p.a.m. signal, to the instantaneous compressors. The outputs of the odd and even compressors are connected alternately by diode gates to the 8-digit encoder. These gates are operated by 10 µs pulses which are out of step with the pulses which operate the discharge gates.

Receive-Channel Circuit

The receive-channel circuit is shown in Fig. 18. The expander is common to all channels and its output is switched to the appropriate channel circuit by the individual channel gates, which operate in step with the sampling gates of the sender. The channel gate uses a symmetrical n-p-n transistor with an 8 µs gating pulse applied to its base. To improve the efficiency of demodulation of the p.a.m. signal it is held during the 125 µs period between samples by a parallel capacitor-resistor combination, which forms the effective load of the gate transistor. A buffer amplifier provides an impedance change and passes the signal to the demodulating filter, which has a 300–3,400 c/s pass-band with peak rejection at the channel sampling frequency.

INSTANTANEOUS COMPANDOR

Essentially the compressor consists of a non-linear amplifier which has maximum gain when the input level is low, and minimum gain when the input level is high. Although it would appear that the characteristic of this device is very similar to that of the well-known volume-range compressor, it differs in one major respect. Whereas the gain of the latter compressor is controlled by the mean level of the speech syllables and has an operating time-constant of a few milliseconds, the instantaneous compressor is required to operate on p.a.m. signals and must attain its final gain almost instantaneously.

The non-linear characteristic of the compressor is obtained by passing a current directly proportional to the input p.a.m. signal through a non-linear network containing rèsistors and diodes, and using the voltage developed across the network as the output signal. The instantaneous expander is required to have the inverse characteristic of the compressor, so that the tandem connexion of compressor and expander has a linear amplitude response. This may easily be obtained by supplying a similar non-linear network with a voltage proportional to the signal at the output of the compressor and using the network current to provide the output signal.

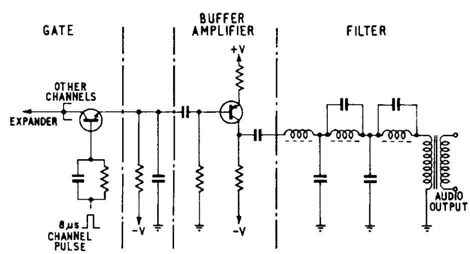


FIG. 18—RECEIVE-CHANNEL CIRCUIT

Non-Linear Network

The design of the instantaneous compressor and expander is such that they require identical non-linear networks. In order to make the form of the network adaptable to a number of input/output laws, it consists of two sets of four biased diodes; one set for each half cycle of the signal, as shown in Fig. 19. These diodes are biased so that all are conducting for full-load signals, and the number of conducting diodes falls as the signal

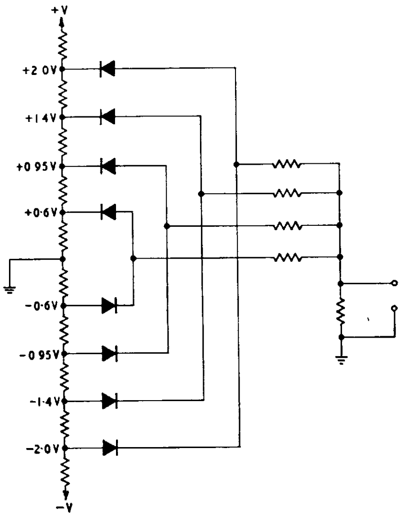


FIG. 19—COMPANDOR NON-LINEAR NETWORK

level is reduced. In this way the input/output law may be changed by altering the resistors in series with the diodes.

An example of a typical compressor law would be for the encoder to change by one step for every 0·3 db change of the incoming signal throughout a substantial part of the range of signal levels, and to revert to a linear law at very low levels.

GENERATION OF TIMING PULSES

Clock Pulse Generator

All switching operations in the equipment are timed with reference to a master oscillator in the sender which is set at 864 kc/s, i.e. (sampling frequency) × (number of channels) / (total number of digits). This oscillator has a number of outlets each of which drives a clock pulse generator, so that by introducing a small phase angle between outlets, variable delays may be introduced between clock pulses to compensate for finite operating times elsewhere in the equipment. The clock pulses are negative-going from earth potential with an amplitude of 6 volts and a half-amplitude duration of about 0·3 μs.

Word Generator

The eight digit pulses of the code word and the single synchronizing pulse are separated in time by the taps on a delay line, as shown in Fig. 20. Only one clock pulse in nine is launched into the delay line, this division being accomplished using the normal outlets from the taps on the delay line and two additional gates, in the following manner:

(*a*) Assume no signal in the delay line.

(*b*) The first clock pulse is passed by the AND gate to the start of the delay line. It then travels along the length of the line.

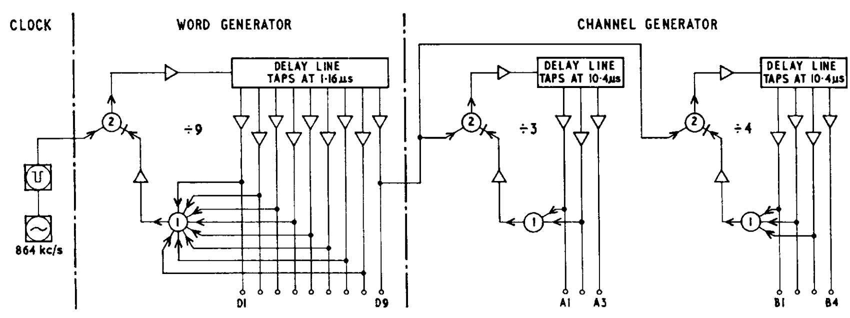
(*c*) When the pulse arrives at the first outlet D1 it is passed by the OR gate to the inhibit input of the AND gate, where it will suppress the second clock pulse.

(*d*) When the pulse in the delay line arrives at the D2 outlet it will suppress the third clock pulse, and in the same manner a total of eight clock pulses are suppressed.

(*e*) As the D9 outlet is not connected to the OR gate, the ninth clock pulse is passed by the AND gate to the input of the delay line. The cycle is then repeated.

Channel Pulse Generator

The 12 channel pulses are obtained by dividing the pulse repetition frequency (p.r.f.) of a digit pulse by 12 and using delay lines to separate the channel pulses in time. So as to reduce the total length of delay line required, the division is performed in two parts (see Fig. 20), each using a dividing circuit similar to that in the word generator, the first dividing the p.r.f. of the D9 pulse by three and the second by four. If it is assumed



All the amplifiers shown are inverting amplifiers which reverse the polarity of the pulses and also establish the pulse amplitude, thus offsetting the effects of attenuation along the delay line; each amplifier is preceded by an emitter-follower circuit so as not to affect adversely the properties of the delay line.

FIG. 20—GENERATION OF TIMING PULSES IN THE SENDER

that a D9 pulse is launched simultaneously in both delay lines, it will be seen that this condition will again apply 12 D9 pulses later. By gating the outlets A1 to A3 of the divide-by-three delay line with the outlets B1 to B4 of the divide-by-four delay line, the 12 channel pulses are obtained. For example, the pulse for channel 1 is obtained when the A1 and B1 pulses are coincident, which occurs only once in the cycle of 12 channel pulses.

INPUT STAGE AND SYNCHRONIZING OF RECEIVER

Input Stage and Extraction of Pulse Repetition Frequency

Incoming p.c.m. signals are first passed through a slicer stage to produce a rectangular wave shape with fast transitions and a fixed amplitude. This wave is then differentiated to produce narrow voltage spikes which synchronize the master oscillator in the receiver to the p.r.f. of the sender. As there may be considerable gaps in the train of code pulses, depending upon the series of code numbers being transmitted, it is necessary to ensure that the Q factor of this circuit is large enough to provide a reasonable amplitude during the longest gap. Clock pulses are then obtained in the same manner as in the sender, and from these the word and channel pulses are generated by circuits which are essentially as indicated in Fig. 20. Digit pulses D1 to D8 and the sliced p.c.m. signal provide the input to the 8-digit decoder shown in Fig. 16.

Recognition of Synchronizing Pattern

The ninth pulse in the code word from the sender is gated so that it is present on certain channels and not on others. If the receiver is correctly synchronized this modulation is available at the outlet marked SYNC in Fig. 16, and by coupling it to a binary counter a wave pattern is obtained. An identical pattern is generated locally in the receiver and compared with the pattern from the sender, and as correct synchronism has been assumed there will be no output from the comparator and so no action will be taken to change the conditions, i.e. one pattern will exactly overlie the other in time.

Suppose now that the receiver is not synchronized, and that instead of the sender's ninth pulse appearing at the SYNC outlet one of the digits of the code appears in its place. The wave pattern produced by this will differ from the locally generated reference, and an output will be produced from the comparator. This is used to change the division ratio of the word generator in the receiver from 9 to 8 so that the next pulse of the incoming p.c.m. signal is captured by the D9 pulse of the receiver. The resulting wave pattern is again compared with the reference, and if it still differs the count is again changed, this process being repeated until synchronism is established.

PERFORMANCE

The standard of performance is very high, and for a small range of signal levels about an optimum level the presence of the p.c.m. equipment is almost imperceptible. Outside this range, the p.c.m. distortion becomes discernible, but acceptable quality is maintained over a range much greater than the 26·4 db range mentioned in the introduction. Detailed studies are in hand to assess the performance on a sound quantitative basis, and to ascertain the effect of tandem connexions through several p.c.m. links.

CONCLUSION

The apparatus described in this article demonstrates that straightforward and reliable solutions are available to the circuit problems encountered in p.c.m. terminal equipments, and the ease with which the distribution and number of coding steps can be varied makes it a valuable and flexible laboratory tool. Although many other methods of achieving similar results are possible, some of which may offer practical advantages over those described here, all will produce similar distortions so that general conclusions may safely be drawn from the experimental equipment.

The complete 12-channel p.c.m. equipment shown in Fig. 21 contains about 500 transistors and 750 diodes, divided almost equally between sender and receiver. Total power consumption is about 45 watts.

The introduction of p.c.m. techniques into the telephone network will depend largely on economic factors, and it remains to be shown whether p.c.m. equipment can be manufactured and installed at a cost which will make it attractive for short-haul junction working.

The sender is on the left and the receiver is on the right; the size of the equipment can be judged by comparing it with that of the telephone

FIG. 21—THE COMPLETE EXPERIMENTAL P.C.M. EQUIPMENT

ACKNOWLEDGEMENT

The authors owe thanks to Mr. P. L. W. Gibbons, of the Signals Research Development Establishment, for helpful discussion at the start of the project.

References

[1] C.C.I.F. XVIIIth Plenary Assembly, 3–14 December 1956. *Green Book*, Vol. III, bis, p. 292.

[2] GIBBONS, P. L. W. The Application of Transistors to Digital Speech Communication Systems. *Proceedings I.E.E.*, Paper No. 2983E, May 1959 (Vol. 106, Part B, Supplement No. 16, p. 601).

[3] FRENCH, J. A. T. and HARDING, D. J. An Efficient Electronic Switch—the Bothway Gate. *P.O.E.E.J.*, Vol. 52, p. 37, Apr. 1959.

Supergroup Derivation Equipment

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U.D.C. 621.315.212:612.395.44

Coaxial line systems provide a large number of circuits between the terminal repeater stations. In certain circumstances, however, it is also desirable to make a number of circuits available at selected intermediate repeater stations. Two types of supergroup derivation equipment that can be fitted at intermediate repeater stations on certain regulated coaxial line systems to give this facility are described.

INTRODUCTION

IN the United Kingdom extensive use is made of coaxial line systems because it can be shown that, if the rate of circuit growth is sufficient, these systems offer the most economic method of providing long-distance circuits.[1] Depending on the type of coaxial line system used, maxima of either 600 or 960 or 2,700 circuits can be made available between the terminal repeater stations, the distances between such stations usually being in the range 40–150 miles.

A coaxial line system is often routed through or near a small town that requires circuits to one or both of the line-system terminals. If the line system has spare circuit capacity it is obviously desirable to use this for the intermediate-station requirement so long as the extra equipment involved is not too expensive and provided that the performance of the main line circuits is not worsened. The provision at one such intermediate station of equipment giving access to, say, three supergroups of the line system would enable up to 180 circuits to be made available between the intermediate station and each of the system terminals. Such a scheme would probably be much cheaper than converting the intermediate station into a line-system terminal station or providing additional line systems.

"Supergroup derivation" equipment has now been developed which enables a number of supergroups, otherwise forming part of the main line system, to be operated between an intermediate station and each of the terminal repeater stations.

The equipment, which is located at the intermediate station, permits the frequency bands appropriate to selected supergroups to be extracted from the main transmission band received from each terminal station; in these bands transmission from terminal station to terminal station is prevented. It also permits signals in the same frequency bands to be injected into the main transmission band for transmission to the terminal stations.

Supergroup derivation equipment is required to give the following facilities:

(*a*) It must be possible to extract and inject supergroups at an intermediate station so that the supergroups concerned may be used between the intermediate station and each of the terminal stations.

(*b*) Excessive amplitude/frequency distortion should not be produced by the equipment.

(*c*) The signal-to-crosstalk ratio of any channel (speech or music-in-band) should not be worsened.

(*d*) Control pilots and level-check pilots should not be adversely affected by the equipment.

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(*e*) The equipment should permit the derived supergroups to be connected to supergroup translating equipment or to other broadband links, or to a combination of the two.

(*f*) In a few instances it may be required to extract supergroups from one line system and, using a second set of equipment, to inject them into a second line system.

(*g*) With requirements (*e*) and (*f*) it may be necessary to prevent the 308 kc/s line pilot of one line system being transmitted as an unwanted frequency into a second line system.

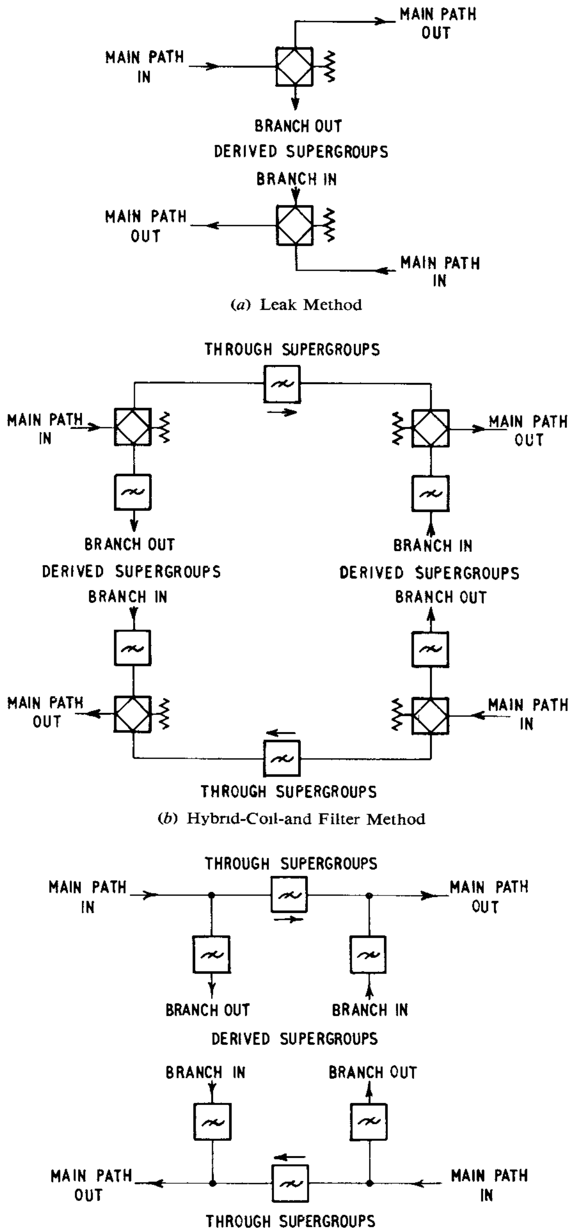
(*h*) It should be possible to derive a 60 kc/s supply from an incoming 308 kc/s pilot; the supply may be used for frequency-check purposes.

When first investigated three possible schemes were considered. In the first method (see Fig. 1(*a*)) the required signal would be "leaked" from the main transmission path. This method would not be satisfactory since "through transmission" from terminal to terminal would not be prevented and thus transmission bands free of spurious signals would not be available between the intermediate station and each of the terminal stations. It would therefore only be possible to operate supergroups injected at the intermediate station to one of the terminal stations. In the second method (Fig. 1 (*b*)) the facilities would be provided using hybrid coils and filters. This method was not favoured, however, because the permissible loss of the equipment would have been exceeded; only 12 db loss is permissible.

The loss due to the additional hybrid coils is avoided in the method finally adopted (see Fig. 1(*c*)) by the use of main-path and branch-path filters designed to have complementary characteristics so that direct parallel connexion is possible. In addition, greater flexibility is offered whereby without further modification the derived supergroups may be re-connected or injected into another coaxial line system or extended over a spur line-system to a distant terminal station. A typical example of this is shown in Fig. 2.

SUITABILITY OF LINE SYSTEMS

For any form of derivation equipment to be economically justified it must be simple and thus relatively inexpensive. In the earlier types of coaxial line systems (Coaxial Equipments, Line (C.E.L.), No. 1, 2, 4 and 4A[2]) seasonal temperature effects are counteracted by the use of equalizing networks at selected intermediate stations. In consequence, the signal levels at any intermediate station vary with frequency over the year as the cable temperature cycle is followed. Furthermore, the requisite margin of gain is not available in the line-system main path at these intermediate stations. These factors make supergroup derivation difficult and therefore equipment has not been produced for use at such intermediate stations. C.E.L. No. 6A,[3] however, employs line-amplifier-gain-regulating pilots which ensure that the output level/frequency characteristic at each intermediate station remains substantially constant with time. This constant level/frequency characteristic is not,

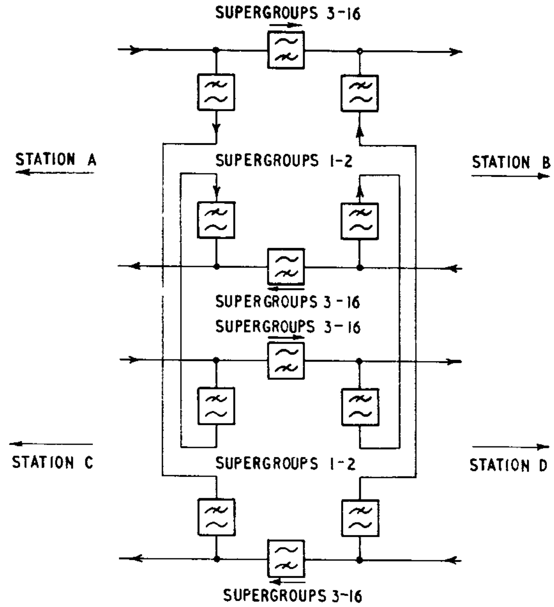


(a) Leak Method

(b) Hybrid-Coil-and Filter Method

(c) Complementary-Filter Method

FIG. 1—PRINCIPLES OF DIFFERENT METHODS OF DERIVING SUPERGROUPS AT AN INTERMEDIATE STATION



Routing of Supergroups

Stations	Supergroups
A–B	3–16
A–C	1 and 2
C–D	3–16
B–D	1 and 2

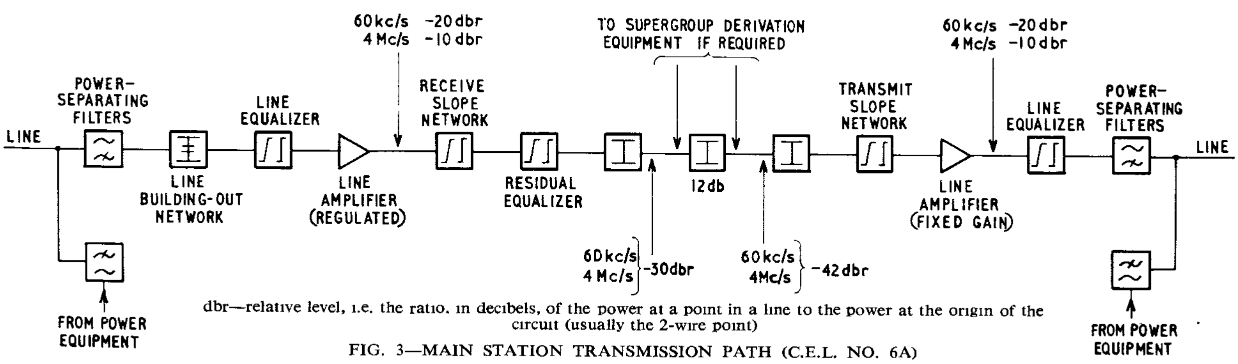
FIG 2—POSSIBLE METHOD OF INTERCHANGING SUPERGROUPS BETWEEN LINE SYSTEMS

however, the sole criterion governing the suitability of an intermediate station for supergroup-derivation purposes. An equally important requirement is that there must be an adequate margin of gain available in the line-system main path to counter the additional loss introduced by the derivation equipment; the introduction of additional amplifiers in the main path is undesirable. Each intermediate power-feeding station or main station is in effect two dependent intermediate stations coupled together, and at these stations 12 db of additional gain is available at a point where the signal levels are maintained constant with frequency. The derivation equipment, known as Supergroup Derivation Equipment No. 1A, is connected at this point, as shown in Fig. 3.

A second type of supergroup derivation equipment (No. 2A) has been developed for use on a non-standard 2·6 Mc/s regulated coaxial line system. This equipment is suitable for use at any intermediate (main or dependent) station on such a system.

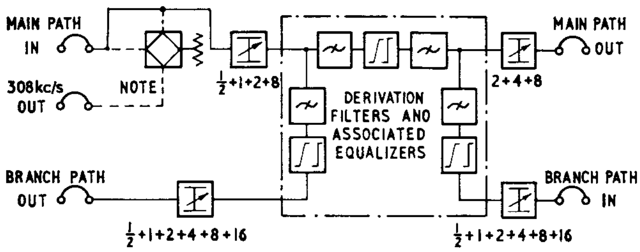
THE DERIVATION FILTERS

The 12 db gain available at a C.E.L. No. 6A main station has been one of the overriding factors when considering the performance requirements of the derivation filters. A schematic diagram of a filter



dbr—relative level, i.e. the ratio, in decibels, of the power at a point in a line to the power at the origin of the circuit (usually the 2-wire point)

FIG. 3—MAIN STATION TRANSMISSION PATH (C.E.L. NO. 6A)



Note: The hybrid coil is fitted only if supergroup 1 or supergroups 6–10 are derived.

FIG. 4—TYPICAL FILTER PANEL SCHEMATIC

panel is given in Fig. 4. Seven sets of filters have been developed to provide the facilities listed in the table.

Facilities Provided by Supergroup Derivation Filters

Supergroups Extracted and Injected	Through Transmission of Supergroups
1	2–16
2	1 and 3–16
1 and 2	3–16
1–3	4–16
1–6	7–16
1–10	12–16 (11 not used)
6–10	1–4 and 12–16 (5 and 11 not used)

Supergroup 2 normally occupies the band 312–552 kc/s but, in this equipment, it is treated as extending from 308–552 kc/s so as to permit ready extraction of the 308 kc/s line-system pilot.

The basic performance requirements of the above filters are as follows:

(*a*) Between the points marked "main path in" and "main path out" (Fig. 4) the insertion loss in the pass band of the filters if supergroup 1 or supergroups 6–10 are derived should not exceed 8·5 db; for all other filters a 12 db loss is permissible. In the stop band(s) the loss is required to be at least 80 db more than in the pass band and not less than 90 db more at frequencies corresponding to channels 4, 5 and 6 in each group, because these channels may be used for music-in-band transmissions. The amplitude/frequency distortion in the pass band should not exceed 0·5 db.

(*b*) Between the points marked "branch path in" and "main path out" and between "main path in" and "branch path out" the insertion loss in the pass band should not exceed 7·5 db for the supergroup 1 and supergroups 6–10 filters; 10·5 db loss is permissible for the other filters. In the stop band(s) the loss is required to be at least 40 db more than in the pass band, and at frequencies corresponding to channels 4, 5 and 6 in each group the loss should be at least 45 db more than in the pass band. The amplitude/frequency distortion in the pass band should not exceed 0·4 db.

(*c*) At the "main path in" and "main path out" connexion points of the filters the return loss, against 75 ohms, throughout the range 60 kc/s–4,092 kc/s should not be less than 18 db, except for frequencies corresponding to channels adjacent to the edges of the filter pass-bands, for which some relaxation is permissible. At the "branch path in" and "branch path out" points, over the frequency range covered by the filter pass-band, a return loss against 75 ohms of at least 18 db should be obtained.

It has been difficult to meet all of the very stringent performance requirements of the filters. Some additional distortion has been accepted in the filters concerned with the derivation of supergroup 1 only, supergroup 2 only, supergroup 1 and 2 only, and supergroups 1–3, and this affects, slightly, the performance of one channel only in each of the four bands. With the supergroups 1–6 filter, however, it has been necessary to accept the loss to traffic of a complete group in supergroup 6.

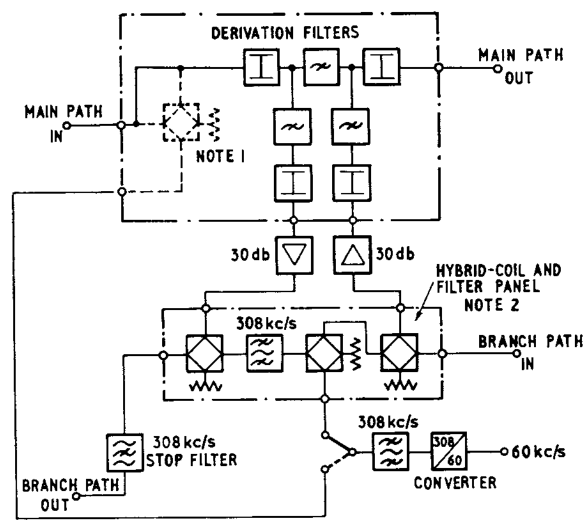
With the exception of 308 kc/s (considered as part of a supergroup) no attempt is made either to pass or suppress inter-supergroup test frequencies.

All seven sets of filters are of the coil-and-capacitor-type; crystals are not used owing to the equalization difficulties which would have been caused by the secondary resonances of the crystals.

EQUIPMENT DETAILS

Supergroup Derivation Equipment No. 1A

The normal use of supergroup derivation equipment in the future will be at C.E.L. No. 6A main stations, and Fig. 5 shows a diagram of the equipment (Supergroup Derivation Equipment No. 1A) for one direction of transmission. The pilot-stop filter is required only if the



Notes: 1. Hybrid-coil provided if 60 kc/s signal is required and 308 kc/s signal is not present in branch path.
2. The hybrid-coil and filter panel is provided if the 308 kc/s pilot is present in the branch path.

FIG. 5—SUPERGROUP DERIVATION EQUIPMENT NO. 1A

branch path is connected to another broadband link and the 308 kc/s pilot has to be stopped. Signals coming from the main path enter the derivation filters, and those supergroups not being derived pass through the main-path filters but are stopped by the filter in the branch path. The derived supergroups are stopped by the main-path filters but pass via the branch-path filters. Injected supergroups, after amplification, pass through the branch input filters and are then connected into the main path to occupy the portion of the frequency spectrum cleared by the main-path filters.

If the 308 kc/s pilot frequency, being considered as part of supergroup 2, is present in the branch path, the hybrid-coil and filter panel is fitted (Fig. 5). This enables a 308 kc/s signal to be extracted and reinjected into the branch input path, where it passes through once more to the main path along with the injected supergroups.

If a 60 kc/s signal is required for frequency-check purposes, the 308 kc/s signal is also applied via the second hybrid coil in the hybrid-coil and filter panel to the 308/60 kc/s converter. The 308 kc/s pass filter shown at the input to the converter is not required for this application.

If supergroup 1 only or supergroups 6–10 are derived, the 308 kc/s pilot is not present in the branch path and the hybrid-coil and filter panel is not therefore required. If, however, a 60 kc/s signal is required, the hybrid coil provided as part of the derivation filter panel is connected in circuit as shown in Fig. 5. The second output from this hybrid coil is then connected via a simple 308 kc/s pass filter to the 308/60 kc/s converter.

The main requirements for the 308 kc/s pass filter in the hybrid-coil and filter panel are that the discrimination against all other frequencies in the ranges 60 kc/s–300 kc/s and 312 kc/s–4,092 kc/s should be at least 80 db and should be 90 db at frequencies corresponding to channels 4, 5 and 6 in each group. The 308 kc/s filter associated with the 308/60 kc/s converter is much simpler, and a discrimination of only 35 db is required. The 308 kc/s pilot stop filter has a discrimination of 40 db.

A complete equipment is mains operated and is assembled on a single-sided 9 ft 51-type rack and caters for both directions of transmission. Only one set of panels for obtaining a 60 kc/s signal is fitted. Space is provided on the rack for the provision of a 308 kc/s stop filter should the derivation-equipment branch-path be connected to a second line system and a 308 kc/s pilot be present in the branch path. Valve-fail-alarm facilities are provided in addition to one spare amplifier and a high-speed amplifier-change-over panel.

Supergroup Derivation Equipment No. 2A

Developed for use with a non-standard 2·6 Mc/s regulated coaxial line system, Supergroup Derivation Equipment No. 2A has only a limited application in the United Kingdom because there are only two such line systems in the network: London–St. Margaret's Bay and Belfast–Dublin. A block schematic diagram for one direction of transmission is shown in Fig. 6, and it will be seen that it is similar to the No. 1A equipment. It uses the same range of derivation filters except that, on a 10-supergroup line system, supergroups 1–10 or 6–10 would never be derived.

Although contrary to the basic principles discussed earlier for the standard derivation arrangement used

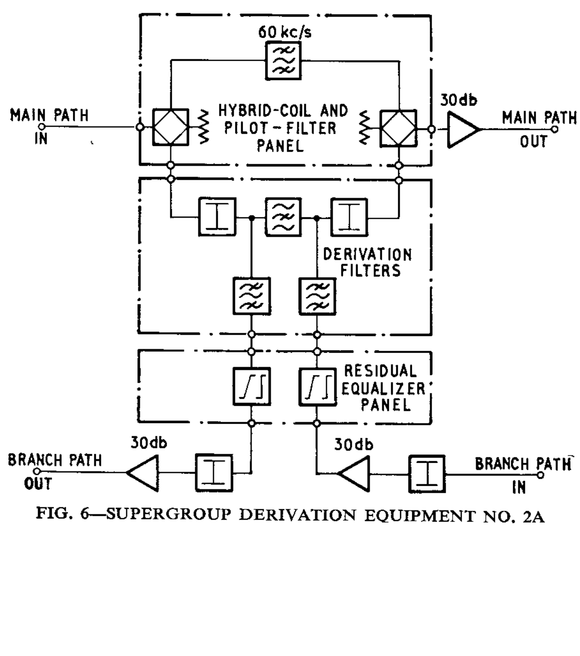


FIG. 6—SUPERGROUP DERIVATION EQUIPMENT NO. 2A

with C.E.L. No. 6A systems, an amplifier in the main path has had to be provided because of the lack of additional gain available at the intermediate stations. However, special alarm arrangements have been made whereby in the event of valve or fuse failure a local alarm is given and in addition an alarm pair in the coaxial line system is looped and this operates an "urgent" fault alarm at the terminal stations. From the latter stations the fault can be traced to the derivation station and the necessary remedial action taken.

With the first installation of Supergroup Derivation Equipment No. 2A the branching facility was urgently required for Continental traffic some while before the derivation filters could be made available. As a result of this and the fact that the maximum loss introduced in the main path was not critical, hybrid coils were inserted in the main path to enable the lower pilot-frequency (60 kc/s) to be passed through. This lower pilot is blocked by the main-path filter except when supergroup 2 alone is derived, and so is given by-pass facilities by means of the hybrid coils and 60 kc/s band-pass filter. The upper pilot-frequency (2,604 kc/s) of the line system is always passed through along the main path and so requires no special treatment.

As only a small amount of residual equalization is possible at intermediate stations on the 2·6 Mc/s line system, facilities have been given on the No. 2A equipment for residual equalization to be effected in the branch paths.

To enable the circuits between one terminal and the derivation station to be kept in service when for any reason a disconnexion occurs between the other terminal and the derivation station, a 2,604 kc/s oscillator is provided as part of the derivation equipment. The output from this oscillator would, when patched in, replace the normal (failed) 2,604 kc/s pilot and control the return-path gain by operating the gain-control units at each intermediate station between the derivation station and the terminal.

This equipment is mains operated and the panels for both directions of transmission are accommodated on a 9 ft 51-type rack.

OTHER DERIVATION EQUIPMENTS

The equipments so far described are not the only equipments which are used to derive supergroups. An additional equipment (Equipment, Filter-Frequency, No. 81A) has been developed for use at terminal stations. It follows the principles already outlined with the exception that as the 308 kc/s pilot has already been stopped at the system terminal special treatment is not required. The equipment therefore consists only of the derivation filters, amplifiers and station-cabling equalizers.

A further development in hand is the slight modification to the 1A-type equipment to make it suitable for use at radio stations. For this purpose the only change necessary is to replace the 308 kc/s by-pass filter by a 60 kc/s by-pass filter. This is because the 308 kc/s pilot that is used to control the radio-system gain is stopped in the radio terminal equipment and a 60 kc/s signal is used as an overall check and synchronizing pilot.

CONCLUSION

Experience to date shows that the supergroup derivation equipments in their present form fulfil a very useful purpose in spite of the fact that their use makes coaxial line-link maintenance slightly more difficult. The prototype tests undertaken on the Supergroup Derivation Equipment No. 1A that has been provided at Cambridge (Trumpington) on the London–Doncaster coaxial line system show that the insertion of the supergroup derivation filters (supergroups 1–3 are derived) produces no material change in the line response over the frequency range covered by the through supergroups 4–16. The results obtained with the No. 2A type equipment at Canterbury were similarly encouraging, and in this instance supergroups 1–6 were derived.

At present no effort has been made to develop suitable equipment for use on the earlier types of coaxial line systems using block temperature-equalization; 12 Mc/s regulated line systems will shortly be in use and a requirement for suitable derivation equipment is likely. Any such equipment would probably be of a similar pattern to that already described, with the exception that perhaps some form of valve-aging equalizer might be required in the branch paths.

ACKNOWLEDGEMENTS

The supergroup derivation equipments described were developed in co-operation with the General Electric Co. Ltd. and Standard Telephones & Cables, Ltd., to whom acknowledgements are due.

References

[1] FRANKLIN, R. H., and WILLIAMS, M. B. Recent Developments in Line Transmission Systems. *I.P.O.E.E. Printed Paper No.* 213, 1958.

[2] DAVIS, E. A 4-Mc/s Coaxial Line Equipment—C.E.L. No. 4A. *P.O.E.E.J.*, Vol. 50, p. 92, July 1957.

[3] COLLIER, M. E., and SIMPSON, W. G. A New 4 Mc/s Coaxial Line Equipment—C.E.L. No. 6A. *P.O.E.E.J.*, Vol. 50, p. 24, Apr. 1957.

Book Reviews

"Introduction to Laplace Transforms for Radio and Electronic Engineers." W. D. Day, Graduate I.E.E., A.M.Brit.I.R.E. Published for *Wireless World* by Iliffe & Sons, Ltd. vii + 183 pp. 51 ill. 32s. 6d.

The Laplace transformation can be regarded as a process which converts a function of time into a function of frequency. When applied to a linear differential equation which defines a function of time, it converts the equation into an algebraic one which defines the corresponding function of frequency. The algebraic equation is usually much simpler to solve than the differential equation, and as long as its solution can be transformed back into a function of time the procedure provides a straightforward method of solving the differential equation. Its success as a practical method is due to the ease with which this reverse transformation can be effected.

The voltages and currents in circuits composed of resistors, inductors and capacitors all satisfy linear differential equations and the Laplace transformation has proved to be a powerful tool for analysing them. Conventional a.c. circuit theory may be considered as the special case into which the transformation degenerates when the driving signal in the circuit is a sine wave which has been applied for a very long time.

In conception the Laplace transformation is a branch of complex-variable theory and to use it effectively one requires some skill in contour integration. However, in the elementary applications to electric circuits it is possible to go quite a long way without employing any elaborate mathematics simply because the transform can normally be split into parts, each of which is recognizable as an entry in a table of standard transforms. It is rather like evaluating an indefinite integral by reference to a table of derivatives.

The book by Mr. Day is an attempt to teach the student who is not equipped with all the necessary mathematical background how to use the Laplace transformation in the manner just described to solve the simpler problems that occur in electrical engineering. The first half of the book treats only the ordinary differential equations that arise in finite, lumped, linear circuits and pre-supposes no more than a knowledge of elementary calculus and algebra. The second half is a little more ambitious and starts by giving an outline of complex-variable theory, which is then used to derive the contour integral that transforms a frequency function back into a time function. Following this are some applications to the partial differential equations arising from transmission lines.

The author has evidently given considerable thought to the method of presentation which, in a book of this type, is of the greatest importance. It is well written and pleasant to read and should prove much more acceptable than earlier efforts, by other authors, which have been developed from the standpoint of operational calculus (R.I.P.). There are a few mistakes, some due to the printers, which have escaped the proof reading and one or two mathematical blunders, but none of much consequence. A student at Higher National Certificate level should have no difficulty in understanding and applying the material in the first half; the later chapters, however, may not go down quite so well.

H. J. O.

"Progress in Dielectrics." Vol. 3. Edited by J. B. Birks, B.A., Ph.D., D.Sc., F.Inst.P., A.M.I.E.E., and J. Hart, Ph.D. Heywood & Co., Ltd. vii + 292 pp. 111 ill. 63s.

This series has taken an unexpected turn, and the present issue is devoted mainly to theory and to its verification in materials which are amenable to calculation though not necessarily of practical importance. The theoretical reviews are good—their authorship is sufficient guarantee of their quality—but they overlap other accessible sources and to some extent repeat information from the earlier volumes of the series.

The paper of most interest to communications engineers will be that on recent developments in cable insulation in the United States. It generalizes rather cheerfully, e.g. "plastics and synthetic rubber have completely captured the areas of low-voltage and communication cable." It is, however, a useful survey of the plastics now in use and describes one, an extrudable variant of p.t.f.e., which appears to be of great interest and was not previously known to the present reviewer. The composition of this material is not stated, although most of those mentioned in the article are described in fair detail.

A paper on the dielectric properties of water is concerned mainly with relating these properties to theories of the molecular structure of water and of ice; incidentally, it provides summaries of observed data which may be technically useful.

Looking back over the series, the reviewer finds that while a few articles in the earlier volumes have been the means of getting up to date in subjects which are outside his normal interests, a few others have proved to be of permanent value as sources of reference. So far as can be judged at this stage, the new volume may be of much the same value as Volume 2, though probably not of the high standard which was set by Volume 1.

A. C. L.

Stafford Cordless Switchboard

J. CHEESBROUGH, A.M.Brit.I.R.E.†

U.D.C. 621.395.65

An interesting experiment, in which only controlling-type cordless switchboards are used to handle all assistance and inquiry traffic, was started at Stafford in July. The modifications made to the physical design of the cordless-type switchboards and the trunking of the traffic are described in this article.

INTRODUCTION

CORDLESS-TYPE switchboards have been working for some time at both Thanet and Middlesbrough. Both of these installations use separate controlling, incoming and monitorial positions, access being gained by means of queues individual to each type of position. In 1957, with the prospect of subscriber trunk dialling (S.T.D.) and changes in the amount of assistance and inquiry traffic, an experimental cordless-switchboard installation was planned using controlling positions only; Stafford exchange, which was at the design stage at this time, was selected for the experiment. The functions and principles of the cordless switchboard have already been described* and this article deals only with the differences between the standard and experimental types of position and the methods of working.

SWITCHBOARD DESIGN

The fact that the experiment called for controlling positions only to be used meant that both controlling and inquiry traffic had to reach the operator by means of a common queue. Consequently, each operator had to be provided with facilities for dealing with both directory and monitorial inquiries as well as for connecting calls. It was necessary, therefore, to experiment with the physical design of the switchboard to provide accommodation for the required directory and monitorial information without interfering with the basic construction of the controlling position.

The result of preliminary trials indicated a preference for open-shelf pedestals under the position keyshelves with a single end-unit bookcase which could be associated with a selected end position (Position 1). The standard end panel was replaced by an end-unit bookcase, which was also arranged to house a single-way pneumatic tube leading to the test desk. The under-keyshelf pedestals replaced the normal stanchions. The two units, as fitted to a position at Stafford, are shown in Fig. 1 and a general view of the switchroom is shown in Fig. 2.

TRUNKING

The trunking of the traffic incoming to the automanual board from all sources is shown in Fig. 3. This traffic is segregated into a main and two subsidiary queues.

Main Queue

The main queue caters for all assistance, inquiry, and directory-inquiry traffic originated by main-exchange subscribers and coin-box users who use the code 100. The queue also carries assistance traffic from U.A.X. subscribers and distant-exchange operators together with changed-number interception, service interception and phonogram night service traffic. Each incoming circuit terminates on a relay-set which is jumpered to a distributor hunter (25-point uniselector). The hunters have access to the distributors (200-outlet motor-uniselectors) which give access to 20 queue places and all the connecting circuits in a single field of 24 positions. As calls arrive they take a position in the queue and are released in turn when one of the operators operates her SPEAK key and depresses the CONNECT ANSWER bar on a cordless-switchboard position. The distributor then hunts for the connecting circuit which has been marked by the signal from the operator's position. The call is thus extended to the operator, who is able either to complete the call via the outgoing selectors or, if it is an inquiry, help the subscriber by reference to her records.

Subsidiary Queues

Use is made of a facility developed for Thanet whereby a nominated position of the cordless-switchboard suite receives, in addition to normal traffic from the main queue, calls via a subsidiary queue from the operators at other positions. This traffic consists of fixed-time-call instructions, fault reports, route and rate inquiries (RRQ), and directory inquiries which the operators are unable to handle because they have not got the appropriate directory. The queue also receives traffic from distant operators dealing with personal calls. Access to this position is obtained by the use of code 051, which routes the call to an incoming relay-set and thence to a subsidiary queue. A signal from this relay-set causes the position to be closed to traffic from the main queue. A green pilot lamp glows on the nominated position to indicate the special nature of the next call and the next connecting circuit marked on this position connects the call to the operator. When the call has been answered the position is reopened to ordinary traffic provided the subsidiary queue is then empty.

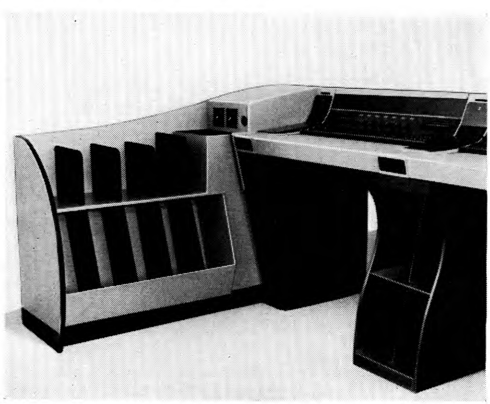


FIG. 1—MODIFIED CORDLESS-SWITCHBOARD POSITION SHOWING OPEN-SHELF PEDESTALS AND END-UNIT BOOKCASE

† Engineering Branch, Midland Region.

* MISSEN, L. A., SNOOK, R. A., and HITCHIN, E. J. T. Thanet Cordless Switchboard. *P.O.E.E.J.*, Vol. 48, p. 102, July 1955.

FIG. 2—GENERAL VIEW OF SWITCHROOM

A second subsidiary queue and nominated position enable subscribers who are barred from making trunk calls, i.e. from dialling 100 and gaining access to the main queue, to make inquiries. Reverted calls from pay-on-answer coin-box users are also directed to this queue. Code 097 is used to enable distant operators dealing with personal calls which have originated from coin-box users to gain access to this subsidiary queue.

Each of the subsidiary queues is equipped with two places, one for a call connected to the operator and one for a waiting call.

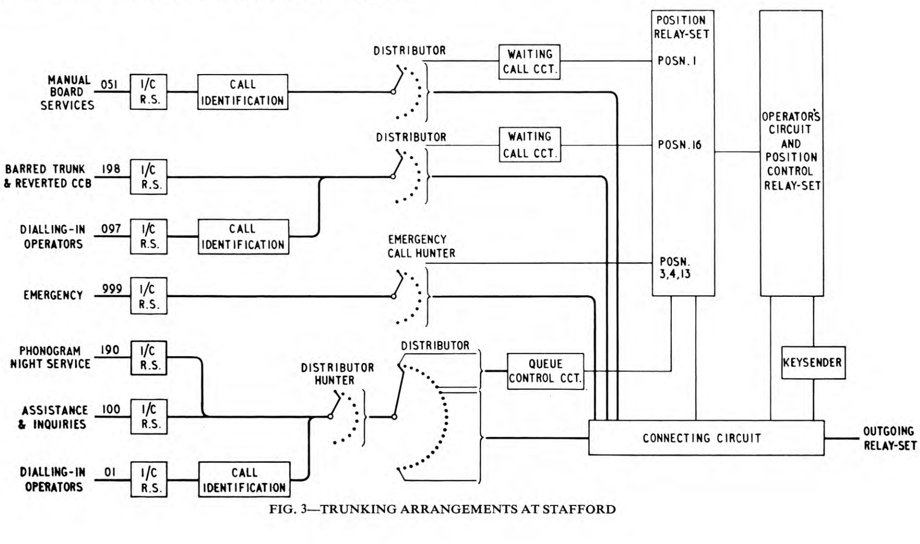


FIG. 3—TRUNKING ARRANGEMENTS AT STAFFORD

Identification of Calls

To enable the Stafford operator to distinguish between types of call being presented to her, identifying signals are required.

Calls from coin-box users can be distinguished from those made by ordinary subscribers by means of the position C.B. lamp, which glows when a discriminating signal is received from the incoming coin-and-fee checking control relay-set or the incoming U.A.X. relay-set. Provision is also made for the operator to hear pay-tone when she answers a call from a pay-on-answer coin-box in the main-exchange area, if required.

Incoming calls made by operators can be identified by a single 900 c/s pip of tone applied, when the call is answered by the Stafford operator, from a relay-set inserted between the selector-level relay-set and the incoming side of the distributor hunter. This relay-set and form of identification are also in use at Thanet and Middlesbrough.

MODIFICATION OF CORDLESS-SWITCHBOARD CIRCUITS

At the cordless-switchboard installations at Thanet and Middlesbrough, inquiry positions were installed which had the facility of switching a service-interception call to the wanted subscriber. Access to the inquiry positions was obtained by the operation of an RRQ key fitted to each controlling position. At Stafford an inquiry suite, and hence the RRQ circuit, has not been provided; use has been made of the RRQ key to provide the facility of switching service-interception calls on every position.

EMERGENCY CALLS

Emergency (999) calls are given priority over any call in the main queue and bypass the distributor. Facilities are provided for the call to be connected to any one of three selected positions. The standard calling signal is supplemented for this type of call by a red alarm lamp and a hooter. When an emergency call has been answered normal working is restored.

DISPLAY PANEL

The Thanet and Middlesbrough installations include section supervisors' display panels and a console for the officer-in-charge. A similar display and console have been provided at Stafford with the additional indication of whether the full or cheap rate of charging is in force. Provision has also been made for a third rate if it should be needed in the future.

CONCLUSION

The pattern of future switchboards has not been settled and it may well be that the experiment at Stafford, which was brought into service on 29 July of this year, will influence the eventual design.

Book Review

"Relativity for Engineers and Science Teachers." L. H. A. Carr, M.Sc.Tech., M.I.E.E., A.R.P.S. Macdonald & Co. (Publishers), Ltd. viii + 52 pp. 5 ill. 12s. 6d.

This little book explains very simply and lucidly the basis and meaning of the special theory of relativity as far as is necessary to understand the relevance of relativity theory in electromagnetism.

The mathematics used and the general ideas introduced make the book easily within the capacity of a university graduate in engineering, or a graduate of one of the professional engineering institutions. The student with a full Technological Certificate in Telecommunications Engineering of the City and Guilds of London Institute, who has taken his mathematical studies seriously, should also find the book readable and informative, although he may perhaps find the academic approach a little strange at first.

The difficulty in approaching the subject of relativity for the first time is that, although one may follow the reasoning in all its detail, the idea behind the whole conception is often extremely elusive and evades the student's grasp without a lot of independent thinking about the subject by the student himself. Relativity is not a subject which can be taught. Students are also usually too eager to gloss over the special theory—which, roughly speaking, is concerned with the mutual effects between bodies whose relative movement is restricted to uniform linear velocity—and pass on to the general theory, which is concerned with the mutual effects between bodies whose relative movement may include accelerations along linear or curved paths. The reason for this eagerness is, of course, that the general theory leads to most interesting conclusions about the nature of gravitation, the curvature of light rays in gravitational fields, and the finite extent of the expanding universe. Mr. Carr's book does not go so far as the general theory, but he concentrates his efforts on getting the student to obtain a firm grasp of the special theory and its relevance to electromagnetism; this he does very well. As far as electromagnetism is concerned, knowledge of the special theory is sufficient, but the student whose interests urge him to delve into the general theory also will find this book an excellent introduction to further study.

Many people may find it an effort to read the book sufficiently carefully to grasp the subject thoroughly, but the effort involved is not excessive and will usually be well repaid.

Many so-called "popular" expositions have been attempted by authors without a sufficiently deep grasp of the meaning of relativity and this has, unfortunately, resulted in their using illustrations of the implication of relativity which are false. This book ends with a short but most useful discussion of two of these fallacies, which are mentioned again and again in a number of popular works on the subject. These discussions in themselves emphasize the soundness of Mr. Carr's exposition. In the author's own words "no one who understands the substance of the previous nine chapters could be guilty of propounding them."

The book is recommended to the professional engineer who wants to understand the implications of relativity as far as it relates to electromagnetism, or who wants a sound introduction to further study of the subject as it relates to gravitation and the nature of the universe.

F. C. M.

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Solderless Wrapped Joints in Telephone Exchanges

K. W. HIX, A.M.I.E.E.†

U.D.C. 621.315.684 : 621.395.722

Solderless wrapping of joints is a method of producing permanent pressure joints with a reliability equal to that of good soldered connexions. The method was adopted experimentally at a telephone exchange in the United Kingdom in 1955, but it is now being used to an increasing extent. A description of the method of making wrapped joints is given, and experience in its application to telephone-exchange practice is discussed.

INTRODUCTION

THE standard method of connecting together items of telephone apparatus and making permanent connexions between equipment is by soldered joints. A high standard of reliability is achieved in making such connexions but, for various reasons, there is an ever-present possibility of some dry joints, which result in subsequent maintenance difficulties. A method of connexion which could prove even more reliable than the soldered joint and also show an overall economy in wiring costs is the solderless wrapped connexion developed originally in the U.S.A.* The method was introduced as an expedient for use on closely spaced terminals but subsequent developments have justified its application to a variety of types of equipment. It is of particular interest in that it enables p.v.c.-insulated wire to be terminated in conditions which might present considerable difficulties if the usual soldering techniques were used. In this article the practical form of the method and its application to exchange equipment are described and some conclusions drawn on its future possibilities.

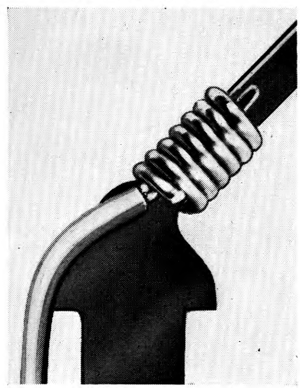
SOLDERLESS WRAPPED JOINTS

Primary Joints

Fig. 1(*a*) illustrates a typical primary wrapped joint, which is composed of seven complete turns of bare wire closely coiled around a terminal. The joint is made by stripping a sufficient length of wire and then inserting the wire into a specially designed tool which wraps it with a continuous motion around a sharp-edged terminal of square or rectangular cross-section. The tension put into the wire holds the connexion, and the magnitude of the stress induced is largely determined by the design of wrapping bit used in the tool. The sharp edges of the terminal bite into the wire and care must be taken to avoid fracture of the wire. Fig. 2 shows the indentations which have been made in the wire at the points of contact with the terminal, and it is obvious that any surface film will have been ruptured in the course of the wrapping operation. The tinned copper wire normally supplied is satisfactory for making wrapped connexions and the wrapping bit can be used for both sizes of conductor in general use for exchange wiring, i.e. 6½ lb/mile (0·020 in.) and 9¼ lb/mile (0·024 in.) conductors. For wrapping a 12½ lb/mile (0·028 in.) conductor a larger wrapping bit is necessary.

The minimum number of seven turns, six of which must be complete, has been chosen to ensure that, with the maximum foreseeable relaxation of tension which is likely to occur over a 40-year life, an adequate number of tensioned contact points will remain to give a low-contact-resistance joint. Whilst this cannot be proved, the results of accelerated aging tests carried out both in this country and the U.S.A. justify this confidence. Studies of the condition at the corners of the terminals have been made, and photographs of a cross-section through a terminal and wrapped connexion, and an enlarged view near one corner, are shown in Fig. 3. It appears that the coating materials (tin coating on the wire, nickel and solder coating on the terminal) flow under pressure from the contact point in such a manner that a mingling of these materials results, forming an effective gas-tight seal of the contact point and preventing any ingress of corrosive agents. As a consequence, severe corrosion, such as illustrated in Fig. 4, can be experienced on solderless wrapped joints without any increase in contact resistance. It would appear that the tin and

(*a*) Primary Wrapped Joint



(*b*) Secondary Wrapped Joint

FIG. 1—SOLDERLESS WRAPPED JOINTS

† Telephone Exchange Standards and Maintenance Branch, E.-in-C.'s Office.

* McRae, J. W., Mallina, R. F., Mason, W. P., Osmer, T. F., Van Horn, R. H. Solderless Wrapped Connexions. *Bell Telephone System Monograph No.* 2085.

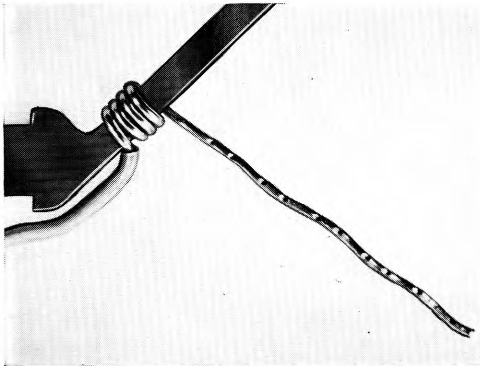
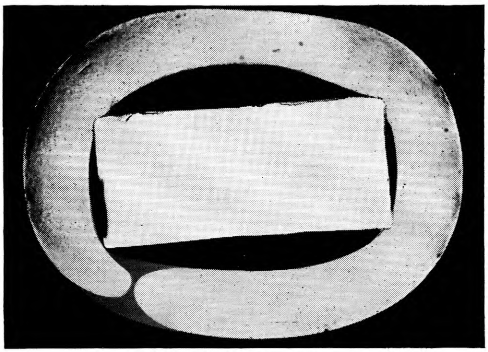
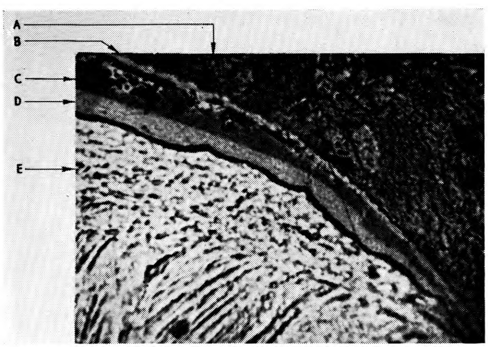


FIG. 2—PARTIALLY UNWRAPPED JOINT SHOWING INDENTS IN THE WIRE

solder coatings, although provided primarily to facilitate any possible reconnexion using solder, have some value in improving the corrosion-resistant properties of the connexion. Whilst it is possible that bare copper wire and untreated base-metal terminals would give satisfactory connexions, particularly as the corners of such terminals are likely to be sharper than similar terminals with a solder coating, lengthy trials would be necessary before such joints could be accepted and no proposals of this nature are under consideration.



(*a*) Complete Cross-section × 21.



(*b*) Cross-section of Interface Between Wire and Corner of Terminal × 1,720

A = Copper wire. B = Tin layer on copper wire.
C = Solder layer on terminal. Note that the voids present in the solder layer are eliminated as pressure increases towards corner edge of terminal to the right of the photograph.
D = Nickel barrier layer on terminal. E = Brass terminal.

FIG. 3—CROSS-SECTION THROUGH TERMINAL AND WRAPPED JOINT

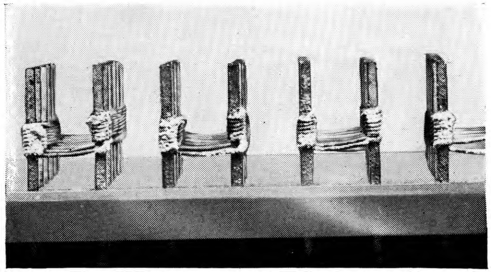


FIG. 4—ARTIFICIALLY CORRODED WRAPPED JOINTS

Secondary or Bound Joints

Any wiring practice must provide a means of re-terminating wires and, as will be seen from an examination of Fig. 2, that part of a wire which has been used for a normal or primary wrapped joint is weakened to such an extent that it cannot safely be used for a second terminating operation. If sufficient slack wire exists, the end of the wire can be cut off, a further length stripped, and a new primary wrapped joint made. If a sufficient length of wire is not available to permit the necessary seven turns, a short length of the wire to be terminated is laid alongside the tag and a length of loose wire is used to lash the wire tail to the terminal. This type of joint is referred to as a secondary or bound joint and is illustrated in Fig. 1(*b*); it differs from the primary joint in that the basic connexion between the terminal and the terminating wire is made through the wrapping wire.

The possibilities of corrosion affecting a secondary joint appear to be greater than for a primary joint and for this reason they may be found less reliable. Furthermore, considering a reconnexion, it will be realized that the edges of the terminal become blunted in making a primary joint and this reduces the efficacy of any subsequent wrapped joints on the same terminal. Nevertheless, tests have indicated that a sufficient margin of safety exists to make secondary joints acceptable for the correction of wiring errors, but it is usually more satisfactory and as simple to employ a soldering iron to correct the few wiring errors that occur, and this method is usually preferred on telephone equipment.

WIRE-WRAPPING TOOLS

The success of wire-wrapping operations is largely dependent upon the design of the tool used for applying the wire to the terminal. Wrapping operations must be carried out smoothly without any jerking of the wire, and the turns must be laid firmly and continuously around the terminal until the stripped portion of the wire is used up. The tools may be rotated by electric motor or pneumatic means, or by hand using crank-handle, pistol-grip, ratchet-drive or direct-action mechanisms. Power-driven tools are considered to give more consistent results than hand tools, but they are bulkier

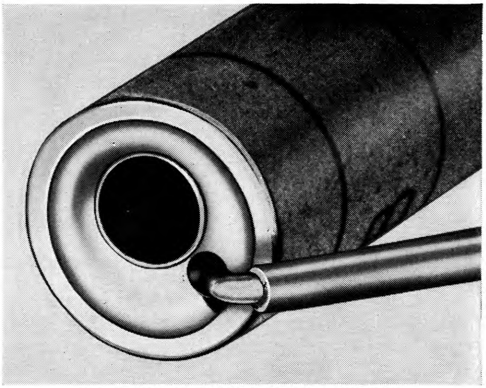


FIG. 5—END OF SPINDLE OF WRAPPING TOOL

and appreciably more expensive. The method of driving the tool is perhaps of less importance than the design of the wrapping bit, which needs to be carefully designed and manufactured to ensure that the wire is released smoothly as the tool is rapidly rotated. The wrapping bits in normal use have two longitudinal holes at the end, a central hole just large enough to fit over the terminal and a smaller hole at its side into which the stripped conductor wire is inserted. The surface of the tool between these holes is slightly rounded, polished and hardened to assist the flow of the wire and avoid wear. Fig. 5 shows an enlarged view of the spindle of a hand tool at the commencement of a wrapping operation. Samples of electrical and hand-operated tools are shown in Fig. 6.

Whilst it is the normal practice to strip enough insulation to give the requisite number of turns from the conductor wire before the commencement of a wrapping operation, it would obviously be an improvement if the tool could cut, strip and wrap insulated wire by consecutive operations. Tools have been designed to carry out these operations and, whilst not yet generally used, they could make the use of solderless wrapped joints more economic.

APPLICATIONS

It has already been stated that solderless wrapped joints are only fully effective if made on terminals of suitable cross-section and rigidity. For this reason the initial application of wire wrapping has been restricted to connexion strips on which little change in tag design was necessary to make them suitable. On existing standard components such as relays, rectifiers and capacitors, redesign of tags would be required and such action is not at present contemplated. For new apparatus, however, the possibility of wire wrapping is considered at the design stage, and the interception unit designed for the exchange side of the new main distribution frame* has been provided with tags suitable for solderless wrapped joints.

The first installation at which solderless connexions were used was an extension of Brixton exchange (in London) in 1955, the connexion strips on the intermediate distribution frame and certain equipment racks being wired in this manner. Since then other installations have been provided throughout the country. At Springpark exchange (in London) wrapped joints have been used on special fuse mountings on an experimental main distribution frame, in addition to being used throughout the exchange for connexion-strip terminations. The particular value of solderless connexion where tags are closely spaced has already been exploited by one manufacturer in the wiring of electronic register-translator equipment for subscriber trunk dialling. Other applications to electronic exchange equipment are expected.

Modification of the flat type of connexion strips for wire wrapping presents no difficulty, consisting of substituting straight shanked tags for the normal notched tags, but it will be appreciated that space does not permit the insertion of a tool between Tee blocks with the tags at right angles to the body of the block, when the blocks are mounted at their normal spacings. An angled tag has been produced, therefore, which enables the tool to be used in the manner shown in Fig. 7.

INSPECTION AND CONTROL

Whilst completed wrapped joints lend themselves to quick inspection, no effective test on the completed joint

* Hix, K. W. The Telephone Exchange Main Distribution Frame. *P.O.E.E.J.*, Vol. 53, p. 226, Jan. 1961.

The tools are, from left to right: (*i*) Pistol-grip wrapping tool (*ii*) Direct-action wrapping tool (*iii*) Wire stripping and cutting tool (*iv*) Crank-handle wrapping tool (*v*) Electric-motor wrapping tool

FIG 6—WIRE-WRAPPING TOOLS

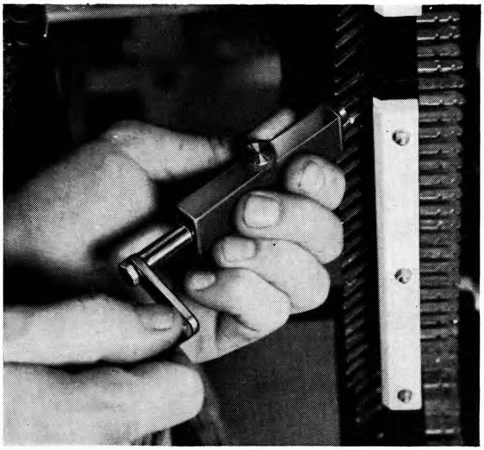


FIG. 7—HAND WRAPPING TOOL BEING USED ON CONNEXION STRIP WITH ANGLED TAGS

can be carried out without the possibility of destroying the essential features of the joint. It is the normal practice, therefore, to require each operator to make test joints on a test stand prior to commencing production, with the object of ensuring that the tool is in good condition. A proportion of these test joints are then checked for wire tension by applying pressure behind the wrapped wire with a "pull-off" tool. The force required to strip the wire from the tag should in all cases exceed $6\frac{1}{2}$ lb and will normally be of the order of 15–18 lb. Low-tension joints can result from a defective tool, and an early indication is usually given by erratic performance before actual failure occurs. Other test joints are unwrapped to verify that the tool is not producing too high a wrapping tension, with its consequent risk of wire fracture. Any wire that has been significantly over-strained will break during the unwrapping test.

In the event of the operator pressing too strongly on the tool the turns tend to pile on top of one another, and where this occurs the joint is soldered afterwards. If the operator moves the tool along the length of the tag too rapidly, gaps between adjacent turns can result. This is usually accompanied by a reduced pressure joint, but providing the gaps are not excessive the joint will rarely have a tension below the acceptable limit. Any attempt to improve the appearance of a joint by manipulation with wiring pliers will destroy the essential quality of the wrapped joint.

As inspection and control is a particularly important feature of the solderless wrapped-joint technique, attention is still being directed to this feature with a view to arriving at the least costly and most reliable means of ensuring that good connexions have been established.

EXPERIENCE WITH WRAPPED JOINTS

From laboratory tests and field experience to date it is probably true to say that, considering low and constant resistance as the criterion, there is little to choose, for practical purposes, between a good soldered joint and a correctly made solderless wrapped joint. It is probable that greater care in preparation and execution is necessary in making soldered joints than is the case with joints made with a well-designed wrapping tool, and the possibility of defective joints should, therefore, be reduced if a consistently high standard of wire wrapping can be maintained. This can only be proved by field experience, which has not yet been fully obtained.

As the method is well suited to large-scale jointing operations some labour savings can be expected which, together with the savings in solder, could result in financial economy. To offset this, however, is the necessity for special care in control, inspection and testing at the present stage, and the capital cost of the special tools.

Advantages which are difficult to evaluate, but nevertheless real, are the ability to terminate p.v.c. wire without fear of damage to insulation, and the freedom from the maintenance hazards resulting from solder splashes and wire cuttings, which are an inevitable accompaniment of soldering operations. A further point of value with the current trend towards miniaturization of apparatus is the closer terminal spacing permissible for wrapped-wire connexions, an advantage which has already been exploited in one instance, i.e. for the connexions to the leaves in the electronic register-translator.*

While experience has shown that connexion-strip tags suitable for wrapping can readily be designed, the position is different for an item such as a relay. A suitable tag on which to terminate $6\frac{1}{2}$ lb/mile and $9\frac{1}{4}$ lb/mile conductors should have cross-sectional dimensions of 0·060 in. × 0·040 in., and although material down to 0·024 in. thickness has been used satisfactorily for single joints, the necessary rigidity is not present in tags made from normal relay-spring materials; accordingly, the redesign of telephone apparatus components such as 3,000-type relays would be involved before wire wrapping could be adopted for the wiring of selectors and relay-sets.

Limited experience with secondary joints has left some doubts on their long-term reliability, but the method is clearly useful for terminating wire-ended components and has been used for connecting silicon rectifiers, operating at high temperatures in power units.

CONCLUSION

A limited amount of solderless wire wrapping has now been used for some years on telephone exchange equipment. The advantages at present are marginal, and until more operational experience is obtained soldering of joints will remain in wider use than wire wrapping. Application of the solderless wire-wrapping technique has largely been limited to connexion strips but its application to new items of exchange apparatus may follow in due course.

ACKNOWLEDGEMENTS

Much of the work of investigating the technique and application of solderless wrapped joints has been undertaken by Standard Telephones & Cables, Ltd., in co-operation with other manufacturers represented on the British Telephone Technical Development Committee. Permission of Automatic Telephone & Electric Co., Ltd., to publish Fig. 4, Ericsson Telephones, Ltd., to publish Fig. 1(*a*) and 3, and Associated Electrical Industries, Ltd., to publish Fig. 7 is acknowledged.

* BANHAM, H. Physical Design of Subscriber-Trunk Dialling Equipment. *P.O.E.E.J.*, Vol. 51, p. 310, Jan. 1959.

Notes and Comments

C. W. Sowton, O.B.E., M.Sc., A.C.G.I., A.M.I.E.E.

On his appointment as Staff Engineer, Overseas Radio Planning and Provision Branch, Mr. C. W. Sowton returns to a field with which he was closely concerned at the outset of his Post Office career. After graduating with honours at the City and Guilds Engineering College of the Imperial College of Science and Technology, London, he entered the Engineering Department as a Probationary Assistant Engineer (old style) in 1933.

He was engaged on research and development work in connexion with h.f. and v.h.f. radio-telephone transmitters at the Post Office Research Station, Dollis Hill, until 1939 when he was promoted to Senior Executive Engineer in the Radio Planning and Provision Branch at Headquarters. There he was responsible for the design, construction and installation of m.f. and h.f. transmitters and receivers, v.h.f. multi-channel radio-telephone systems and the Radio-Telephone Terminal at Brent.

Mr. Sowton was promoted to Assistant Staff Engineer in 1951 and since then has been closely concerned with the technical aspects of the development and control of the sound and television broadcasting services, radio interference suppression and frequency allocation matters. He has served on a number of national and international committees, and has participated in several international conferences, including the Plenary Assemblies of the C.C.I.R. in 1953, 1956 and 1959, the European V.H.F. Broadcasting Conferences in 1952 and 1961, and the Administrative Radio Conference in 1959.

Mr. Sowton has gained a well-deserved reputation as a good committee man, not only because of his sound grasp of the subjects with which he is dealing but also through his imperturbability and good humour, which has often tided committees successfully and with apparent ease over difficult and troublesome situations. In recognition of his work in the national and international fields he was awarded the O.B.E. in 1961.

Charles Sowton has many friends, within and outside the Engineering Department, in this country and overseas; they will all wish him every success in his new field of activity. W. J. B.

Awards by the Institution of Electrical Engineers

The Board of Editors has noted with pleasure that Mr. L. R. F. Harris, of the Post Office Engineering Department, and other authors have been jointly awarded an Electronics and Communications Section premium by the Institution of Electrical Engineers for the following papers read during 1960:

L. R. F. Harris, M.A., A.M.I.E.E., V. E. Mann, and P. W. Ward, B.Sc.(Eng.), A.M.I.E.E. "The Highgate Wood Experimental Electronic Telephone Exchange System."

R. G. Knight, B.Sc.(Eng.), A.M.I.E.E., A. D. Martin, A.M.I.E.E., E. A. R. Peddle, B.Sc., and B. D. Simmons, A.M.I.E.E. "System Operation of a T.D.M. Switched-Highways Electronic Telephone Exchange."

Radio and Electronics Industry Awards for Published Technical Articles

This year the Radio and Electronics Industry Awards Committee will present up to eight premiums of 30 guineas each to writers of published articles which, in the opinion of the panel of judges, are likely to enhance the reputation of the industry and focus the attention of people throughout the world on Britain's leadership in radio, television and electronics.

Any writer will be eligible who is not earning 25 per cent or more of his income from fees for articles or from book royalties.

Writers are invited to submit published articles, together with signed declarations of eligibility, to the Secretary of the Awards Committee, The Electronic Engineering Association, 11 Green Street, Mayfair, London, W.1, with a request that the article should be considered for an award. Articles will be considered for awards at the end of the year and the results announced early next year. Writers are, however, urged to send in their entries as soon as possible after publication; all entries must reach the Secretary before 15 January 1962.

Articles published in this Journal are eligible for the awards.

Institution of Post Office Electrical Engineers

Essay Competition 1961–62

To further interest in the performance of engineering duties, and to encourage the expression of thought given to day-to-day departmental activities, the Council of the Institution of Post Office Electrical Engineers offers five prizes, a first prize of six guineas and four prizes of three guineas, for the five most meritorious essays submitted by members of the Post Office Engineering Department *below the rank of Inspector*. In addition to the five prizes, the Council awards five certificates of merit. Awards of prizes and certificates made by the I.P.O.E.E. are recorded on the staff dockets of the recipients.

An essay submitted for consideration of an award in the essay competition and also submitted in connexion with the Associate Section I.P.O.E.E. prizes will not be eligible to receive both awards.

In judging the merits of an essay, consideration will be given to clearness of expression, correct use of words, neatness and arrangement, and although technical accuracy is essential, a high technical standard is not absolutely necessary to qualify for an award. The Council hopes that this assurance will encourage a larger number to enter. Marks will be awarded for originality of essays submitted.

Copies of previous prize-winning essays have been bound and placed in the Institution Central Library. Members of the Associate Section can borrow these copies from the Librarian, I.P.O.E.E., G.P.O., 2–12 Gresham Street, London, E.C.2.

Competitors may choose any subject relevant to current telephone, telegraph or radio practice. Foolscap or quarto-size paper should be used, and the essay should be between 2,000 and 5,000 words. An inch margin is to be left on each page. A certificate is required to be given by each competitor, at the end of the essay, in the following terms:—

"*In forwarding the foregoing essay of words, I certify that the work is my own unaided effort both as regards composition and drawing.*"

Name (in block capitals)

Signature

Rank

Departmental Address

Date .

The essays must reach
The Secretary,
The Institution of Post Office Electrical Engineers,
G.P.O.,
2–12 Gresham Street,
London, E.C.2.
by 31 December 1961.

The Council reserves the right to refrain from awarding the full number of prizes and certificates if in its opinion the essays submitted do not attain a sufficiently high standard.

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.

2631 *Mathematics in the Making*. L. Hogben (Brit. 1960).
A review of the history of mathematics designed to appeal to the general reader.

2632 *Errors of Observation and Their Treatment*. J. Topping (Brit. 1957).
Written mainly for students in technical colleges taking National Certificate courses in applied physics.

2633 *High Frequency Applications of Ferrites*. J. Roberts (Brit. 1960).
Intended for the benefit of research workers, advanced students of electrical engineering and physics, and those engaged in the design or operation of electronic equipment.

2634 *Understanding Microwaves*. V. J. Young (Amer. 1960).
Presents the material which will form a basis for understanding microwave radio and radar.

2635 *The Amateur's Lathe*. L. H. Sparey (Brit. 1960).
A full guide to the use of the small lathe.

2636 *The Private Car*. Institution of Mechanical Engineers (Brit. 1960).
A collection of 12 lectures on design trends presented to the Automobile Division of the Institution of Mechanical Engineers.

2637 *Domestic Heating*. W. F. B. Shaw (Editor) (Brit. 1960).
A guide to all forms of space heating and hot-water supply systems for the home.

2638 *Semiconductor Technology*. G. K. T. Conn (Editor) (Brit. 1960).
Reprint of articles in *Research* presenting a simple survey of the subject.

2639 *The Dielectric Circuit*. P. Kemp (Brit. 1960).
The basic principles of electrostatics in their applications to high-voltage a.c. circuits.

2640 *The Testing of Electrical Machines*. L. H. A. Carr (Brit. 1960).
Deals with the techniques of testing, the purposes of the tests, and the subsequent treatment of the data obtained, and gives details of the principles underlying the actions of the machines concerned. Assumes a technical standard of the Higher National Certificate in electrical engineering.

2641 *A to Z in Audio*. G. A. Briggs and R. E. Cooke (Brit. 1960).
A glossary to answer most of the questions which puzzle the amateur, and an outline of some of the facts which even the experts may forget.

2642 *A Course in Pure Mathematics*. M. M. Gow (Brit. 1960).
Designed especially for the first-year student reading mathematics for Part 1 of the new London B.Sc. General Degree, or as an ancillary subject in the B.Sc. Special Degree.

2643 *Services Textbook for Radio, Vol. 7. Radiolocation Techniques*. J. D. Haigh (Brit. 1960).
A full textbook for the technician, with difficult passages marked for omission by a reader with no previous experience of the subject.

2644 *Electronic Circuit Analysis, Vol. 1. Passive Networks*. P. Cutler and H. Hoover (Amer. 1960).
Designed to bridge the gap between engineering and technician-level electronics; includes many solved and unsolved problems.

2645 *A Second Course in Statistics*. R. Loveday (Brit. 1961).
A follow-on to the author's book *A First Course in Statistics*. Aimed at sixth-form pupils and students in universities, colleges of technology, etc.

2646 *An Introduction to the Theory and Practice of Transistors*. J. R. Tillman and F. F. Roberts (Brit. 1961).
A wide treatment of the subject intended to help the student to obtain a confident quantitative understanding of all the primary physical effects on which minority-carrier transistors depend for their electrical behaviour, and an insight into the potentialities and limitations of the devices as circuit elements.

W. D. Florence,
Librarian.

Regional Notes

North Eastern Region

THE ROYAL WEDDING

Following the announcement that H.R.H. The Duke of Kent would marry Miss Katherine Worsley of Hovingham, in York Minster, requests for circuits flowed in, and it was very soon apparent that the radio, television and press network would be bigger than anything previously handled in the provinces.

Three localities were affected: York, Hovingham and the rest of the country. The planning, provision and commissioning of the network took seven weeks.

Work at Hovingham

The reception was to be held at Hovingham village, which is the Yorkshire home of the Worsley family and is 25 miles from York.

The village is served by a U.A.X. 13, which is parented on Malton. All spare line plant was brought into use between York and Hovingham, and a further 30 cable pairs were diverted to the U.A.X. Additional cables with a total sheath length of 14 miles were also provided along hedge bottoms but through duct where possible. These were polythene cables and, because they had to be matched with lead-sheathed junction cables, they were laid and balanced in a go-and-return fashion. The capacitance characteristic of the cable was 0·095 μF/mile, and the joints were spaced at 500-yard intervals. The loading sections were therefore given 1,500-yard spacings and all pairs were jointed as test-selected pairs. Laying, balancing, loading, jointing and terminating were completed two weeks before the wedding, so that time was available for testing.

At Hovingham, provision was made for 15 broadcast circuits, five circuits for picture transmission, 10 kiosk trunk subscribers to York, and four additional junctions to the parent exchange. These circuits were distributed among the three cables to provide a maximum of alternative routings.

Five television cameras were used in Hovingham, and to four of these the television engineers provided their own cables. The fifth one, half a mile from its control point, was fed by a 7-pair screened polythene cable.

Arrangements in the City of York

Kiosks were installed in suites of four and eight at strategic points in the City and the Minster, and 23 exchange lines were provided for press, police, B.B.C., I.T.V. and the Lord Chamberlain's Office.

A very extensive network was installed at the Minster, which was used as the main control centre by B.B.C. and I.T.V. for vision and sound. Forty-one television cameras were used in and about the Minster and each was cabled to its control vehicle on the royal wedding route.

Six miles of polythene cable were laid outside the Minster, and as it was forbidden to interfere with the cathedral fabric, circuitous routes had to be used for cabling to the various points inside—galleries 100 ft high were amongst the hazards encountered. Three miles of cable were used inside the Minster. All cabling was finished and the plant was tested out a few days before the wedding. During the testing the screening of one cable was found to be disconnected. Further nvestigation revealed that the screening of the cable concerned was of anodized polythene or eurethene, and was not a conductor or an effective screen. This cable was promptly replaced by a polythene cable containing an effective screen.

The Post Office Television Outside-Broadcast Units

Seventeen vision circuits were provided by the Post Office; the B.B.C. and Granada Television each had eight circuits in York, and the B.B.C. had one at Hovingham to connect a remote camera to the mobile control room outside the gates of Hovingham Hall. Each of the circuits required the normal transmit amplifier and an equalizer-amplifier at the receiving end. Three circuits which were routed through the telephone exchange had intermediate amplifiers at that point, making a total of 37 operational amplifiers.

The B.B.C. used 21 cameras and Granada used 25 for approximately the same territorial coverage, but the control arrangements differed considerably. The B.B.C. built a temporary control console in the Minster Chapter House where their radio links were terminated, and they had an intermediate producer in a mobile control room at the Lord Mayor's Walk. Post Office equipment was also installed in the Chapter House, but at the Lord Mayor's Walk the normal outside-broadcast van was much too small and the equipment was installed in a fleet-transport vehicle lent by the Engineering Department. Granada radio links terminated in the telephone exchange and were extended with the other vision links to one production point in the Minster yard, where there was a concentration of eight Post Office video amplifiers. These were housed in a larger fleet-transport vehicle, which was parked in the Minster yard.

The remainder of the equipment was located in six of the special outside-broadcast Karrier vans, an estate car and a minibus. The equipment in the vehicles, the Chapter House and the telephone exchange was placed on temporary shelving built from lengths of "slotted angle."

The Manchester outside-broadcast team is normally responsible for vision circuits in the North Eastern Region and they organized the assembly of vehicles, staff and equipment. The size of this operation was, however, completely beyond their resources, and therefore assistance was given by the teams from the Scottish, Midland and London Regions. Seven Assistant Engineers and 14 Technical Officers were engaged on the temporary vision circuits.

Vision signals were fed into the national network via the television network switching centre in Manchester. Granada provided a radio link from the roof of York telephone exchange to the Independent Television Authority station at Emley Moor, with a reserve to Winter Hill. Post Office cable links were used between those stations and Manchester. The B.B.C. used two radio links: one from an aerial on the Minster to Holme Moss, which is connected to Manchester by cable; the other was routed from the Minster to Tinshill, which is an intermediate station on the Manchester–Edinburgh radio link, where the signals were injected into the return channel.

The Day of the Event

On the wedding day York City centre was closed to all but pedestrians and essential service vehicles. Post Office maintenance staff were provided with labels for the windscreens of their vehicles, which were stationed at strategic points on the perimeter of the closed area.

The press made a dark-room in York exchange, and at one time 26 pictures were being transmitted simultaneously.

Conclusion

Despite the pressure on the staff the work was carried out cheerfully and efficiently. Since the war communications have been provided for many events and staff have come to look upon these as everyday work. The Royal Wedding, however, was different; it was important, exciting and stimulating. Six thousand hours were spent on the work, and the complete success of the whole project served to reward this effort.

H. C. (Manchester).
E. S. (York).

London Telecommunications Region

THE LONDON CITADEL EXCHANGE

The first centralized S.T.D. unit for the London director area opened on 1 July, when Metropolitan, Moorgate, and London Wall exchanges were given access to the unit. The unit, named London Citadel Exchange, is equipped with six magnetic-drum register-translator racks, providing 230 registers, 3,526 incoming relay-sets each associated with a 4,000-type 1st selector, 1,300 motor-driven 2nd group selectors and 646 signalling system A.C.9 outgoing relay-sets. For generating the periodic-metering pulses and controlling the full-rate/cheap-rate change-over, five tariff-pulse-machine racks were provided.

The installation was made more difficult by the use of accommodation not designed to house this type of equipment. Cable-holes and an apparatus entrance had to be cut through extra-thick walls. Cabling was complicated by non-standard ceiling heights and ventilation had to be supplemented by refrigeration units to keep working temperatures down to acceptable limits. All the main items of equipment, except the motor-driven group selectors, were of a design which was new to the acceptance staff and considerable training, care and willingness were required, especially as the opening date left no margin of time to deal with unexpected events.

The installation of five additional magnetic-drum register-translator racks, which will increase the number of registers available to 432, commenced immediately after the opening. The unit will later be extended to handle a large proportion of the S.T.D. traffic from over 200 exchanges serving some 1,200,000 subscribers.

K. E. S.

THE INTRODUCTION OF S.T.D. IN THE CITY AREA

The inaugural S.T.D. telephone call from City Area was made by the Lord Mayor, Sir Bernard Waley-Cohen, at midday on 3 July 1961. It was fitting that the call was to the Lord Mayor of Bristol, where the service was first introduced.

Publicity before the introduction of the service had included demonstrations and lectures to executives of City business houses and had culminated in an exhibition held in the Royal Exchange. This exhibition was open for 12 days, 17,136 visitors attended, and the S.T.D. film was shown 218 times.

The new equipment was brought into use on 1 July at 8.30 a.m. at Metropolitan, London Wall and Moorgate exchanges. This time was chosen because these exchanges serve mainly business subscribers and Saturday traffic is not heavy. The opening had been preceded by three weeks' traffic trials to test not only local equipment, but also the centralized equipment in the London Citadel exchange and the associated routes.

The work at Metropolitan, London Wall and Moorgate exchanges involved the fitting of 14 local registers, 144 metering-over-junction relay-sets, 344 subscribers' private meter relay-sets, 23 coin-and-fee checking relay-sets, 80 subscribers' call-barring relay-sets, 7 printer-meter-check equipments, a multi-phase pulse-supply rack and 344 time-pulse relays on the 1st code selector racks; 1,612 1st code selectors were modified by the Factories Department and fitted with ratchet relays. A "pool" of several hundred spare switches was used to permit this large number of switches to be sent away and thus speed up the work. In the same exchange building, another job of similar size was completed in Monarch exchange, where S.T.D. was introduced at the end of July.

The demand for private meters has been less than expected. Up to the time of the introduction of S.T.D., 84 advice notes had been issued for the fitting of 139 private meters. This work is being carried out by a special fitting team, who will also fit the new-type coin-boxes as they become available.

F. K. M.

Home Counties Region

FIRE AT PRESTON EXCHANGE (BRIGHTON AREA)

A fire occurred early in the afternoon of 25 May 1961 at Preston, an 8,000-line Siemens 16 satellite exchange in Brighton multi-exchange area. It started in the lower selectors on a final-selector rack and spread rapidly, extensively damaging the whole rack of equipment. The rising flames also burnt the many cables passing over the rack (1st and 2nd preselector cabling) together with a large number of jumpers. The immediate effect was to disconnect service from the 400 lines served from this rack, and a further 2,000 lines were affected by the damaged cable and jumper runs.

The fire was discovered at a very early stage by an officer visiting the room to clear a howler alarm; he immediately shouted for assistance and attacked the rapidly-spreading fire with a carbon-tetrachloride extinguisher. He was joined by two other members of the staff who, after summoning the fire brigade, attacked the fire with similar extinguishers. These three officers were unable to maintain their effort for long, however, owing to the increasing concentration of very pungent gases generated from the carbon tetrachloride, and they were forced to vacate the room before the fire was out. It was put out shortly afterwards by the fire brigade, using the same kind of extinguisher, but with the aid of breathing apparatus. Some 13 or 14 extinguishers were used, eight of the Post Office type, and five or six of the smaller hand-pump type supplied by the fire brigade.

As soon as possible the best method to be adopted to restore service was determined. Repair teams started immediately on a 24-hour shift basis to piece in replacement cable lengths and jumpers over the damaged sections. The burnt apparatus was replaced by reconditioned shelves of switches (held locally) which were cabled back to the M.D.F. Restoration of service to the affected subscribers commenced the following day and service to all was given (on a temporary basis) by midday on 29 May.

Subsequent investigation tended to indicate that the fire was started by arcing between the C-wiper cord termination and the A-wiper cord tag on the selector tag block. These appeared abnormally close to each other and under certain conditions, with the Siemens 16 system, a current of 1½ amp could flow between them. Tests made on similar apparatus showed that the wiper cord covering can be ignited, with some difficulty, from such an arc, and the flame travelling along the cord will in turn set fire to the bank multiples. In addition to the inflammability of the wiring the fire was fed by the ebonite tag and jack blocks and by the pitch and paraffin wax from the capacitors.

A particular trouble encountered during the repair period was due to the fumes which had spready widely over the apparatus room and condensed on switch mechanisms, even remote from the seat of the fire. This condensation took the form of a sticky deposit which appeared mainly on wiper shafts and prevented switch operation. It was necessary to give the switches four separate cleanings to restore full operating efficiency.

The possibility of a similar fire has now been greatly reduced by the fitting of a short length of sleeving over the C-wiper cord at the tag block end on all final selectors in the Siemens 16 equipment at Brighton. The question of alternative types of fire extinguishers is also under consideration.

H. M. W.

Scotland

GLASGOW DIRECTOR EXCHANGES GET S.T.D.

Glasgow became the first director area in the country to introduce subscriber trunk dialling (S.T.D.), and also the first Post Office installation where the magnetic-drum type controlling register-translators have been used for this purpose, when the interim S.T.D. installation was brought into service at 8 a.m. on 6 May 1961. The official inauguration ceremony was formally held on 8 May 1961, when the Lord Provost dialled a call to the Lord Mayor of Liverpool before a large and distinguished gathering of civic dignitaries. The call went through successfully and the conversation was broadcast to the assembly.

The interim installation caters for approximately 28,000 subscribers' connexions to seven exchanges, Central, City, Bell, Douglas, South, Bishopsbriggs and Kirkintilloch. The S.T.D. installation, and trunk switching unit, were provided at the earliest possible date because the steady increase in trunk traffic, especially during the summer season, would have resulted in heavy overloading of the joint trunk switchboard if the S.T.D. installation had not been completed by May 1961, at the latest.

The installation includes three magnetic-drum type register-translator racks installed centrally in Telephone House. This equipment provides a relatively cheap storage unit, and the associated common circuits can operate at high speeds to control the functions of a large number of registers. All three register-translator racks are normally in service but any one of the three can be withdrawn from service for maintenance or other purposes, without causing the grade of service to fall below standard.

The contract for the main installation was allocated to the General Electric Co., Ltd., who provided and installed the trunk switching equipment. The register-translators, however, were provided and installed by the Automatic Telephone and Electric Co., Ltd., acting on behalf of the G.E.C., Ltd. The switching equipment installation commenced in April 1960, and was completed by February 1961. The register-translators were installed during the period November 1960 to April 1961. A flood tester was used during joint acceptance testing of the register-translators, and 43,000 calls were passed through each register-translator rack in eight hours. Less than eight failures were recorded against any rack.

Two weeks before opening date an extensive program of test calls to other centres was carried out by the operating staff. The effectiveness of the testing, the reliability of the equipment and the efficiency of the national trunk network can be gauged from the first service-observation results which indicated that only a low number of ineffective calls could be attributed to failure of the system.

The S.T.D. interim equipment has been installed in a temporary position, and by design the traffic handling capacity is limited. In the meantime, a large new wing has been added to Telephone House (Bishop Street building), and installation of the Glasgow trunk mechanization equipment and permanent S.T.D. equipment has already commenced. When this project is completed in 1963–64, there will be sufficient switching and circuit capacity to give S.T.D. facilities to many more Glasgow and Scotland West exchanges.

F. J. de C.

Wales and Border Counties

RENEWAL OF CABLE BEARERS IN THE SEVERN TUNNEL

Early this year the British Transport Commission and B.I.C.C. Co. fitted new bearers to support the Post Office cables routed through the Severn Tunnel. The cables were then transferred to the new bearers under Post Office supervision.

The cables, a 4 screened-pr 40 lb/mile + 208 pr 20 lb/mile P.C.Q.T., two 24 pr 40 lb/mile carrier and a coaxial $6 \times 0{\cdot}375$ coaxial tubes + 32 pr 20 lb/mile P.C.Q. + 148 pr 20 lb/mile P.C.Q.T., all armoured and protected, were supported by 3,700 bearers on the southern wall of the tunnel between the ventilation and pumping shafts at Sudbrook and the tunnel mouth at the English end, a distance of about $2\frac{3}{4}$ miles.

Since the route was first established in 1923, chemical attack by the corrosive atmosphere of the tunnel on the metal supports has necessitated their renewal roughly every 10 years. The opportunity was taken on this occasion to install supports and fixings incorporating plastic materials. The bearers were of smooth cast-iron, multiple-coated to a thickness of 0·025 in. with "Neoprene"; the fixing pins were of hard p.v.c. and the bushes into which they were driven were of resin-bonded rubber. The "Neoprene" coating was adopted because it proved resistant to the acidic climate of the tunnel and tough enough to withstand damage during installation of the bearers.

Three Sundays were scheduled for the installation of the new bearers and shifting the cable. There was a chance that when the cables were shifted sheaths would be damaged or coaxial centre-conductor joints disconnected. The cables being accessible only on Sundays, the repair work might have become protracted with serious effect on the trunk traffic and television services. Reasonable precautions were therefore taken against both eventualities. and the cables were pressurized to preserve their insulation in the event of sheath failure.

More elaborate measures were taken to maintain the h.f. service. Provision was made for the continuous monitoring of all the coaxial pairs. Four of them constituted two both-way television systems between Cardiff and Bristol. At Crick and Pilning repeater stations, at opposite ends of the tunnel, it was arranged that failure of a pilot signal on either system would produce an audible alarm, and means of switching quickly to a spare tube between these stations were provided. The spare tubes were monitored initially with a d.c. signal. In addition, two 4,000 Mc/s radio links* bridging the river Severn were installed; these links were connected into the spare tubes at points remote from the tunnel to provide two standby channels from Bristol to Cardiff.

It was imperative that the responsible supervising officer in the tunnel should be informed instantly if any fault occurred so that its position would be known precisely and marked physically on the cable. A telephone line was therefore set up connecting the two repeater stations and the mouth of the tunnel, to be extended as required to the site of operations in the tunnel. The possibility of a second fault occurring could not be overlooked and pulse-echo test equipment was placed at Crick repeater-station to continue monitoring any faulty tube for further defects.

It was known that, while the cables were being moved, transmission of television would be from Bristol to Cardiff. Both B.B.C. and I.T.A. programs were transmitted, therefore, over the radio-cable standby links as well as normal paths during the hours of work. The Cardiff network switching centre was thus assured of reception in the event of failure of a working tube in the tunnel.

The contractor commenced at the English end and used two trains of borail wagons drawn by diesel locomotives. The borails were modified in British Railways workshops so that each train presented about 100 yd of continuous working platform at a height suited to the work. Both trains were lighted by generating sets and carried pneumatic drills and compressors.

The new bearers were fixed from the contractor's first train and this work was completed on the second Sunday.

The contractor's second train was used to lower the cables from the old bearers to the new and fix individual bearers near joints in the cables to ensure their proper support. When all of the cables had been lowered for the length of a train they were secured and the train moved forward. The operation was then repeated. This work was finished on the third Sunday and a second-harmonic tester was used to prove that the coaxial joints were free from damage.

A. H. S.

*Temporary Television Links." *P.O.E.E.J.*, Vol. 54, p. 142, July 1961.

Associate Section Notes

Sheffield Centre

At our April meeting a paper entitled "Closed-Circuit Television" was presented by Messrs. J. B. Holt and W. E. Ready, Main Lines Development and Maintenance Branch and Main Lines Planning and Provision Branch, Engineering Department, respectively. The types of camera, equipment, and line used for closed-circuit work were described, and descriptions of two permanent networks, i.e. those used by the Stock Exchange and by the Banking Houses, were given. The speakers mentioned the use of colour television in hospitals and methods of providing other occasional closed-circuit links. The waveform-comparison method of testing was described. A demonstration set was in operation throughout the lecture, which was also illustrated with slides.

The annual general meeting was held during May, at which the following officials were elected: *Chairman:* Mr. L. G. P. Farmer; *Vice-Chairman:* Mr. F. S. Brasher; *Secretary:* Mr. D. Ashton; *Assistant Secretary:* Mr. B. A. Sargent; *Treasurer:* Mr. C. S. Shepherd; *Librarian:* Mr. G. Woodhouse; *Scribe:* Mr. J. E. Simons; *Committee:* Messrs. G. T. Ridsdale, J. Tomlinson, F. Bough, C. B. Gray, R. B. Lines, A. Knowles, J. Watts, S. Cottage and D. Millington.

During June we visited the Nottingham factory of Boots Pure Drug Co., where we saw a number of their products being made and tested, and learned more about the organization by means of which supplies are dispatched fortnightly to each of some 1,300 branches.

Due to his forthcoming retirement our chairman, Mr. McInes, has resigned from office. He has been a strong supporter of the Associate Section for over 20 years. Our appreciation of his services was shown in a presentation at the annual general meeting.

J. E. S.

Leeds Centre

In March our two Area Engineers, Messrs. E. Hopkinson and P. D. Gilby, gave us a most interesting lecture on the future policy of the Post Office as it concerns Leeds Area. The lecture, entitled "We Look Ahead," was very well attended and a lively discussion took place during question time.

A visit was also paid to Chloride Batteries, Ltd., and 30 of our members made a very interesting tour of the factory.

In April, six of our members visited the Simonstone factory of Mullards, Ltd. This was the second visit we had made during the season and it proved to be very successful.

The annual general meeting was held on 19 June in the Griffin Hotel, when the committee for the coming year was elected. Afterwards, Mr. Knight, of the Leeds City Parks Department, gave us a talk on roses, and we were invited to visit Red Hall, one of the Leeds nurseries.

The program for 1961–62 is as yet incomplete but tentatively includes visits to Messrs. David Brown Tractors, Ford Motor Works, British Railways at York and B.I.C.C. Cables (Prescott), Ltd.

E. B. B.

Bletchley Centre

The inaugural meeting of the Bletchley Centre was held at the Home Counties Region Training Centre on 19 June. Mr. H. W. Harrison, Regional Liaison Officer, presided for this meeting. The meeting was followed by a talk on "Appraisements and Promotions," by Mr. A. H. C. Knox.

This Centre will cater largely for the interests of the staff centred in and around Bletchley and also the staff at the Training Centre. Early indications are that the Centre is much welcomed by the local staff and it is expected that considerable growth will take place as the activities of the Centre become more widely known.

A program of events for the winter session is being prepared by the committee. The following officers have been appointed: *Chairman:* Mr. W. J. Allen; *Secretary:* Mr. A. J. Hudson; *Assistant Secretary:* Mr. E. W. H. Philcox; *Treasurer:* Mr. D. Castle; *Committee:* Messrs. B. H. G. Currell, R. J. Daniels, R. E. Gooden, C. Hamilton, C. Tooth, J. Vickers and M. Walduck.

A. J. H.

Cornwall Centre

The annual general meeting was held in April when the following officers were elected: *Chairman:* Mr. J. C. Wyatt; *Vice-Chairman:* Mr. R. R. Sweet; *Secretary:* Mr. A. R. Brown; *Treasurer:* Mr. D. L. Moore; *Committee:* Messrs. H. H. Pearce, K. Tonkin, K. Barlow, D. Corin and R. Moore.

The secretary thanked the retiring chairman, Mr. A. E. Furse, for the help he had given the Centre as committee member and chairman and wished him success on his promotion. The president, Mr. K. E. Spurlock, then held an open forum.

The May visit was to the new power-operated signal box at British Railways' North Road Station, Plymouth, and all members were most impressed by this modern method of train routing and automatic signalling. Coupled with this visit was a visit to the new Independent Television Authority's switching centre and transmitters at Plymouth.

In early June our president, Mr. K. E. Spurlock, was promoted to Regional Training Officer, Wales and Border Counties Directorate. Mr. Spurlock was the Centre's first chairman and "piloted" us through our first year. His helpful personality will be missed by all our members and we wish him every success on his promotion.

The June visit was to the Cable and Wireless cable ship, *Retriever*, which was in Falmouth dock, following cable-laying operations off U.S.A. This is a new ship and proved to be of great interest to our members.

A. R. B.

Gloucester Centre

The activities of 1960–61 started in August when a small party of members and their wives visited G. F. Lovell's sweet factory, Newport. An interesting tour of the works was followed by tea in the canteen.

A very-well-supported visit was made to Pirelli-General Cable Works, Southampton, where we were able to watch the manufacture of a variety of cables.

Some 40 members visited Morris Motors, Ltd., Cowley, in November. Our generous hosts spared no trouble in making this a memorable day. After leaving Oxford we travelled to Bath where we were entertained by the Bath Centre. A quiz contest was held between six members from each Centre. So successful was the evening that a return visit by the Bath members was arranged on the spot.

The following talks were given during the winter session:

18 October: Mr. B. M. Stanley, of Blackstone & Co., Dursley, talked on "Some Applications of Diesel Engines" to a small but appreciative audience.

29 November: Mr. C. W. Bufton gave a talk on "Subscriber Trunk Dialling." His knowledge of the subject combined with his simple presentation made this an outstanding talk. The S.T.D. equipment at Gloucester was also demonstrated. It was pleasing to see a record attendance at this meeting.

18 January: Mr. M. W. Bayley, Regional Liaison Officer, gave a very informative talk "Telex Wales and the West." Added interest was provided by a demonstration of Continental Telex dialling.

3 March: We had the pleasure of entertaining our Bath friends, when they visited us at Cheltenham to hold a return quiz.

15 March: A talk "Plastics in Industry" was given by Mr. B. J. Wain of Erinoids, Ltd., a local plastics firm.
6 April: A combined meeting was held at Bath to hear Mr. A. H. C. Knox talk on "Appraisements and Promotions."
28 April: Projection of 8 mm amateur film by Mr. B. L. Shaw was followed by the annual general meeting.

The following officers and committee members were elected: *President:* Mr. S. D. Chapman; *Vice-President:* Mr. R. T. Hoare; *Chairman:* Mr. A. K. Franklin; *Vice-Chairman and Librarian:* Mr. N. Mountjoy; *Secretary:* Mr. J. A. Wallis; *Treasurer:* Mr. G. Franklin; *Assistant Secretary:* Mr. R. Harvey; *Committee:* Messrs. R. H. Smart, T. D. Jones and R. Moule.

The present membership is 120.

J. A. W.

London Centre

The April talk, "Recent Developments in Electronic Switching," given before the Centre by Mr. C. A. May, Telephone Exchange Systems Development Branch, Engineering Department, was a stimulating appraisal of present electronic-exchange switching techniques. The audience, comprising some 70 people, were introduced to the basic concepts of space-division and time-division systems and were then shown how the latter technique is being used in the first fully-electronic public telephone exchange now being built in this country at Highgate Wood.

It was with great pleasure that we heard our president, Mr. A. H. C. Knox, give his talk "Appraisements and Promotions" at the last meeting of the session in May. Speaking in the Faraday Room at the Institution of Electrical Engineers, before an audience that exceeded 100, he ranged over the whole field of the present promotion and appeals procedure. At this meeting Mr. J. L. Garland's certificate, for his first-prize-winning paper "The Continental Semi-Automatic Switching Exchange," was presented by Mr. Knox to the London Centre chairman, Mr. A. G. Welling. Mr. Knox also presented the Inter-Area Technical Quiz Shield to Mr. R. Hammond, captain of the winning South-West Area team. The C. W. Brown Award was received this year by Mr. G. F. Morley, secretary of North-West Area, as the Area member who most fulfilled the aims and objects of the Centre during the session. On display before the meeting was an exhibition of new subscribers' apparatus, kindly loaned by the Subscribers' Apparatus and Miscellaneous Services Branch of the Engineering Department. Items on show included the new Plan 625 installation (which replaces the existing Plans 5 and 7), with its associated mains unit; the 2 + 6 cordless switchboard; Telephones No. 706 and 710 with the full range of add-on units, compared with the equivalent 300-type instruments that they have replaced; the S.T.D. coin-box; and other recent developments in the field of subscribers' apparatus.

As the result of correspondence in connexion with the Associate Section tie, two visits to the Circuit Laboratory were made recently by members from other Centres. During May a party of 39, the biggest visiting party the laboratory has had, came from the Leicester Centre and in June a dozen members from the Wolverhampton Centre visited the laboratory. New developments in the switching field, which included the equipment developed for S.T.D. and continental and international dialling, were shown to the visitors.

The Inter-Area Technical Quiz between South-West and West Areas was held early in May at the Circuit Laboratory. As in the finals of the previous two years' contests, Mr. F. C. G. Greening, London Centre Regional Liaison Officer, and Mr. J. H. Broadhurst, Circuit Laboratory Branch Liaison Officer, adjudicated at this exciting contest in which South-West Area narrowly beat their opponents.

Changes in the London Centre Committee took place at the annual general meeting in May. The General Secretary, Mr. D. W. Webber, and the Librarian, Mr. S. Challoner, resigned, the post of the latter being taken by Mr. G. S. Milne of the Circuit Laboratory Branch.

Correspondence concerning the Associate Section tie, orders for which have now exceeded 1,100, should in future be addressed to Mr. B. C. Hatch, Museum A.T.E., Howland Street, London, W.1.

D. W. W.

Shrewsbury Centre

A successful double visit was made by 54 members in June to the British Railways' new signal box at Sandbach and the Granada television studios at Manchester.

The signal box at Sandbach is on the new electrified Manchester–Crewe section and controls traffic in this section over a distance of 12 miles. The facilities provided were well illustrated when a train passed with a door open. We were then able to see how the train was halted and the driver notified, how the following train was advised and how the oncoming train was warned of the possibility of a body on the line.

At the television studios we were able to see the control rooms, telecine rooms, and recording rooms.

The annual general meeting was held on 8 September at Shrewsbury automatic telephone exchange.

H. C.

Salisbury Centre

Interest in the Associate Section in the Salisbury and Andover areas has not declined in the past 12 months although it has not increased by any appreciable amount.

We have held six meetings:

A quiz with Portsmouth Centre.
A lecture on "Assembling and Finishing Plastic Model Kits."
A film show, together with a conducted tour of Harnham Repeater Station.
A lecture on "The Television Receiver."
A lecture on "Efficiency" by Mr. Wilcher, of Bristol.
The annual general meeting.

The attendances at these meetings have not been very impressive. We have found that better publicity is required and that posters tend to be ignored. A scheme is, therefore, in hand to obtain a list of interested persons and we intend to keep these informed individually of our activities.

This, together with a more ambitious program, will, we hope, increase the attendance during 1961–62.

J. H. G.

Colchester Centre

The committee of the Colchester Centre are pleased to report that no loss of membership was suffered due to the re-registration of members during April, and the latest recruitment drive has resulted in an increase of membership of 41. Most of the new members are external staff to whom we extend a warm welcome.

Details of the winter session lectures are:

14 September: "Provision and Maintenance of Underground Equipment," by Mr. R. Cavill, Colchester.
9 November: "Line Connectors," by Mr. A. J. Barker, until recently a member of the Local Lines and Wire Broadcasting Branch, Engineering Department.
14 December: "Quiz," Colchester versus Ipswich.
16 January: Film show.
14 February: "Bees," by Mr. J. Huke.
15 March: "Subscribers' Apparatus," by Mr. J. Rowson.
10 April: Annual general meeting.

At the time of compiling these notes the summer program is in full swing with visits to Gamet Precision Bearings, Davey Paximans, Anglia Studios, Norwich, Standard Telephones and Cables, Ltd., and "BX" Plastics.

J. W. J.

Staff Changes

Promotions

Name	Region, etc.	Date
Assistant Staff Engineer to Staff Engineer		
Sowton, C. W.	E.-in-C.O.	19.6.61
Senior Executive Engineer to Assistant Staff Engineer		
Jemmeson, A. E.	E.-in-C.O.	5.6.61
Executive Engineer to Area Engineer		
Trueman, G. F.	N.W. Reg.	7.4.61
Saunders, J. C.	Mid. Reg. to N.W. Reg.	1.5.61
Batt, T. D.	H.C. Reg. to W.B.C.	19.6.61
Abbott, P. W.	W.B.C.	1.3.61
Executive Engineer to Efficiency Engineer		
Hulcoop, G. J.	H.C. Reg. to Mid. Reg.	8.5.61
Executive Engineer to Senior Executive Engineer		
Fudge, G. A. E.	E.-in-C.O.	17.4.61
Anthistle, A. W.	W.B.C. to Mid. Reg.	4.5.61
Wilson, F. A.	E.-in-C.O.	8.5.61
Executive Engineer (Limited Competition)		
Allwood, M. E.	E.-in-C.O.	24.4.61
Bishop, G.	E.-in-C.O.	24.4.61
Bordiss, H. J. K.	E.-in-C.O.	17.4.61
Chambers, J. A.	E.-in-C.O.	24.4.61
Easterbrook, B. J.	E.-in-C.O.	24.4.61
Ellis, N.	E.-in-C.O.	24.4.61
Hussey, E. D. F.	E.-in-C.O.	24.4.61
Longden, T. E.	E.-in-C.O.	24.4.61
Preston, A. G.	E.-in-C.O.	24.4.61
Redburn, L. A.	E.-in-C.O.	24.4.61
Thomson, A. M. M.	E.-in-C.O. to T.S.U.	24.4.61
Turnbull, M. G.	E.-in-C.O.	18.4.61
Cocking, R.	E.-in-C.O. to N.E. Reg.	24.4.61
Watt, S. A.	Scot. to E.-in-C.O.	24.4.61
Bedford, R. A.	E.-in-C.O.	8.5.61
Balls, R. W.	H.C. Reg. to E.-in-C.O.	24.4.61
Cramphorn, R. H.	H.C. Reg. to E.-in-C.O.	24.4.61
Light, R. A. M.	H.C. Reg. to E.-in-C.O.	24.4.61
Parker, R. J.	H.C. Reg. to E.-in-C.O.	8.5.61
Ball, D.	E.-in-C.O.	15.5.61
Hunt, D. G.	Mid. Reg. to E.-in-C.O.	24.4.61
Cooper, W. J.	E.T.E.	14.3.61
Glover, P. H.	W.B.C. to Mid. Reg.	24.4.61
Hands, D. C.	Mid. Reg.	24.4.61
Sheldon, W.	Scot.	24.4.61
Stamp, J.	S.W. Reg. to W.B.C.	24.4.61
Smith, N. G.	L.T. Reg. to E.-in-C.O.	24.4.61
Killip, R. H.	N.W. Reg. to E.-in-C.O.	24.4.61
Assistant Engineer to Executive Engineer		
Hedley, C. E.	N.W. Reg.	4.4.61
Dunn, L. C.	L.T. Reg.	17.2.61
Haywood, E. E.	L.T. Reg.	17.2.61
Henty, G. A.	L.T. Reg.	17.2.61
Garvey, A. W.	L.T. Reg.	8.3.61
Norman, R. H.	H.C. Reg. to N.W. Reg.	17.4.61
Goldsmith, J. R.	L.T. Reg. to E.-in-C.O.	15.3.61
Mills, W. T.	L.T. Reg.	23.3.61
Watson, W. J.	L.T. Reg.	22.3.61
Lennard, G. F.	L.T. Reg.	27.4.61
Shone, A. E.	L.T. Reg.	27.4.61
Tankard, A. H.	E.T.E.	11.4.61
Taylor, G. N.	N.E. Reg.	21.4.61
Leask, D. R.	Scot.	27.4.61
Scanlan, F. J.	E.-in-C.O.	17.4.61
Varney, R. E. H.	Mid. Reg.	2.5.61
Smith, R. G. T.	H.C. Reg.	3.5.61
Budgen, J. E.	H.C. Reg.	3.5.61
Hitchin, E. J. T.	H.C. Reg.	3.5.61
Hyatt, F. S.	L.T. Reg.	26.5.61
Bishop, K. G. T.	E.-in-C.O.	15.6.61
Driver, E. R.	E.-in-C.O.	28.6.61
Moulds, R. E.	E.-in-C.O.	28.6.61
Wood, R. A.	E.-in-C.O.	28.6.61
Assistant Engineer to Executive Engineer—continued		
Myerson, R. J. W.	E.-in-C.O.	28.6.61
Smith, G. E.	E.-in-C.O.	28.6.61
King, R. E.	E.-in-C.O.	28.6.61
Loomes, E. A.	E.-in-C.O.	10.7.61
Bate, E.	W.B.C.	15.6.61
Carter, P. E.	L.T. Reg.	15.6.61
Inspector to Assistant Engineer		
McCarthy, R. E.	N.I.	6.3.61
Walker, E. H.	L.T. Reg.	17.5.61
Collins, W. H.	L.T. Reg.	17.5.61
Williams, W. J.	L.T. Reg.	17.5.61
Simmons, H. W.	L.T. Reg.	17.5.61
Speed, R. J.	L.T. Reg.	17.5.61
Wynne, H. S.	N.I.	23.1.61
Cripps, T. A.	L.T. Reg.	16.6.61
Technical Officer to Assistant Engineer		
Davies, G. T.	N.W. Reg. to E.-in-C.O.	19.1.61
Scott, S. B.	L.T. Reg. to E.-in-C.O.	19.1.61
Wainwright, W. P.	Mid. Reg. to E.-in-C.O.	19.1.61
Bentley, H. F.	H.C. Reg.	24.3.61
Mullett, J. G.	H.C. Reg.	17.3.61
Vincent, R. C.	L.T. Reg.	26.4.61
Harrison, H.	N.I.	23.2.61
Wagstaff, F. A.	Mid. Reg.	7.4.61
Wishart, D. W.	E.-in-C.O.	6.4.61
Morris, A. W.	L.T. Reg.	26.4.61
Winser, J. A.	L.T. Reg.	26.4.61
Philip, J. G.	Scot.	4.4.61
Holehouse, J. H.	S.W. Reg.	17.4.61
Trussler, K. J.	S.W. Reg.	4.4.61
Elder, I. S.	Scot.	21.3.61
Martingell, L.	L.T. Reg.	14.4.61
Tyler, J. D.	L.T. Reg.	4.4.61
Brand, B. A.	L.T. Reg.	19.4.61
Smith, W.	N.E. Reg.	28.4.61
Bruce, R. H.	Scot.	10.4.61
Jordan, T.	Scot.	10.4.61
Mathews, P. W.	N.W. Reg.	27.3.61
Pearce, M. A.	S.W. Reg.	17.4.61
Elkins, D. H. V.	E.-in-C.O.	1.5.61
Davies, G. L.	Mid. Reg. to E.-in-C.O.	1.5.61
Morrissey, M. P.	L.T. Reg. to E.-in-C.O.	1.5.61
McCarthy, J. T.	E.-in-C.O.	1.5.61
Rimmer, R.	E.-in-C.O.	1.5.61
Brewer, R. W. B.	L.T. Reg. to E.-in-C.O.	1.5.61
Gilbertson, D. J.	E.-in-C.O.	1.5.61
Webb, R. S.	L.T. Reg. to E.-in-C.O.	1.5.61
Dunstan, P. C.	N.E. Reg. to E.-in-C.O.	1.5.61
Leavitt, F. C.	L.T. Reg. to E.-in-C.O.	1.5.61
Smith, A. C. J.	E.-in-C.O.	1.5.61
Jerome, P. H.	E.-in-C.O.	1.5.61
Gray, N. F.	E.-in-C.O.	1.5.61
Diver, K. J.	H.C. Reg. to E.-in-C.O.	1.5.61
Wheeler, C. H.	S.W. Reg. to E.-in-C.O.	1.5.61
Barnes, H. E.	E.-in-C.O.	1.5.61
Barnes, S. L. S.	E.-in-C.O.	1.5.61
Hopwood, J. E.	N.W. Reg.	29.3.61
Leaper, L. S. H.	E.-in-C.O.	10.5.61
MacCarthy, P. J. A.	L.T. Reg.	17.5.61
Hourhan, O. H.	L.T. Reg.	17.5.61
Malcolm, G. F.	L.T. Reg.	17.5.61
Sands, R. B.	L.T. Reg.	17.5.61
Etheridge, W. F.	L.T. Reg.	17.5.61
Graham, D. F.	L.T. Reg.	17.5.61
Rhodes, J. K.	Mid. Reg.	30.5.61
Ingle, J. T.	N.W. Reg.	1.5.61
Evans, K.	N.W. Reg.	1.5.61
Dawson, B.	N.W. Reg.	1.5.61
Mears, F. J.	H.C. Reg.	25.5.61
Dowding, H. B.	S.W. Reg.	29.3.61
Petty, P. L.	H.C. Reg.	15.5.61
Wilkes, C. S. W.	N.E. Reg.	2.6.61

Name	Region, etc.	Date
Technical Officer to Assistant Engineer—continued		
Parkin, A.	N.E. Reg.	2.6.61
Burke, F.	N.E. Reg.	2.6.61
Flegg, R. A. W.	L.T. Reg. to E.-in-C.O.	21.6.61
Rosbotham, F. C.	N.W. Reg. to E.-in-C.O.	21.6.61
Keitch, E. H.	E.-in-C.O.	21.6.61
Mercer, R. M.	E.-in-C.O.	21.6.61
Schicknek, M. J.	L.T. Reg. to E.-in-C.O.	21.6.61
Crocket, R.	L.T. Reg. to E.-in-C.O.	21.6.61
Hayes, D. W.	L.T. Reg. to E.-in-C.O.	21.6.61
Owen, W. J.	E.-in-C.O.	21.6.61
Coll, P. J.	N.I.	14.6.61
Mercer, T. F.	N.I.	14.6.61
McGoran, J. F.	N.I.	14.6.61
McFeeter, S.	N.I.	14.6.61
Technical Officer to Inspector		
Wilson, T. A. G.	S.W. Reg.	22.3.61
Pratt, E.	W.B.C.	3.5.61
Wellington, E.	W.B.C.	23.5.61
Macawley, L. W.	L.T. Reg.	17.5.61
Allen, S. R.	L.T. Reg.	17.5.61
Whelan, T. G.	N.W. Reg.	8.5.61
Technician I to Inspector		
Dibbens, K.	H.C. Reg.	24.3.61
Evans, S.	H.C. Reg.	17.3.61
Haskell, R. F.	H.C. Reg.	24.3.61
Meredith, C. J.	W.B.C.	15.4.61
Lally, J. F. P.	W.B.C.	24.4.61
Stanley, A.	H.C. Reg.	24.3.61
Smith, S. G.	H.C. Reg.	24.3.61
Lennox, G.	N.W. Reg.	12.4.61
Squire, K.	N.W. Reg.	4.4.61
Taylor, K. L.	N.E. Reg.	12.4.61
Ashman, W. H. D.	H.C. Reg.	17.4.61
Worcester, J. D.	H.C. Reg.	17.4.61
Bushby, R. H.	H.C. Reg.	17.4.61
Hannah, M.	H.C. Reg.	17.4.61
Watkins, C. D.	H.C. Reg.	10.4.61
Rolfe, T.	H.C. Reg.	24.4.61
Rice, T. W.	H.C. Reg.	14.4.61
Boylett, A.	N.W. Reg.	10.4.61
Curry, J. B.	N.E. Reg.	16.5.61
Mayor, S.	N.W. Reg.	29.3.61
Stevens, R. B.	W.B.C.	9.5.61
Legg, K. T.	L.T. Reg.	17.5.61
Clark, E. J.	L.T. Reg.	17.5.61
Robinson, E. H.	L.T. Reg.	17.5.61
Jenkins, F. J.	L.T. Reg.	17.5.61
Stickland, D. T.	L.T. Reg.	29.5.61
Harding, K. F. C.	L.T. Reg.	17.5.61
Davies, G. E.	L.T. Reg.	17.5.61
Brown, L. W.	L.T. Reg.	17.5.61
Colbourn, F. C.	L.T. Reg.	17.5.61
Ellis, G. C.	L.T. Reg.	17.5.61
Czuny, A.	Mid. Reg.	30.5.61
Greer, R. S.	N.I.	17.5.61
Nevitt, R.	H.C. Reg.	1.5.61
Blacklee, A. E.	L.T. Reg.	16.6.61
Cannon, F. E.	L.T. Reg.	16.6.61

Name	Region, etc.	Date
Scientific Officer to Senior Scientific Officer		
Grieve, J. I. (Mrs.)	E.-in-C.O.	21.3.61
Experimental Officer (Open Competition)		
Jackson, C. A.	E.-in-C.O.	14.4.61
Assistant Experimental Officer to Experimental Officer		
Rogers, M. W.	E.-in-C.O.	24.3.61
Conen, B. H.	E.-in.C.O.	24.3.61
Technical Assistant I to Motor Transport Officer III		
Smith, P. F.	E.-in-C.O.	26.5.61
Technical Assistant II to Technical Assistant I		
Royer, E. V.	E.-in-C.O.	14.4.61
Workshop Supervisor I to Technical Assistant II		
Knowles, L. C.	Scot. to H.C. Reg.	19.5.61
Beattie, H. H.	S.W. Reg. to H.C. Reg.	29.5.61
Blades, J. J.	Scot.	19.5.61
Workshop Supervisor II to Technical Assistant II		
Morgan, E. G.	E.-in-C.O.	19.5.61
Heddon, W. J.	E.-in-C.O.	19.5.61
Potter, W. A.	H.C. Reg. to E.-in-C.O.	19.5.61
Tanner, J.	E.-in-C.O. to London Reg.	19.5.61
Leading Draughtsman to Senior Draughtsman		
Wharmby, L. C.	Scot.	4.4.61
Dodds, A. T.	W.B.C. to N.W. Reg.	10.4.61
Tompkins, L. J.	E.-in-C.O.	24.5.61
Illustrator to Leading Illustrator		
Baker, N. H.	E.-in-C.O.	31.1.61
Executive Officer to Higher Executive Officer		
Cowan, P. L.	E.-in-C.O. to Ministry of Health	19.6.61
Browne, K. C.	E.-in-C.O. to Board of Trade	19.6.61
Pinkney, L. W.	E.-in-C.O.	3.7.61
Welfare Officer II to Welfare Officer I		
Fox, L. G.	E.-in-C.O.	12.4.61
Clerical Officer to Executive Officer		
Hobbs, H. W. W.	Savings Bank Department to E.-in-C.O.	4.4.61
Harwood, W. H.	E.-in-C.O.	5.5.61
Cutts, W.	E.-in-C.O.	8.5.61
Crowson, E. C.	Savings Bank Department to E.-in-C.O.	3.5.61

Retirements and Resignations

Name	Region, etc.	Date
Area Engineer		
Colledge, T. A. P.*	W.B.C.	6.4.61
Barry, C.	W.B.C.	30.6.61
Executive Engineer		
Fenton, K. C. (*Resigned*)	E.-in-C.O.	12.4.61
Assistant Engineer		
Brunton, J. B.	Scot.	6.3.61
Inwood, F. W.	H.C. Reg.	30.3.61
Fletcher, E. A.	H.C. Reg.	31.3.61
Assistant Engineer—continued		
Palmer, W. H.	L.T. Reg.	3.4.61
Adamson, A.	N.W. Reg.	10.4.61
Moffett, R.	N.E. Reg.	13.4.61
Campbell, D.	L.T. Reg.	13.4.61
John, G. L.	W.B.C.	13.4.61
Musson, F. E.	L.T. Reg.	18.4.61
Cooper, E. E. T.	L.T. Reg.	27.4.61
London, W. P.	L.T. Reg.	28.4.61
Hewing, A. W.	L.T. Reg.	28.4.61
Hart, H. T. L.	L.T. Reg.	30.4.61

* Mr. T. A. P. Colledge is continuing as a disestablished officer with S.W. Reg.

Retirements and Resignations—*continued*

Name	Region, etc.	Date	Name	Region, etc.	Date
Assistant Engineer—continued			*Inspector—continued*		
Beer, W. C.	W.B.C.	30.4.61	Brealey, E. C.	Mid. Reg.	1.5.61
Rintoul, D. A. (*Resigned*)	E.-in-C.O.	30.4.61	Sinclair, C.	Scot.	2.5.61
Hutchins, H.	H.C. Reg.	19.2.61	Moul, W. B.	N.E. Reg.	12.5.61
Payne, W. J.	L.T. Reg.	31.3.61			
Fagg, R. L.	H.C. Reg.	1.4.61	*Senior Scientific Officer*		
Gore, S.	H.C. Reg.	13.4.61	Grieve, J. I. (Mrs.) (*Resigned*)	E.-in-C.O.	31.5.61
Russell, F. W.	H.C. Reg.	14.4.61			
Banks, E. T.	H.C. Reg.	30.4.61	*Experimental Officer*		
Martin, T. W.	Scot.	30.4.61	Harrison, J. I. (*Resigned*)	E.-in-C.O.	7.4.61
Ingram, C. S.	E.-in-C.O.	6.5.61			
Hewson, E.	N.W. Reg.	9.5.61	*Assistant Experimental Officer*		
Brydon, W.	N.E. Reg.	16.5.61	Whitehouse, D. L. (*Resigned*)	E.-in-C.O.	28.4.61
Wilkinson, A. H.	Scot.	16.5.61			
Goff, A. A.	E.-in-C.O.	26.5.61	*Technical Assistant II*		
Phillips, R. H. (*Resigned*)	H.C. Reg.	18.4.61	Leggett, H. E.	S.W. Reg.	8.6.61
Mullins, B. (*Resigned*)	E.-in-C.O.	19.5.61			
Wallace, A.	H.C. Reg.	15.5.61	*Higher Executive Officer*		
Foulsham, R.	H.C. Reg.	31.5.61	Craik, A.	E.-in-C.O.	30.6.61
Jackson, W. H.	N.E. Reg.	31.5.61			
Kilby, G. F.	W.B.C.	1.6.61	*Hostel Manager*		
Marrow, T. R.	N.W. Reg.	10.6.61	Nash, R. W.	E.-in-C.O.	20.5.61
Thompson, S.	E.-in-C.O.	21.6.61			
Cormack, M. (*Resigned*)	E.-in-C.O.	25.6.61	*Executive Officer*		
			McEwen, A. (*Resigned*)	E.-in-C.O.	12.5.61
Inspector			Stoddart, C. H.	E.-in-C.O.	1.6.61
Paver, T. R.	N.E. Reg.	6.4.61	Laidlaw, W. G. (*Resigned*)	E.-in-C.O.	31.3.61
Clarkson, C. W.	L.T. Reg.	13.4.61			
Davies, S. W.	W.B.C.	14.4.61			
Edwards, F. C.	S.W. Reg.	1.4.61			
Greenhaigh, E. R.	N.W. Reg.	11.4.61			

Transfers

Name	Region, etc.	Date	Name	Region, etc.	Date
Senior Executive Engineer			*Assistant Engineer—continued*		
Barker, A. J.	E.-in-C.O. to H.C. Reg.	17.4.61	Brooks, G. G.	E.-in-C.O. to I.T.D.	19.6.61
Froom, R. P.	E.-in-C.O. to I.T.U. Geneva	18.3.61	Cave, R. D.	E.-in-C.O. to L.T. Reg.	26.6.61
Roberts, W. G.	E.-in-C.O. to H.C. Reg.	12.6.61	Powell, E.	E.-in-C.O. to Mid. Reg.	26.6.61
Ruben, M. J.	E.-in-C.O. to E.T.E.	3.7.61			
Executive Engineer			*Experimental Officer*		
Hawley, A. E.	E.-in-C.O. to L.T. Reg.	23.5.61	Griffen, E. J.	T.S.U. to Patent Office	4.4.61
Campbell, K. W.	E.-in-C.O. to L.T. Reg.	1.6.61			
Assistant Engineer			*Assistant (Scientific)*		
Logue, H.	E.-in-C.O. to Board of Trade	4.4.61	Gorrell, R. W.	E.-in-C.O. to War Office	1.6.61
Forty, A. S.	E.-in-C.O. to Guernsey State Telegraphs	8.4.61	*Senior Draughtsman*		
Lough, J.	E.-in-C.O. to N.E. Reg.	1.5.61	Holding, S. J.	L.T. Reg. to H.C. Reg.	10.5.61
Corner, F. B.	E.-in-C.O. to L.T. Reg.	23.5.61			
Miller, G. H.	E.-in-C.O. to L.T. Reg.	1.6.61	*Welfare Officer I*		
Clarke, A. J.	E.-in-C.O. to H.C. Reg.	5.6.61	Broster, L. J.	E.-in-C.O. to L.P. Reg.	12.4.61
Stevens, H. J.	E.-in-C.O. to L.T. Reg.	12.6.61			

Deaths

Name	Region, etc.	Date	Name	Region, etc.	Date
Executive Engineer			*Assistant Engineer—continued*		
Sharman, H. W.	Mid. Reg.	18.4.61	Moore, E.	N.W. Reg.	18.6.61
Birch, F.	W.B.C.	29.4.61	Spreadbury, R. S.	L.T. Reg.	28.6.61
Duncan, N.	E.-in-C.O.	10.5.61	*Inspector*		
Chapman, A.	N.E. Reg.	11.6.61	Jones, F. A. L.	W.B.C.	3.4.61
Assistant Engineer			*Senior Experimental Officer*		
Honeybone, A. J.	E.-in-C.O.	29.5.61	Taylor, E. A.	E.-in-C.O.	31.5.61
Melville, E.	Scot.	1.6.61			

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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.

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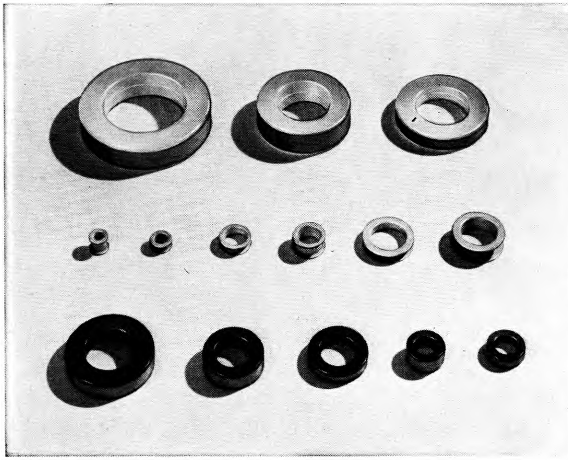

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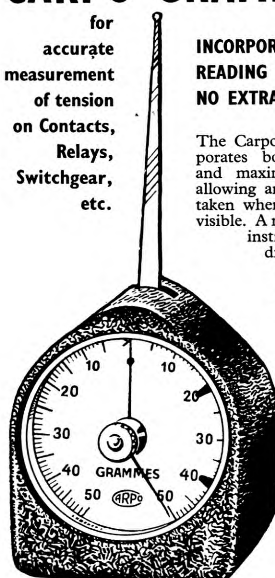

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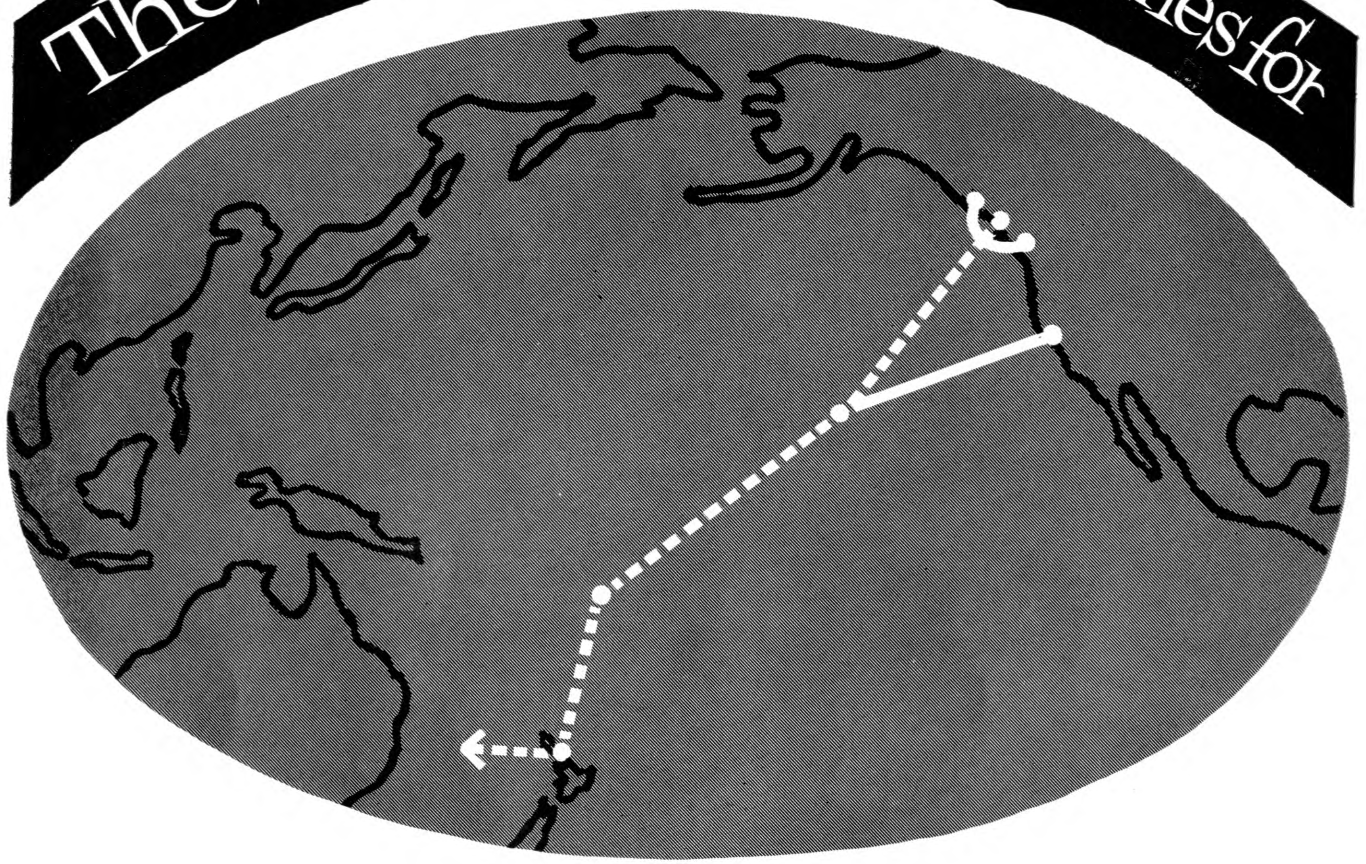

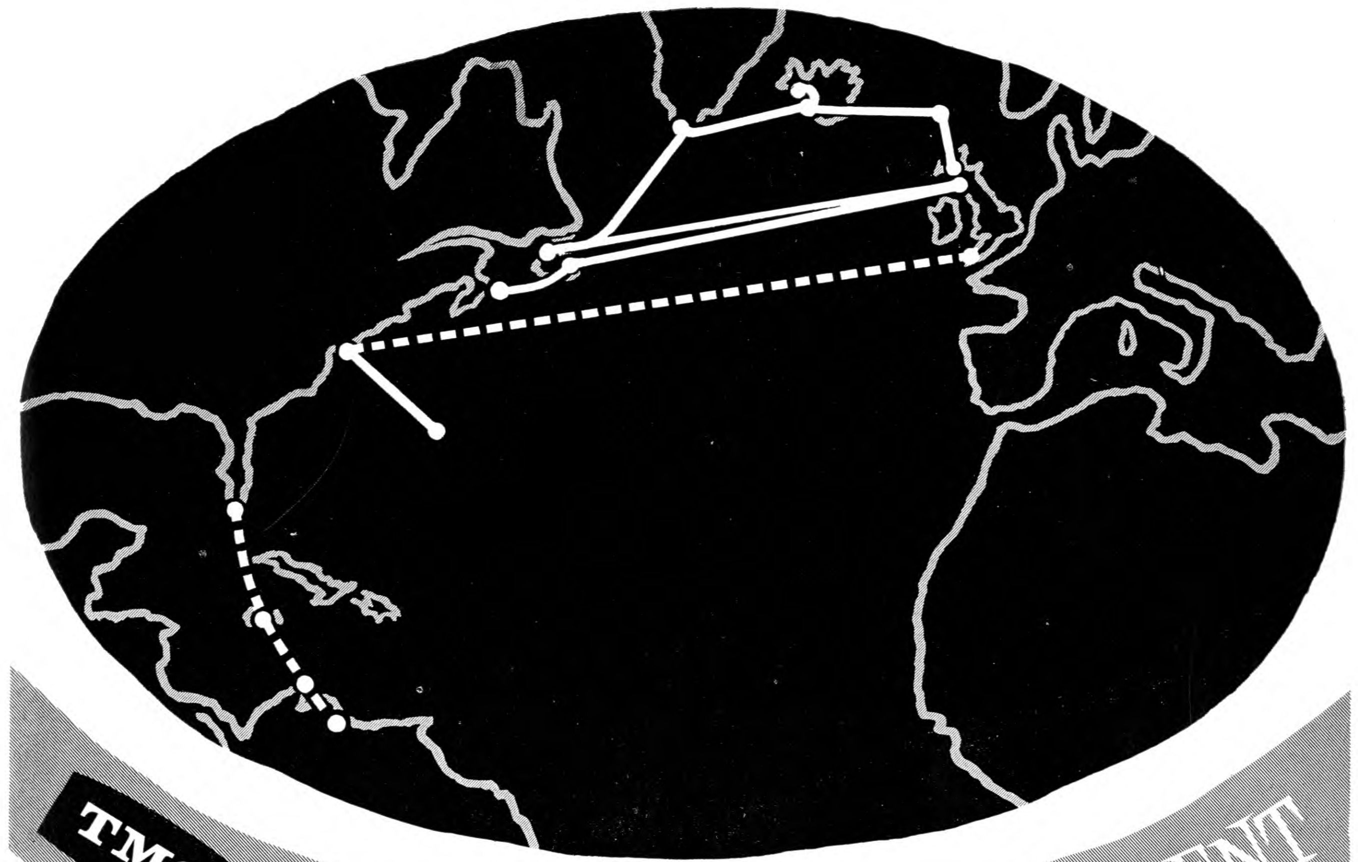

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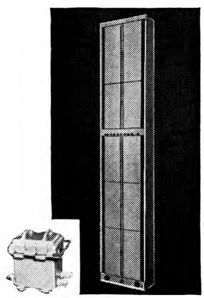

Right: Terminal Repeater
Left: Intermediate Buried Repeater

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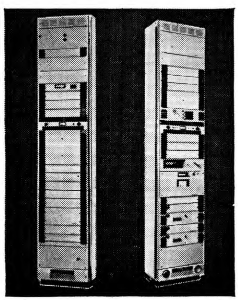

Left: Terminal Repeater (Receive)
Right: Terminal Repeater (Transmit)

C960A 4 Mc/s Coaxial System

- Up to 960 high-grade telephone circuits on each pair of conventional coaxial tubes.
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- Main power feed stations up to 100 miles apart.
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- Conforms to C.C.I.T.T. recommendations.

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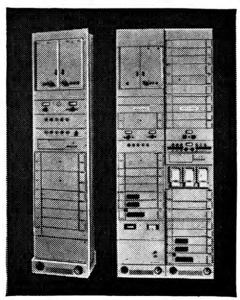

Left: Dependent Repeater—6 ft.
Right: Terminal Repeater—9 ft.

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- Up to 2,700 high grade telephone circuits or transmission of mixed traffic on a pair of conventional .375 inch dia. coaxial tubes.
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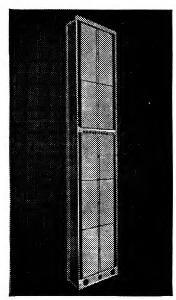

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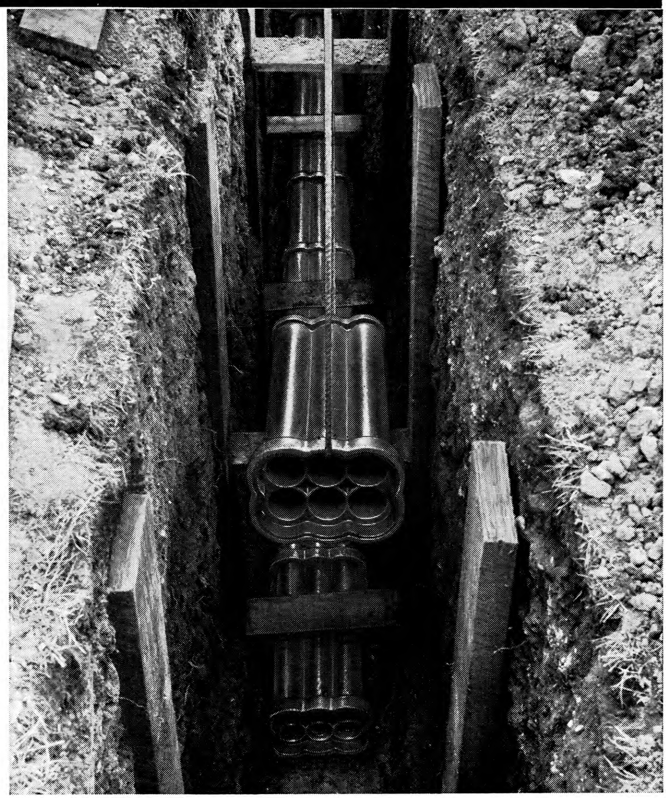

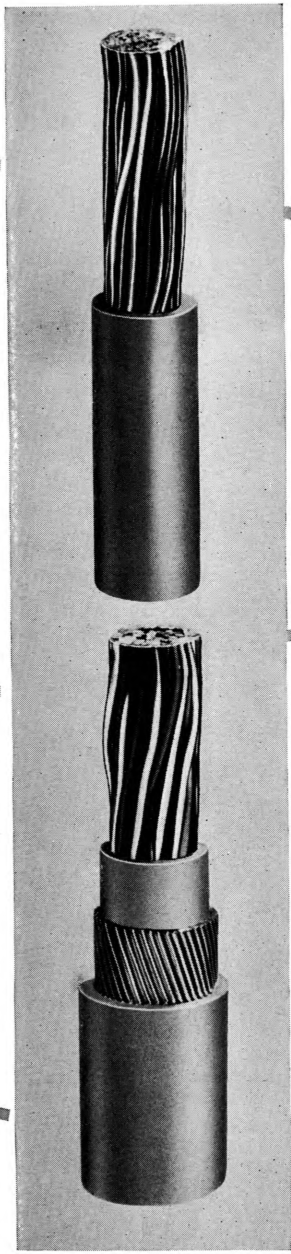

Top: Unarmoured Type — Bottom: Armoured Type

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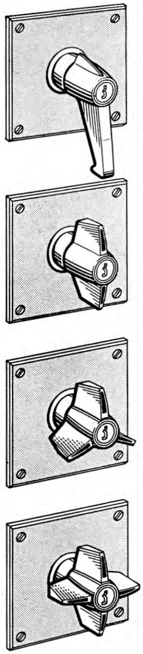

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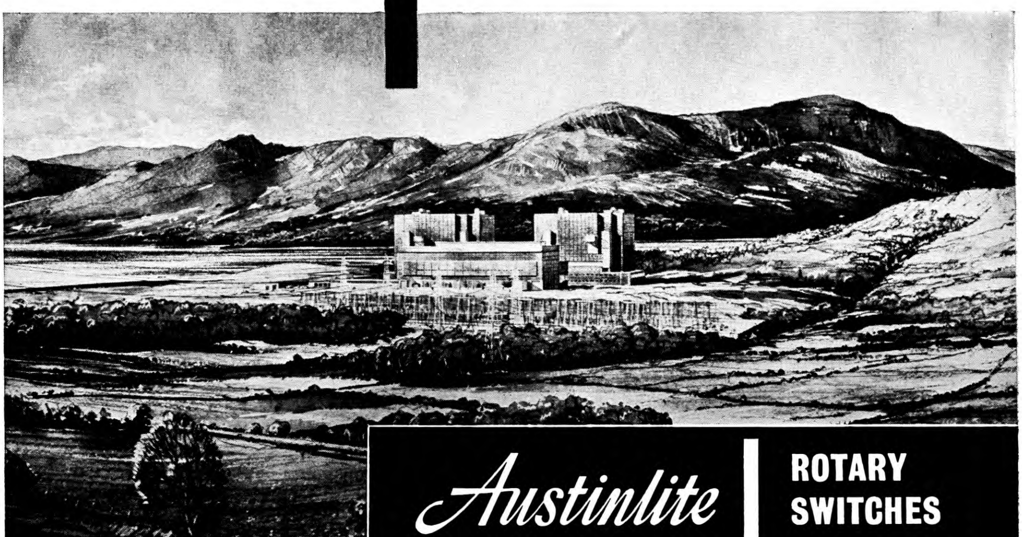

(Artist's impression of Trawsfynydd by courtesy of C.E.G.B.)

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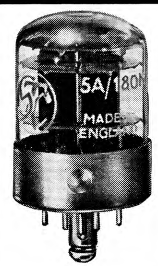

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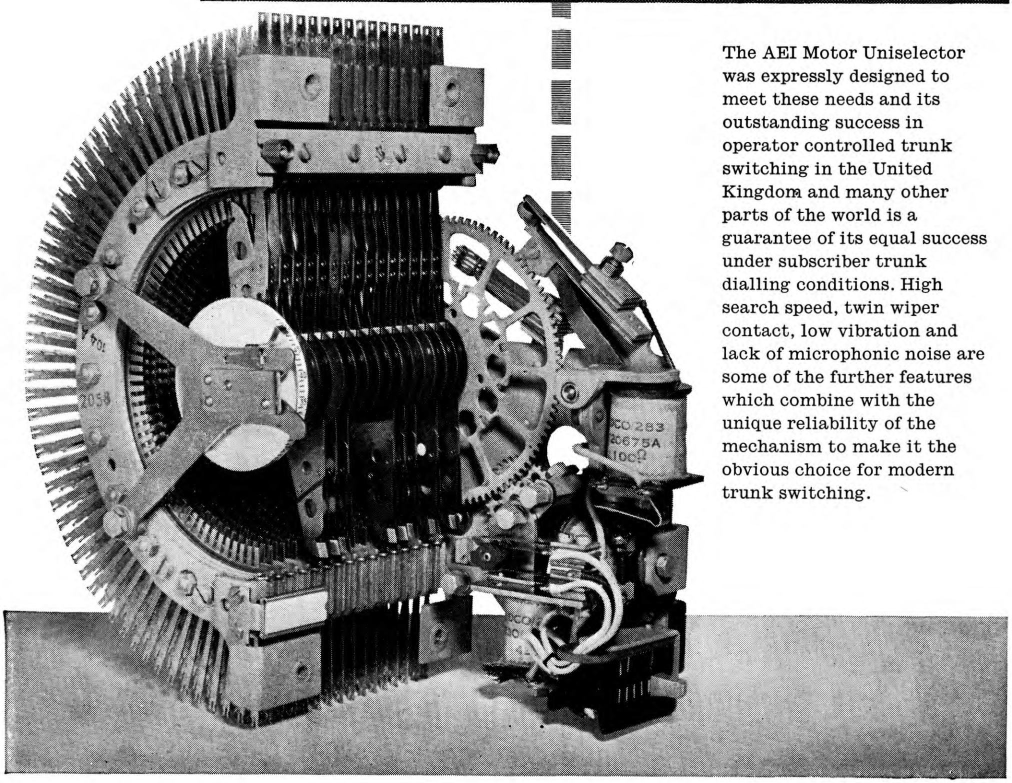

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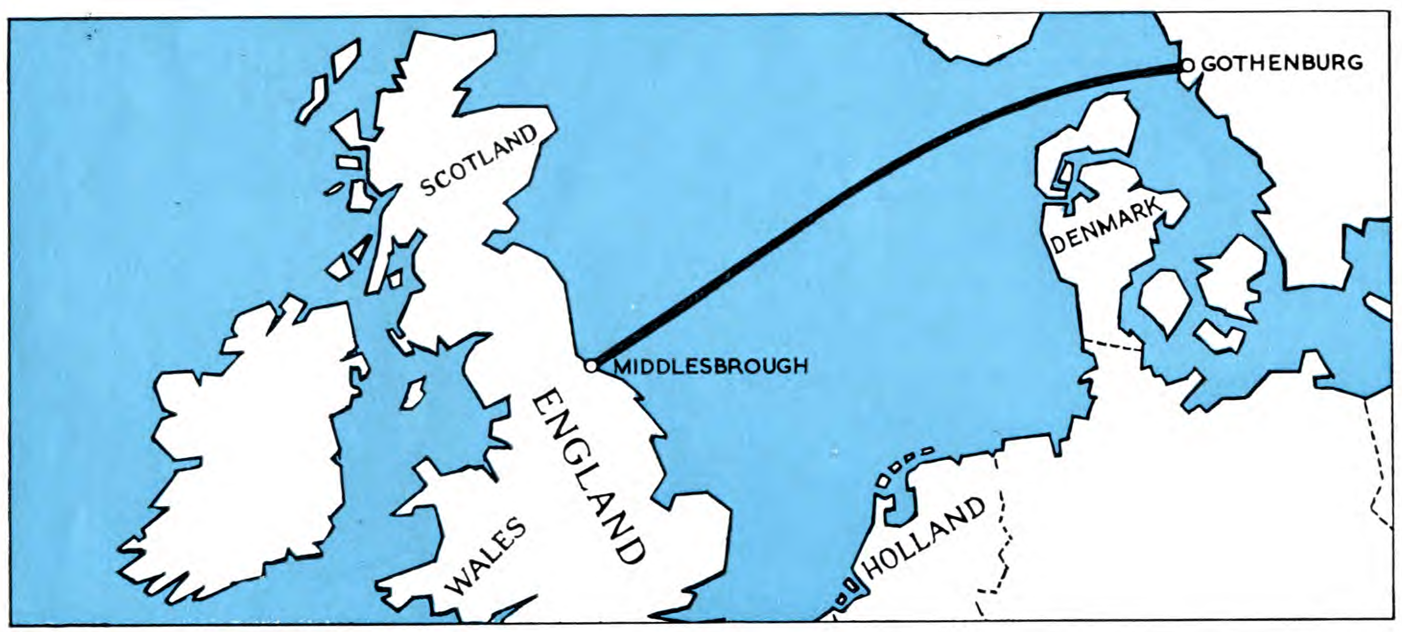

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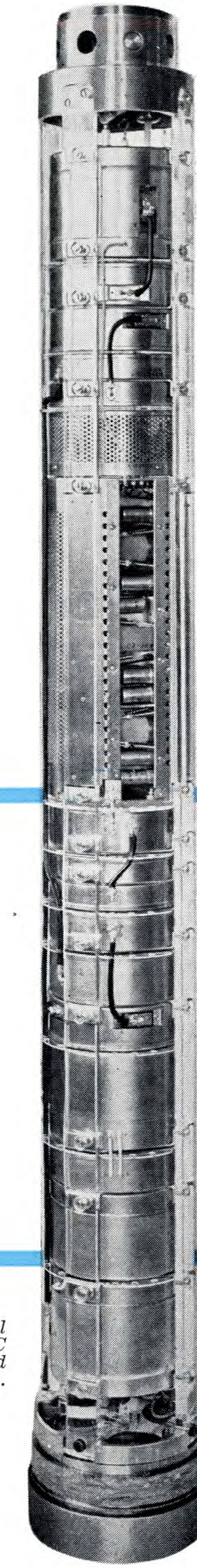
Publication C/2050 lists major STC submarine telephone installations.



The internal unit of an STC submerged repeater.

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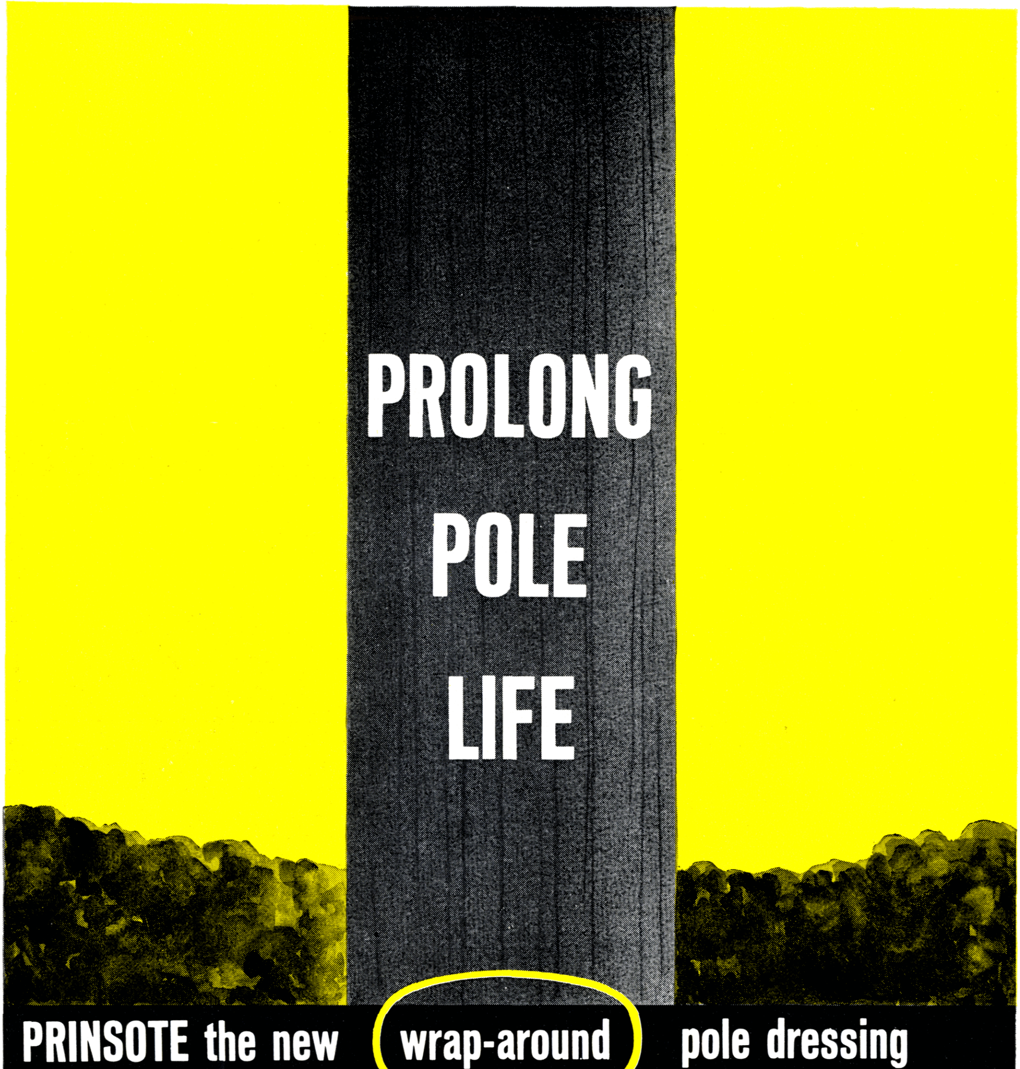

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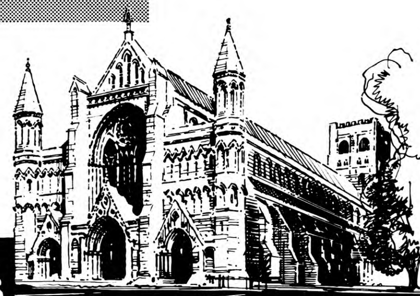

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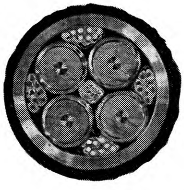
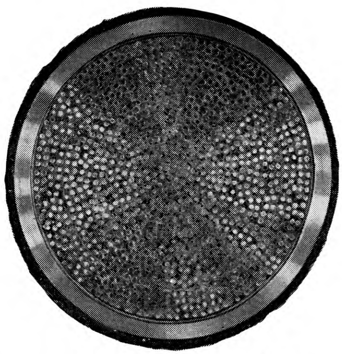
for London to St Albans

main line trunk telephone route



4-tube Type 375 PDWI Coaxial Cable



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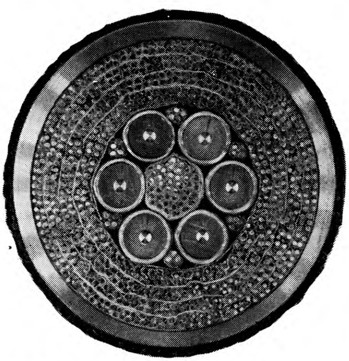

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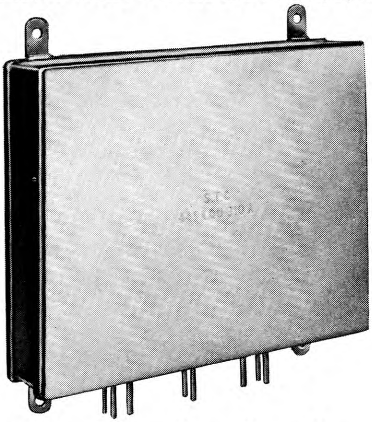

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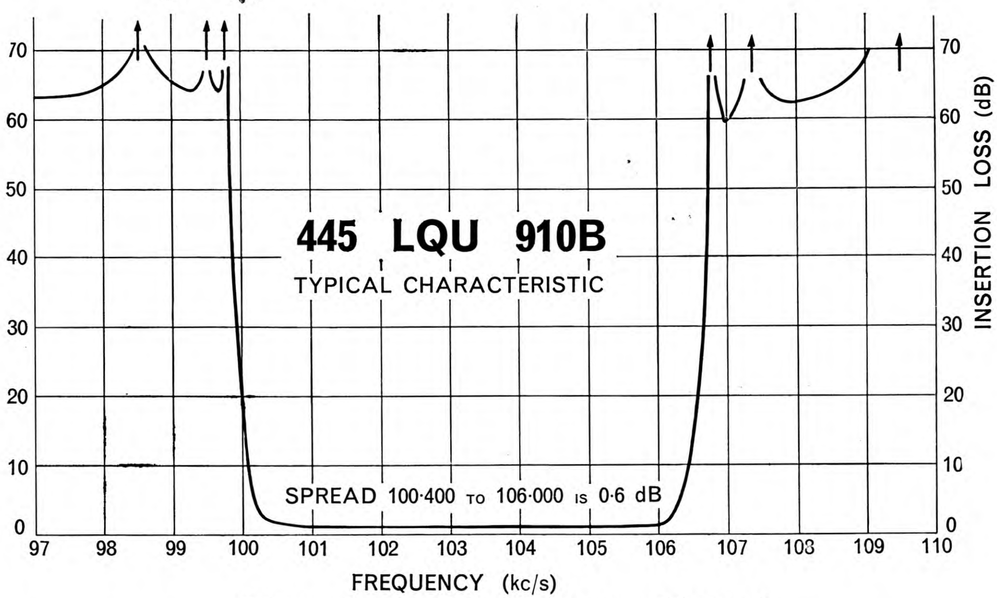

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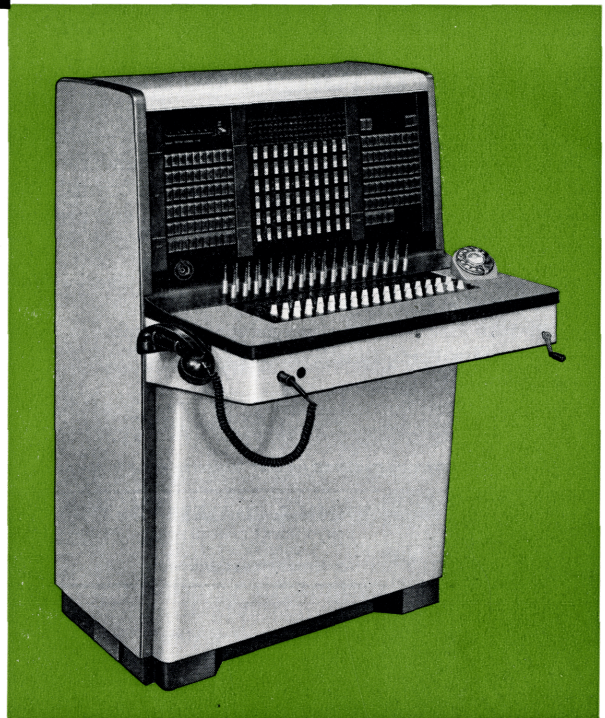
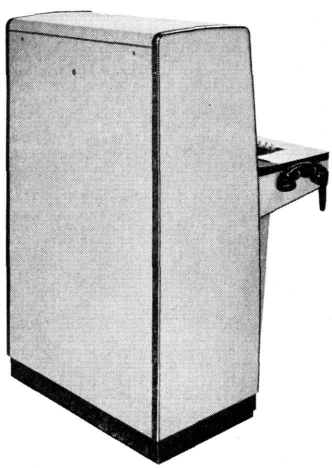
Much attention has been paid in the design of these switchboards to functional efficiency and ease of operation and they are an attractive addition to our new and unrivalled range of switchboard equipments.

Identical in size and general appearance, they are available as Magneto and C.B. Switchboards and are intended for use in Single or Multiple Units, each with a capacity for 100 extensions, multiple jack field and 17 cord circuits.



Registered Design Nos. 900242 & 201/61. 202/61.



Up to 20 Magneto, C.B. or Auto exchange lines can be accommodated.

Easy identification of "thrown" keys.

Latest lightweight "plug-in" handset.

Cord test and night service facilities on C.B. switchboards.

Magneto switchboards have single positive supervision.

C.B. switchboards have through dialling and clearing, double positive or double negative supervision, operator re-call, follow-on call signal, exchange prohibition. A lamp signalling version is also available.

Welded pressed steel frame covered by replaceable laminate plastic panels.

Fully tropicalized.

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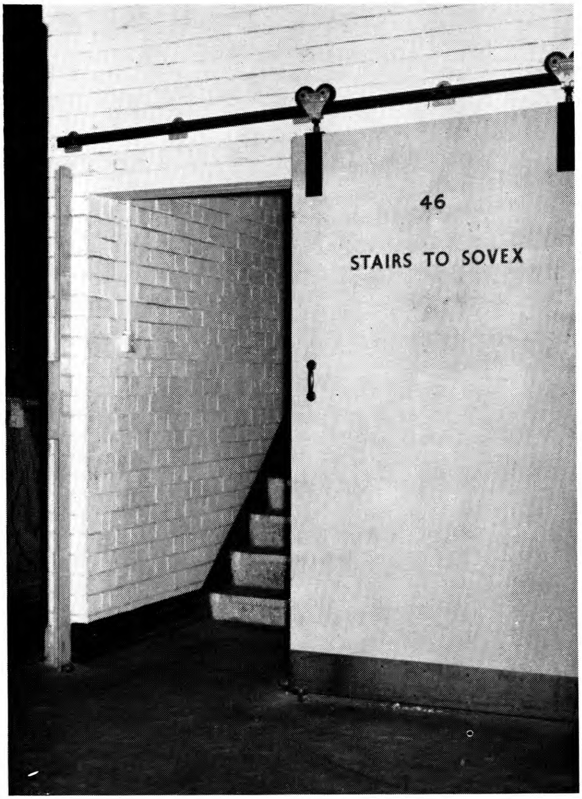
The people who specialize in the Mechanical Handling of mail



Here, as you can see, is our name, neatly painted (not by us) upon a door. Behind the door, a flight of ordinary stairs. But the stairs lead to no ordinary room . . . .

In that room, at the new Parcels Sorting Office in Leeds, twelve men can sort 10,000 parcels per hour. They are using the Sovex Push-Button Parcel Sorting System.

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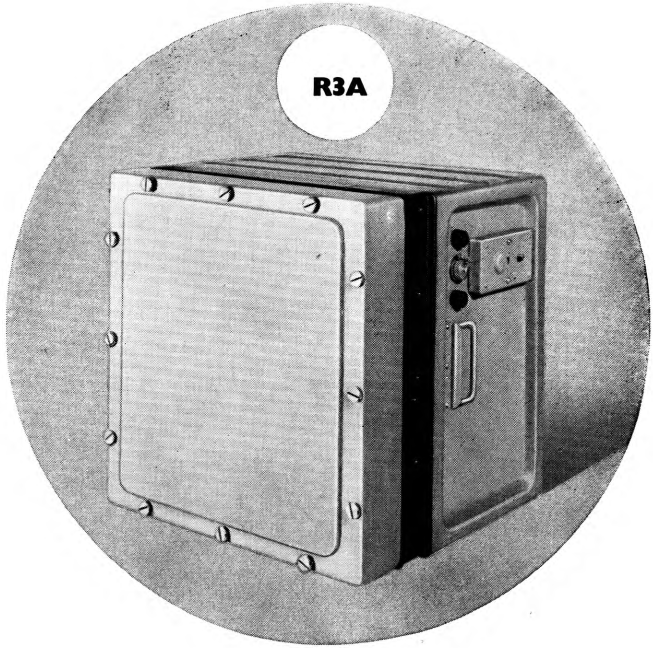
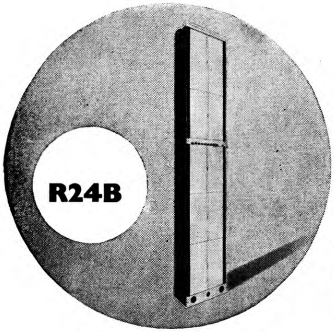
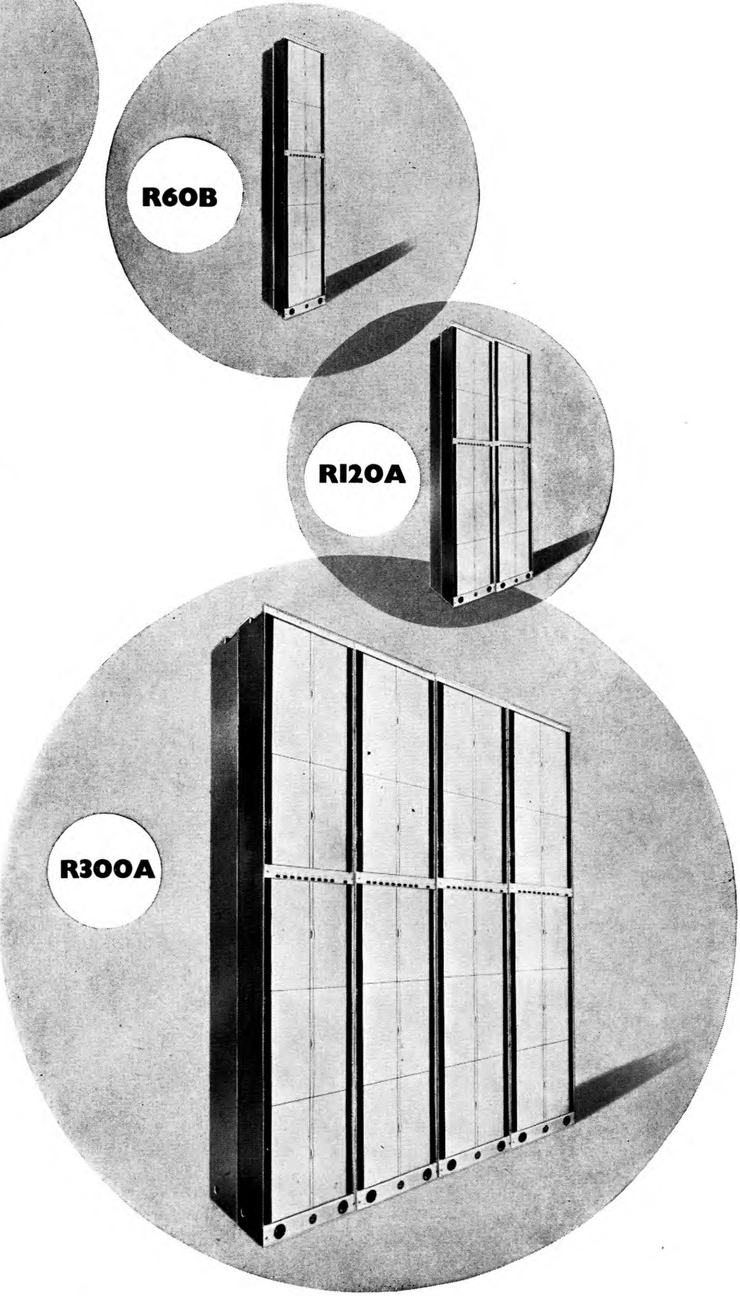
The almost perfect screening of the television circuits within the cable, and lower transmission losses than corresponding double copper braided cable, have been achieved by producing a co-axial cable insulated with solid or low-loss foam polythene, and having an outer conductor of thin-wall welded copper with either a straight or corrugated profile.
The secret behind the success of this new Pirelli-General cable is the company's masterly application of continuous welding techniques.

PIRELLI-GENERAL *best way to buy*

PIRELLI-GENERAL CABLE WORKS LIMITED · SOUTHAMPTON & EASTLEIGH


R3A





R3A A transportable 3 channel terminal designed for field or Service use. Write for Bulletin TEB. 3303

R24B A 12/24 channel terminal in the 6-108 Kc/s spectrum, complete on one rackside. Write for Bulletin TEB. 3301

R60B A 60 channel terminal (12-252 or 60-300 Kc/s), complete on two racksides. Write for Bulletin TEB. 3302

R120A A 120 channel terminal (12-552 Kc/s), complete on four racksides. Write for Bulletin TEB. 3304

R300A A 300 channel terminal (60-1300 Kc/s), complete on eight racksides. Write for Bulletin TEB. 3305

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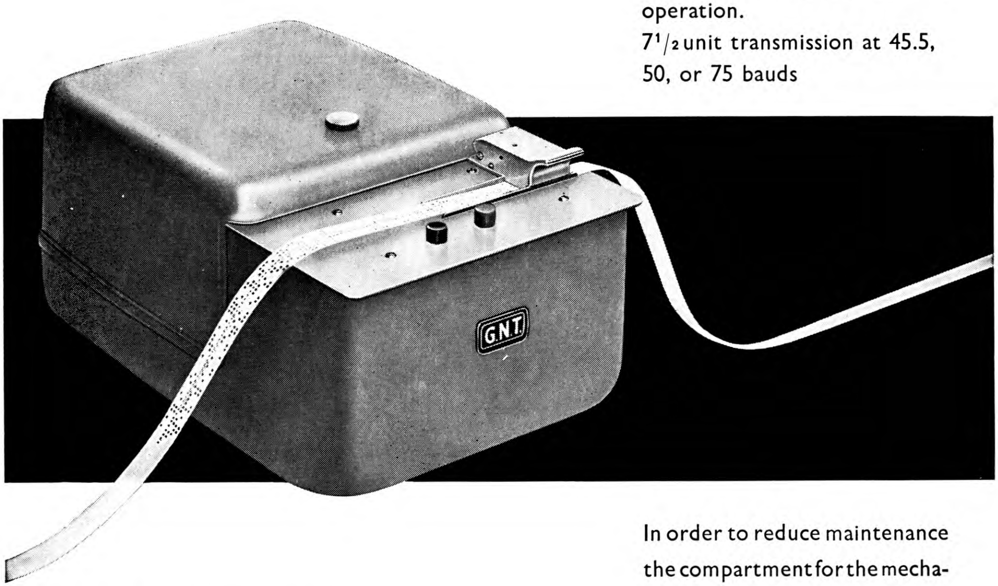
G.N.T. 5-unit tape transmitter

model 20

Sequential type for single wire transmission.
For single or double current operation.
7¹/₂ unit transmission at 45.5, 50, or 75 bauds



Meets all the requirements of a modern 5-unit tape transmitter.

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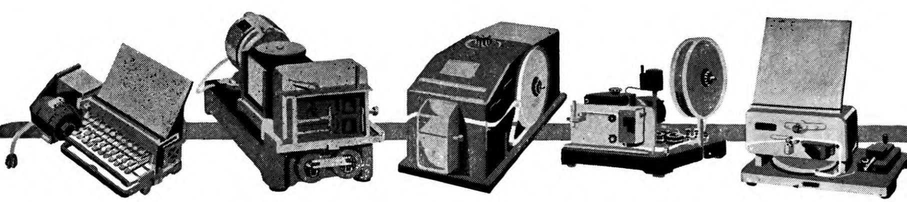

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'Diakon' puts colour on the line

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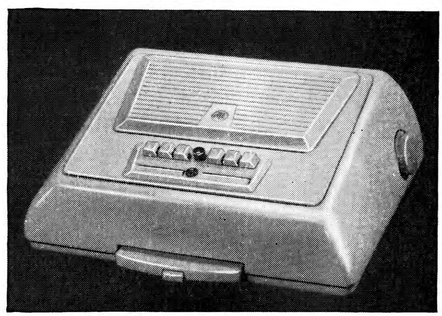

"Prescall" Master Station

'DIAKON' POLYMER

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DN13

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Electrical Measuring Instruments

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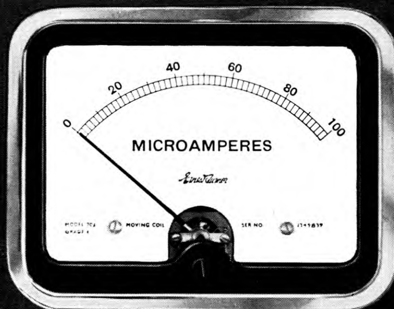

Ernest Turner Electrical Instruments Ltd

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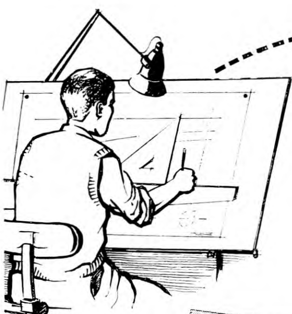
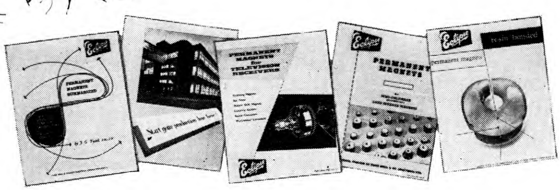


Economy begins at the design stage



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M25

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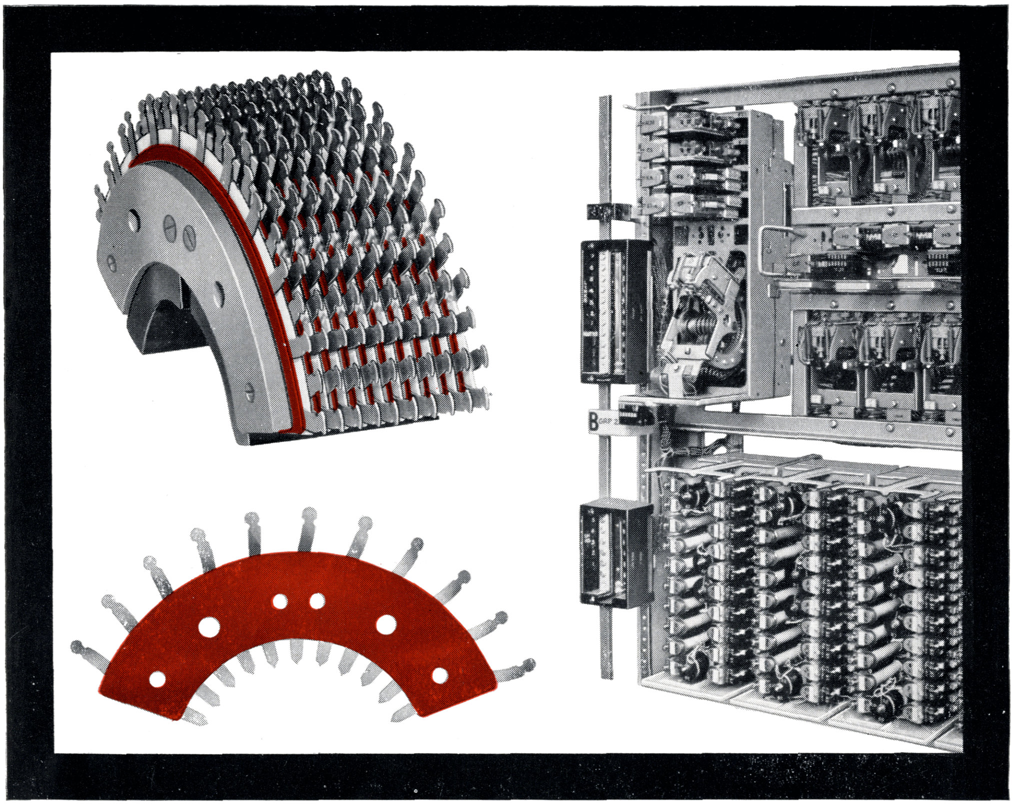

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Through signalling and dialling.

Exchange line hold.

Night service.

Audible alarm extension and cut-off.

Over call, for answering calls when switchboard is busy.

Registered Design Nos. 898879 & 1/61. 2/61

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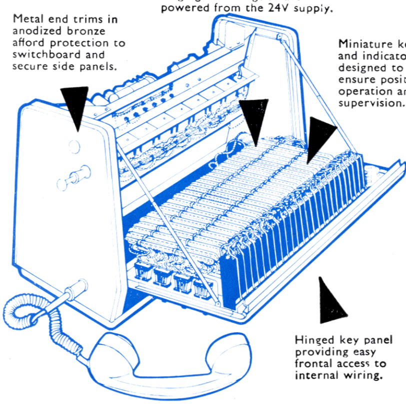

These CORDLESS SWITCHBOARDS, suitable for Auto or CB working and economising operator effort, are an attractive addition to our new and unrivalled range of switchboard equipments. They have an operational capacity for 25 lines hitherto impracticable in a table-type cordless switchboard of reasonable size and are proportioned to permit easy accommodation on either table or desk. New materials and components of small bulk and proven reliability are used to achieve this modern and compact design and to provide those good-service features long associated with our products—**dependability, low maintenance requirements and ease of operation.**

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