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The 2 + 5 'Keymaster'

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Low cost, compactness and ease of operation are highlights of this new key-system design. Elaboration of equipment is avoided without restricting the potential applications or narrowing the range of facilities offered.

IN the intensive setting of the modern compact business, the surrender of office space to a switchboard and the allocation of staff duties for its surveillance, tend to become equally unacceptable. The development of ' key ' systems may be seen as a series of efforts, progressively more effective, to provide a basis of communication free from these disadvantages.

The success of a given system is therefore to be judged by two criteria. Firstly, by its compactness; the aim should be to introduce only a condensed minimum of equipment external to the station instruments. Secondly, by its simplicity of operation; this is especially important since the task of handling traffic may in practice fall to varying grades of staff, senior as well as junior.

As a basis of design the Plan-Etelphone conception of station instrument has a number of favourable features. Sufficient mechanical switching flexibility exists to permit all the main functions of a moderately-sized system to be brought under direct control of the button-operated springsets without resort to external switching apparatus.

There is a comparable degree of flexibility in the physical layout of springsets and signalling lamps within the instrument. The ideal layout is one in which the pattern of buttons and lamps itself suggests to the user what the system is capable of doing and how it may be made to do it. With a reasonable approach to this ideal, operation soon becomes practically instinctive, the only conscious rapport between hand and eye being that necessary in dialling.

Figure 1—Typical 2 + 5 Station Telephone with Recall Button

A study of these considerations in the development of the 2 + 5 ' Keymaster ' has resulted in a notably compact system, simpler to operate than its predecessors and of unusually low installed cost. The facilities offered include all those likely to be required by an intermediate-sized business.

General Features

There is provision, under normal circumstances, for a maximum of five stations, each equipped with the instrument shown in Figure 1. Instruments are available in ivory, two-tone grey and black, and in forms suitable for operation in auto or manual CB areas.

The station button arrangement shows the logical separation of intercom and exchange line functions, the former being associated with the four ' CALL ' buttons arranged symmetrically around the dial and the latter with the 2 : 1 : 1 : 2 button formation in line above it. A bell cut-off toggle switch is positioned below the dial. Operationally, the exchange line button formation is divided into two groups of three buttons, each consisting of the single ' EXCH ' button, giving access to the exchange line concerned, and the two ' twinned ' buttons adjacent. These latter respectively operate in association with the ' EXCH ' button, to give a ' cancel ' facility and to produce a ' HOLD ' condition on the line. Each button-group is mechanically independent of the other. Within a group the ' EXCH ' and ' HOLD ' buttons, both of locking type, mutually intertrip, i.e. the depression of either button releases the other. The ' X ' button releases both, and is itself non-locking.

To prevent loss of exchange facilities due to ' button fiddling ' when the instrument is not in use, replacement of the handset renders locking buttons mechanically inoperative as well as restoring any which are locked down. Intercom call buttons are non-locking and can be operated with the handset on rest; a useful feature because intercom signals may be required for subsidiary purposes, e.g. for summoning secretaries or announcing break periods.

Visual signalling of incoming exchange line calls is by means of the white lamp mounted in front of each ' EXCH ' button, this lamp also serving to give supervisory indication when calls are in progress. The adjacent red lamp, in front of the ' HOLD ' button, indicates a ' held ' condition on the line.

Audible signalling of incoming exchange line calls, on either line, is by means of the instrument bells at all stations where the bell cut-off switch is not operated. It is usual to arrange, by strapping in the appropriate instrument, for one station bell to remain operative at all times.

With the system as normally installed, exchange lines are series-multipled from station to station and series secrecy is thus afforded, stations usually being arranged in order of priority from the exchange end of the multiple.

If the requirements of an organization are such that two or more stations commonly need to enter exchange lines together, the series multiple arrangement can be replaced by a parallel one.

To remove the possibility of the two exchange lines being connected together—a first necessity in system design—the station switching is so arranged that connection to Exchange Line 2 at a station instrument is via break-action springs in the ' Exch 1 ' springset. Connection to Exchange Line 1, on the other hand, is direct, through these springs only. Exchange Line 1 therefore has a form of switching priority over Exchange Line 2.

Full exchange line service is maintained during local supply failure, but supervisory lamp signals are absent.

The intercom system is non-secret and features a common speech-link. Audible signals are employed and are given by buzzers in the station instruments; signalling is selective, utilizing separate conductors in the interstation cable.

Operation

Intercom

Removal of the handset at any station causes the instrument to be directly connected to the intercom link. To establish a call it is only necessary to verify, by a brief listening check, that the link is free, and then to press the appropriate ' CALL ' button. The buzzer signal is given at the wanted station for the duration of the press.

Conference calls may be set up in a similar manner by calling the wanted stations in turn.

Exchange Lines

An exchange call is originated by removing the handset, selecting a free exchange line (associated white lamp extinguished) and pressing the corresponding ' EXCH ' button. The call may then be made through the external system in the normal manner; for its duration the associated white lamp is continuously lit at all stations.

If the call is not successful, it may be cancelled by operating the ' X ' button momentarily and the ' EXCH ' button re-pressed to originate a new call, without need to replace the handset. The same procedure may be adopted on conclusion of a call if it is required to take up the other exchange line or the intercom.

The ' hold ' facility permits the concurrent handling by any station of up to three calls (both exchange lines and intercom) with an operating flexibility comparable with that given by a cordless switchboard.

When for instance an exchange call on Line 1 has been established, the station concerned may operate the appropriate ' HOLD ' button in order to make an enquiry or answer a call on Line 2 or upon the intercom, or to enter the latter for the purpose of offering transfer of the Line 1 call to another station.

Having completed the Line 2 or intercom call, he can then return to Line 1 by re-pressing the associated ' EXCH ' button or, if transfer of the Line 1 call has been accepted elsewhere he may relinquish it, either by replacing the handset or, if further calls are to be made, by pressing the associated ' X ' button. In a similar way, Line 2 may be left ' held ' while a call on Line 1 or the intercom is being dealt with, and may subsequently be taken up again, or the call on it transferred.

While the ' HOLD ' button is locked down, that is until the ' EXCH ' button is re-pressed, the ' X ' button operated or the handset replaced, there is a glow on the associated red lamp at the holding station. The white lamp indication continues unchanged at all stations during the hold period and until the line is finally released.

In the concurrent handling of calls, conversation on any one of the three outlets from a station is private from waiting callers on the other two.

An incoming exchange call, in addition to ringing at selected stations, is signalled by a flash on the associated white lamps throughout the system, this flash being at the ringing interval. To take the call, the answering station removes the handset and presses the appropriate ' EXCH ' button; bell signals then cease and white lamp indications change to a steady glow.

One selected station is normally designated as 'answering station' and the bell cut-off switch will normally be made inoperative here. If this station operator goes off duty, arrangements will be made to ensure that bell signals are received at a manned station elsewhere.

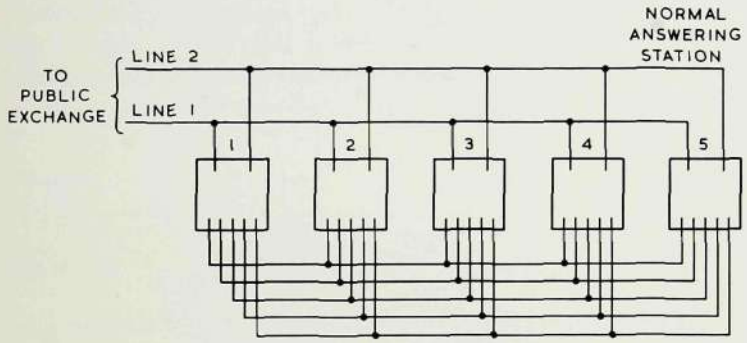

Figure 2—Intercom with connection to two public exchange lines

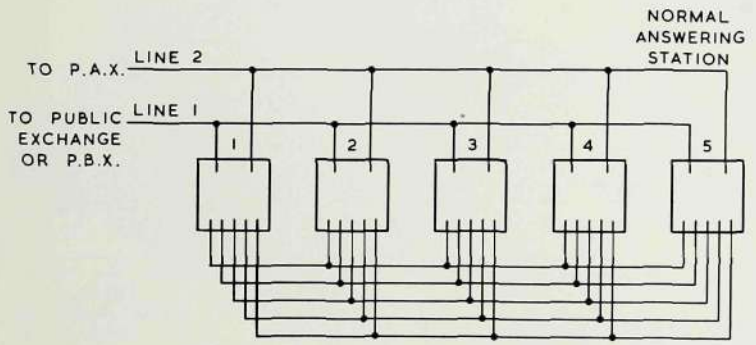

Figure 3—Intercom with connection to one PAX and to one public exchange or PBX line

Additional Features

Barring

Any station may be barred exchange line access by ' slipping ' the multiple at the station instrument; barring may be applied on either exchange line, or on both.

Exchange Outlets

Lines to an associated PABX, PBX or PAX may be substituted for one or both exchange line outlets. Because of the switching priority given to Exchange Line 1, where the two lines actually connected are of differing importance, it will be the recommended practice to associate the one of greater priority with this outlet.

Figures 2 and 3 illustrate two different exchange line arrangements.

The question of the relative priority of exchange lines is also of interest in relation to an optional feature of the system, that of suppression of intercom buzzer signals at one or more selected stations when exchange lines are in use. This provision may obtain when one exchange line is switched to a station, or when either line is switched.

The application of this feature will depend on organizational factors. It may, for instance, be of value when a principal regularly makes important calls on a higher priority line and must give his undivided attention to them. It will be less desirable to apply it with respect to a lower priority line as this may prevent or delay transfers of calls on the higher priority line to the station concerned. The actual arrangement adopted may be varied after installation by a simple re-adjustment of strappings.

Additional buzzers and bells, if required, may be mounted externally to the station instruments at any convenient point.

System Variants

Considerable flexibility is possible in the arrangement of the system to suit differing requirements, two examples being illustrated by the diagram in Figures 4 and 5.

A typical secretarial arrangement is shown in Figure 4. One secretary serves two principals with intercom between all three, the secretary normally filtering exchange calls on both lines.

An arrangement permitting the connection of seven stations is shown in Figure 5. Two stations are divided into two close-proximity pairs. Intercom is provided between the pairs and the other stations, but not between stations in a pair. Individual intercom calling of one of a pair is by code.

Sharing by one station may also be imposed as a modification to the standard system if an 'Operator Recall' or similar facility is required at station instruments, the necessary button being installed in place of one of the 'CALL' buttons.

In any of the above arrangements, full exchange line facilities can be given throughout.

CONSTRUCTIONAL FEATURES

The key springsets are contained in a single unit of box construction mounted between the handset rest pillars, and consist of eight banks of comb-operated contacts. To facilitate connection of the key unit to the main telephone circuit, it is wired by a short cable form to three terminal strips, each comprising six terminals. These are mounted horizontally on a framework locating at the rear of the telephone chassis and held in place by spring plungers.

The four lamps, of miniature type, are slide-mounted in a unit which is wired to the key unit and secured to the body by a single screw. Individual lamps are readily accessible. The lamp, key and terminal strip units with their inter-connecting wiring may be removed from the instrument as a complete assembly.

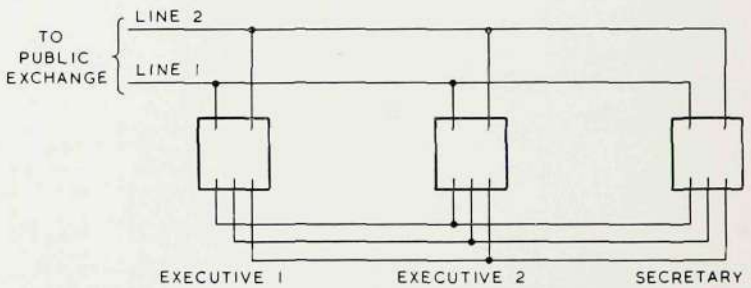

Figure 4—Secretarial service for two principals and one secretary, with full intercom

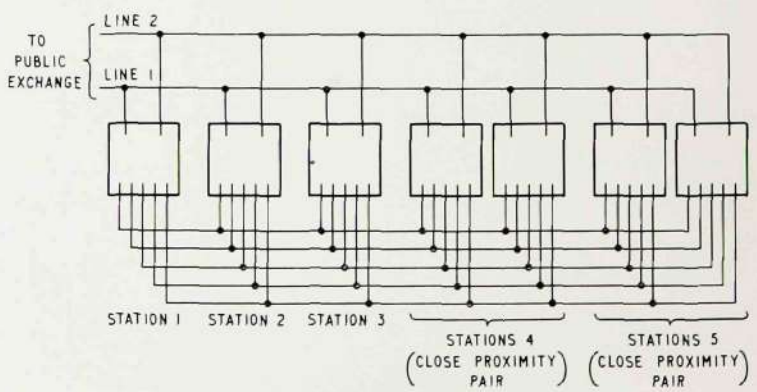

Figure 5—Typical arrangement for more than five stations. Four of the stations illustrated are arranged in two close-proximity pairs

The lamps accurately align with the lens axes to give optimum light transmission. This, despite the inconspicuous blending of the lenses with the instrument body, is so effective as to make signals prominent even in direct sunlight.

To simplify subsequent rearrangement of intercom system numbering, the ' CALL ' button caps are easily removable and can be interchanged with a fifth, spare cap numbered '5', stored within the instrument body.

The desk terminal block consists of a two-sided terminal arrangement contained in a moulded case with detachable cover.

The common equipment unit contains a transmission feed retard for the intercom and two relays for ringing and lamp signalling purposes, together with a cable terminal strip.

Power Supply

An important feature of the system is the low operating voltage (6V) made possible by the absence of locally energized relays, and there is a correspondingly small power supply requirement; no energy is wasted in dropping resistors and the only drain on the local source is in supplying the low-consumption signalling lamps and the intercom transmission feed.

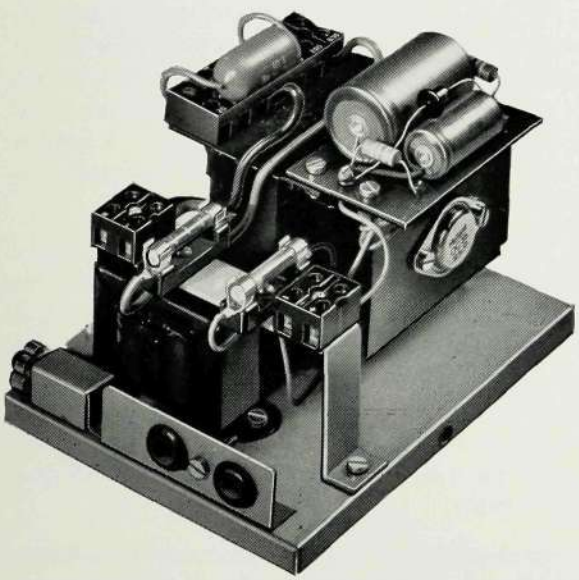

Figure 6—Battery eliminator with cover removed

A battery eliminator, shown in Figure 6, is normally specified for the system. This is capable of a maximum output of 1 amp at 6 volts and is suitable for use on a.c. mains in the voltage range 100–125 (5-volt steps) or 200–250 (10-volt steps). Its dimensions are $6\frac{1}{8}$ in. long by $4\frac{9}{16}$ in. high by $4\frac{9}{16}$ in. wide (15·6 × 11·6 × 11·6 cm).

In the absence of a mains supply the system may be operated from dry batteries. In the interests of maximum economy it is then arranged, by suitable internal strappings in the instruments, for station signalling lamps to be inoperative while the handset is on rest.

Cabling and Line Limits

The interstation cable is connected to the instrument desk blocks and requires a total of only 17 conductors where there is a ' straight ' series multiple, i.e. when the position of stations along the cable from the exchange-end to the tail coincides with the required order of exchange line priority. If some other order of position is more convenient, a larger cable may be installed giving the necessary extra pairs for routing the multiple to and fro as required. Incoming exchange pairs may be taken to some intermediate station if this proves more economic of cabling; these pairs are again connected to the instrument desk block.

The common equipment unit is invariably connected at the tail end of the cable.

The maximum loop resistance between the first station and the common equipment is fixed by considerations of satisfactory local signalling performance. This limit is unlikely to be approached in any normal layout of offices, even dispersed within relatively large buildings.

Satisfactory transmission is achieved over exchange line loops up to 1000 ohms.

Conclusion

The facilities provided by the system are in many respects comparable with those hitherto associated with appreciably larger desk units and much more complex central apparatus.

Simplifications have been considered entirely from a user standpoint; in this the economics of an installation, its operating demand and its effectiveness in service have well-defined significance.

British Patent No. 918,150 and corresponding foreign patents

U.D.C.621.395.342

Small Exchanges for Subscriber Trunk Dialling

A. Foster—Circuit Development Engineering Department

Although the conversion from manual to automatic telephone exchanges started in many countries some fifty years ago, subscriber dialling has in general only been available for local calls, or for very limited distances. The present trend, however, is for subscriber trunk and extended area dialling to be introduced on an ever increasing scale in all parts of the world. This article describes a range of automatic telephone exchanges designed to meet the present day requirements of existing or new networks where the smaller communities are concerned.

ALTHOUGH the development stages of the telephone system vary a great deal from country to country, the introduction of automatic telephone operation in general has been on the basis of a single exchange providing the local service for a particular town and access between exchanges by dialling a single or multi-digit code. The exception to this generalization is usually to be found in the larger towns or cities which warrant more than one exchange to serve the needs of the local community. These exchanges are usually combined into a linked numbering plan, thus avoiding the need for providing special dialling instructions to the subscribers on each exchange. However, access to exchanges outside the local number boundary may still require the use of special dialling codes.

The method of charging for calls also varies from one administration to another. Local calls may be charged a unit fee which is registered on a meter associated with the originating subscriber's line, no account being taken of the duration of the call. Dialled calls to other nearby automatic exchanges may be registered by one or more unit fees, the number of unit fees charged being dependent upon the distance between the originating and terminating exchanges. Such calls may be sometimes charged according to their duration by repeating the initial charge at fixed time intervals, say every three minutes.

Because of the complicated dialling instructions which would be necessary for subscribers on each exchange and the unwieldiness of multi-fee metering for long distance calls, the number of exchanges and the distance over which dialling can be allowed is rather limited.

In the more rural areas of certain countries, multi-party line operation is essential in order to give economical service to as great a number of subscribers as possible. To avoid the difficulties involved in providing selective metering for more than two subscribers on a line, a flat rate system of charging is employed. This means that a fixed annual rental is charged and local calls are allowed free, all other calls being completed by an operator.

Systems which have developed on the patterns outlined above can reach the point where single-operator control of calls is possible, because the originating operator in one area may dial the actual routing digits to reach the required exchange in another area and these routing digits can vary according to where the call originates.

The operator can also time and ticket all such calls. However, for the final stage of development, that is, the stage which allows a subscriber to dial his own call to any part of the country and ultimately to any subscriber in the world, it becomes necessary to replace the operator by suitable automatic switching equipment, to arrange a suitable means of charging for calls, and to allocate to each subscriber in the country a distinctive number.

To meet this latter requirement, the subscriber's number usually takes the form of a group of digits made up of an area code and a local number. The area-code digits are used for routing the call to the required

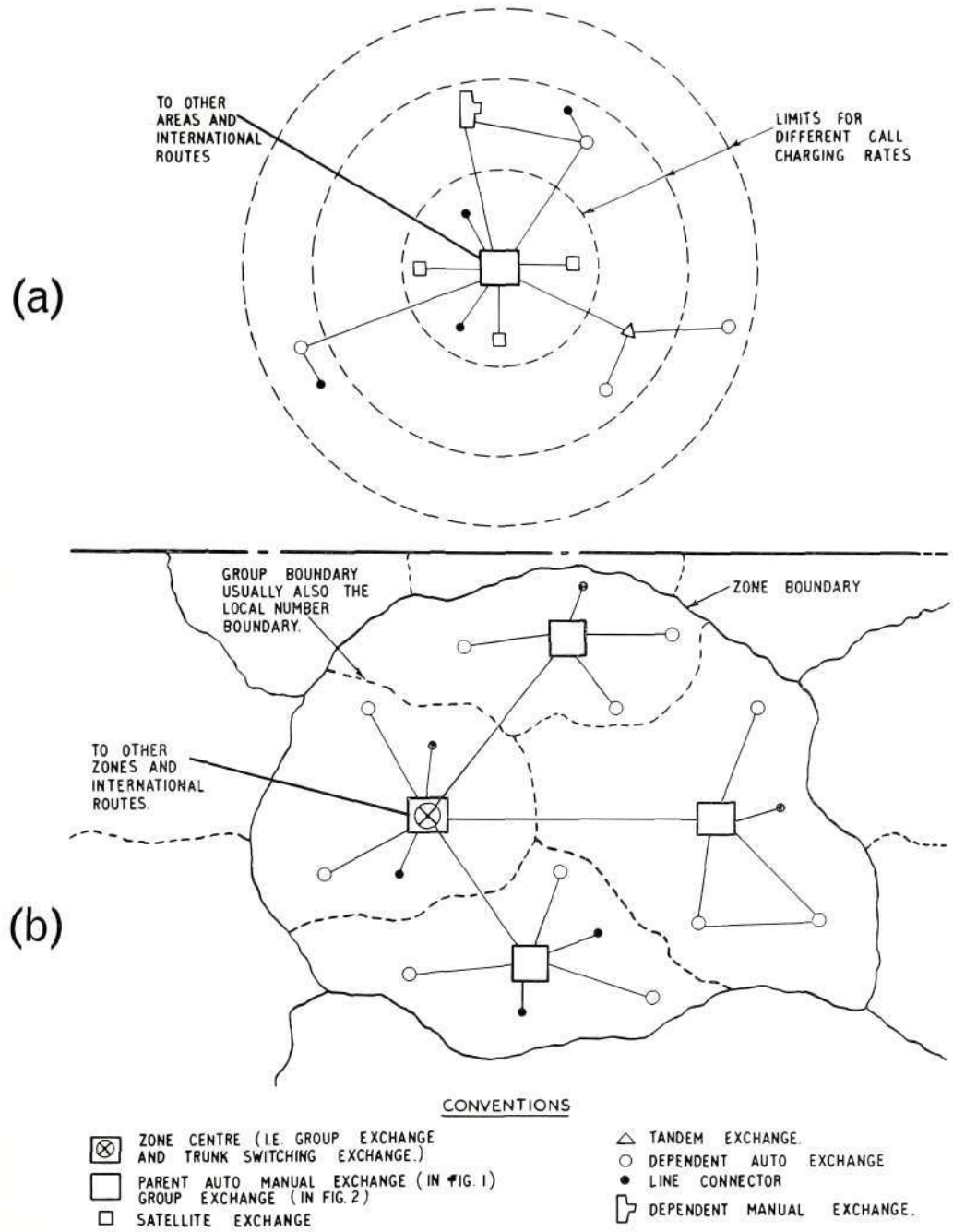

Figure 1

(a) Typical arrangement of an area developed on a single-exchange basis

(b) Typical zone/area arrangement for nationwide subscriber trunk dialling

exchange and, in order to keep the number of these codes to the minimum, it often becomes necessary to combine exchanges into linked numbering areas and allocate an area code to each group of exchanges.

Figure 1 (*a*) illustrates a typical simplified arrangement of an area that has developed on a single-exchange basis with interconnection via an operator or by dialling code digits. The dotted lines indicate radial distances

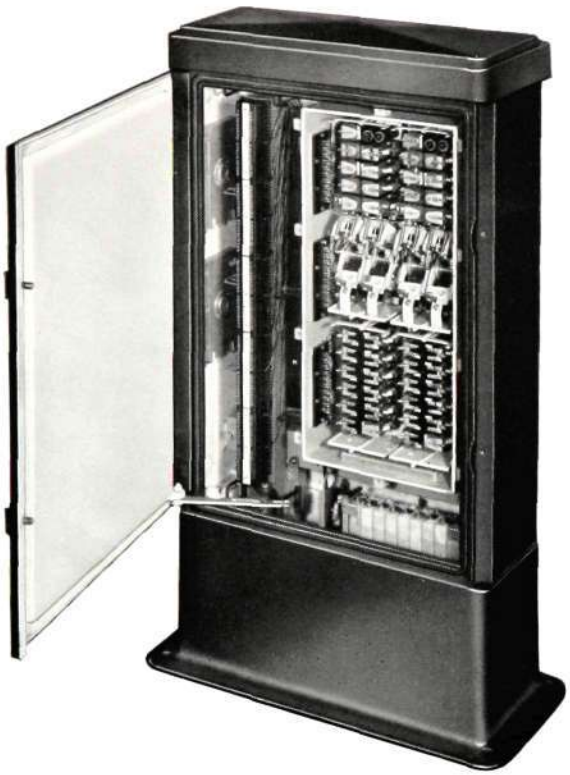

Figure 2—Line Connector installed in roadside cabinet

from the parent exchange for establishing the charging rate from that particular exchange to other exchanges. Calls outside the area are switched via the manual board at the parent exchange. Figure 1 (*b*) indicates an arrangement based upon nationwide subscriber dialling facilities. Here the country is divided into zones, each zone being sub-divided into areas. The exchanges in an area are arranged to have a linked numbering scheme, the calls between exchanges generally being switched via the group centre. Calls between areas are obtained by employing area codes and are switched via trunk switching equipment at the zone centre.

There are of course many problems involved in introducing subscriber trunk dialling, most of which are concerned with the economics and complexities of providing trunk switching equipment and sufficient high-quality trunk circuits. From the above brief outline it can be seen that as far as the smaller exchanges are concerned, the two main requirements are their suitability for operating in a linked numbering scheme, and the economic provision of equipment for registering the charge for dialled calls.

The following paragraphs give a brief outline of a range of exchanges designed to meet these requirements.

The Line Connector

The line connector, or line concentrator as it is sometimes called, is a device designed to save line plant by enabling a relatively small number of exchange lines to be shared among a group of low-calling-rate subscribers without impairing service. The line connector manufactured by Ericsson Telephones Ltd. provides for the use of four exchange lines by up to 22 subscribers.

The function of the connector is to join any of the subscribers' lines to a free exchange line when a call is either made or received and, at the end of the call, to disconnect the subscriber's line and leave the exchange line free for the use of other subscribers served by the same connector. Because the connector provides an unbridged pair of wires from the subscriber to the exchange, exactly the same facilities are provided to the subscriber as if he were connected directly to the exchange on a private pair of wires.

The connector is suitable for mounting in a roadside cabinet, as illustrated (see Figure 2), or other unattended enclosure. Installation is extremely easy, whilst the use of relays and very robust uniselectors makes maintenance very simple. Since the connection of a power supply at sites remote from the exchange introduces difficulties, the power is obtained from a local 24-volt battery which is kept in a charged condition over the speech pairs (when these are not in use) from the 50-volt main-exchange battery. This feature has a definite advantage over certain line connectors which require power lines in addition to the speaking pairs, since the saving in line plant is increased and the functioning of the apparatus is not dependent on the serviceability of one pair of wires.

No restriction is imposed by the connector on the specified loop resistance of the exchange, and the maximum loop resistance between the exchange and the remote unit may be up to 800 ohms.

The connector operates in the same manner as a trombone satellite, which means that a local call necessitates the use of two exchange lines, one to originate the call and the other to terminate it. It is therefore desirable that the number of local calls should be small.

A final selector terminal is required at the exchange for each subscriber fed by the line connector. The individual meters for registering the calls made by each subscriber are located at the exchange; a great advantage from an Administration's point of view.

A comprehensive alarm system indicates faults on the links which are then busied out of circuit. Those only affected by transient faults are returned to service automatically when all links are busy.

The line connector is therefore ideally suited for providing service to small groups of low-calling-rate subscribers situated on the fringe of exchange areas, and can provide the same service to these subscribers, including subscriber trunk dialling, as that available to directly connected subscribers. Since coin-box telephones can be connected just as easily as regular subscribers, the line connector can also prove quite useful for temporary service at, for example, agricultural shows and exhibitions.

The Minirax

The Minirax, described elsewhere in this issue, is a small automatic exchange designed to provide service to 20 subscribers, and is complementary to the line connector. As previously indicated, one of the main disadvantages of the line connector is its use of two exchange lines for a local call. The Minirax however has been designed to be completely self-contained and to switch local calls independently of its parent exchange. Like the line connector, it operates from a small 24-volt battery which can be charged over the physical junction pair or pairs. For this reason the equipment is specially designed for minimum current drain.

It is anticipated that in many instances these small exchanges may be connected to the parent exchange by only one physical pair and therefore any additional circuits can be obtained by the use of transistor rural carrier. Because of this the design permits the use of three junction circuits comprising physical or rural carrier. Two channels of RC101 rural carrier can be fitted inside the Minirax cabinet and, because of their extremely small current requirements, can be powered from the battery used for the switching equipment.

The exchange, when used in a subscriber trunk dialling network, is strapped to operate as a discriminating satellite and is thus incorporated in the linked numbering scheme of the area.

It is of course impractical as well as too costly to provide full S.T.D. fee-determining and pulse-supply equipment at these small exchanges.

To overcome this difficulty, use is made of the metering equipment at the parent exchange, and the necessary periodic meter pulses are passed back to the Minirax from the parent exchange, over the junctions. Where physical junction lines are concerned, the metering back takes the form of reversals of potential, precautions being taken to ensure that these are inaudible to the subscribers. However, with rural carrier working, the calling, dialling and release signals, etc., are effected by connection or disconnection of the carrier. By this method of signalling, a meter pulse passed back over the junction would have to be represented by a momentary disconnection of the carrier and this signal break would be audible to the calling subscriber. For each rural carrier channel, therefore, a separate band is used for metering

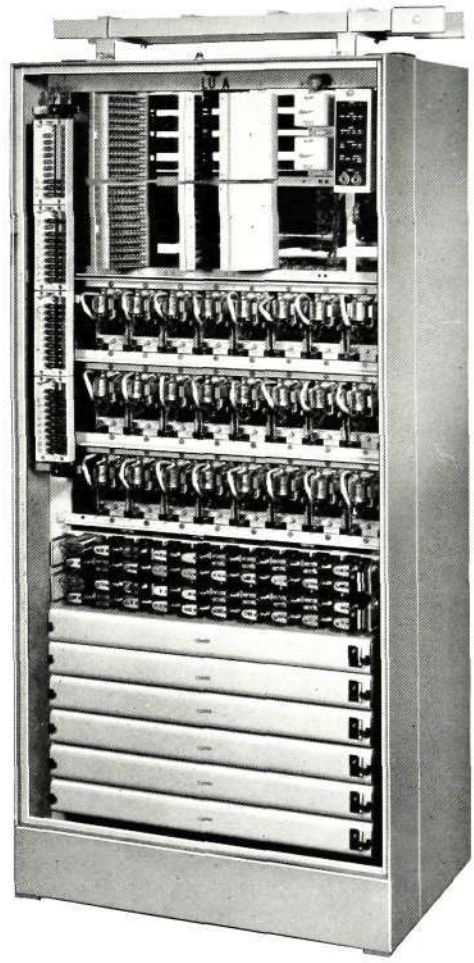

Figure 3—Typical Rurax Unit with door removed

purposes. These bands are in the range between the top frequency used by the physical circuit and the lowest carrier channel frequency, i.e., between 3 and 10 kc/s.

A possible disadvantage of the Minirax, as with any small exchange other than a line connector, is that it requires the allocation of a selector level at the parent exchange, and this for only 20 subscribers.

The use of a level in this way is of no consequence if group-selector levels are available, but to help overcome the problem where shortage of levels could mean a costly extension, a very simple and economic jack-in uniselector-type group selector having 4 levels, each with an availability of 3, has been designed. These relay sets can be mounted along with the junction circuits at the parent exchange and used as a second or third group-selector stage, giving access to 4 Minirax exchanges feeding up to 80 subscribers.

The Rurax

Rurax equipment, typically illustrated in Figure 3, has now been manufactured for several years and has proved to be invaluable for the development of the rural automatic exchange networks in many parts of the world. The equipment, constructed on the extensible self-contained 50-line unit principle, was originally designed to give facilities similar to the UAX12 and 13 but, with the advent of STD, has been modified to allow its use in a linked numbering scheme. Modification has been achieved with the minimum of change to the basic switching circuits and equipment layout.

The trunking diagram in Figure 4 shows how auxiliary hunter equipment is interposed between the linefinders and connectors, or group selectors, to give the exchange discriminating satellite facilities. With this mode of operation, a calling subscriber is connected via a junction to the parent exchange immediately the handset is lifted. In addition to repeating the dialled pulses into the parent exchange, the junction circuit and associated discriminating equipment examines the initial digits to ascertain whether or not the call is to a local subscriber.

If the code indication is that of a local call, a signal is passed back to the auxiliary circuit which causes the junction to be released and the associated auxiliary hunter switch to search for a free local connecting link. The remaining digits route the call to the required subscriber. On the other hand, if the call is for a subscriber or service outside the local exchange, the junction circuit is not released and all digits are repeated into the parent exchange.

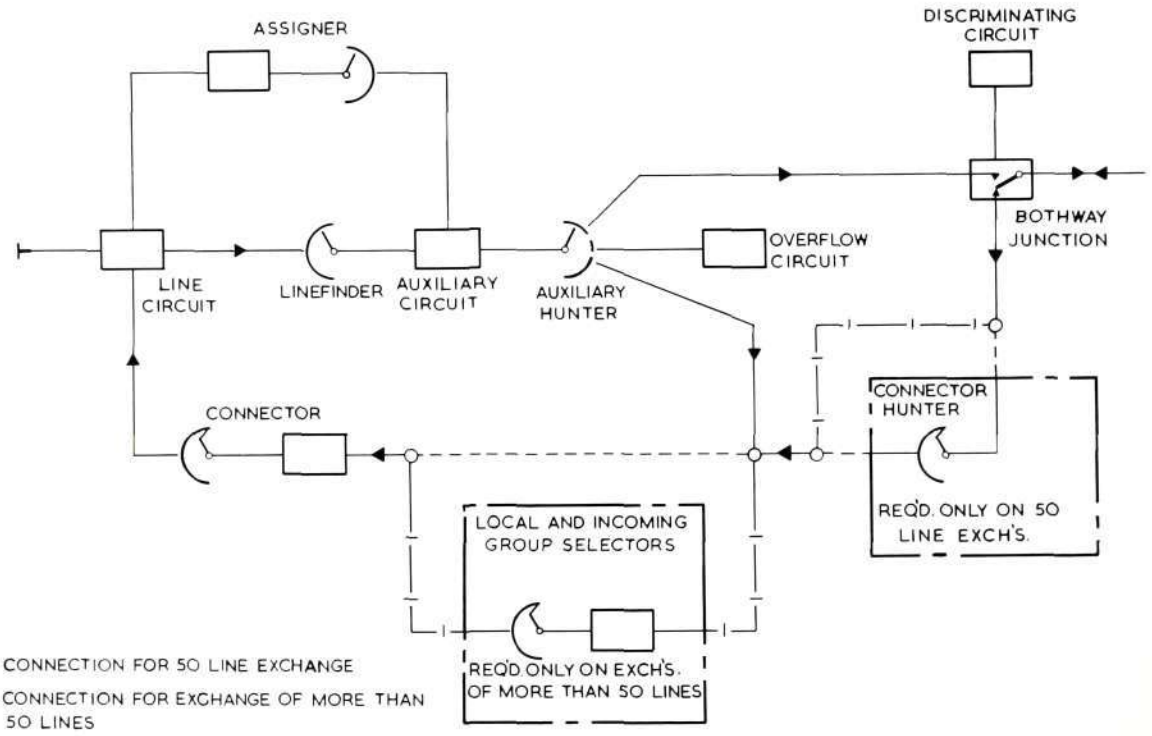

Figure 4—Trunking diagram of Rurax illustrating auxiliary hunter equipment interposed between linefinders and connectors (or group selectors) to give discriminating satellite facilities

Because the junctions at the parent exchange are terminated on incoming group selectors or their equivalent, there is negligible seizure time on an outgoing call from the Rurax, and therefore dial tone is returned to the caller from the outgoing junction circuit. This arrangement enables subscribers to complete a local call in the event of a faulty junction line being seized.

Overflow circuits are included to enable subscribers to complete local calls if all junction circuits are busy. The hunter switch can only test into these circuits if all the junctions are engaged. As with the junction circuit, the overflow circuit is released immediately local discrimination takes place. If a subscriber dials other than a local number after seizing an overflow circuit, a busy indication is returned, forced release being applied after a pre-determined period.

Since the hunter switch associated with the auxiliary circuits is of non-homing type, the junction circuits are not tested in the same sequence each time a call is originated. Should a junction become faulty, this arrangement in conjunction with the sequential allocation of auxiliary circuits by means of the assigner, overcomes the difficulties associated with seizing the faulty junction circuit on successive attempts at making a call.

In addition to making the exchange suitable for operating in a linked numbering area, the trunking scheme outlined also presents certain other advantages over previous arrangements. Firstly, apart from the slight increase in cost of a 50-line exchange because of its use of auxiliary circuits, savings in cost can be progressively accrued with increase in exchange capacity. These savings stem from the reduced number of local group selectors required due to the diversion of outgoing traffic via the hunter switch and to the more efficient concentration of traffic. A second advantage is that, because subscriber lines are fed only from group-selector levels, both local and incoming group selectors can be mixed in the same rank, making for greater economy and flexibility of arrangement. Finally, the exchange can be extended up to 450 lines without the need to introduce a second group selector stage.

As in the case of Minirax, meter pulses can be passed back over the junctions from the parent exchange, but when Rurax is used as a group centre exchange, suitable meter fee determining and pulse supply equipment is provided.

The Extensible Unit Type Exchange

Unit construction forms the basis of the design of this new extensible exchange which uses heavy-duty uniselectors and 4000-type selectors to provide switching facilities for exchanges which are expected to exceed the economic limits of Rurax.

The 4000-type selectors are of 100-outlet type and therefore the exchange is designed in 100-line units. As in most unit-type exchanges, a linefinder scheme is employed, each linefinder consisting of two 50-point uniselectors. Each of the two assigner switches controls half the quantity of linefinders and normally deals with calls from a sub group of 50 lines, but either assigner, under fault or congestion conditions, can control calls from the whole 100 line group. This arrangement permits traffic to be regarded as originating from groups of 100 lines and, at the same time, prevents a line unit from being dependent upon the correct functioning of a single assigner.

All the equipment for 100 lines, together with junction or trunk circuits, is mounted on a double-sided rack, hinged mountings being used where necessary to allow accessibility of equipment for maintenance purposes.

The units (see Figure 5) can be totally enclosed with transparent plastic panels front and rear. These are held in position magnetically and allow observation of the equipment while excluding dust. The panels are of a convenient size for handling and allow maintenance to be carried out by exposing only a small area of the unit. This dust-proofing of the units greatly reduces fault liability and increases the working life of the equipment.

The exchange can be provided with normal trunking arrangements for use as a group-centre exchange or as a discriminating satellite employing the same trunking arrangements as described earlier for Rurax.

Multi-party Line Exchanges

In certain areas of the world, multi-party-line operation makes service economically feasible for the greatest number of people by reducing appreciably the outside and inside plant cost per subscriber.

Both the Rurax and the Extensible Unit Type Exchange can be arranged for multi-party-line operation, a facility which is most useful in areas where charging is on a flat rate basis. In fact, it is probable that in general it is because party line operation has

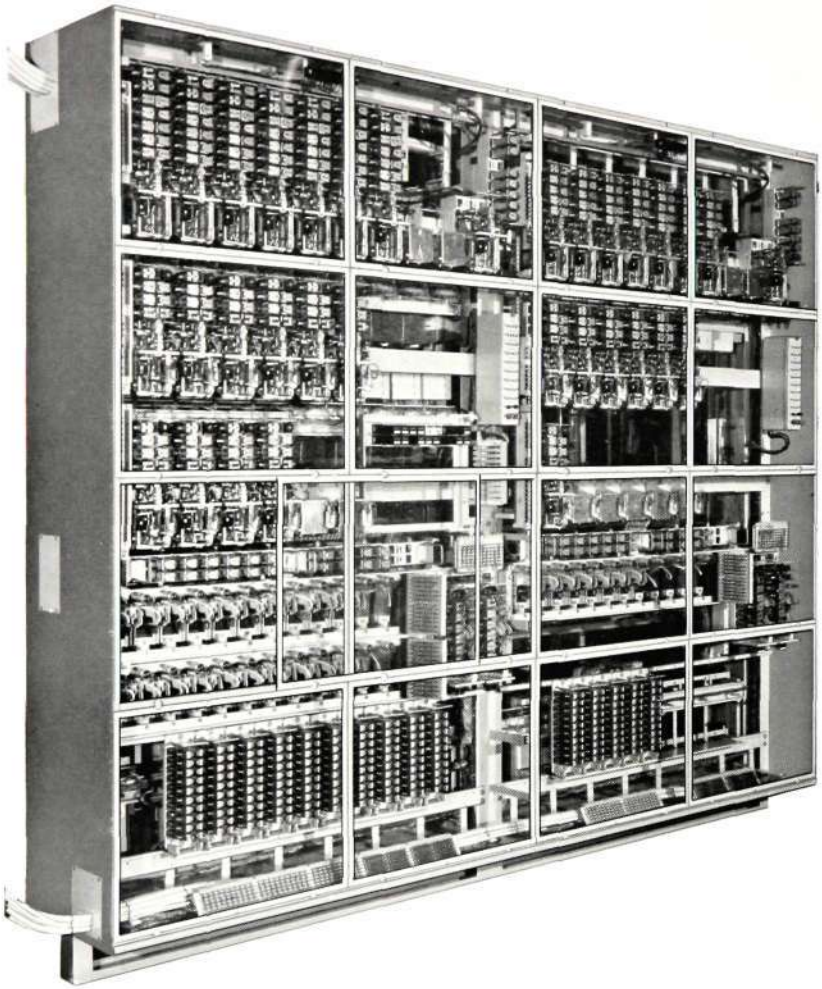

Figure 5—Extensible unit-type exchange totally enclosed with transparent plastic panels front and rear

been essential that a flat rate tariff has had to be introduced initially. This feature limited subscriber dialling to the area in which the Administration was prepared to allow free calls, all other calls being completed and accordingly charged by an operator.

For subscriber metering on party lines, calling-party identification is necessary. This can be provided by interposing a relatively simple circuit between every line used as a party line and the associated line circuit. The party-line telephone must also be fitted with a special dial which has an additional springset and cam. With this system a party-line subscriber must always dial ' O ' when initiating a call, thus enabling the calling station to be identified and its associated subscriber's meter to be connected in circuit. With this facility incorporated, the flat-rate tariff system can still be maintained or local call charging can be introduced. With either method, access into the national network is now possible without the aid of an operator.

Conclusions

Although the basic principles of the step-by-step system have remained unchanged since the advent of automatic telephony, equipment and circuitry have developed to keep pace with modern production methods and facility requirements. It is at this stage of advanced development in the art of electro-mechanical switching that the introduction of new ideas in the form of electronic switching are reaching the stage of fruition. Whilst there is no doubt that electronic will gradually replace electro-mechanical switching, the latter, as represented by the exchanges described above, has reached the point of simplicity, economy and freedom from maintenance problems that may never be attained by other forms of switching which require complex common control.

U.D.C.621.395.342.21

The Minirax Mk II

J. SIDWELL—Etelco Canada Ltd., Engineering Department

A new miniature 24-volt rural automatic exchange is described. It has capacity for 20 subscriber lines and presents the attractive features of small physical size, ready mobility and dual purpose. It can function either as a dependent exchange with up to three junctions, physical or carrier, or as a discriminating satellite to allow inter-calling with other automatic exchanges and access to the nationwide network if required. Its in-built battery can be charged over a physical junction from a remote location thus making the Minirax completely independent of a mains supply.

SOME years ago the Company introduced the Minirax,[1] a miniature automatic exchange arranged to meet the specialized needs of small rural communities. This 20-line exchange, designed for unattended operation as a dependent exchange, provided fully automatic local service and direct bothway working with a parent exchange, manual, auto-manual or automatic. Its power was derived from a small-capacity 24-volt battery trickle charged over one or more physical junctions from the parent exchange.

Recent years however have seen a phenomenal increase in the demand for direct subscriber dialling of calls outside the home exchange. In some areas the requirement is merely for the inter-dialling of calls between a group-centre exchange and its dependents; in others, a nationwide plan. In the next few years it is almost certain that facilities allowing subscriber-dialled international calls will be demanded.

In order to permit the telephone subscriber in a remote area to enjoy similar facilities to those offered by large public exchanges, it was decided to introduce the Minirax Mk II which, whilst maintaining all the facilities of the original design, would allow its integration with a nationwide subscriber dialling scheme.

A fundamental requirement for such a scheme is a nationwide numbering plan in which all the subscribers have a unique designation which nevertheless is similar in form to that of all other subscribers connected to the network. With this arrangement, all operators and subscribers wherever connected must use this designation as a destination code to reach the required subscriber through the dial-switching network. All exchanges therefore become part of a large multi-exchange area with each exchange having its own distinctive identity for routing purposes. Complementary to this numbering plan is the need for selection by the equipment of the appropriate charging rate on calls to various destinations.

With these considerations in mind the Minirax Mk II has been designed to operate either as a dependent exchange in a similar manner to the original design or as a discriminating satellite, thus obviating the need for special routing codes. Its ability to assume either of these roles makes the new exchange suitable for an Administration not requiring subscriber dialling initially but contemplating its inclusion at a later date.

Conversion to discriminating satellite working merely entails the adjustment of straps in the equipment and the substitution of appropriate jack-in junction relay sets where necessary, dependent upon the type of junctions and metering arrangements existing at the particular exchange.

The features listed below can all be catered for by the exchange whose design flexibility allows equipment for some of the facilities to be fitted or omitted to suit particular requirements.

Automatic connection between subscribers on the Minirax.

Automatic connection from the Minirax to a parent exchange and to a neighbouring Minirax if required.

Physical or carrier junctions to parent exchange.

Alternate testing of 1st and 2nd choice junctions.

[1]Described in Bulletin No. 42, pp. 28-32.

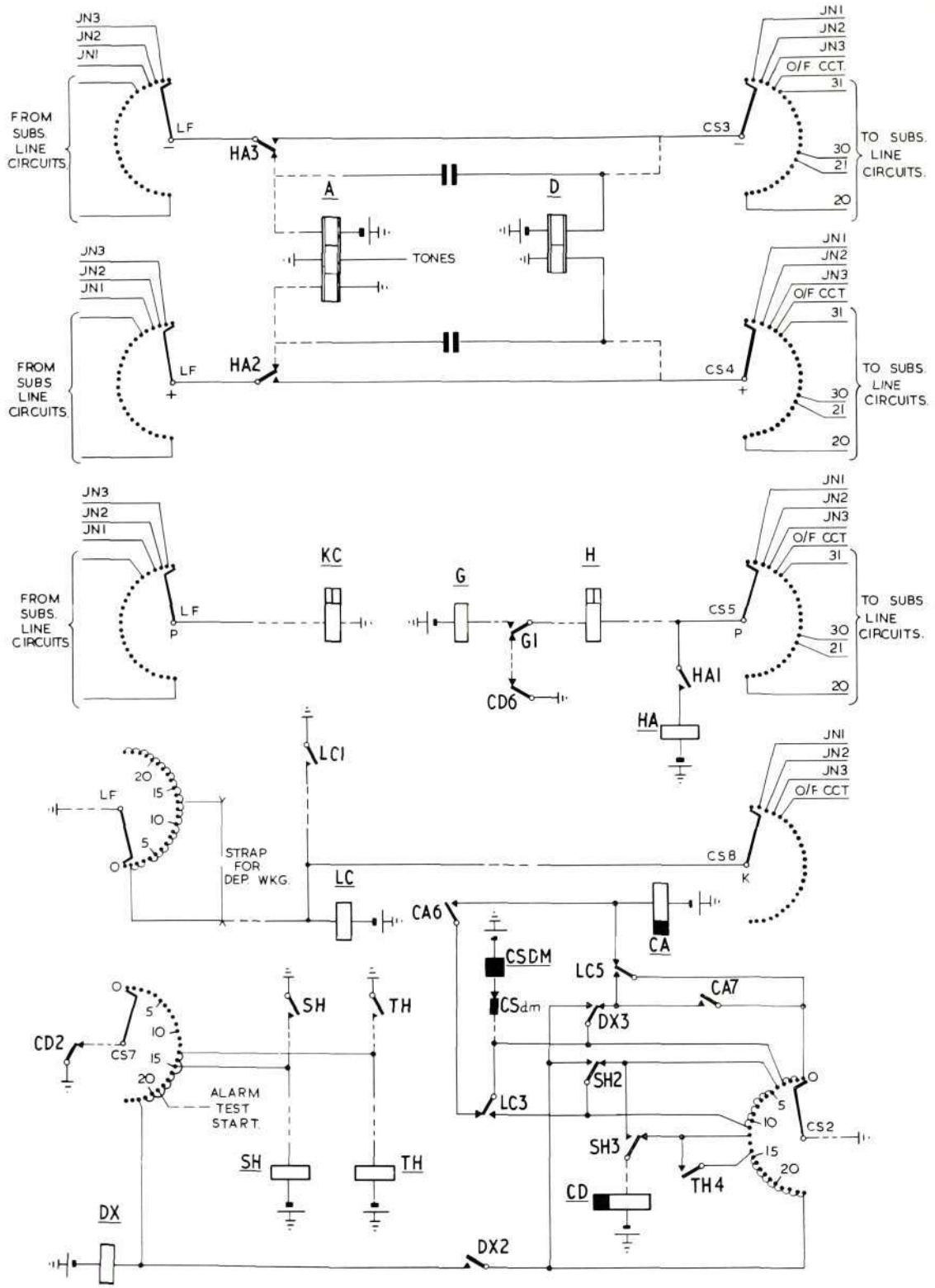

Figure 1—Simplified diagram of connecting link

Coin-box (paystation) discrimination with visual or audible signal to parent exchange operator.

Metering equipment (single fee, multi-fee and periodic).

Manual hold.

Visual and audible fault alarms.

Visual indication of a fault condition extended to a panel in the Minirax building or in an adjacent building.

Alarm test circuit.

Ringing and tones with periodicities to Administrations' requirements.

Battery charging over junctions.

Performance

The equipment functions satisfactorily on subscriber lines and junctions having a maximum loop resistance of 500 ohms including the telephone instrument, and an insulation resistance of not less than 50,000 ohms. The exchange is designed to consume the minimum of current and to operate with a variation of battery voltage between 22 and 28 volts.

Numbering and Trunking

A 2-digit numbering scheme 20–39 is used for all subscriber lines when the Minirax functions as a dependent exchange. Access to an outgoing junction is by dialling a single digit which may be 8, 9 or 0.

For discriminating-satellite working, these local numbers are prefixed by two or three digits to conform to the numbering scheme of the area. Seizure of a junction and the switching equipment at the parent exchange is immediate on pick-up.

Four connecting links are provided each with strapping arrangements for adaptation to either method of working. Each link (see Figure 1) comprises a linefinder and a connector switch both of the single-motion 25-point type. Subscriber line circuits are connected direct to the linefinder bank contacts and multipled in corresponding order to the bank contacts of the connector switch which functions as a combined group and final selector. Incoming and outgoing sections of the bothway junctions are connected to the early outlets of the linefinder and connector switches respectively and trunked to line via relay sets.

Discriminating Satellite Working

For all calls, local and junction, a linefinder (LF) in the link circuit is allotted to search for and find the calling condition.

Incoming Junction Call

When an incoming call is received over one of the three junctions the wipers of LF are arrested at the appropriate outlet (1, 2 or 3) and an operate circuit is completed for relay LC. As a result, the connector switch CS self-drives to outlet 12 and relay CD operates to prepare the dialling circuit for the acceptance of the two local digits from the incoming-junction caller.

If the first of the two digits of the wanted number commences with 2, CS steps to the appropriate outlet under control of the dial. As it steps on to outlet 14, relay TH operates to release LC and re-operate CD, thus allowing the switch to respond to the final digit and step to the called-subscriber outlet (i.e. 15 to 24).

Similarly, when digit 3 is dialled as the penultimate digit, CS steps under control of the dial to outlet 15. On reaching this position, relay SH operates and the switch then self-drives to outlet 4. Relays TH, LC and CD function again, as described above, to position CS under control of the final digit on the appropriate called-subscriber outlet (i.e. 5 to 14).

At this stage the called line is tested for three conditions; (*a*) free, (*b*) busy and (*c*) spare connection. Busy and NU tones are transmitted for (*b*) and (*c*) respectively. In addition, NU tone is applied to the calling line when a penultimate local digit other than 2 or 3 is dialled.

Because of the need to maintain current drain at the minimum for this type of exchange, only four relays are held operated in the connecting link during the conversational period.

Local and Outgoing Junction Calls

When a call originates from a local subscriber the linefinder drives over outlets 1–3 and consequently relay LC does not operate. When the linefinder cuts-drive on the appropriate outlet, CS searches over the junction and overflow outlets. On seizure of the junction, dial tone is transmitted to the caller and all relays release with the exception of HA.

As the caller dials the wanted subscriber's number following the receipt of dial tone, the digits are repeated into the parent exchange and also into the discriminator associated with the junction circuit. If the digits dialled correspond with the exchange code of the Minirax, an earth is returned over the K lead; otherwise the call remains routed through the parent exchange.

When earth is returned, relay LC operates, CS drives to outlet 12 and the junction circuit is released. Thus conditions are established for completing a local call as described under ' Incoming Calls '.

Should all junctions be busy, an overflow circuit connected to outlet 4 is seized, enabling the local call to be completed.

Dependent Working

For dependent working, no differentiation is made between calls originated locally or incoming via the junctions; relay LC operates on both types of call after the linefinder has found the calling line. In both instances therefore, CS drives to outlet 12, CD operates and the function of the circuit for the acceptance of the two local digits as well as the testing of the called line is identical to that described for discriminating satellite working.

When the single digit (8, 9 or 0) is dialled for an outgoing junction call, relay DX operates and CS is driven to the home position. This causes the release of the LC relay and the subsequent operation of CA to drive CS in search of a free junction. On seizure, relay HA is maintained held and all other relays in the link circuit release, further digits being repeated over the junction to the parent exchange if necessary.

Junction Circuits

All junction circuits irrespective of classification, i.e. manual, auto-manual or automatic, can be supplied to function over physical lines or over line or radio carrier. Line-carrier equipment (RC101 Rural Carrier) can be incorporated in the Minirax.

For complete reliability of operation, the circuits are so designed as to eliminate all possibility of false metering, especially in the event of simultaneous junction seizure at both exchange terminals. In addition, the first and second-choice junctions are arranged for alternate seizure by the calling subscriber during periods of light traffic. This arrangement not only permits uniform distribution of traffic over the two junctions but, more important, it ensures that if a fault occurs on a junction, a calling subscriber is not isolated from the junctions by seizure of the same faulty junction on successive attempts at originating a call. A further design facet of interest is that an incoming junction call can still be completed even though the outgoing side of the circuit is held by a subscriber who has dialled a barred service.

Route Barring and Call Charging

Equipment can be associated with auto-auto junctions to determine the treatment (i.e. barring and metering) to be applied to various types of call. Three classes of subscribers are catered for, ordinary, restricted, and coin-box. Coin-box subscribers are barred from chargeable services and calls to the nationwide network. Restricted subscribers can be denied access to STD on a temporary basis under control of a lock and key in the telephone.

Table 1 shows a typical range of metering and barring facilities applicable to the discriminating satellite and dependent systems.

The additional coin-facility referred to in the table is one which enables a line unbalance to be applied from a coin-box when a further coin is inserted. This allows the metering equipment to recognize that further units of time have been purchased.

Coin-box Discrimination

Any subscriber's line circuit can be arranged for coin-box working by appropriate terminal strapping. Calls to the operator from these lines can be recognized either by a different calling lamp or by the application of a burst of distinctive tone when the operator answers. This tone can be checked by removal and re-insertion of the operator's plug.

Forced Release

This feature is provided to ensure that common switching equipment is not held up unnecessarily owing to a loop or earth fault condition. If a subscriber fails to dial after lifting the handset or omits to clear-down the connection at the termination of a call, the switching equipment is forced-released after 30 seconds, and the calling line locked out as long as the condition persists.

Types of Call	*Types of Metering*			*Method of Working*
	Ordinary Subscribers	*Coin-box Subscribers without additional coin facility*	*Coin-box Subscribers with additional coin facility (D.S.R. system only)*	
Local Calls, i.e. within the Minirax	Unit fee untimed	Unit fee untimed	Unit fee untimed	D.S.R. or Dependent
Interurban Calls, i.e. junction calls where meter rate is same for all routes.	Unit fee untimed	Unit fee untimed	Unit fee untimed	D.S.R. or Dependent
		Barred	Barred	
	Unit fee on answer and thereafter repeated at intervals of 1, 2, 3, 4 or 5 minutes.	Unit fee timed out after interval determined for calls from ordinary subscribers.	Unit fee repeated after interval determined for calls from ordinary subscribers if further coin is inserted, otherwise call is released.	D.S.R.
		Barred	Barred	D.S.R. or Dependent
	Multi fee untimed, 1—6 pulses.	Unit fee timed out after arbitrary interval of 1, 2, 3, 4 or 5 minutes.	Unit fee repeated after arbitrary interval of 1, 2, 3, 4 or 5 minutes if further coin inserted, otherwise call is released.	D.S.R.
		Barred	Barred	D.S.R. or Dependent
	Multi fee, 1—6 pulses, on answer and thereafter repeated at intervals of 1, 2, 3, 4 or 5 minutes.	Barred	Barred	D.S.R. or Dependent

Types of Call	*Types of Metering*			*Method of Working*
	Ordinary Subscribers	*Coin-box Subscribers without additional coin facility*	*Coin-box Subscribers with additional coin facility (D.S.R. system only)*	
Interurban calls where meter rates depend on route.	Unit fee on answer and thereafter at intervals of 1, 2, 3, 4 or 5 minutes appropriate to route (determined at parent exchange and repeated over the junction to the Minirax).	Unit fee timed out after compromise interval of 1, 2, 3, 4 or 5 minutes on all routes.	Unit fee repeated at compromised interval of 1, 2, 3, 4 or 5 minutes on all routes if further coin is inserted, otherwise call is released.	D.S.R.
		Barred	Barred	D.S.R. or Dependent
Calls to nationwide network.	Time and Zone metering, i.e. single pulses repeated at intervals determined in the register equipment at the trunk or zone centre, and returned over the junction to the Minirax.	Barred	Barred	D.S.R.
Calls to chargeable special services.	Unit fee repeated at intervals determined in the register or other equipment at the trunk or zone centre and returned over the junction to the Minirax.	Unit fee timed-out after arbitrary interval or that interval used for interurban calls from ordinary subscribers determined at Minirax.	Unit fee repeated after arbitrary interval or that interval used for interurban calls from ordinary subscribers if further coin is inserted, otherwise call is released.	D.S.R.
		Barred	Barred	

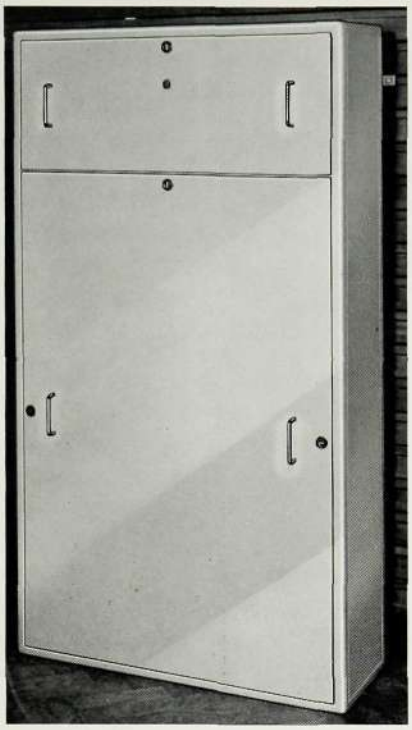

Figure 2—General view of Minirax Mk II Unit

Alarms

Fault conditions are indicated by a lamp display and also by tones which are obtained by dialling an alarm-test number either locally or from a distant exchange.

Alarms may be extended locally, if required, to operate a buzzer in a nearby room. Operation of the buzzer cut-off key illuminates a lamp display at the remote point to indicate the nature of the fault.

Battery Charging

The 12Ah capacity of the 24 volt battery is larger than that of the original design, but similar arrangements have been made for charging the battery over physical junctions during the non-conversational time. Where a combination of carrier and physical circuits is provided, the physical circuit is arranged to be taken into use last.

Three junctions will carry approximately 0·6 erlangs at a grade of service of 1 in 50 and the traffic carried by the third trunk under these circumstances is 0·048 erlangs. With a day-to-busy hour ratio of 8 : 1 the physical junction is occupied for a total of 0·384 hours per day and is therefore available for charging purposes for 23·6 hours out of every 24.

Should a local power source be available, a conventional charging scheme may be employed if desired, thus enabling the exchange to function entirely with carrier junctions in areas where land lines do not exist and all communication is provided by v.h.f. radio.

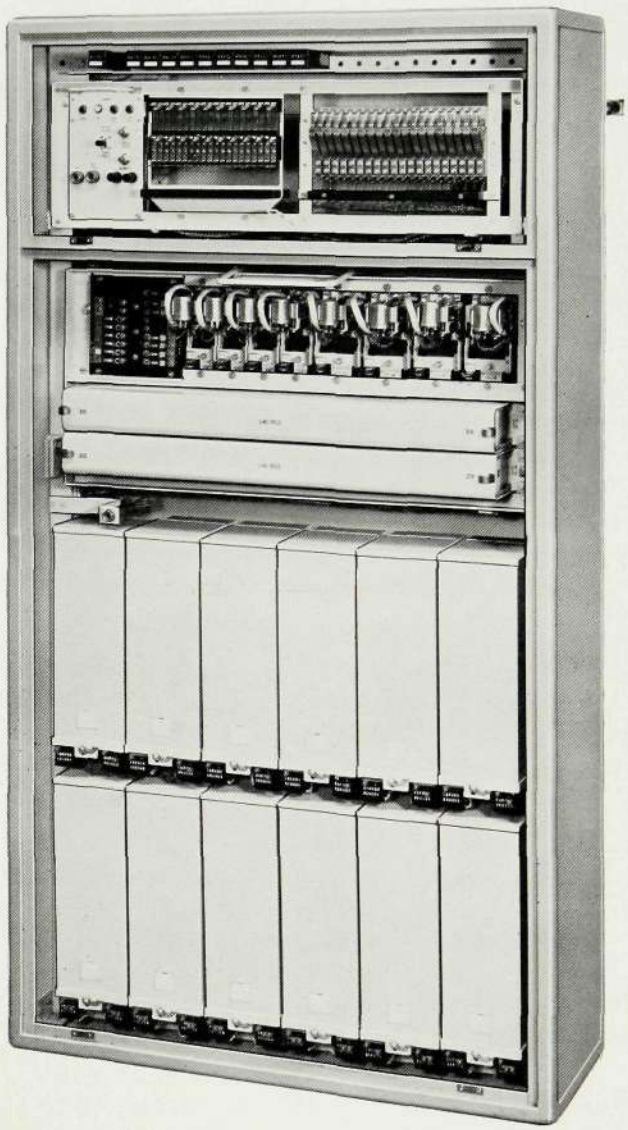

Figure 3—Minirax Mk II Unit with dustproof doors removed

Ringing, Tones and Meter Pulse Supplies

The various ringing and tone interruption and meter pulse are derived from transistor generators and pulse circuits actuated by a uniselector and self-interrupting relay chains.

Equipment

The cabinet (Figure 2), which houses the telephone switching and Rural Carrier equipment, is identical to that used in the original design but the mounting arrangements have been altered slightly to provide space for the additional equipment. Figure 3 shows the layout of the equipment in which the jack-in relay sets occupy two shelves, each with capacity for 6 units. The upper shelf accommodates the four connecting links, the ring, tone and meter pulse generator, and the alarm and miscellaneous equipment, including the overflow circuit if required. The lower shelf mounts three junction relay sets and three discriminators or route restriction and metering sets. Common shelf-jack wiring enables the various types of junction relay set to be jacked-in in any of the positions.

The connector, linefinder and discriminator switches are of heavy-duty pattern and the relays are of minor, major and high-speed type. The circuitry is conventional and the components orthodox to ensure complete reliability.

Conclusion

The Minirax Mk II offers wide scope of application and is suited to meet the present-day telephone requirements of progressive rural communities. By its use, the desired parity with larger areas served by STD facilities can be fulfilled, either immediately or at an Administration's convenience. Its small size and independence of a mains supply avoids the need of special site accommodation, and the use of dependable components and established switching principles ensures minimum fault liability.

U.D.C.621.395.26

ET4H Cordless PABX for Hotels

E. C. DYSON—Circuit Development Engineering Department

The ET4H private automatic branch exchange makes a significant contribution to hotel efficiency and service. Designed originally for the Mayfair Hotel, London, it offers a wide range of facilities for both guests and staff and its basic design is such that it can be adapted to meet the diverse service requirements of other hotel managements.

TO be successful, hotel telephone installations must cater for a number of special requirements not covered by the standard facilities of an automatic system. While the merits of the modern cordless PABX, as typified by the ET4,[1] are becoming increasingly recognized by hotel managements, such systems are designed primarily for industry or commerce and lack the personal service features desirable for hotel use.

The engineering problems vary in detail between different installations but always there is the need to combine two quite different categories of service in a single efficient system; communications for the staff and service to the guests.

Staff require enquiry and transfer facilities, direct access to exchange lines and, in fact, all the features provided by a modern cordless PABX.

Guest extensions on the other hand have little need of transfer facilities and generally little community of interest with other guests. Thus, calls between guest extensions are comparatively rare and the management will usually wish to exercise some degree of supervision over those that do take place. The majority of internal calls are to staff outlets such as Room Service and, by permitting direct dialling, the guest receives a faster service, whilst the hotel reaps the benefit of lower operating costs as the switchboard is bypassed.

None the less, a guest is confronted with an additional complication, the telephone dial, which some may tend to regard as an encumbrance. Operation should therefore be as simple as possible and in the interests of guests who object to dialling a digit-sequence at all, assisted access to all services via the ' O ' level is available as an alternative. The need for the phrase " what is your room number ?" with its suggestion of impersonality and the risk of misunderstanding must be eliminated; calling-line identification and a simple room/telephone number relationship are essentials.

While these features help to reconcile some guests to the presence of a dial, other guests will demand a dial for unrestricted local and STD access in secrecy to the public exchange. These services are of considerable value to businessmen and, other things being equal, will often determine the choice of hotel. Growing familiarity with automatic facilities, and particularly with STD or its equivalent abroad, make direct access a necessary feature for any new luxury hotel. Given facilities for meter pulse recording and billing of effective calls, its provision is in the interests of the hotel management, because the load on the switchboard is reduced, with consequent savings in operating costs, and requests for separate exchange lines by long-term guests can often be eliminated.

Apart from these general features, hotel managements usually require provision in the telephone system for handling special requests from guests. The two most common requests are to prevent calls to those guests who for some reason wish to remain undisturbed, and to arrange for the filtering of calls to VIP guests.

With a PMBX the usual procedure is to insert dummy plugs in the relevant jacks, thus furnishing a positive reminder to the operator to consult her list of special requests before extending a call. On a cordless installation a similar degree of protection can be given by means of a form of interception on the MDF or, if the number of special requests justifies it, by a barring facility that the operator alone can over-ride by trunk-offering procedure.

[1]Described in Bulletin No. 39, pp. 14-22.

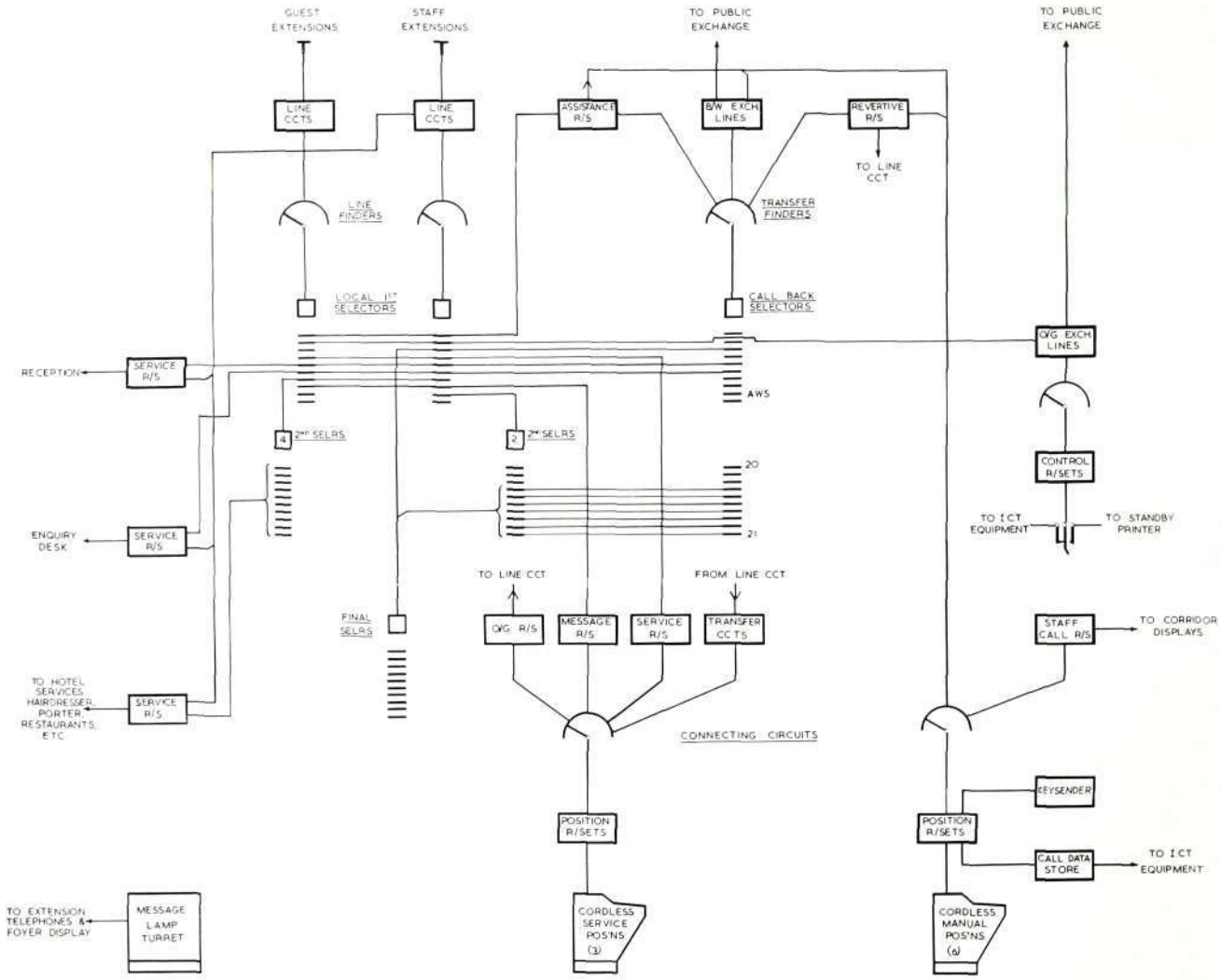

Figure 1—Simplified trunking diagram of the ET4H PABX

The ET4H Cordless Switchboard

A modified version of the ET4 cordless switchboard, known as the ET4H, incorporates the features described in this introductory outline. Much of the development work was carried out in close consultation with the management of the Mayfair Hotel where installation of the PABX was completed in June, 1962.

Equipment Details

The Extensions

Trunking arrangements can be seen from the simplified trunking diagram in Figure 1. Although this generally follows standard ET4 practice, the equipment layout has been modified to segregate guest and staff extensions. An IDF is included to give numbering flexibility and permit guest extension numbers to comply with room numbers prefixed by the digit '2', the actual numbering allocation being between 2100 and 2799. But as none of the seven guest floors at the Mayfair will ever have more than 70 guest rooms, the numbers from 70–00 can be used for staff extensions when it is convenient to number them on a floor basis.

Dialling is permitted from staff extensions to guest extensions but not between guest and guest, and appropriate marking conditions are applied to bar call-back enquiries by guests to any extension or service other than the cordless manual positions, leaving staff extensions unrestricted.

Staff extension line circuits are routed to a separate grading of Local 1st Selectors and the main group of staff extensions is numbered between 800 and 899.

Barring of direct exchange access can be applied to any extension by strapping in the equipment, either permanently or under control of a lock in the telephone instrument, the authorized user alone holding the key. On all extensions, whether lock control is provided or not, incoming exchange calls, and calls to or from other services, are unaffected by barring. Actually, in the conditions obtaining at the Mayfair Hotel, the use of lock control is confined solely to safeguarding staff extensions from access by unauthorized persons and is not provided at guest extensions because of the high ' nuisance value '.

Level ' 7 ' gives access to a suite of special manual positions, equipped to deal with requests for Room Service and manned by multi-lingual operators to provide maximum assistance to guests of all nationalities. These operators are also responsible for the hotel message service, and extensions notified of awaiting messages are asked to call on this suite via level ' 3 ', which is assigned for message collection.

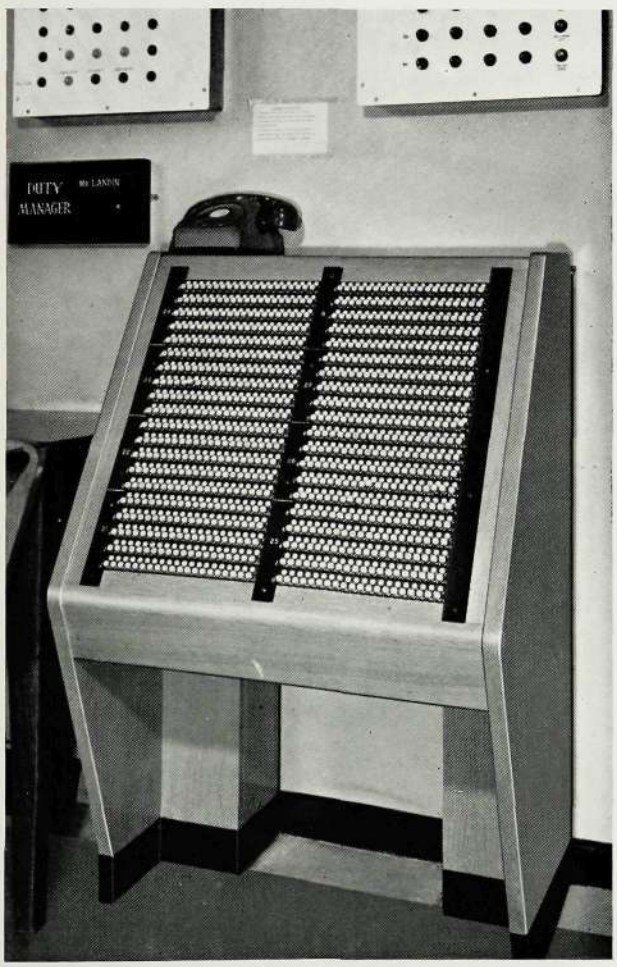

Figure 2—Message-waiting lamp panel for guests

Notification that a message is awaiting a guest is by a message lamp on each telephone. This lamp is controlled from a panel (see Figure 2) adjacent to the Room Service positions. There is one push key per extension, the operation of the key causing a continuous flashing of the lamp on the extension telephone and also a steady glow of a guard lamp in the panel. In addition, there is a parallel lamp appearance in the guest's pigeon-hole in the hotel foyer.

The use of separate key circuits for each message lamp imposes no restriction on the number of extensions capable of being signalled simultaneously, and separate line wires avoid cessation of the lamp signals when the handset is lifted, a feature often wrongly interpreted by the guest.

Exchange Lines and Meter Pulse Recording

Incoming exchange calls are normally extended by the manual operators to the required guest, staff, or service extension via the final selectors, and the standard ' Park on Busy ' facility is retained. The same provisions apply to service extensions, but for Enquiry Desk and Reception where exchange-line traffic is much heavier, calls can also be extended via the first selectors.

Exchange lines are divided into two separate groups, one group being used for incoming calls and for calls originated from the manual positions. The other group is associated with level ' 9 ' and gives direct and secret access to the exchange; its use is shared by guest extensions and non-barred staff extensions alike.

The relay-sets associated with the level ' 9 ' group of exchange lines, store the called number up to a total of 10 digits, and also prevent access to all chargeable codes, such as telegrams, and trunk demand where STD meter pulses are not received.

Up to 999 STD pulses may be stored, but to avoid the possibility of a guest running up an embarrassingly high account on a single call, the equipment is arranged so that calls are automatically disconnected at an arbitrary lower total of pulses. The figure adopted is 500, but other values may be selected by strapping.

When the extension replaces his handset, the exchange line is released if the call has not involved a charge, but if one or more meter pulses have been received, start and mark signals are extended to a

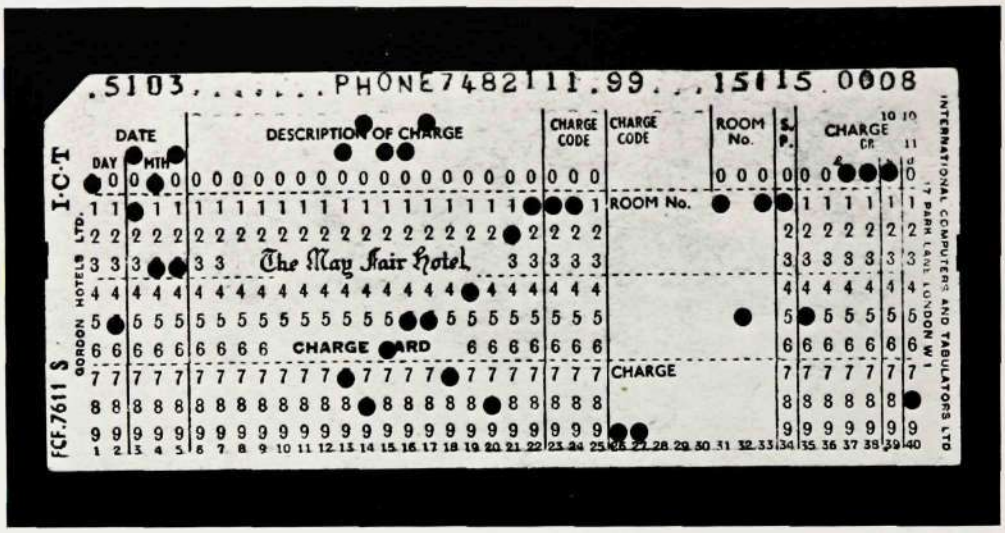

Figure 3—Typical punch-card record for room No. 151. The call charge of eight pence may be seen at the bottom right-hand corner

control relay set whose finder hunts for the exchange line. The control relay set comprises a buffer store for the information held in the exchange-line relay set; this information is transferred in substantially parallel mode and assembled in such a manner that it can be read out by ICT card punching equipment or by a standby printer.

Simultaneously with the collection of information from the exchange-line relay set, Calling Line Identification (C.L.I.) equipment is set in operation, resulting in the last three digits of the extension number being recorded in a relay store.

The exchange-line and extension are freed as soon as the respective transfers of information are completed. At this stage, the control circuit indicates that it is ready for the read-out cycle.

The ICT equipment or the standby printer circuit then causes the various relay trees in the buffer and C.L.I. stores to be examined, extracts the relevant information and produces a record of the call, including the time and date.

Figure 3 illustrates a typical punched card for room 151 where the charge is shown in £ s. d. as eight pence. The conversion from meter units is effected with the aid of a small ICT computer. This automatically adds a sliding scale hotel surcharge.

The system of charge recording for guest calls made with manual-operator assistance is similar to that for dialled calls, ICT punched cards again being the basis.

Since ADC (advise duration and charge) information is always subject to some delay, the procedure is for the operator to make out a temporary docket on completing the call and, when full ADC information is later received, a ' Punch Seize ' key is pressed to seize a ' Call Data Store '. This is analogous to the Control R/S associated with the direct-access exchange lines. Information concerning the call is keyed into the store using the normal keysender keys, the stored information being displayed for check purposes on in-line projection-type indicators on the switchboard.

When the operator has verified that the details shown are correct, depression of the keysender ' start ' key causes the ICT cycle to commence. After the card has been punched, the Call Data Store automatically releases and the keysender is restored to its normal function.

Accounting

Punched cards are used for telephone calls in the Mayfair Hotel since all other hotel charges are recorded on similar punched cards, remote control keysets for instance being used in the restaurants to prepare cards for meal charges. Details of all charges can thus be rapidly collated in a central billing office, and the inclusion of charges for telephone calls made by a guest just before departure (ordinarily a subject of special difficulty) is readily achieved. When a guest asks for his account, the relevant cards are taken from a pigeon hole, fed into a tabulator, and the account automatically prepared in a few seconds.

Figure 4—Part of the manual suite with two of the Room Service positions on the left

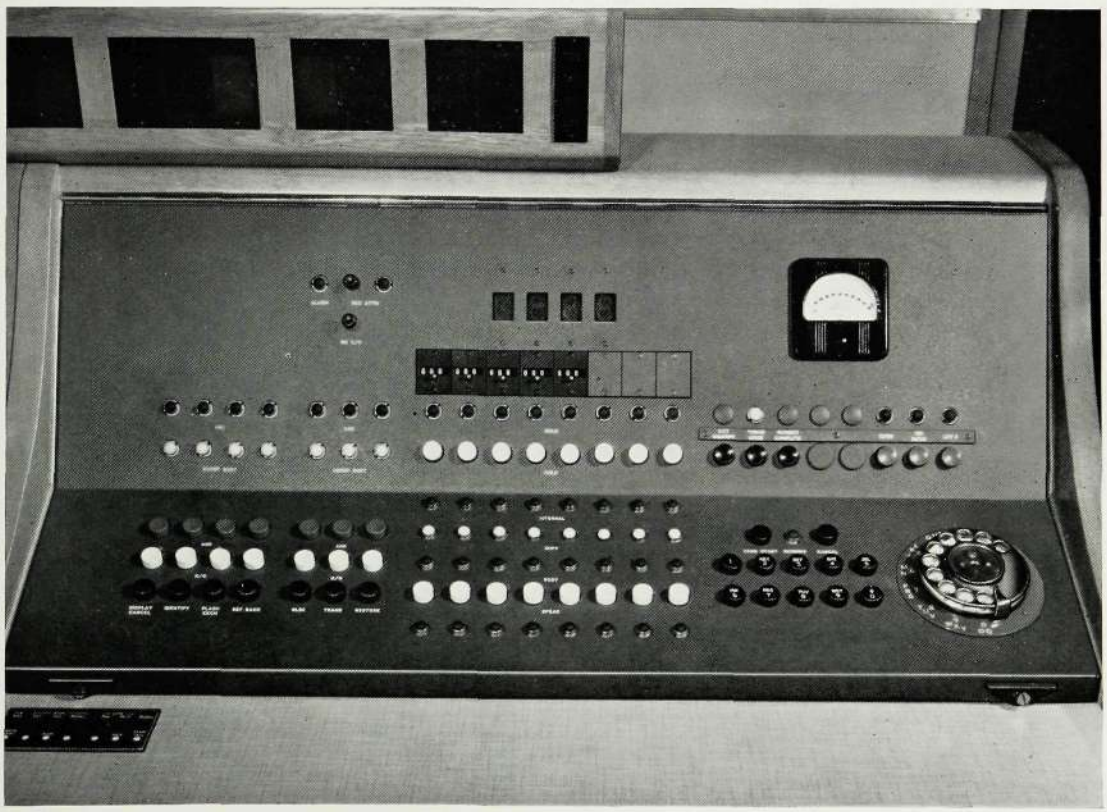

Figure 5—Face equipment of general-traffic position

The Switchboards

Figure 4 shows part of the manual suite with two of the Room Service positions on the left. The other positions, dealing with normal telephone traffic, incorporate a number of features for hotel application in addition to the data store access and the message arrangements already mentioned, and can be seen in greater detail in Figure 5.

The ' O ' level circuits are used for booking exchange calls and for extending guests' extension-to-extension calls on demand and thus have access to the call-back selector gradings. If the wanted extension happens to be busy on the first attempt, the operator can later employ a Revertive relay set to establish a call between two extensions.

It will be seen that the general traffic positions are equipped with four edge-lit identification indicators instead of the normal provision of three, so that circuits, as well as extensions dialling ' O ', can be identified. Every connecting circuit can be equipped with an STD meter for ascertaining charges on operator-originated calls.

The Room Service positions, handling messages and requests for room services, also have calling-line identification but the position circuitry is of a comparatively simple nature since the only circuits required in addition to the answering levels ' 3 ' and ' 7 ' are for making calls to extensions and for extending occasional calls to a special head waiter's telephone.

Miscellaneous Services

All the other various services provided by the hotel, such as Reception, Foyer Enquiry Desk, Restaurants, Valet Service and Hairdressers, terminate on telephone instruments with conventional final-selector access. They also have access from group-selector levels by one or two digit codes, since guests cannot dial the final-selector number. A guest can also be extended to any service via the ' O '-level operator as there will always be occasions when operator assistance is necessary.

Dependent on the exchange barring facility, service extensions have direct access to exchange lines with one C.L.I. number per service group, and incoming calls are normally extended by operators via the final selector.

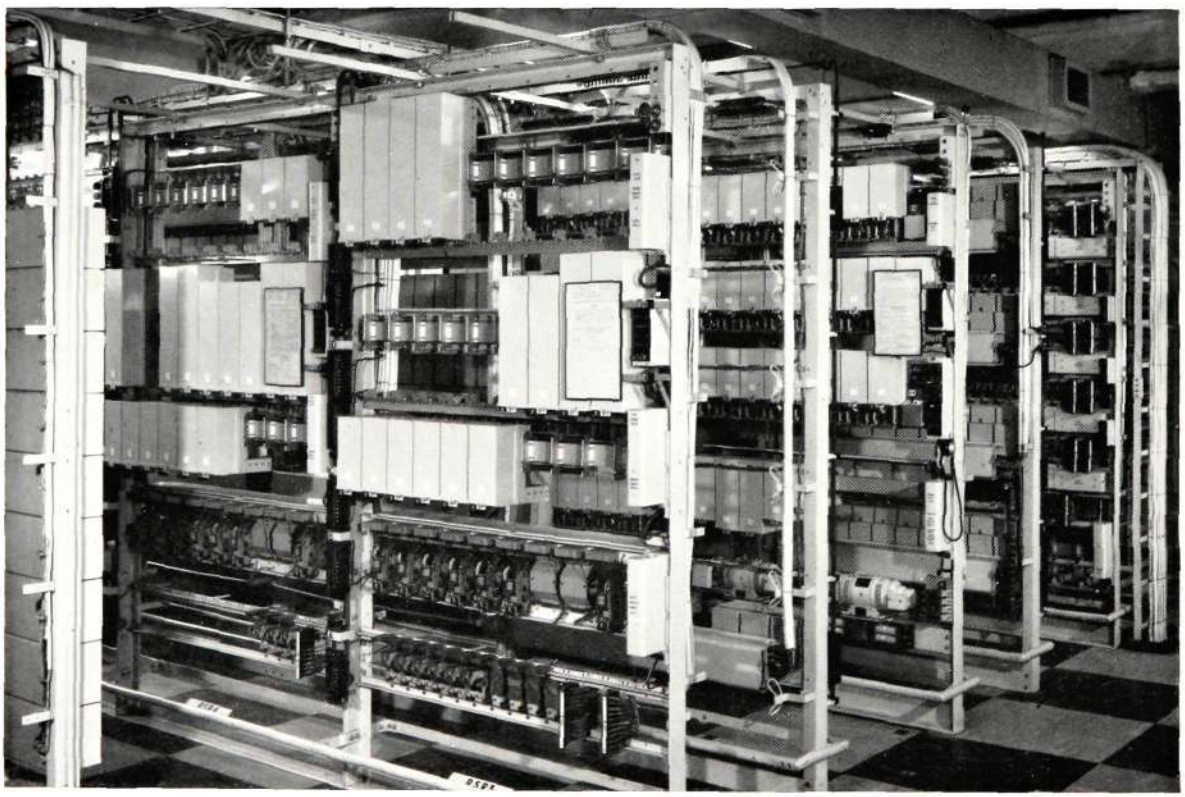

Figure 6—Section of the apparatus room

Other operational features include means of diverting calls to other locations for services not continuously staffed, such as restaurants. Discriminating ringing of all extension bells as on standard ET4 equipment is retained and, although of no particular advantage to guests, it indicates to staff extensions and services those calls which can be transferred.

A special staff-call system is installed for the operators to attract the attention of valets, housekeepers and certain managerial staff. After dialling the necessary code into relay sets, accessible from the manual-position connecting-circuit finders, the appropriate mains-operated lamps flash in hotel corridors on the required floors or, in certain circumstances, on all floors. Up to three calls can be established simultaneously and, in addition, there is a personal induction ' bleep ' system controlled from the manual room and a call bell system from guests' rooms. Neither of these auxiliary systems forms part of the telephone equipment.

Switching Equipment

A section of the apparatus room is shown in Figure 6. The switching equipment conforms generally to ET4 practice in that the minimum number of uniselectors and selectors are employed, and ' relay ' circuitry is used wherever feasible. For example, most of the information stored in exchange-line relay sets is transferred to ratchet relays, and reading-out by intermediate (buffer) stores is accomplished by relays alone. These count the number of pulses required to drive the ratchets to the next home position.

Two-motion selectors are of BPO 2000 type, and the call-back selectors operate on digit-absorbing principles. Absorption is effected entirely by relays. The selector does not step at all when the initial digits ' 1 ' or ' 2 ' are dialled; digit ' 1 ' causes NU tone to be returned to the caller and ' 2 ' prepares the selector for subsequent switching in the lower bank, whose levels are associated with guest extensions.

Higher initial digits, e.g. 3, 4, 5, cause the selector to move up 1, 2 or 3 steps correspondingly, where it switches into the upper bank on a level which is physically two levels lower than the digit dialled.

The use of relays in this manner permits digit absorption to be achieved on a 2000-type selector without limiting hunting time or affecting the inter-digital pause margin, and mechanical wear is less than with conventional non-absorbing group selectors.

Separate racks are used for line circuits and final selectors.

Alternative Facilities

Considerable variation is possible within the general framework of ET4H design to cover different service arrangements and operating methods.

For example, in another ET4H installation now in progress at the Royal Garden Hotel, London, the room service positions will be merely small key and lamp units located on teleprinter tables. Meal orders from guests will be received via the units and transmitted to the kitchens from the teleprinters, thus providing a permanent record of orders. At night, service calls will be diverted to a ' Coffee Shop ' telephone also with an associated CLI display.

In addition, for the benefit of conventions and similar parties, it will be possible to provide direct dialling facilities between guest extensions on selected floors by switching controlled from the manual positions.

Certain functions or facilities can be omitted or simplified according to requirements. In this case, where individual billing of exchange calls is not required, bulk-billing extension meters will be installed in the accounts office.

Conclusion

Since the Mayfair Hotel installation opened in June, 1962, a 40-line extension has been added and the system has now been in service sufficiently long to satisfy the hotel management that the basic concepts have been justified in practice. Calling-line identification has proved invaluable.

Always there will be some guests who prefer a simple manual system but, if this were provided, other guests would complain because they were unable to dial numbers themselves. The compromise the ET4H offers has been favourably received by the vast majority of guests because the system has been designed specifically for hotels, delicately balancing the rival claims of low operating cost and personal service with a not excessive capital outlay.

U.D.C.621.395.38

Voice-Frequency Signalling and Dialling Equipment (VFS 2)

J. E. DAVIES—Transmission Engineering Department

and

I. R. ILIFFE—Circuit Development Engineering Department

This compact equipment meets pulsing and supervisory requirements for auto-auto or auto-manual working over any circuit not exceeding 15 db loss at the in-band signalling frequency. Both direct and indirect forms of protection against speech interference are incorporated. No power supplies are required other than the normal exchange battery.

THE spread of automatic telephony and the increasing use of carrier channels for trunk circuits has led to a greater demand for voice frequency signalling and dialling equipment. In order that a system may have the widest possible application it is desirable that the signalling frequency should lie within the audio band, thus enabling the equipment to be used on existing carrier or physical circuits. For this reason the VFS 2 system described uses in-band signalling at the CCITT recommended frequency of 2280 c/s.

With in-band signalling there must be thorough provision for discrimination against speech-simulated tone. Because of this, the VFS 2 system incorporates a form of double protection provided by a guard circuit in the signalling receiver supplemented by certain delay functions in the relay set. It is however a disadvantage of any practicable form of receiver guard that energetic bursts of speech may ' block ' the receiver, delaying or inhibiting operation to signalling tone. This is overcome by narrowing to a minimum the time interval during which it is possible for speech blocking to occur, and by repeating certain signals until terminated by an ' acknowledge ' pulse from the distant end.

SYSTEM FACILITIES

General

The system is suitable for use over all normal junction and trunk lines and in fact over any circuit giving 2-wire facilities and having an overall attenuation not greater than 15 db at the signalling frequency employed, namely 2280 c/s. An important feature is that outgoing connection may be taken direct to the 2-wire line or to the 2-wire side of a hybrid, that is, in the same manner as an ordinary speech circuit. No special wiring arrangement or conversion equipment is necessary.

A signalling link embodying the equipment is self-contained and will work satisfactorily in any link-by-link arrangement with other types of equipment in neighbouring links.

Unidirectional or both-way signalling can be provided between automatic exchanges or on auto-manual links with dialling facilities as appropriate. Where dialling pulse distortion is present, due to poor quality lines or cumulative errors in a number of tandem links, correction of the fixed break or fixed ratio type can be applied.

The system maintains the speech path connected at all times, except when signals are actually being transmitted or received. As a result, it is possible to provide for operation on types of call where an answer signal is not received before speech occurs. A common example is an ' O ' level request for some ticketed service where the answer signal is omitted because it would cause the call to be metered.

Pad Switching

When a link is used singly with amplified circuits, a pad is normally interposed between the equipment and the local line in order to secure the correct level to and from the subscriber and to provide a reasonably

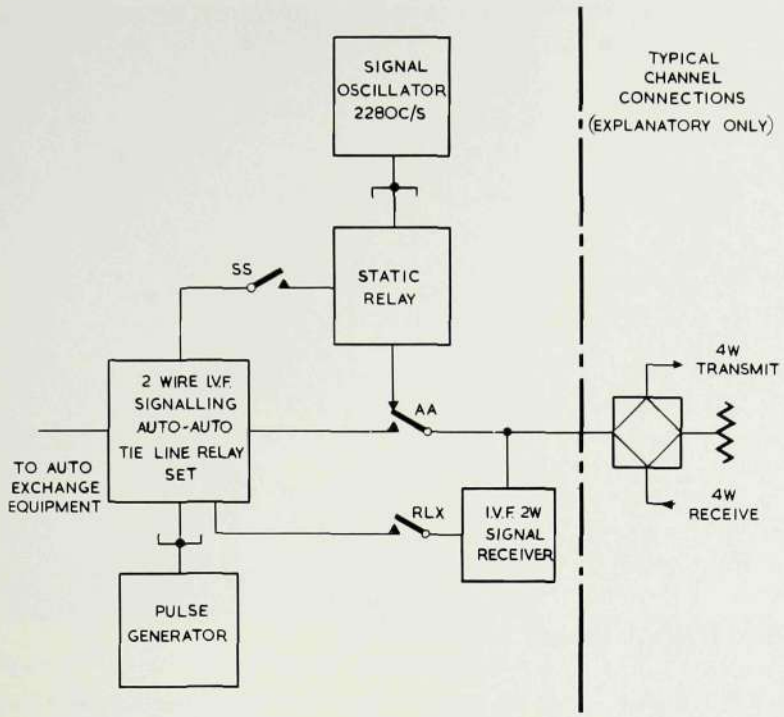

Figure 1—Block schematic showing general arrangement and interconnection of equipment for one subscriber

constant termination for the link, irrespective of local line characteristics. Tandem calls on the other hand demand no level correction at the intermediate (tandem) station, and there is no requirement for mismatch absorption since the terminations are accurately matched to each other. At tandem stations therefore the pad is switched out of circuit under control of ancillary equipment and in response to the appropriate routing instructions.

Terminal Equipment

The general arrangement and inter-connection of equipment for one link is indicated in the block schematic diagram Figure 1.

Each termination is provided with an individual relay set, a static relay for pulsing the outgoing signalling tone, and a signal receiver. Common equipment consists of pulse generators and signal oscillators, the number of units of each type depending on the total number of links, the expected volume of traffic and the standby facilities required.

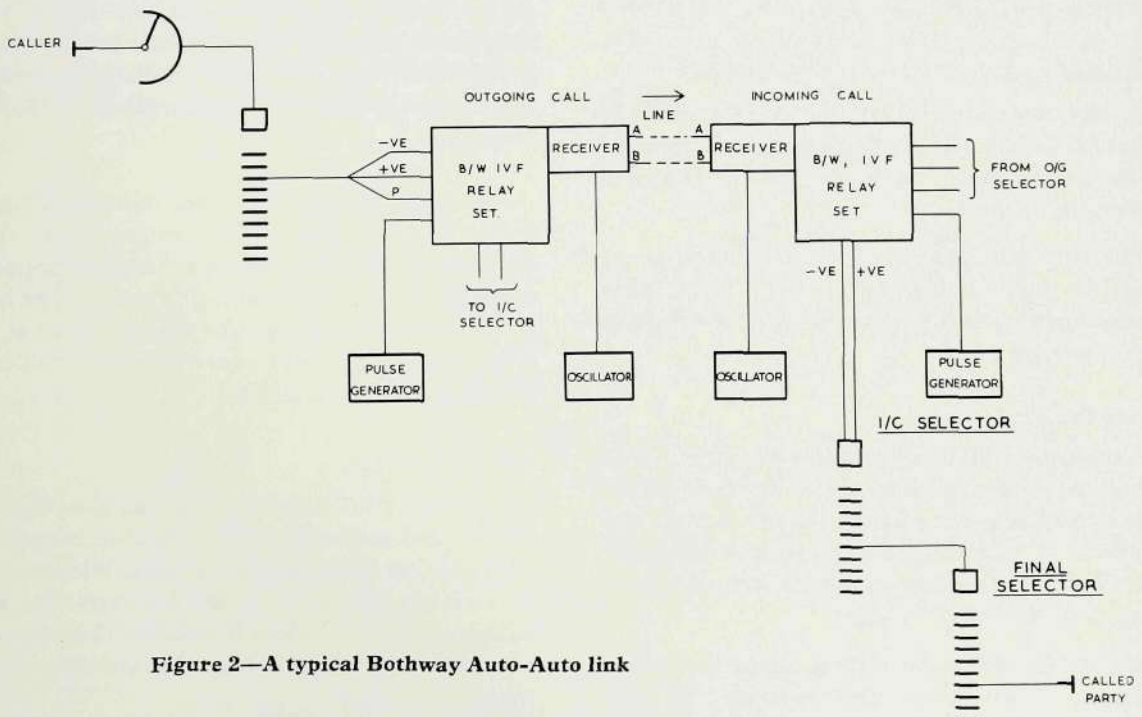

Figure 2—A typical Bothway Auto-Auto link

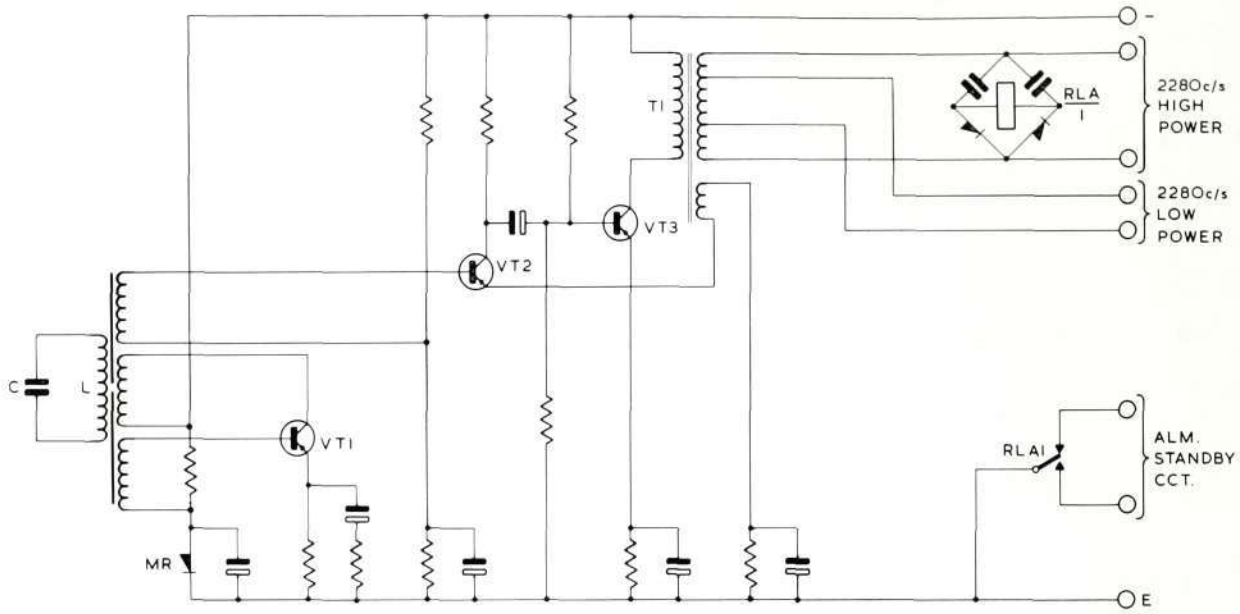

Figure 3—Simplified diagram of the Oscillator

Figure 2 shows a block schematic of a typical both-way auto-auto link. Outgoing calls originate from the selector level via the Positive (+ve), Negative (—ve) and Private (P) wires and proceed to line via the A and B wires. Incoming calls emerge from the 1VF equipment via the +ve and —ve loop controlled pair and so proceed to the associated incoming selector. For pad switching, an additional wire to the incoming selector is required.

Pulse Generator

The function of this unit is to provide d.c. controlling pulses for the several types of repeated signals required by the system; pulses for single signals are generated by the relay set itself.

The unit may optionally be of the uniselector or transistor type, and its mounting will normally accommodate relays for automatic changeover under fault conditions.

Signal Oscillator

An essential feature of the oscillator design is good output regulation, because the number of circuits requiring signalling tone at any given time will vary considerably. Further, frequency and amplitude must have a high degree of stability with changes in temperature and supply voltage.

A simplified schematic of the oscillator is shown in Figure 3. The oscillator stage consists of VT1 tuned by the resonant circuit LC, the output being stabilized against changes of supply voltage by using a zener diode MR to hold the base voltage of VT1 at a constant potential.

This stage is inductively coupled to the base of transistor VT2, which, together with VT3, forms a two-stage resistance-capacity coupled amplifier employing a large amount of negative feedback. This is applied by means of a separate winding on the output transformer T1, and results in a very low output impedance with consequent good regulation of output voltage.

Alternative taps on the output winding of transformer T1 give a choice of two output levels. The low power output, which is normally used, corresponds to a level of —6 dbm at the 2-wire point. The high power output corresponds to a level of 0 dbm at the 2-wire point and is used where long lines with high attenuation are encountered.

Standby Facilities

A portion of the output from the signal oscillator is rectified and used to operate a miniature relay RLA. This relay, which is normally operated, releases when the oscillator output falls by approximately 50%, and its contact unit RLA1 may be used for changeover to a standby oscillator and to operate an associated alarm circuit.

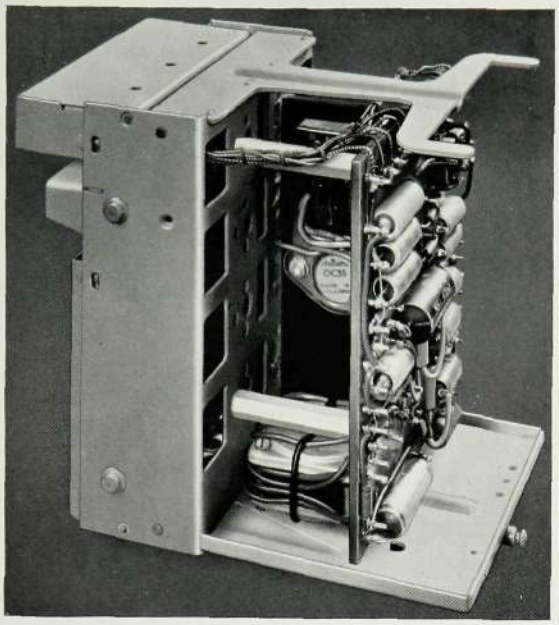

Figure 4—The Oscillator Unit with dust cover removed

Figure 4 shows the oscillator unit with dust cover removed.

Static Relay

The static relay (Figure 1) is mounted on the same relay plate as the signal receiver. It consists of a network of germanium diodes and resistors connected in such a way that they offer a high impedance to the signalling tone, until the application of an earth via the SS contact biases the diodes in the forward direction and allows the passage of tone to line.

Signal Receiver

The function of the receiver is to operate a double-contact, high-speed relay when pulses of 2280 c/s tone are present at the input. On the other hand, the relay must not operate to any 2280 c/s content in speech.

A simplified schematic of the signalling receiver is shown in Figure 5. The input transformer T1 provides the high impedance necessary to ensure that the bridging loss is negligible when the signalling receiver is connected across the 600 ohm 2-wire point. Transformer T1 is followed by a two-stage transistor amplifier which is designed to limit above a predetermined level, thereby giving a constant output for a wide range of input levels. This results in low pulse distortion over the working range of the receiver.

The amplifier is loaded via T2 by a tuned circuit LC (resonant at the signalling frequency) and a guard circuit. The tuned circuit LC is followed by a voltage doubler and smoothing circuit which rectifies the signal and applies a negative potential to the base of transistor VT1. The guard circuit is aperiodic, and is also followed by a voltage doubler and smoothing circuit which applies a positive potential to the base of VT1. The circuit is so arranged that, when a pure tone of 2280 c/s is applied to the receiver, the d.c. voltage due to the guard circuit is approximately 80% of the d.c. voltage produced by the signal circuit. This results in a negative potential being applied to the base of VT1.

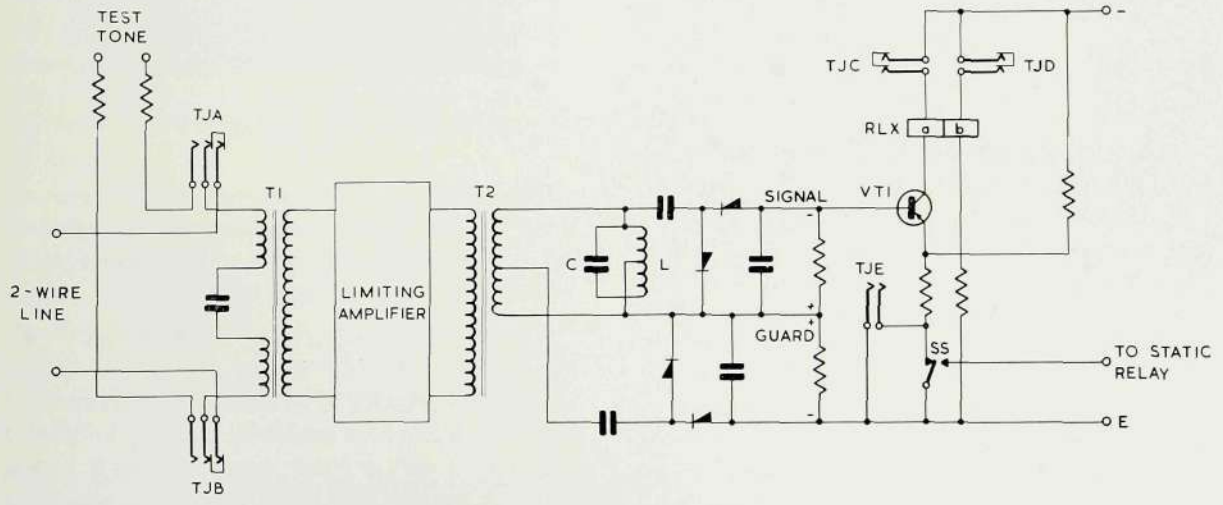

Figure 5—Simplified diagram of the Signalling Receiver

In the quiescent condition, only a small leakage current flows in winding ' a ' of the high-speed relay, RLX. The resulting flux is cancelled owing to the opposing bias current flowing in winding ' b '; this latter also assists in securing the rapid release of RLX when pulsed.

When a pure 2280 c/s tone is applied to the receiver, the resulting negative potential on the base of VT1 causes current to flow in the ' a ' winding and RLX to operate. However, if speech is present, the positive potential produced by the guard circuit overrides any negative potential which may be produced in the signal circuit as a result of any 2280 c/s content in the speech. The reason for this is that the major portion of the speech energy is confined to the frequency range 80–1000 c/s. Under these conditions RLX will not operate.

To prevent the receiver from functioning when signal tone is being originated locally, the changeover action of SS disconnects the emitter circuit of VT1 before activating the static relay.

From Figure 5 it will be seen that test points are available to enable quick functional checks to be carried out on the receiver. By changing over test links TJA and TJB it is possible to inject a tone level of —15 dbm into the receiver and observe that RLX operates. By means of TJC and TJD a milliameter can be inserted in either coil of RLX and the current monitored under working conditions. Test link TJE makes it possible to energize the signalling receiver permanently, should this be required for testing purposes, in the absence of an earth via the SS contacts.

Figure 6 shows the receiver unit with cover removed.

Relay Set

General

This performs all the functions normal to an equivalent d.c. junction circuit. However, because all signalling is by tone pulses within the speech band, an important requirement is the need to guard against false operation due to signalling frequency content in speech. For this reason the guard circuit in the receiver is supplemented by delay circuits in the relay set (R/S) for signal recognition before any switching functions are effected. The exception to this is during the dialling stage when the delay caused by this feature could not be tolerated owing to the possibility of introducing distortion of the dialled pulses.

Dialling

Dialling pulses are transmitted in the form of tone pulses which operate relay RLX in the signal receiver at the incoming termination. Normally, RLX controls a high-speed relay in the R/S to repeat loop/disconnect pulses to the local equipment, but a pulse-correction circuit may be associated with it if the R/S is intended for use on tandem working where distortion is frequently cumulative.

Delay Characteristics

The delay function of the relay set becomes effective when the call is answered.

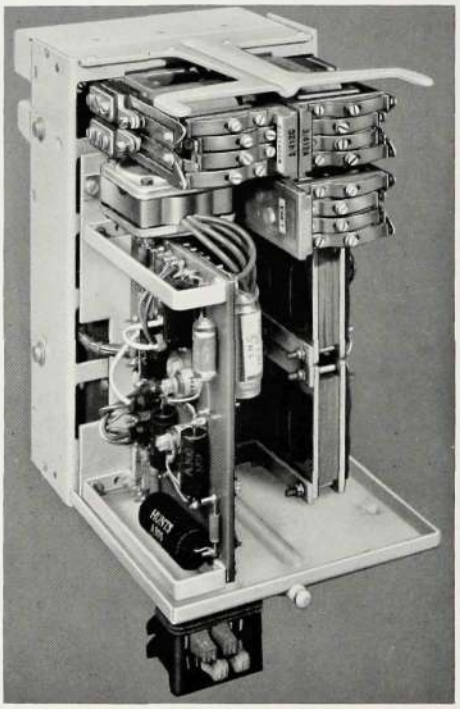

Figure 6—The Receiver Unit with cover removed

When RLX operates to incoming signalling tone, an initial step prior to the interpretation of the signals is the release of AA (Figure 1). This disconnects or ' splits ' the path to the local subscriber.

There are two elements in the delay function. The first is complementary to the second, but is best considered in relation to its immediate effect after the speech path has been established, namely to prevent interruption due to short bursts of speech having 2280 c/s content sufficiently pure to overcome the receiver guard. The delay is of 25 ms and is termed

the ' splitting time '. Shorter bursts than this, i.e. the great majority, will not cause AA to release.

Any release of AA due to speech simulation beyond the splitting time will occur at both ends of the link, disconnecting the source of spurious tone from the receivers irrespective of whether it is at the near or far end. RLX will release and AA, after some 10–15 ms, re-operate. In the event of spurious tone then persisting for a further 25 ms—rare unless simulation is deliberate—the process will be repeated.

Genuine signalling tone will not be interrupted in this way. Its continuity affords a means of recognition, and this is the purpose of the additional delay element.

The splitting time is determined by the release lag of a relay SG (not shown) which controls the high-speed relay AA. A further contact of SG releases an auxiliary relay SR to provide a further delay of 25 ms before the relay set will function. A minimum signal duration of 50 ms is thus necessary for acceptance by the equipment.

The SR delay also serves to cover small adjustment differences in the actual splitting time at the two ends of a link, whereby spurious tone from one end might momentarily reach the other after splitting has occurred at the latter.

Delay provisions may be varied or simplified in equipment designed for use on a one-way junction. For example, in an i/c junction relay set, advantage is taken of the fact that the only signal arriving after dialling when both ends of the link are not split is the ' Forward Clear ' (calling party clearing first). This is a relatively lengthy signal and it is more conveniently recognized by the release of a relay BB (not shown) with a lag of some 200 ms. An SR delay would be superfluous here as elsewhere in the call sequence, and it is omitted.

Signal Code

Signals occur in a definite sequence, the only variation being at the conclusion of the call, the order then depending on whether the called or calling subscriber clears first. The point of arrival of a signal in the sequence determines the appropriate relay-set operation.

The order of signals is as follows, signals shown thus ( ) being returned to the calling equipment:—

Seize, dialling (answer), answer acknowledge forward clear *or* (backward clear), (forward clear acknowledge) *or* backward clear acknowledge.

Repeated signals of 200 ms on, 400 ms off are employed for the answer and backward clear, and of 900 ms on, 700 ms off for the forward clear, because in each instance there is a telephone instrument connected at one end of the link and thus a possibility of the signal receiver being intermittently blocked by speech. The first pulse to reach the receiver and operate RLX in the absence of blocking for 25 ms will split the circuit and gain control of the relay set.

Single pulses suffice for the seize signal (55 ms duration) and for the acknowledge signals (80 ms minimum) since both ends of the link are split when these occur.

As a matter of design convenience, the forward clear signal train is preceded by a single signal of shorter duration, generated by the relay set. If this signal is acknowledged, the repeated signal is not sent.

MOUNTING ARRANGEMENTS

The equipment is designed for mounting on single sided open-type racks, the rack and shelf mountings conforming to the standard BPO 2000 type practice.

The size of rack installed will necessarily depend on the number of circuits to be equipped and upon the facilities required; for example, an outgoing relay set can be accommodated on a 16-space relay plate, but a bothway auto-manual set with pulse correction will require a 30-space plate.

In a typical example of a four-rack installation, each rack is 8′ 6½″ high by 4′ 6″ wide and may contain up to 30 bothway circuits, i.e. relay sets and receiver units. In the space allotted to one junction relay set, two oscillators or two pulse generators can be accommodated; it is usual to allocate working oscillators at the rate of one per rack and working pulse generators at the rate of one per two racks. Typically, the installation would be equipped for 28, 30, 29 and 30 bothway circuits in racks 1 to 4 respectively. Two pairs of oscillators, one in rack 1 and one in rack 3, would serve racks 1 and 2, 3 and 4 respectively. One pair of pulse generators in rack 1 would serve the whole installation. Standby facilities would be obtained here by temporary doubling of the load on a working oscillator or pulse generator; on a single rack or where traffic is unusually heavy separate standby units are of course necessary.

The equipment is designed to operate from the normal 50-volt exchange battery supply, no auxiliary power supplies being necessary.

Alarms

Should the system fail to clear within a specified time, an alarm is given and the equipment is busied against incoming and outgoing calls. The alarm features of the system cover all the associated equipment. A fault developing would effect an appropriate alarm and either busy the equipment or disconnect it from service.

Finish

The normal equipment finish is to standard BPO specification, but full tropical protection can be provided if required.

Conclusion

Apart from qualities of reliability and wide application now proven over several years of operation in the field, the VFS 2 system demonstrates the benefits of transistorized design. In particular, the use of transistors in the voice-frequency units has eased the design problems, taking into account the limitations imposed by low-voltage exchange supplies.

U.D.C.621.391.7; 621.395

The Speech Inverter

W. G. Soar—Audio Development Department

The equipment described is for use on physical or carrier circuits and provides complete secrecy of conversation between two subscribers using Auto or CB telephones suitably equipped for press-button control. Its small size permits inconspicuous and convenient installation at each station end. Similar equipment for use on magneto systems is currently under development.

A conversation by telephone frequently involves the exchange of confidential information but the telephone circuit does not provide the necessary secrecy. A simple receiving device connected to any intermediate point permits the conversation to be overheard where the transmission path is provided over audio circuits. This offers considerable opportunity to unauthorized intruders who can select the location most suitable for their activities and perform them without the speakers being aware that interception has occurred.

In the fundamental speech transmission circuit, acoustic vibrations are converted into varying electric currents to be conveyed by metallic conductors to a distant point where they are reproduced as acoustic vibrations. Ideally, the electric currents are identical in frequency and relative amplitude to the sound pressures which produced them and, in order to ensure that the reproduced speech is recognized as such by the listener it is necessary to maintain this relationship as closely as possible.

If the various frequency components of the speech currents are re-arranged in coded form before transmission along the line and restored to normal prior to reproduction at the remote end, the listener at an intermediate point will hear only an unintelligible series of sounds.

The Speech Inverter (Figure 1), which has been devised to perform this coding function, inverts the

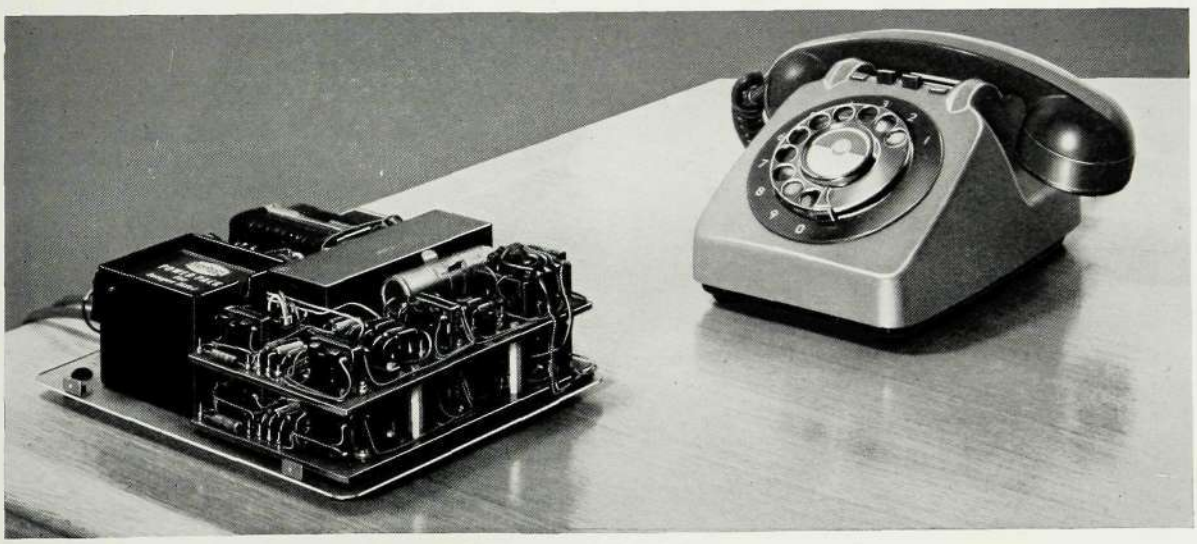

Figure 1—General view of speech inverter equipment connected to subscriber's telephone

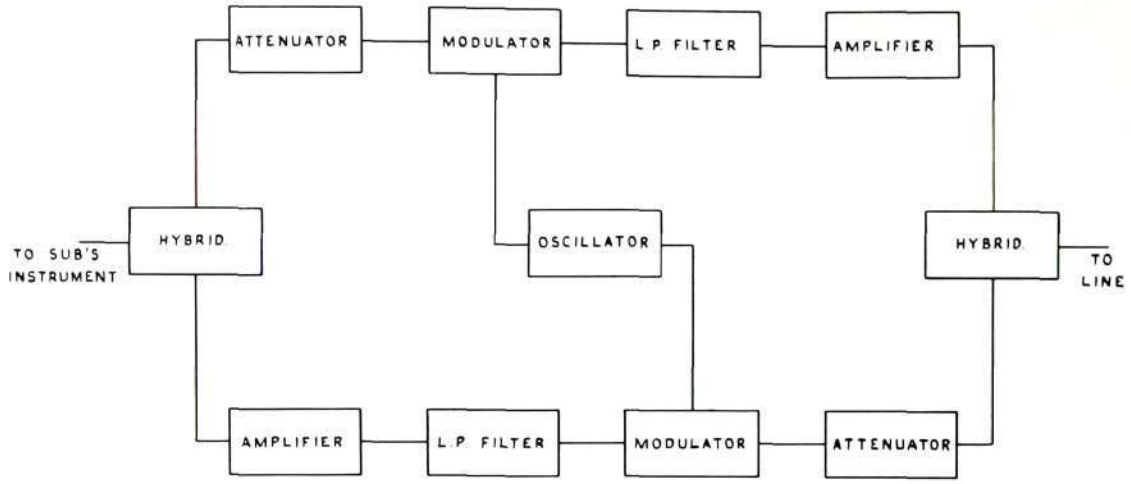

Figure 2—Speech Inverter. Block schematic

band of speech frequencies before transmission. At the distant end an identical unit receives the inverted signals and restores them to their original form. Transmit and receive paths are provided in each unit, rendering the conversation intelligible at each terminal but not at any intermediate point.

The block schematic, Figure 2, illustrates the general layout of each unit.

The speech-frequency currents generated by the telephone instrument pass through the hybrid transformer, at the input of the inverter, to the transmit channel shown in the upper half of the illustration. At this point they are reduced by the attenuator to a suitable level before entry to the ring modulator.

In Figure 3, showing the circuit of this section, an alternating potential applied to points A and B causes the diode pairs MR1, MR2 and MR3, MR4 to conduct alternately. When point A is positive with respect to B, MR1 and MR2 become low impedance to provide a conducting path between T1 and T2; MR3, MR4 are high impedance. When point A is negative with respect to B, MR3 and MR4 conduct and MR1, MR2 are high impedance.

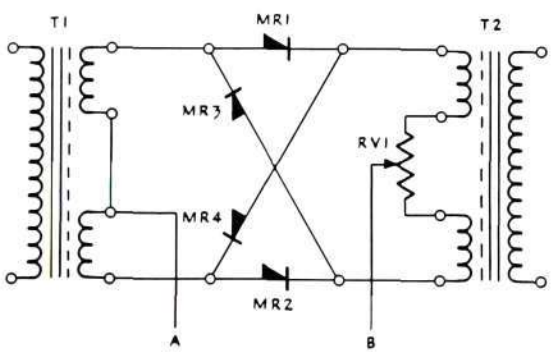

Figure 3—Ring Modulator

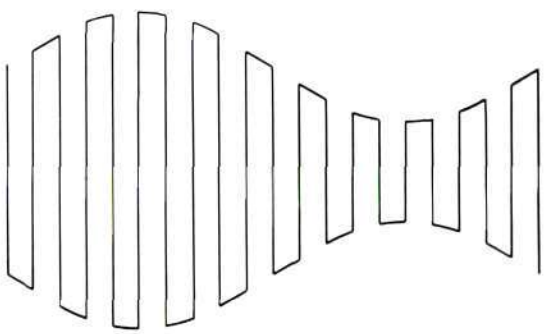

Figure 4—Output waveform of Ring Modulator showing 3 kc/s carrier with 300 c/s modulation

The switching current divides and flows in opposite directions through the two sections of the centre tapped windings of T1 and T2. The half windings are carefully balanced, giving a low resultant flux in the cores of T1 and T2 which minimizes the level of the switching voltage in the output signal. The final null is obtained by adjustment of RV1.

An alternating current in the primary of T1 induces into the secondary a current which is transferred to the coupled winding of T2 through the switching diodes.

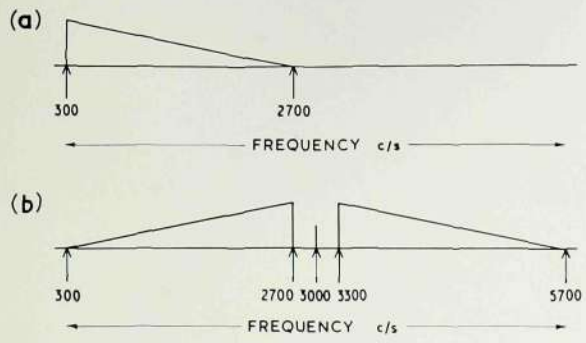

Figure 5

(a) Speech frequency band
(b) Upper and lower sidebands relative to the carrier

Each half cycle of the switching voltage causes a reversal of the current flow through the winding of T2, as the diodes are switched on and off.

The amplitude is the algebraic sum of the switching current and the current due to the input through T1. A typical output waveform of the ring modulator system is illustrated by Figure 4.

The switching carrier frequency is 3 kc/s and the effective speech frequency band is from 300 c/s to 2700 c/s. The modulation process has produced two side-bands symmetrically disposed around the carrier and arranged progressively above and below it as in Figure 5. The upper sideband, 3300 c/s to 5700 c/s is too high in frequency for satisfactory transmission on an audio cable and, in any case, is not required. The lower sideband occupies exactly the same band of frequencies as the normal speech, but all the component frequencies are transposed. Speech frequency components of 300 c/s, 1000 c/s and 2700 c/s become sideband frequencies of 2700 c/s, 2000 c/s and 300 c/s respectively.

The ring modulator output is passed through a low pass filter which removes the upper sideband and any carrier leak. The lower sideband passes through the filter, is amplified to the original speech signal level and applied to line through the output hybrid transformer.

Inverted signals received from the line pass via the hybrid to the receive channel in the lower section of Figure 2. The transmit and receive channels are identical, but in the receive channel the inversion process restores the speech currents to their normal state before passing by way of the input hybrid transformer to the telephone instrument. The hybrid transformers at the input and output prevent the singing which would otherwise occur with a 2-way, 2-wire device.

The oscillator which supplies the carrier switching current is common to both transmit and receive channels. It is designed to maintain the extremely high order of accuracy and stability necessary to eliminate the change of voice pitch which would occur if the modulating and demodulating carrier frequencies of individual units differed appreciably.

Transistors are used throughout, one for the oscillator and one for each amplifier. The filter units are encapsulated in an epoxy resin to provide mechanical protection for the components and to ensure stability. The unit may be operated from an internal battery or from an external mains supply. The total power consumption during use is approximately 144 milliwatts, 24 milliamperes at 6 volts d.c., giving a battery life of about one year with average use. The nominal insertion loss of each unit is 0·5 db within the operating frequency range of 300 c/s to 2700 c/s.

Switching is provided in the telephone instrument associated with each inverter to bring the equipment into use when required. A call between two subscribers is made in the normal manner. At any time during the conversation they can both switch to privacy by pressing the appropriate button on the instrument. The system is restored to normal by operation of a second press-button or, automatically, when the handset is replaced. The inverter, contained in a case measuring $8\frac{3}{4}$ in. x $7\frac{1}{8}$ in. x $3\frac{1}{4}$ in. (22·2 x 18·1 x 8·25 cm.) can be fixed in any convenient place under or near a desk or on a wall. The telephone instrument has an appearance differing little from a normal installation, the whole system affording a high degree of privacy in a compact form.

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