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No. 44 JANUARY 1962

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Published by ERICSSON TELEPHONES LTD., Beeston, Nottingham, England,
and Printed by DERRY AND SONS LTD., Nottingham, England.

U.D.C.621.395.22

THE 'KEYMASTER'

AN IMPROVED 1 + 5 HOUSE EXCHANGE SYSTEM

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This improved 'House Exchange' system, known as the 'Keymaster', adds significantly to the special services and features offered by the new extension-plan arrangements recently introduced by the Company. Designed for the B.P.O., the Keymaster gives maximum flexibility of services and basically provides access from any one of five local stations to one c.b./auto exchange line or P.B.X.-extension line, and intercom between stations. The system includes lamp signalling and, in addition, provides for the connection of a single long-line station in lieu of one local station.

Operation is from a 50-volt d.c. supply derived from a battery or power unit.

THE House Exchange system, designed in two versions (1 + 5 and 2 + 10), was first introduced into service in the early '30's. Since this time it has provided a very satisfactory answer to the problem of meeting intermediate service needs in large private residences and small businesses where telephone requirements have expanded beyond the extension-plan stage, but do not justify the expense of a p.a.b.x. installation. As might be expected with any telephone system, no matter how useful or functionally efficient, there comes a time when new ideas in apparatus design and the availability of smaller components and more versatile telephones suggest improvements which can usefully be made. For this reason, and because of the continuing demand for this type of service, it was decided that a major revision of the existing system be undertaken, commencing with the 1 + 5 version.

In general, when re-designing any telephone equipment which the customer both sees and uses, it is logical that effort should be directed to improving its appearance, making it available in colour, and reducing its size. To these aims must be added the always desirable objectives of easier operation and maintenance as well as more simplified and economical installation. Most important, the new design must offer improved communication facilities.

The new system, known as the 'Keymaster' and designed for the B.P.O., fulfils these requirements. The 'Keymaster' accommodates up to five stations interconnected by multiple cable and, basically, provides intercom services between stations and access from any station to one cb/auto exchange line or p.b.x.-extension line. Provision is also made for the inclusion of a non-multiple 2-wire station *in lieu* of one multiple station. This useful feature permits communication to a remote location within or beyond the curtilage of the subscriber's premises where the cost of extending the multiple cable would be prohibitive.

Key-switching telephones of Plan-Etelphone type, suitably modified for multiple and non-multiple working, are used in the interests of standardization, appearance, colour range and transmission performance. Because of the telephone's basic design, all individual switching and signalling arrangements, including lamp signalling, are incorporated in each multiple-station instrument, thus eliminating the previous need and inconvenience of desk-mounting units accommodating lever keys and drop indicators. In addition, this arrangement has allowed the common equipment for a purely multiple-station system to be accommodated in a single wall-mounting unit of small dimensions. Even when the long-line 2-wire station is introduced, the auxiliary signalling relays required can be combined with the common equipment in a similar but larger unit. Besides these advantages, further economies have been obtained and both maintenance and installation simplified by the use of the instrument's desk-block, which dispenses with the need for junction boxes or distribution cases.

Figure 1—The new Multiple Station Telephone and predecessor

Operation of the system is from a 50-volt d.c. supply derived from a battery or an external a.c. mains-driven power unit.

FACILITIES

A summary of the facilities offered by the 'Key-master' is listed below, new and improved service features being indicated in italics.

INTERCOM CALLS

(*a*) Direct calling between multiple stations by d.c. buzzer.

(*b*) *Direct calling from multiple station to the 2-wire station by a.c. bell, ringing being derived from a transistor-ringing unit common to all multiple stations.*

(*c*) Calling of multiple stations from the 2-wire station via selected multiple station.

(*d*) *Lamp indication at all multiple stations of intercom call in progress.*

(*e*) Conference.

EXCHANGE CALLS

(*a*) Direct access to the exchange from multiple stations.

(*b*) *Direct access to the exchange from 2-wire station.*

(*c*) Answering of exchange calls direct at multiple stations; and at 2-wire station under night service conditions.

(*d*) Holding of exchange calls at multiple stations for purposes of information and transfer calls.

(*e*) *Holding of exchange calls at 2-wire station* and transfer with the assistance of a selected station.

(*f*) Restricted access to exchange from any station.

(*g*) *Series-secrecy on exchange connections.*

(*h*) *Visual indication of 'exchange ringing', 'call answered', and 'exchange held' conditions at multiple stations.*

(*i*) *Re-call of p.b.x. or exchange operator from multiple stations.*

(*j*) Universal night service.

(*k*) *Access from all stations to exchange line in event of power failure.*

(*l*) *Exchange-bell cut-off at any multiple station.*

(*m*) Audible engaged test at multiple station when any called station is occupying exchange line.

(*n*) Monitoring facilities from any multiple station.

(*o*) Extension bells and buzzers.

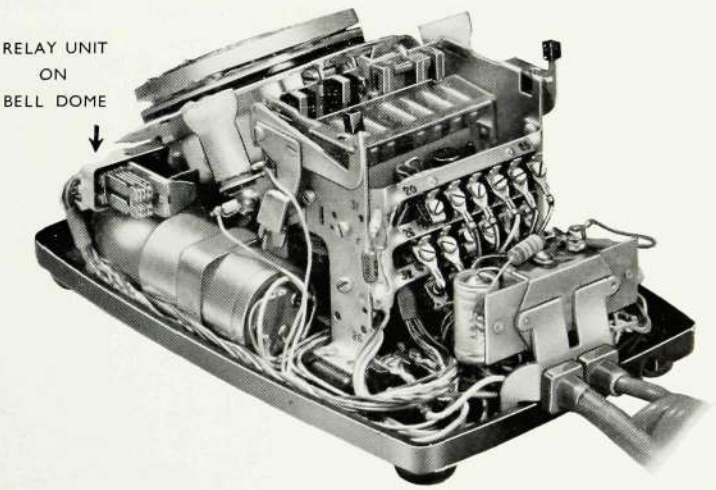


Figure 2—Internal view of Multiple Station Telephone showing the monitor/restrict-access relay with cover removed

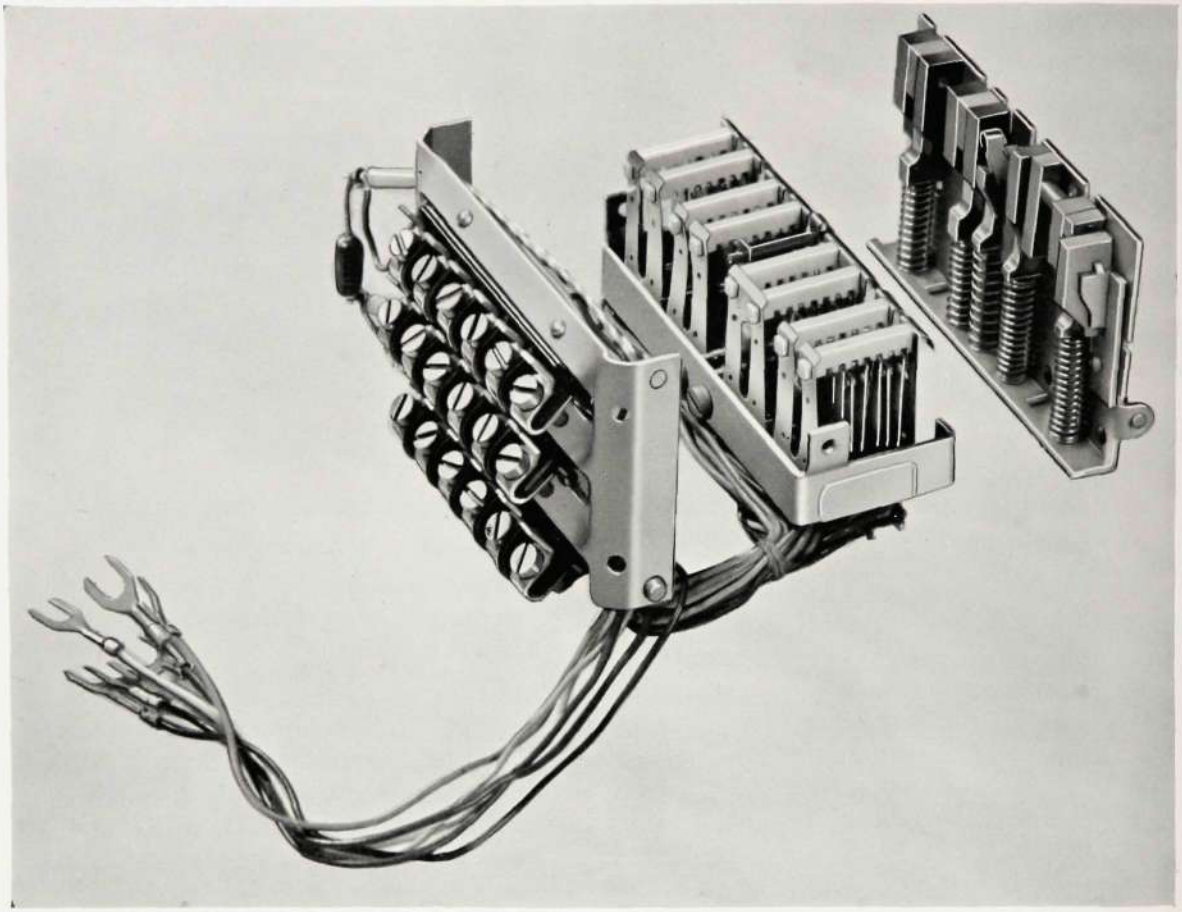


Figure 3—Key mechanism/terminal-assembly unit

MULTIPLE-STATION TELEPHONE

The new multiple-station telephone, illustrated alongside its predecessor in Figure 1, has six press-button keys conveniently arranged in 1 : 1 : 2 : 2 formation above the dial. These consist of a 'bell/off' key, a locking 'exchange' key, and four non-locking intercom keys of the familar 'two-in-one' pattern. Key legends are clearly marked, and the numeral inserts 1-4 in the intercom keys are removable and inscribed with the figure 5 on the reverse side to permit easy re-arrangement of station numbering.

Mechanical Arrangement of Line Keys

Economy of buttons has been obtained by applying secondary functions to the 'exchange' key, which is mechanically coupled with the cradle-switch and all intercom keys. The mechanical arrangement of these two types of keys is such that on the depression of the 'exchange' press-button to originate or answer an exchange call, an associated group of plungers and springsets operate and the 'exchange' key locks to the 'speak' position. When any intercom key is subsequently pressed for the purpose of a local information call, a plunger in the operated group releases to restore the 'exchange' key button and cause a 'hold' condition to be applied to the exchange line. The released plunger is re-engaged with its group when the 'exchange' key is again pressed to the 'speak' position to return the station user to the exchange caller. From this position the 'exchange' key may be restored and its plungers fully released on replacement of the handset at the conclusion of the call, or may be pressed again beyond the 'speak' position to provide a further function, i.e. operator recall. An important feature of this function is that 'recall' is possible only in the sequence described and the operation is rendered ineffective should the

exchange key be pressed in error direct to the over-press position.

To prevent unnecessary operation of the 'exchange' key while the handset is on its rest, a locking device is included in the key unit.

Applications of Bell/Off Key

The bell/off key may be used as a non-locking key or be locked in position and subsequently released by means of its sliding cap to provide the switching functions for any one of four facilities. Simple strap adjustment in the telephone introduces the key into circuit.

As a non-locking key it serves to restrict access from any station to the exchange line, the key being connected to an add-on relay unit in the telephone to be restricted. This unit, shown in Figure 2, mounts above one of the exchange-bell gongs in the instrument and comprises a miniature-type relay using comb-operated springs with twin contacts.

As a locking key it may be used to control a similar relay unit for monitoring purposes. In this application, the relay unit is mounted above the bell as before, but incorporated in the same telephone as the controlling key. A further use is diverting incoming exchange ringing to the 2-wire station for night-service working, the required switching function being performed usually at the last multiple station in the system. Finally, as its designation implies, the bell/off key may be utilized to silence the instrument's exchange bell. This facility is of considerable convenience where, for example, a station user wishes to be undisturbed by unimportant calls or where it is essential to prevent an unstaffed station from being fruitlessly rung during night-service. Usually the bell off facility is denied to one station to ensure that one bell is permanently connected to line.

Key-Unit Connection

To facilitate connection of the key unit to the main telephone circuit, three terminal strips, each comprising six terminals, are mounted horizontally on a framework secured to the rear of the telephone chassis by a spring plunger. The assembly, together with the key mechanism, is shown in Figure 3, and the whole may be removed from the instrument as a unit.

Lamps

Positive lamp signalling is ensured by the provision of simple signals, the use of different coloured lamps and lenses allowing adequate penetration of light.

The two lamps seen in the instrument face provide a total of four signals. The right-hand lamp, termed the 'intercom-busy' lamp, provides a single signal and emits a steady white glow when any station's handset is removed from its rest. The corresponding 'exchange-line' lamp gives three red signal indications as follows:—

Figure 4

Cord-termination plate before connection to desk-block base

(*a*) An interrupted signal at ringing frequency on receipt of an incoming exchange or p.b.x. call and until the call is answered.

(*b*) A continuous glow when the incoming call is answered.

(*c*) A flashing signal at approximately 3 p.p.s. when a user 'holds' an exchange call while making an information call. The signal becomes steady when the user returns to the 'held' line or when a second station takes over the call.

Instrument Cords

The instrument is usually connected to the desk-block by a 20-way cord. At installations where stations are not continuously staffed, however, an instrument may be equipped with a 25-way cord to enable an additional buzzer or exchange bell or both to be provided at particular locations on the premises.

Desk-Block

The desk terminal block consists of a mounting plate, a cord termination plate and a moulded case and cover. As illustrated in Figure 4, the instrument cord conductors are permanently connected to metal tags fixed on the upper and lower sides of the insulating plate. Associated tag screws, held captive to prevent complete withdrawal, serve to align the plate quickly and clamp the tags to corresponding metal bushes pressed into the case. The bushes are knurled to 'bite' the case moulding and eliminate any possibility of movement from excessive screw tightening. In addition, the bushes are 'tapped' on the underside to provide screw terminations for the multiple cables. Two cord and cable entries are provided at opposite ends of the block and this number can be increased to four by use of 'break-ins' in the cover.

When all connections are completed and the terminal plate assembled, the case is located over the threaded spigot of the mounting plate and retained in position by the cover-fixing screw.

2-Wire Station Telephone

Because this instrument uses a 2-wire line, lamp signalling and direct calling of all multiple stations is not feasible. For this reason the 2-wire station telephone, while resembling the multiple-station instrument in general appearance and size, includes no lamps, has fewer press-button keys and is associated directly with a selected multiple station to obtain assistance when a call to the remaining stations is desired.

The two press-button keys provided consist of one locking 'extension' key for access to the selected station, and a non-locking 'exchange' key. Both keys correspond in type to the line keys in the multiple-station telephone but differ in function. Internally, the visible differences are the omission of the key-unit terminal assembly, and the replacement of the d.c. buzzer by an a.c. bell, which is dual purpose, serving both for signalling intercom as well as exchange-line calls.

Units

A common or combined services unit is the only additional switching apparatus required in the system. The common-services unit (Figure 5) is $12\frac{1}{8}''$ long x $7\frac{5}{16}''$ high and $4\frac{3}{4}''$ wide (308 x 186 x 121 mm.) and contains a transmission-feed relay for the intercom line and three 3000-type relays for ringing and lamp-signalling purposes, together with a cabling terminal strip. The combined unit (Figure 6) is a similar all-metal unit, but is four inches wider to include the 2-wire station's auxiliary equipment. This consists of six switching and signalling relays, all of 3000 type, and a 25-cycle transistor ringing unit, which is an optional extra for use when no suitable ringing source exists on site.

The power unit is also an optional extra. This unit is a battery eliminator used as an alternative to a battery to provide the 50-volt d.c. supply for the system. It is designed to operate from 200/250-volt 50 c s mains and incorporates a transformer, choke, fuses and terminal strip. The unit, for wall or rack mounting, has a louvred pull-off cover.

Cabling

All multiple stations are inter-connected by a 21-wire cable. The exchange line terminates on the desk-block at the first station (see Figure 7 (*a*)) and is continued from this point in the multiple cable to the desk-block at Station 2 and so on, to terminate finally in the common-services unit, to which the power unit cable is also connected.

When the 2-wire station replaces a multiple one, its cable terminates, together with the power-unit and multiple cables, in the combined services unit as shown in Figure 7 (*b*).

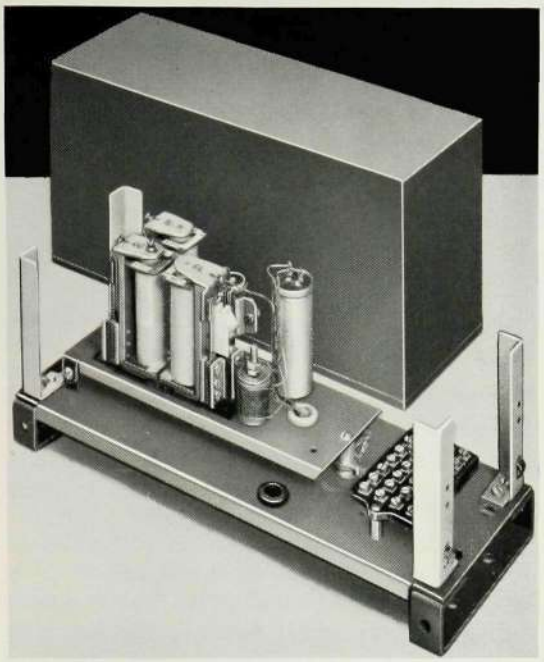


Figure 5—Common-Services Unit

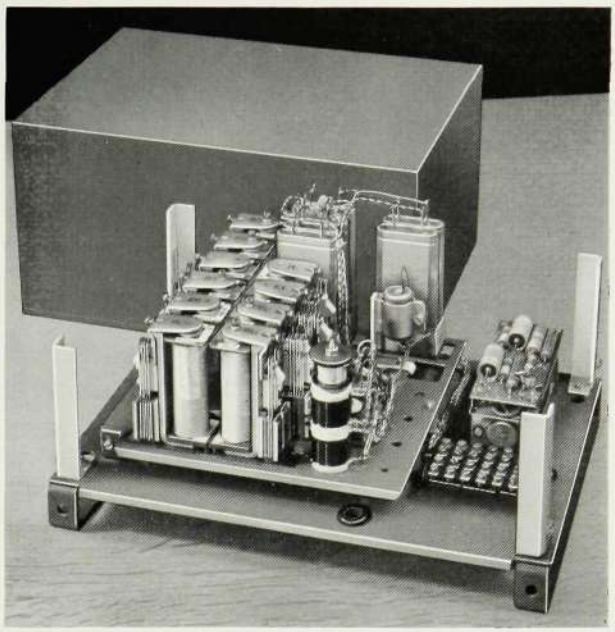


Figure 6—Combined-Services Unit

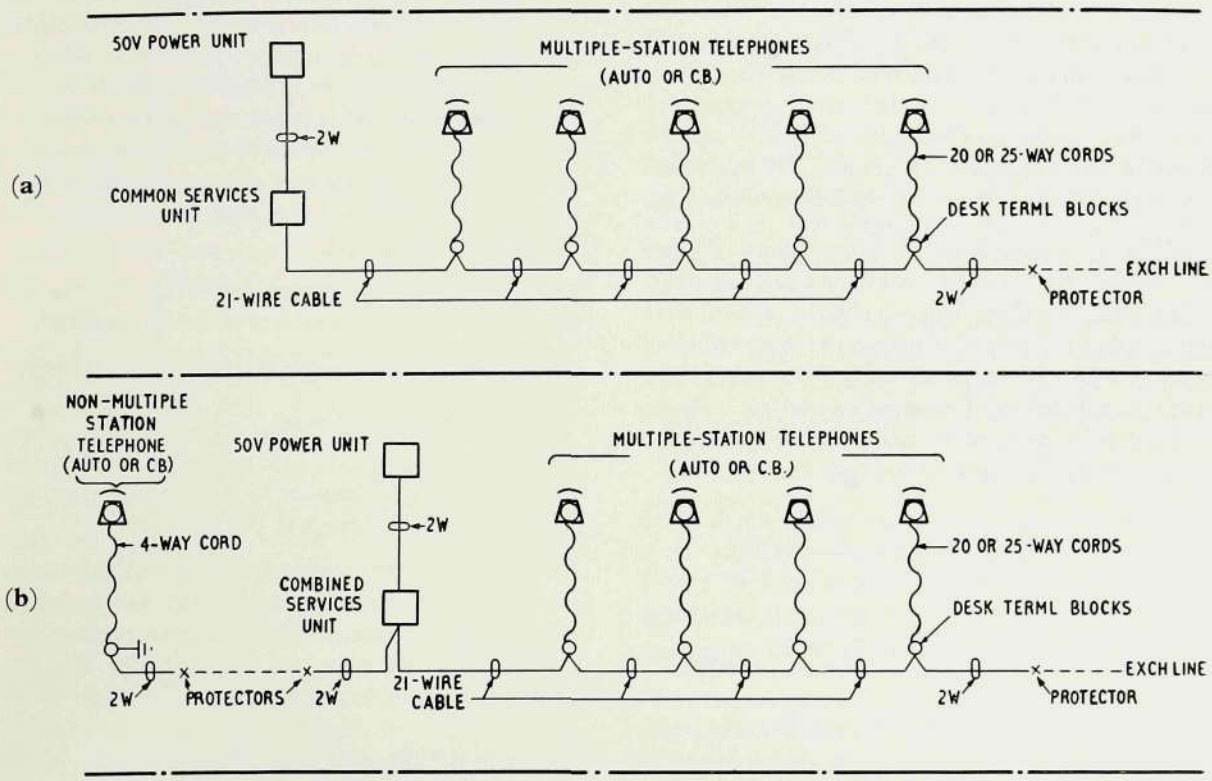


Figure 7—Cabling Layout of System

(*a*) For complete multiple-station scheme

(*b*) For multiple-station scheme including 2-wire station

OPERATION

Intercom Calls

When a call between multiple stations is originated, the caller lifts the handset and the individual 'intercom-busy' lamps glow steadily at all multiple stations, giving visual warning that the intercom line has been seized. On momentary operation of the appropriate intercom key, a signalling earth is applied to the called line to sound the d.c. buzzer in the telephone of the wanted station. Removal of the handset at the called station completes the through connection, and the call proceeds in the normal manner, the intercom-busy lamps remaining lit until the replacement of both handsets at the termination of the call.

To call the remote 2-wire station (when fitted), the same operating procedure and visual signalling conditions apply as for a multiple-to-multiple station call. Because this station uses a common-signalling a.c. bell, however, a suitable ringing current is necessary in place of the normal earth-calling signal used between multiple stations. This is provided automatically by the transistor ringing generator in the combined services unit when the relevant calling key is pressed. Connection between the two stations is established when the 2-wire station user lifts the handset and operates his 'extension' key. Replacement of the handsets restores both telephones to normal, the 'extension' key at the called station being released automatically.

All intercom calls from the 2-wire station circulate via the selected multiple station and are originated by pressing the locking 'extension' key. A distinctive signal is then given by the instrument buzzer sounding continuously at the selected station, thus permitting ready identification of the calling station. Meanwhile, tone is passed to the caller and the appropriate lamp signal is given at all other stations.

The attendant at the selected station responds by lifting the handset, thereby disconnecting both buzzer and tone from the line, and proceeds to call the wanted station. On reply, the call is set up and the selected station withdraws from the connection by replacing the handset.

If any station (multiple or 2-wire) is called while engaged on an exchange line, the calling signal is diverted at the engaged station to operate the buzzer in the caller's telephone during the period the relevant intercom key is pressed, thus providing an engaged test.

As there is a common talking path for intercom purposes, conference calls can be set up from any multiple-station telephone with any group of stations by simply pressing the appropriate intercom keys.

Exchange Calls

Unrestricted Station

Any multiple station with full facilities can originate an exchange call direct by pressing the 'exchange' key. During progress of the call the 'exchange-line' lamps glow continuously.

An incoming exchange call is signalled visually by the associated lamp at all multiple stations, and audible indication is given by each instrument exchange bell, except at restricted stations or where the 'silent call' facility is provided and in use.

To answer the call, a station user presses the 'exchange' key, thus silencing the bells. Simultaneously, the lamp signal denoting the incoming call changes to a steady glow, and the answering station is switched to the exchange-line caller.

While occupying the exchange line, a station user may initiate an information call to any other unrestricted station by pressing the key associated with the required intercom station. This action releases the 'exchange' button to the 'hold' position, signals the called station and switches the calling telephone to the intercom line. Meanwhile, relay operations in the common services unit cause the flashing signal to be given on all 'exchange line' lamps to indicate that a call is being held.

When the wanted station answers, conversation takes place in complete secrecy from the exchange.

If the called station wishes to take over the exchange-line call, he 'picks-up' the line by operating his 'exchange' key. All 'exchange-line' lamps then revert to a steady glow, whereupon the transferring station replaces his handset to remove his telephone from the line and complete the transfer.

If transfer of the exchange call to the called station is not required, the station holding the exchange call can switch from the local intercom circuit and re-establish connection to the exchange line by again pressing his 'exchange' key.

Restricted Station

Any multiple station may be barred direct access to the exchange line but may be allowed exchange calls at the discretion of a controlling station.

If an exchange call is allowed to originate, the 'restrict-access' key (i.e. bell/off) is initially maintained pressed at the multiple station designated for control. This causes the associated add-on relay in the restricted-station telephone to operate and permit access to the line in the normal manner. Following seizure of the line, all appropriate lamps are lit and, at the controlling station, pressure is released from the key and the handset replaced.

At the conclusion of the permitted call, the 'restrict-access' relay is automatically released on restoration of the caller's handset.

2-Wire Station

When the non-locking 'exchange' key is pressed to call the exchange, the adjacent 'extension' key operates simultaneously and locks. The operation of the 'extension' key connects the station telephone to the combined services unit where relay operations, initiated by the momentary operation of the 'exchange' key, cause the telephone to be switched to line and the appropriate visual signal to be given at each multiple station.

With a call established on the exchange line, the user at the 2-wire station may perform the following sequence of operations:—

(*a*) Re-press the 'exchange' key to hold the line and simultaneously call the selected station. On reply, request the attendant to signal the wanted station for the purpose of setting up an information call, or to ask this station to take over the exchange call.

(*b*) Press the 'exchange' key a third time to revert to the exchange line.

During day service, incoming exchange calls for the 2-wire station are received and answered initially at any unrestricted-station telephone and transferred to the 2-wire station in the same way as for a transfer call to a multiple station.

The 2-wire station acknowledges the call from the transferring station by operating his 'extension' key and, when informed of the exchange call, presses his 'exchange' key to establish connection with the exchange-line caller. At the same time, the flashing lamp signal at all multiple stations becomes steady.

NIGHT SERVICE

Since all unrestricted stations have direct access to the exchange line, and common signalling of exchange calls is provided, night service is automatic at these stations.

On installations where the 2-wire station is included, night service facilities can be given at this station on operation of the 'night-service' key (i.e. bell/off) in a selected multiple-station telephone. When the key is locked down, incoming exchange ringing is repeated by the transistor ringing generator in the combined services unit to sound the instrument bell at the 2-wire station. Audible and visual indications of the call continue to be given at multiple stations.

This simple method of establishing night service merely by extending a signal to the 2-wire station, enables incoming exchange calls to be received direct at the station even during normal working hours, if necessary, without sacrifice of day-service facilities.

SECRECY

Because the exchange line is connected in series to all stations, there is a form of priority in access to the line, and secrecy depends on the relative positions of the stations in the multiple, station 1 disconnecting stations 2 to 5, and station 2 disconnecting stations 3 to 5, and so on.

MONITORING

When a monitoring station wishes to listen-in to an exchange call, the 'monitor' key (i.e. bell/off) is manually locked down, thus causing the associated add-on relay unit to operate and extend the station to the beginning of the exchange-line multiple.

LINE LIMITS

The system is suitable for connection to a 1,000-ohm exchange line and a 500-ohm 2-wire station line, with the proviso that the resistance from the 2-wire station to the exchange is not greater than 1,000 ohms.

For maximum local-signalling performance between multiple stations, it is recommended that the distance between the first and last multiple station should not exceed $\frac{1}{2}$ mile, using 21-wire $6\frac{1}{2}$ lb. cable.

POWER FAILURE

The circuits are arranged to allow all stations direct access to the exchange line under mains-failure conditions.

CURRENT DEVELOPMENTS

Units are currently under development to permit the use of a tie-line in place of a multiple station. This will allow two systems to be inter-connected, or the system to work in conjunction with a distant switchboard, using standard signalling methods, i.e. A-wire earth, a.c. calling or balanced-battery calling.

U.D.C.621.395.23

A NEW SERIES OF FLOOR-PATTERN P.B.X'S.

K. J. CLARKE — P.M.B.X. Equipment Section, Engineering Department

The article describes, with particular emphasis on equipment detail, a new range of indicator and lamp-signalling floor-pattern private branch exchanges of most attractive design. These p.b.x's. are suitable for use as single-position or multiple switchboards in magneto, c.b. and auto systems and each accommodates a maximum of 100 *extension lines,* 20 *exchange lines and* 17 *cord circuits. Operation is from a* 24*-volt d.c. supply. A novel building-block arrangement for the main equipment components allows a basic switchboard to be adapted with minor modification to suit differing capacity and circuit requirements, thus permitting switchboards identical in size and general appearance to be provided with features incorporated to suit customers' specific needs. Chief among the other benefits to be obtained from these switchboards are good telephone service, reliability and simplicity of handling.*

THE design of floor-type private branch exchanges has followed a conventional pattern for nearly a quarter of a century and although attempts have been made from time to time to eliminate unnecessary detail and create more pleasing lines, their angular form has remained substantially unchanged. Similarly, the material used for the main structure of the switchboards has been timber

Facilities	*Magneto Version*	*CB/Auto Indicator Signalling*			*Lamp Sig. Version*
		Version 1	*Version 2*	*Version 3*	
Through Dialling and Clearing		X	X	X	X
Night Service		X	X	X	X
Operator Recall		X	X	X	X
Cord Test		X	X	X	X
Ring Back	X	X	X	X	X
Audible Alarm	X	X	X	X	X
Visual Ringing Indication	X	X	X	X	X
Single Positive Supervision	X				
Double Positive Supervision				X	X
Double Negative Supervision		X	X		
Exchange Prohibition				X	X
'Exch. Hold'		X		X	X
Automatic 'Exch. Hold'			X		

X = With

TABLE 1—Summary of the Standard Facilities provided by each type of Switchboard

of various types, generally stained and polished but occasionally faced with a durable plastic. Modern design in the wider spheres of industry has however given impetus to a desire for floor-pattern p.b.x's. in pleasing colours and of more attractive shape and practical construction.

To meet this need a new range of switchboards identical in basic design has been developed. The complete series consists of one magneto switchboard, three c.b./auto types with indicator-signalling facilities and one c.b./auto lamp-signalling version. A concise summary of the standard service features provided by each is presented in Table 1.

BASIC DESIGN FEATURES

The low silhouette of the new switchboards represents a pleasing departure from previous wood-constructed types. The desirable characteristic of low height, fundamental to good design and of particular importance from the operator's point of view, has been obtained without sacrifice of extension or exchange-line capacity by adoption of standard overall height, width and depth measurements of 4′ 0″ x 2′ 5⅜″ x 2′ 8″ (122 x 77 x 81 cms.). A well-balanced combination of aesthetic and practical design has been obtained by sloping the face equipment backward and the plug-shelf downward to present an angle of 100° between the two. This feature, clearly seen in the switchboard illustrated on the preceding page, not only enhances the switchboard's modern lines but, in addition, provides improved visibility and consequently greater ease and efficiency of operation.

Colour and finish complete a distinctive appearance. The casing, composed of removable panels, is in 'buff-linette' (a light brown colour with a faint grain pattern), while the keyshelf, mushroom-tinted and edged in brown, contrasts with the black plug-shelf and face equipment framing. The panels, formed in laminated wood, are faced in a melamine plastic providing a smooth and easy-to-clean exterior.

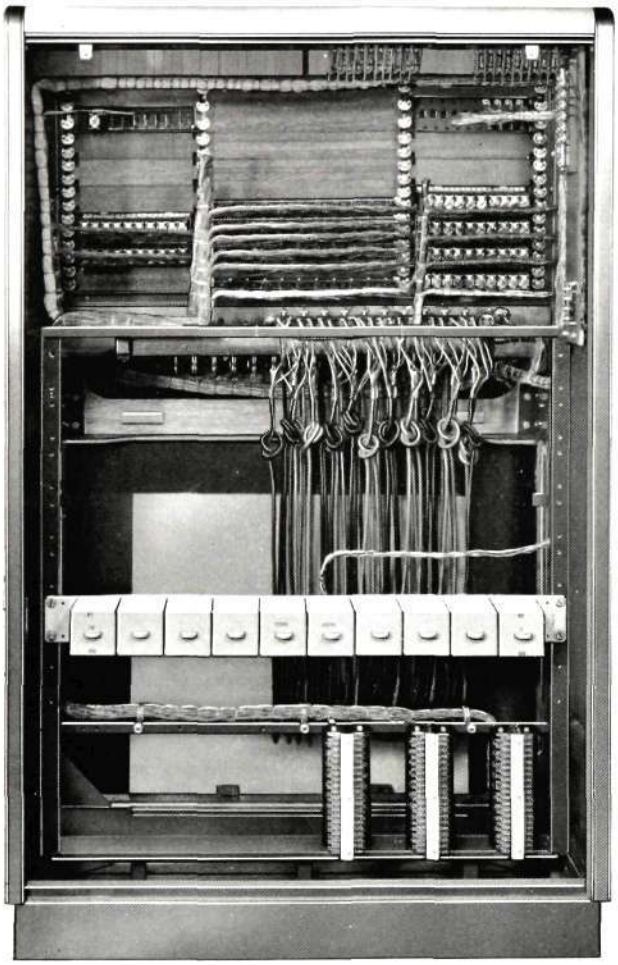


Figure 1—Rear view of typical Switchboard with cover removed

This method of case construction provides a light yet robust covering and offers the additional advantage of allowing the standard colour scheme to be changed to suit particular tastes and decor.

The elimination of wood as the main constructional material meant that an alternative method of forming a rigid framework had to be devised. This problem was solved by making a welded pressed-steel skeleton, with an integral plinth to give added strength and complete stability. Wood screws from inside the framework secure the top and keyshelf-apron panels, while the side panels are held in place by neat metal trims in anodized bronze. The front bottom panel, or 'kicking' panel, simply lifts out and the back panel, giving access to relay equipment in the rear of the board, is locked by two captive screws. Covered apertures for cable entry are located in the base and, since this is of open construction, an alternative means for cable access is afforded from below. To enable the p.b.x. to be easily manoeuvred in confined spaces prior to its installation, for example through narrow doorways and corridors, it is arranged to reduce the overall depth of the switchboard to the convenient dimension of 1′ $11\frac{1}{4}$″ (59 cms.). This is achieved simply by raising the hinged key-shelf, removing the kicking panel and withdrawing four screws within the switchboard to allow the apron to be pulled forward and lowered.

Equipment Flexibility

A feature of considerable importance is that the p.b.x. is not restricted to a particular circuit—an inherent drawback of earlier types of switchboards. With minor modifications it can be adapted to accommodate any standard or special circuit for auto, c.b. or magneto working. The switchboard's range of utility is further extended since it is equally suitable as a single-position or multiple p.b.x.

The flexibility of the new board stems from the equipment arrangement. As shown in Figure 1, all the rear equipment with the exception of the fuse panel is carried on a single metal frame bolted firmly to the switchboard's framework. Space is available within the frame for a joint total of 140 line, cord-circuit and miscellaneous relays, all of B.P.O. 3000-type; six terminal blocks for apparatus interconnection and external line terminations, and 17 cord fasteners. The face equipment is similarly mounted and accommodates lamps or indicators and associated jacks for 100 extension lines, indicators and jacks for 20 exchange lines and, in addition, a 100-line multiple-jack field for use when the switchboard is included in a suite. This unit-frame construction enables the basic board to be stocked and units to be readily added to suit a wide range of circuit and capacity requirements.

Indicator-Signalling Switchboards

In the magneto version, manually restored indicators of the twin-shutter type are used for extension and exchange-line signalling, but for

supervision, the totally enclosed disc type is employed. On the other hand, c.b./auto switchboards utilize fully automatic indicators throughout or, alternatively, a combination of automatic and manually-restored indicators, all of twin-shutter type[1].

When manually restored indicators are included on c.b./auto switchboards as shown in Figure 2, these are employed on exchange lines only and arranged in the lower section of the left-hand panel below one group of extension-line indicators. This extension-line group and its corresponding one in the right-hand panel are composed of strips of 10 indicators mounted to align with associated central-panel jacks below the space provided for the multiple-jack field. Each strip of extension-line indicators is protected against dust and incidental damage by a clear plastic shield while manually restored exchange-line indicators are similarly but individually guarded.

[1] Bulletin No. 35 pp. 39, 40. July 1957.

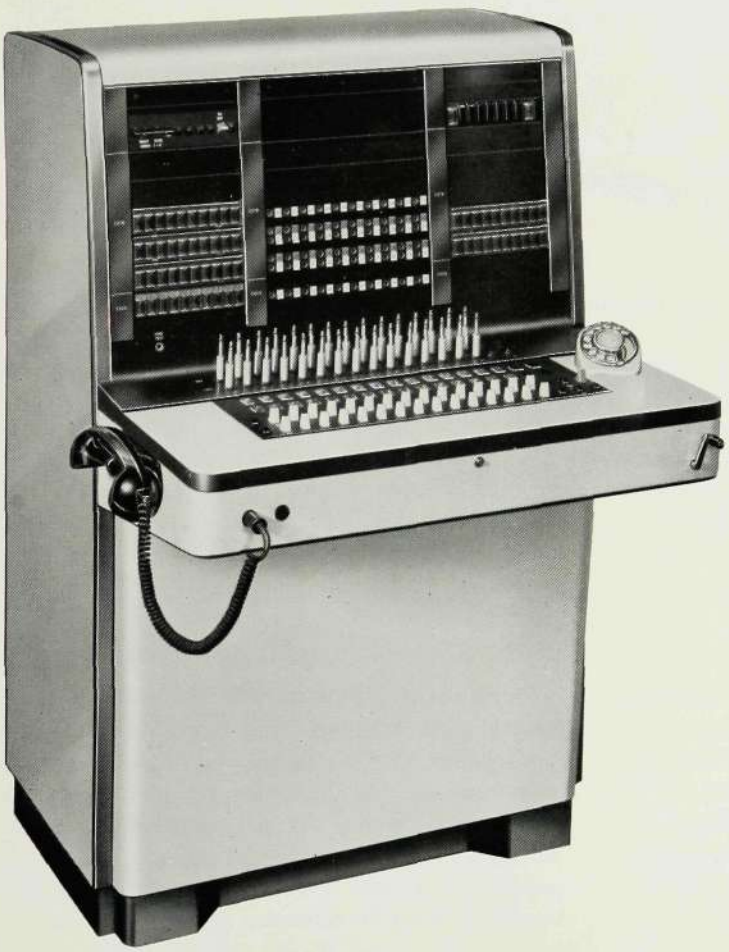


Figure 2—General view of CB/Auto Indicator-Signalling Switchboard

Easy identification of calling lines is ensured by clearly inscribed stile-strip legends and printed numerals on the indicator-protection shields. In addition, differentiating colours are used for extension-jack labels and each group of indicators. As an indicator operates in the left-hand group the twin shutters swing open horizontally to display the extension's designation against a background of pink, while in the other group an operated indicator shows the calling extension's number surrounded in green. Since the jack labels are coloured to coincide with their respective indicator labels, improved 'speed of answer' is assured.

All areas of the switchboard facing the operator are within easy reach. Keys for night service and miscellaneous use, such as 'night alarm' 'fuse alarm' and 'battery cut-off', are located at the top of the left-hand panel, while in the upper section of the corresponding outer panel, miscellaneous indicators for 'fuse alarm' 'ring indication' and 'dial guard' etc. are mounted.

Below the face equipment, on the plug-shelf, are the switchboard cords. Provision is made for up to 17 pairs, and these are accommodated in removable cord seats of long-wearing nylon pressed into the plug-shelf panel. Keys and supervisory indicators associated with the cords are arranged in double-row units mounted within metal frames in the adjoining keyshelf. Here, space is also available for the latest 'trigger' dial. This, when incorporated in the switchboard, is offset towards the operator and all fixing details are concealed by a pleasantly contoured plastic shroud.

The supervisory indicators, viewed through clear-plastic windows raised above the keyshelf surface, are of twin-shutter pattern, except in the magneto switchboard where, as previously mentioned, disc-type indicators are employed.

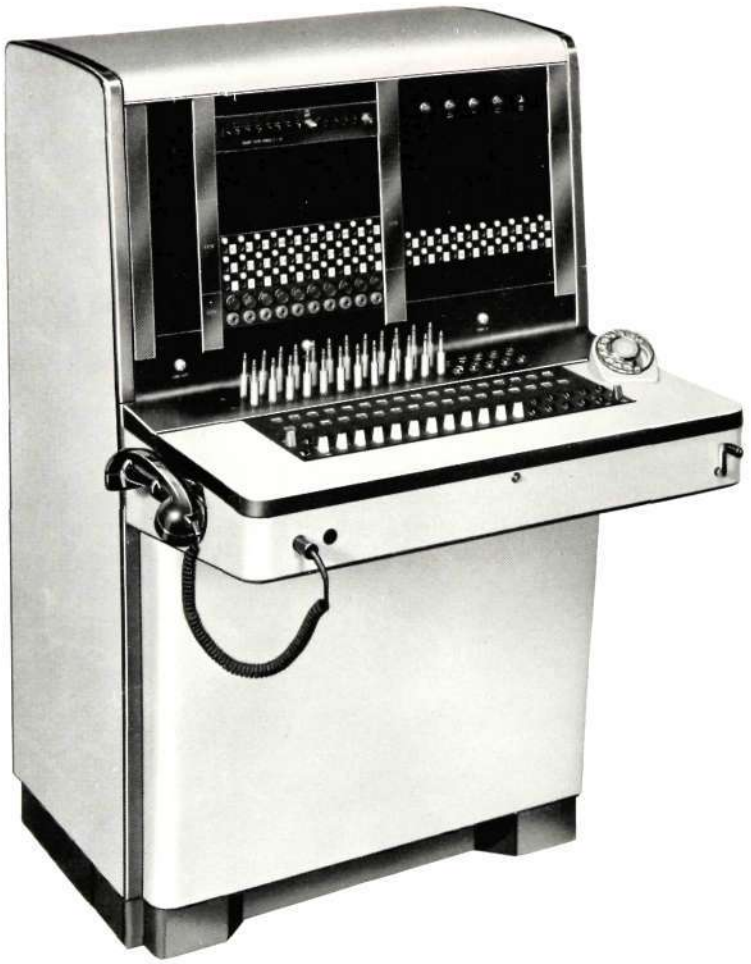


Figure 3—General view of CB Auto Lamp-Signalling Switchboard

The keys are of the well-proved miniature type[2] used extensively in our B.P.O.-approved cordless switchboard range. Their smooth action and specially designed ivory-coloured handles contribute to a main objective—simplicity of operation. The key handles are wedge shaped, offering a better grip than old-type lever keys, and coloured inserts in their tips serve as 'flags' to indicate at a glance the position of the keys.

In the front apron and conveniently to hand is the rotating-magnet generator. This is mounted directly opposite the twin jack serving the operator's plug-in handset which rests, when not in use, on the cradle at the side of the switchboard apron. The handset, similar to that used on the Etelphone instrument, is light in weight to prevent fatigue and equipped with a retractable cord, allowing the operator complete freedom of movement.

[2] Bulletin No. 35 pp. 38, 39. July 1957.

Although the rotating-magnet generator is provided as standard, space is available in the switchboard apron for a transistor ringing unit, supplying a 25-cycle ringing current with power sufficient for the simultaneous ringing of 10 bells. This unit may be utilized to supplement or replace the hand-generator; alternatively, any existing means of power ringing can be used.

CB Auto Lamp-Signalling Switchboards

Because of the space saved by the use of lamps in the c.b. auto lamp-signalling board (Figure 3) the face equipment occupies only two panels, adequate room remaining for directory storage on the left-hand side. Despite the advantage of space conservation gained by the use of lamps, these are not employed throughout for all signalling purposes. Lamps are used for extension working and, together

with their associated jacks, are arranged in both panels. But exchange lines are equipped with indicators, as may be seen in the lower section of the left-hand panel. These are the standard combined indicator-jack type which automatically restore when the exchange call is answered. To suit particular requirements, these indicators may be replaced by a similar type which is manually restored.

For exchange line signalling, mechanically-locking indicators are preferred to lamps, since they are independent of the switchboard's power supply. Thus exchange calls can be signalled and answered even in the event of power failure. If however the switchboard power supply can be regarded as reasonably dependable, lamp signalling can be incorporated in the exchange lines in place of indicators.

The layout of the switchboard's relay equipment, keyboard and ancillary items is, in general, as previously described for the indicator-signalling board. Similarly, all relays are of B.P.O. 3000-type and these, together with all other components, are designed to withstand wide extremes of temperatures. Plastic-covered wire is used throughout and maximum protection against dust is given to vital components.

Line Limits

When Etelphone-type instruments are employed for extensions, the permissible loop resistance between an extension and the exchange is 1,000 ohms.

Power

All c.b./auto switchboards are designed for a supply voltage of 24V but will operate satisfactorily within the wide range 18 to 28 volts. The c.b./auto switchboards when equipped to full capacity each have a busy-hour current consumption of 2A.

Design Registrations: *UK. No.* 900242. *Australia Nos.* 41792-3. *South Africa Nos.* 201-202/61.

PROTECTION AND DUSTPROOFING OF ELECTRICAL EQUIPMENT

The article outlines the effects of dust on electrical apparatus. The efficacy of existing methods to minimize dust ingress from known sources is briefly discussed and attention drawn to some authoritative recommendations for more effective dust control in telephone exchange buildings. A description follows of the experimental work and field trials carried out by the Company in collaboration with the Australian Post Office in the development of prototype methods of construction for complete dust-proof enclosure of step-by-step equipment.

THE detrimental effect of various forms of dust deposits on delicate electrical and mechanical apparatus is widely recognized and in recent years the problem of dust in telephone exchanges has been studied comprehensively by a number of authorities. Although the provision of individual covers for relays, groups of relays, mechanisms and other apparatus is standard practice, banks and wipers are generally unprotected. Cable forms, connection blocks and a great deal of miscellaneous apparatus are also exposed to the local atmosphere and are therefore vulnerable to the effects of dust and dirt. It is very difficult and costly to clean regularly all surfaces as they become contaminated, and therefore accumulation of deposits is frequently of a progressive nature.

Examples of deterioration arising from the presence of dust and dirt are, excessive wear, electrical contact faults, lowering of insulation, and metal corrosion. In addition to detracting from the general appearance of the apparatus these faults can cause abnormally high maintenance demands.

It has been established that dust in telephone exchanges originates from three main sources:

(*a*) The surrounding atmosphere.

(*b*) Cleaning materials and the movement of personnel within the apparatus room.

(*c*) To a lesser extent—the raw materials used in the construction of apparatus, wires, cables etc.

Atmospheric Dust

The introduction of suspended matter from atmospheric sources can be limited by the installation of air filtering systems. Usually, ventilation plant is designed to give a slight positive pressure within the building, thus providing an outflow of air to

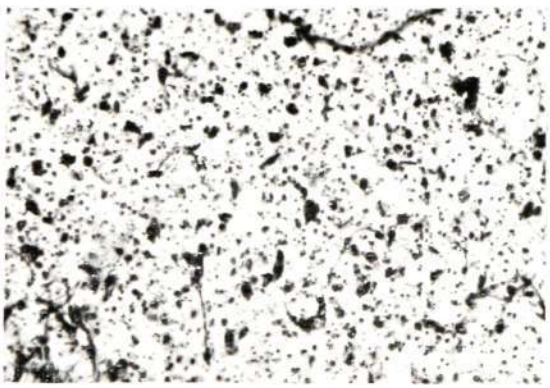


Figure 1(*a*)—Typical deposit of industrial-area particulate matter in exchange building without air filtration.

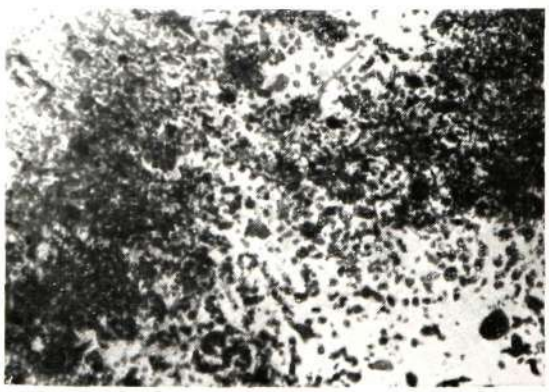


Figure 1(*b*)—Siliceous dust brushed from selector switches in a Middle East exchange.

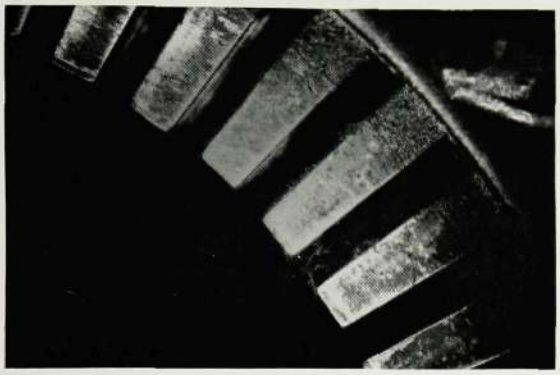


Figure 2(*a*)—Extreme example of accumulated dirt deposit on uniselector switch in exchange located in industrial area.

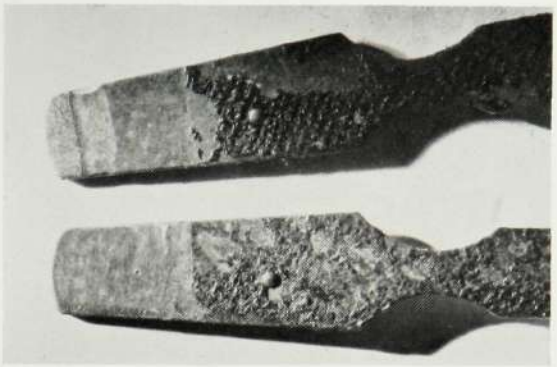


Figure 2(*b*)—Abrasion of bank contacts resulting from substantial deposits of fine sand and siliceous dust in an exchange atmosphere.

minimize the dust entering through porous areas, cracks, ill-fitting windows and doors etc. However, a building must be more than normally air tight if considerable ingress of dust is to be prevented. Strong prevailing winds may, in some instances, readily force dust into a building against the outflow of air from ventilation plant. This problem is particularly serious in densely populated industrial areas where airborne solid concentrations may be very heavy.

A special committee, set up by the Department of Scientific and Industrial Research to study the problem of polluted atmospheres in the United Kingdom, carried out a number of systematic measurements in various parts of the country. These revealed that in an industrial town the atmosphere may contain up to 1.2 m.g. of solid particles per cubic metre, and even a country district frequently has as much as 0.24 m.g. per cubic metre. Contamination also varies with the season and prevailing weather conditions as, for example, in agricultural areas where dry summer atmospheres contain large quantities of seeds and vegetable matter

Special problems are presented when telephone exchanges are sited in proximity to chemical and mineral industries, and in arid areas overseas where high velocity winds carry siliceous dust and fibrous particles. A typical example of particulate matter from an industrial atmosphere, deposited inside an exchange building with no air filtration, is shown in Figure 1 (*a*). This deposit, as microscopic, chemical and spectrographic tests confirm, is composed mainly of soot, mineral grit and fibrous vegetable matter. In contrast, Figure 1 (*b*) is an example of siliceous dust brushed from the selectors of an exchange situated in the Middle East.

It is generally recognized that the elimination of dust and dirt from outside sources by air filtering systems does not provide a satisfactory answer to the problem of cleanliness. Furthermore, a proportion of telephone exchange installations have little or no air filtration and where this does exist it is sometimes inadequate. Maintenance of the filtering elements may also be below the required standard. On the other hand, modern developments with electrostatic and other air filtering systems provide the means to ensure a very high standard of cleanliness within the telephone exchange buildings. Unfortunately, the efficiency of this plant may be impaired by an emergency of one kind or another, for example, building repairs and extensions, damage to windows etc.

Personnel Movement and Cleaning Materials

Dust introduced by personnel is difficult to control and little can be done to overcome this problem completely, apart from the obvious need to limit or prohibit smoking and unnecessary movement. Cleaning materials and methods on the other hand can be closely controlled and there is scope for improvement in this respect. Many examples of deterioration and failure due to dust and dirt have been examined in the E.T. laboratories and two of these are illustrated. Figure 2 (*a*) is a photograph of a uniselector switch from a telephone exchange and is an extreme example of accumulated dirt deposits

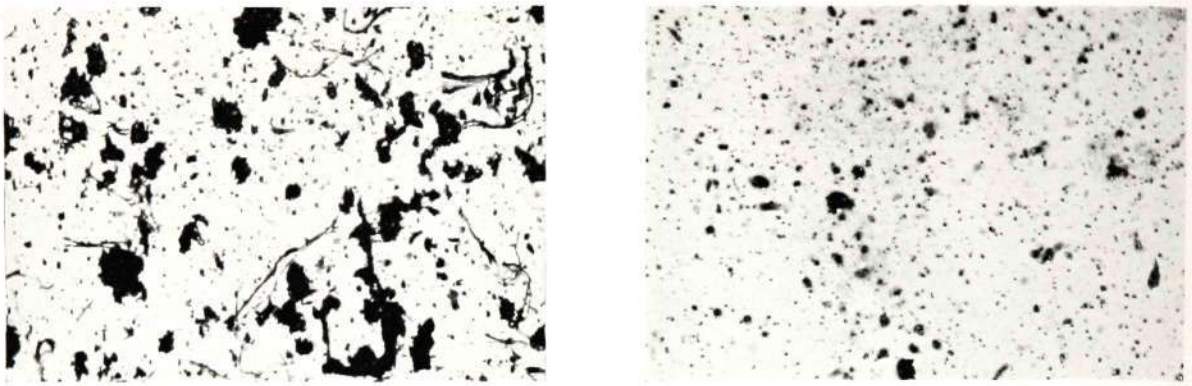


Figure 3—Accumulated deposits on dust plates after 12 weeks exposure:

(*a*) **Busy thoroughfare in exchange switchroom** (*b*) **More remote area in same switchroom**

found on apparatus in an industrial area. Figure 2 (*b*) shows the abrasion of bank contacts resulting from the presence of substantial deposits of fine sand or siliceous dust in the exchange atmosphere.

Limiting Dust with Improved Materials

Much progress has been made in recent years in the application of materials, for the manufacture of apparatus, which in themselves do not provide potential sources of dust particles. A notable example is the adoption of p.v.c. insulation for wires and cables in place of textiles, thus eliminating internally-generated fibre dusts and dispensing with the need for waxes during installation which promote dust retaining surfaces. Non-fraying nylon-braided wiper cords have superseded the textile pattern, and paper busbar insulators have been replaced by a plastic type. The cut edges of s.r.b.p. insulators are sealed with varnish, and high adhesion stoving enamels are used for general finishing on telephone equipment to minimize loose particles from these sources. Because of these improvements the amount of dust produced from the apparatus itself is reduced to the minimum.

Published References on Dust Hazards

The problems of maintenance in automatic exchanges were studied in the U.S.A. in 1953 by a visiting team of Post Office officials and, subsequently in 1954, a report on this subject was issued by the British Productivity Council.[1] One of the principal recommendations was the need for a new approach to the limitation and

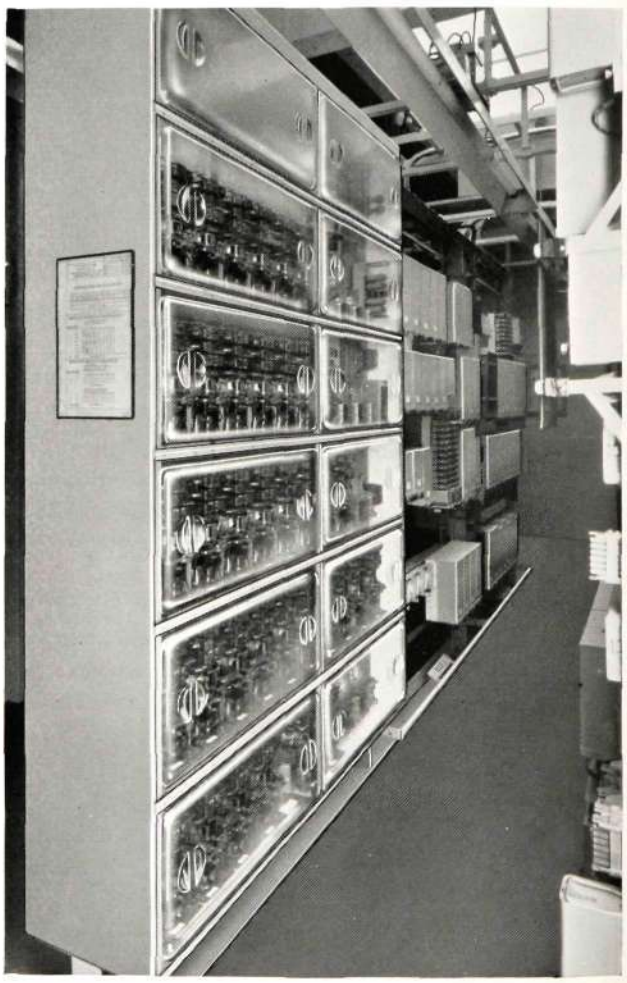


Figure 4—Front view of first prototype Dust-Proof Enclosure

[1] *Productivity Report, 'Maintenance of Automatic Exchanges', published March 1954.*

control of dust with particular attention directed to the rigid avoidance of dust-producing cleaning materials. The report refers to an investigation designed to establish the particular type of dust responsible for the failure of relay contacts and concludes that 80% of disconnections are caused by fibrous dust larger than 25 microns in size. Much of this is produced inside the exchange and cannot, therefore, be excluded by air filtration plant. The remaining 20% of faults are caused by epidermal scales and other dust of larger size; particles smaller than 25 microns apparently do not cause contact failures.

More recently the P.M.G's. Engineering Dept. of the Commonwealth of Australia issued a research report[2] also stressing the need for improved methods of dust control in telephone exchanges. Among the specific recommendations made in this report are an improved exchange layout with all centres of personnel activity, such as test desks, well segregated from the switch racks, since measurements show that staff movements contribute a large proportion of the most damaging dust inside the exchange. Improvements could also be made by the provision of regularly washed lint-free protective clothing for maintenance engineers working in the switch rooms.

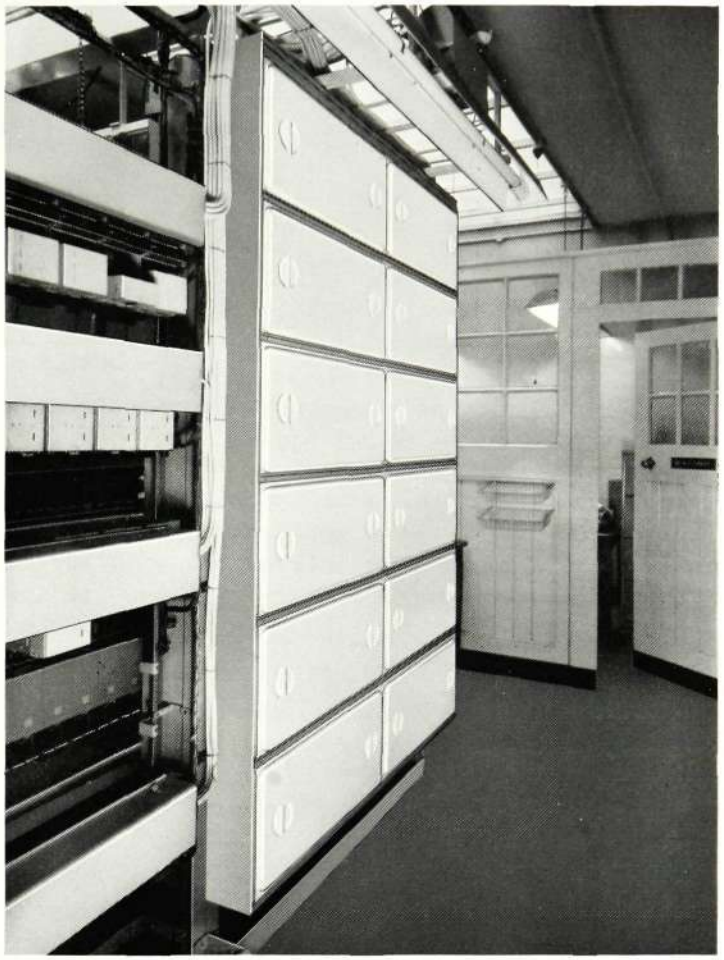


Figure 5—Rear view of first prototype Dust-Proof Enclosure

In a statistical analysis of faults in South Africa it was described how, in a recent campaign to reduce contact faults, 4½ ozs. of dust were collected when a batch of 1,300 troublesome final selectors was cleaned by a jet of compressed air. Because of this cleaning, elusive faults, designated as 'no fault found' were reduced from a monthly total of 560 to 275.

A striking feature of all published reference to exchange dust hazards is the general recognition that most of the particles causing complete disconnection come from within the exchange building itself and are circulated by maintenance staff. Smaller particles of less than 2 microns entering the building through the filtering plant contribute mainly to mechanical wear and metal corrosion although, as the Australian report points out, some disconnections may result from aggregates of small particles.

Methods of Dust Measurement

A number of specially constructed forms of apparatus are used in the E.T. laboratories for the measurement of suspended solid particles in the atmosphere. These normally cause a definite volume of air to impinge on a glass disc, coated with a slightly tacky film to which the dust adheres for subsequent examination. However, when deposits of dust are to be measured, a relatively simple and direct technique may be applied. Small glass plates are white stove enamelled on one side and coated with a very thin film of soft paraffin grease, applied by evaporation after immersion in a hydrocarbon solution (e.g., 5% solution of paraffinum molle in xylol). This surface securely holds dust particles settling on it and provides an excellent background for microscopic examination and photography.

[2] *Research Laboratory Report No. 5063, 'Dust Conditions in Automatic Exchanges', issued 16th July 1959 by Commonwealth of Australia P.M.G's. Department, Engineering Division.*

	Below 25 u	25 u to 35 u	35 u to 50 u	50 u to 90 u	Above 90 u	Total Count	Hairs and Lint
Manual Room *	3,230	1,938	807	323	162	6,460	42
Switch Room							
Top row of selectors	508	386	258	13	—	1,237	—
Middle row selectors	998	451	258	32	—	1,739	—
Bottom row selectors	1,739	773	644	129	64	3,349	26

* No air filtration.

Table 1—Particle Size Analysis—Counts per Square Centimetre

After a period of exposure in a dusty atmosphere, the particles are counted and classified according to size, and the rate of deposition is determined by exposing a series of plates.

Dust Measurement in Main Telephone Exchanges

In order to study the distribution and rate of deposition of dust deposits in an exchange, groups of dust retaining plates were mounted in a variety of positions. These included well used passages and areas near to entrances and ventilating ducts as well as more remote parts of the exchange where there is little disturbance. A plate was removed from each group after exposure periods of one, two and three months.

Table 1 shows typical results obtained from dust plate micrographs after an exposure period of one month in an industrial p.a.b.x. fitted with cloth type air filtering equipment.

The analysis shown in the Table is only one of many carried out in telephone exchange buildings and reveals a general pattern found to exist throughout all measurements. It is quite clear that air filtration is effective in reducing the amount of dust present in the exchange atmosphere and the Table shows almost twice the quantity of dust deposited in a manual room compared with the worst position in an air filtered switch room. Racks in busy thoroughfares accumulate most dust on the lower rows of switches where the turbulent air flow caused by personnel movement re-circulates particles from the floor. Hairs and lint from clothing are present in large numbers on the lower selectors and the larger, heavier particles are usually more concentrated in this region.

Dust plate micrographs Figures 3 (*a*) and (*b*) show a comparison between a busy thoroughfare and a more remote area in the same switch room after twelve weeks exposure.

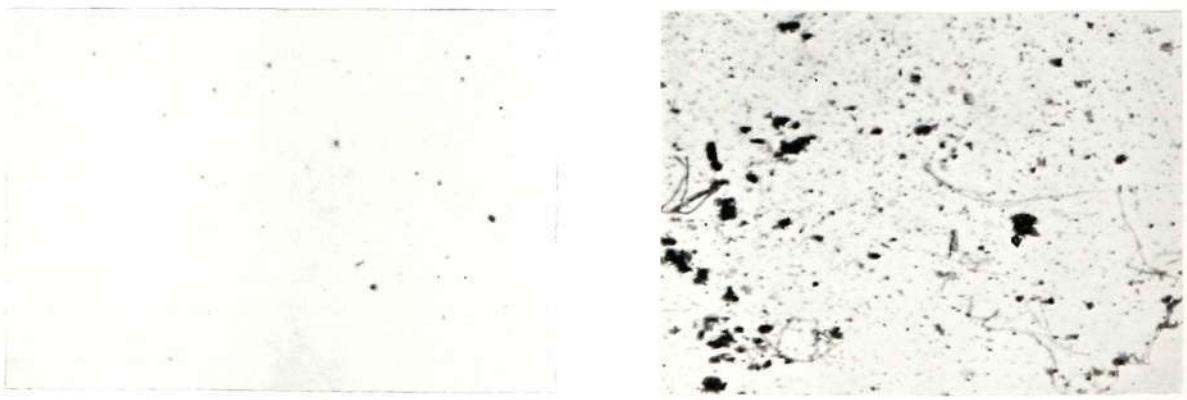


Figure 6—Typical deposits after one month:

(*a*) **Prototype enclosure** (*b*) **Open rack**

Experimental Dust-Proof Rack Enclosure

Experience has shown that small covers fitted to individual groups of relays, selectors, etc., do not by themselves constitute a completely effective means of excluding dust from vital contact areas. Many authorities, including the A.P.O., have expressed the view that complete enclosure would be the most desirable solution to the problem, especially if such a system could be economically applied to existing, as well as new equipment. In 1959 an experimental enclosure was designed and constructed in the E.T. laboratories. Construction was based on a rectangular sheet metal frame with vacuum-formed plastic panels at front and rear, and the unit was fitted to an existing p.a.b.x. from which all individual switch and relay covers were removed. This arrangement was studied to obtain information on the following points:

(*a*) Problems concerned with fitting enclosures to existing installations, including methods of sealing cable entries.

(*b*) Effectiveness of the enclosure in preventing ingress of dust.

(*c*) Assessment of possible economies in terms of reduced general cleaning and bank maintenance.

(*d*) Temperature conditions inside the enclosures during normal busy periods.

The first prototype model is illustrated in Figures 4 and 5 showing a light metal frame enclosing the existing rack ironwork. The front is enclosed by transparent vacuum-formed p.v.c. panels, and white opaque panels of similar type are provided at the rear. Foamed-polyurethane strips form the seal between the panels and the middle frame, and the panel edges are firmly retained in specially constructed horizontal channels.

Exclusion of Dust

When construction of the enclosure was complete, the apparatus was cleaned as thoroughly as possible. A set of five dust-retaining plates were placed in the enclosed unit and supported on suitably positioned shelves beneath the top, middle and bottom rows of switches. The vacuum-formed panels were replaced immediately after inserting the test plates and were not removed until the end of each test period except for maintenance purposes; all removals being accurately recorded. An identical number of test plates were placed in the same relative positions on a similar open rack sited in an adjacent position to provide a basis for comparison. At the end of a period of one month a test plate was removed from each of the three levels on both the enclosed and open racks. The micrographs taken from these plates are shown in Figures 6 (*a*) and (*b*) and clearly demonstrate the efficiency of the enclosure.

Maintenance

The enclosed rack was not cleaned for two years and at the end of this period was remarkably free from dust. On the other hand, it was necessary to clean apparatus situated in other parts of the exchange four times a year as an essential maintenance operation. Faults attributed to dust occurring on the enclosed rack were reduced to negligible proportions when compared with similar faults cleared on adjacent open racks. Furthermore, the wipers on two-motion selectors inside the experimental enclosure showed considerably less wear.

Extensive temperature measurements made inside the enclosure revealed no significant rise under normal or busy conditions of service.

Field Trial

The A.P.O. showed considerable interest in the development of this dust-proof enclosure and, at their request, a field trial was arranged at Civic Exchange, Melbourne, with a view to obtaining additional functional information. A full account of this field trial is given by G. P. Jolley[3] in an article which states that a number of advantages are to be gained from complete enclosure. These include reduced maintenance and cleaning, freedom of personnel with regard to movement and ventilation and almost complete elimination of noise in the apparatus room.

Further Development of Experimental Enclosures

As a result of our own experimental experience and the A.P.O. field trial, a series of design objectives were agreed as follows:—

(*a*) The enclosure should be capable of being fitted to new or existing installations and to all types of racks.

(*b*) Design should be simple, with smooth external contours, and of sufficient thickness and rigidity to give ease of cleaning. All complicated fixing devices should be avoided so that fitting or removal is a simple and rapid procedure.

[3] *Jolley, G. P. 'Protection and Dustproofing of Automatic Equipment', Telecommunications Journal of Australia, pp. 324-328, October 1960.*

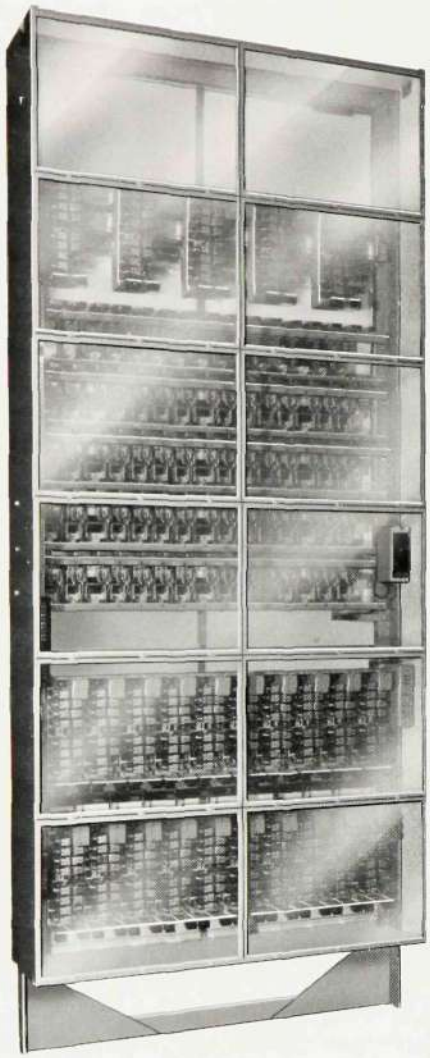


Figure 7—Front view of improved Dust-Proof Enclosure

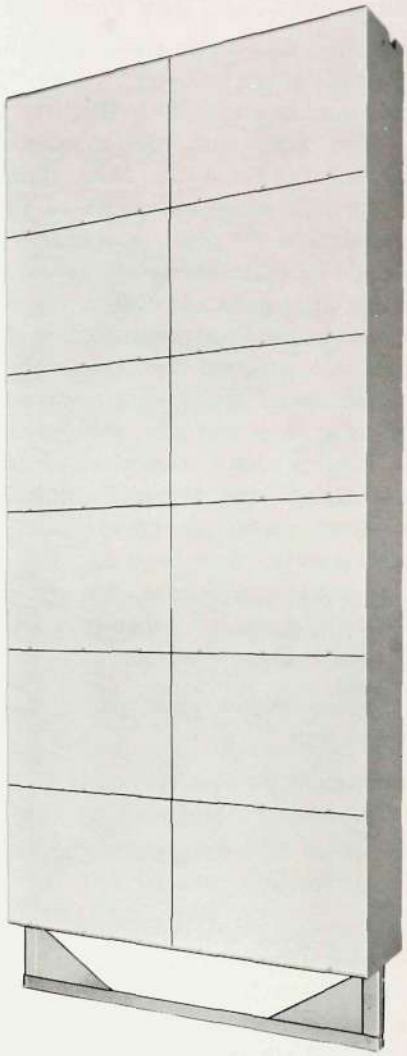


Figure 8—Rear view of improved Dust-Proof Enclosure

(*c*) The panels must be non-inflammable, light to handle, not subject to corrosion, and shock resisting so that no special care is required in handling.

(*d*) Panels should be transparent on the side which is in front of the relay sets and mechanisms, thus providing a desirable inspection facility for the maintenance engineer.

(*e*) Panels should be small to promote ease of handling and to minimize the area of dust entry to equipment when they are removed for maintenance.

(*f*) The sealing efficiency should be adequate to eliminate the need for separate covers on relay sets etc.

(*g*) Thickness and nature of panels to be such that the enclosures form an acoustic screen, thus reducing the noise level in the apparatus room.

(*h*) Rear panels to be white to give good light diffusion in the inter-rack areas.

(*i*) The surface of the panels should be feebly electrostatic so that small dust particles are retained on the outer surfaces for subsequent removal by cleaning.

(*j*) Thermal characteristics of the structure must provide adequate heat dissipation and so minimize the rise in temperature caused by switch operation.

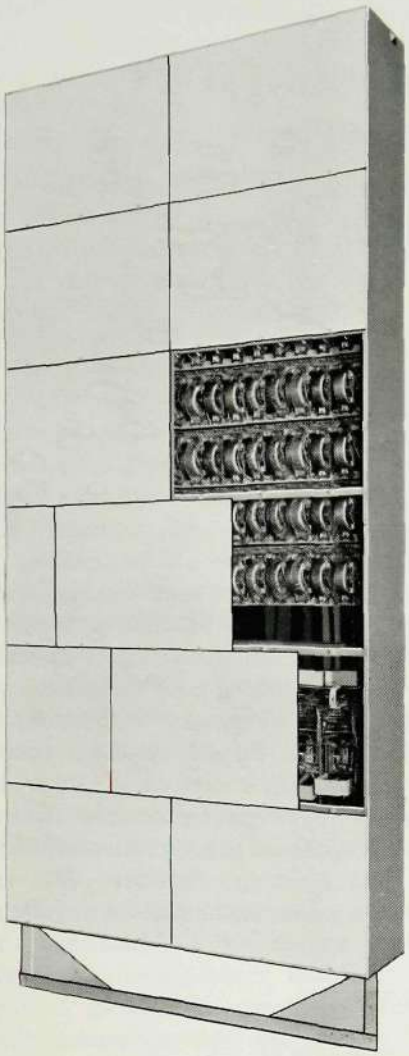


Figure 9—Panels temporarily parked in front of adjacent panel

In conjunction with the A.P.O. a further dust-proof rack enclosure was constructed based on these design objectives.

The enclosure consists, as before, of a pressed steel framework but with plain p.v.c. panels fitted to the front and rear. A novel and most efficient dust seal is provided between the panels and framework by strips of 'magnetic rubber' fixed securely to the panel edges by an adhesive. This recently developed, flexible magnetic material consists of a rubber, heavily loaded with barium ferrite which offers a resistance to demagnetization unsurpassed by any other commercial magnetic material.

Panels at the front of the enclosure are made from a transparent grade of semi-rigid p.v.c. and a white pigmented grade is used for the rear, as shown in Figures 7 and 8. The front and rear of the enclosure are fitted with a number of 'T' section cross members which span the entire rack and support the panels, and may easily be spaced to suit existing apparatus. Small nylon studs ensure correct location of each panel and magnetic attraction provides the force required to hold them firmly in contact with the mild steel framework. Thus, the panels are fixed merely by placing them in contact with the metal framework.

If large scale circuit or switch adjustments are necessary, the cross members can be removed easily and quickly, giving access to the entire rack, although for most routine adjustments it is sufficient to remove one panel at a time. Because of their light weight construction and simple fixing technique any panel can be removed using only one hand and parked temporarily in front of an adjacent panel (see Figure 9). This is a most valuable feature when removing upper panels from a rack enclosure.

Future Development

Effective exclusion of dust and dirt is the essential basis for further specific improvements to step-by-step switching apparatus. This condition permits the application of improved materials and designs in construction of selector banks, and enables film lubrication to be fully effective.

In adverse environments, such as industrial towns or geo-thermal regions where concentrations of sulphur dioxide or hydrogen sulphide may be as high as 5 parts per million, purified air can be supplied to individual racks with very small and relatively inexpensive apparatus. Without controlled ventilation, minor air changes within the enclosures result from diffusion and expansion caused by changes in temperature.

It is expected that limited ventilation with purified air will significantly reduce the formation of harmful tarnish films induced by polluted atmospheres. Various methods of purification are being examined in the E.T. laboratories and arrangements have been made to install an experimental unit in the Works' p.a.b.x.

U.K. Patent Application No. 30630/60.

Acknowledgment

We would like to acknowledge the collaboration of A.P.O. Liaison Officer, Mr. A. Kellock, and his engineering colleagues for their constructive suggestions in helping to solve many of the problems arising in the development of the enclosures.

U.D.C.621.318.562.3:621.314.58

ELECTROMECHANICAL MODULATORS

L. S. DISTIN, A.M.I.E.E. — Relay Research Section

The article outlines some of the principal problems involved in the design of electromechanical modulators or 'choppers' used to convert minute d.c. signals into a.c. form for the purpose of amplification in computer and precision control equipment. A brief description follows of a long-life low-noise chopper based on the design of the time-tested E.T.L. polarized relay. Essentially a single-pole double-throw or double-pole double-throw switch, this chopper can be arranged to operate at any frequency within the range of 10-100 *c/s and can accommodate coil resistances between* 1-12000 *ohms to suit various voltages.*

ELECTROMECHANICAL modulators, or 'choppers' as they are often called, are used to assist with the problem of d.c. amplification. In this field, their function is to convert weak d.c. signals from a transducer, such as a strain gauge, photo-electric cell etc., into a.c. form, so that amplification can be effected by means of an a.c. amplifier. A composite amplifier of this type is referred to generally as a d.c. chopper amplifier, and is free from many of the drift troubles associated with straight d.c. amplifiers.

Basically, an electromechanical chopper is an electrically-driven vibrating switch incorporating one or two changeover contacts. The magnet system is polarized and the drive coil is connected to a local source of a.c. power, which maintains continuous oscillation of the contact system at the source frequency, usually between 25/100 cycles per second, although by no means confined to this band. The chopper mechanism oscillates continually while the amplifier is in operation and must do so without maintenance attention for some thousands of hours. The contact system can be utilized in many ways, and choice is influenced by many factors. One method particularly suitable for explanatory purposes is shown basically in Figure 1 (*a*). With this arrangement the idealized voltage waveform occurring at various points in the system are as shown in Figure 1 (*b*) and from this it may be seen that the output at D is unidirectional and of a level essentially dependent on the gain of the a.c. amplifier. This amplified signal is a very close function of the original signal at A and hence may be used to operate indicating and control equipment, the power requirements for which would normally be quite incompatible with the weak signals obtained direct from the originating transducer.

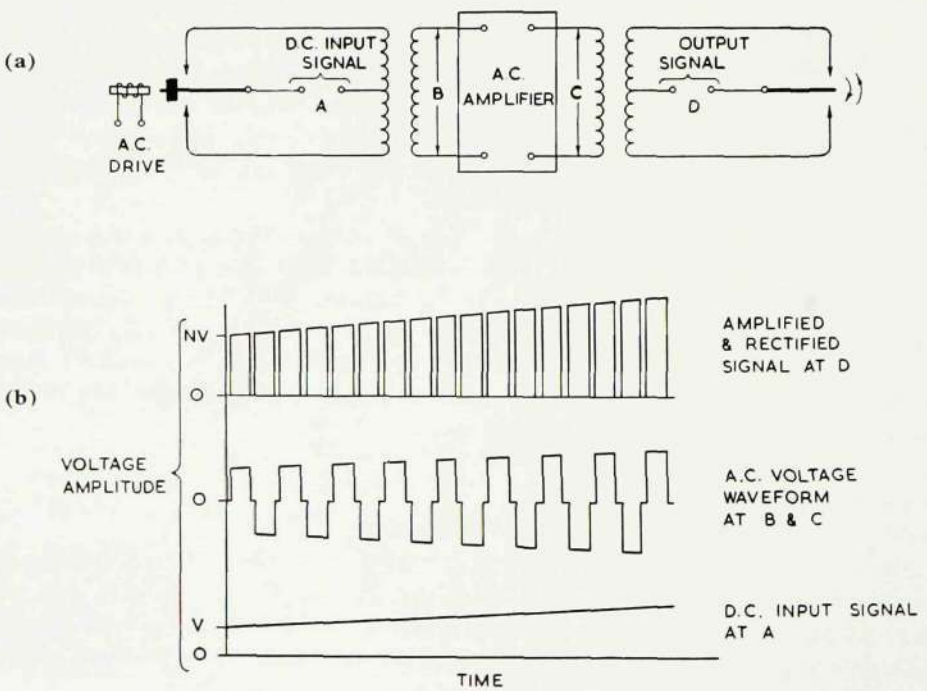


Fig. 1—Typical Contact Arrangement of a Chopper, and Idealized Voltage Waveform

It is of course evident that other ways of providing a modulating means to the amplifier are available. Transistors, thermionic valves and other devices can all be used for this purpose; nevertheless the electromechanical chopper has a wide appeal owing to the good combination of features that it can offer.

These include: (*a*) low electrical noise, (*b*) low drift (thermal and general), (*c*) high input impedance, (*d*) good life expectancy, (*e*) compactness and (*f*) reasonable cost.

Despite the apparent simplicity of the switch itself, however, the general design problem to achieve the requisite standard of performance is quite involved. A first requirement on the mechanical side is for an oscillating system of very high stability irrespective of changes in applied voltage, temperature, orientation, and adjustment throughout life. The closure period developed by the contacts must be high, usually not less than 42% of the cyclic time, while the asymmetry of dwell must not exceed 4% of the same time. Additionally, the allowable contact bounce must be limited to a few millionths of a second. Moreover, the efficiency of the driving system should be high so that the level of the energizing field is low, a factor materially conducive to a low electrical noise level. Finally, the generation of particles due to the movement of working parts must be strictly limited, otherwise particle build-up can lead to serious contact difficulties. Some further reference to this is made later when dealing with contamination.

On the electrical side, the generation of spurious voltages within the contact system is a serious problem. The principal sources of these voltages are: (*a*) stray field of the drive magnet linking with conducting materials in the contact system, (*b*) thermal e.m.f.'s which appear mainly at metallic junctions, (*c*) electrostatic coupling between the driving and output systems, and (*d*) stray current leakage between insulated metallic parts at different potentials.

With high gain amplifiers, where the input signal volts are low, the sum total of spurious voltages from all sources must be controlled within the limits of 5 to 15 micro-volts, while for medium gain amplifiers, much higher values between 1 to 2 milli-volts can be accepted. These voltages are the main constituents of the unwanted electrical signal disturbance produced by a modulator, and this disturbance is referred to variously as 'electrical noise', 'pick-up' and 'interference'. The technique of measurement is highly specialized and involves the use of high gain amplification and special circuit arrangement.

Methods of attaining the necessary low noise levels vary and depend to a large extent upon the basic design of the chopper. A fundamentally good design is one producing a low leakage field and, without constructional elaboration, capable of locating the contacts outside or on the fringe of this low field. Subsequent attention to terminal separation, conductor routing and screening is then usually sufficient to enable the desired low noise level to be reached.

The low-noise chopper, described later, is an example of this approach and is suitable for use with high gain amplifiers. Not all choppers, however, are able to reach levels much below 100 micro-volts: these are therefore confined to medium gain amplifier application unless elaborate methods of magnetic and electrostatic screening are adopted to attain the low noise levels desired.

Contact contamination is another phenomenon which can cause serious difficulty unless great precautions are taken. Its chief effect is to cause resistance instability of the contacts. Although this hazard is ever present in mechanically operated electrical contacts it is particularly emphasized in electromechanical choppers, since signal levels with which they have to deal are exceptionally low. The e.m.f. of these signals can be down to 10 millionths of a volt; hence, only slight irregularity of contact resistance will cause waveform distortion and often failure of the equipment.

Because the problem of contamination is involved, it is the subject of considerable independent research and has a wide bibliography. In this short article, therefore, only brief reference is made to principal causes and to methods of minimizing their effects.

The main factors affecting contamination are: (*a*) vapours given off by materials used in construction —mostly insulants, (*b*) by-products generated at working surfaces of the mechanism, (*c*) unsuitable contact materials, and (*d*) contaminated atmospheric conditions. Any of these can have a profoundly detrimental effect upon the useful life of an electromechanical modulator. Collectively they can ruin performance within a 100 hours or so, while under storage conditions, the presence of a quite moderate vapour concentration within the container can produce contact filming and consequent failure of the modulator to function at all. It is vital, therefore, that the greatest care is taken to minimize contamination from all sources.

Vapour concentration can be sufficiently reduced by careful selection of materials and, where necessary, by applying various treatments to them to disperse the vapour content and finally seal it off by suitable surface coatings. Additionally, vapour absorbing pellets (getters) can be housed in proximity to the

Figure 2—External and internal views of Low-noise Chopper Type 'D'

contacts, or the container itself filled under pressure with an inert gas to minimize vapour diffusion.

Foreign matter generated at the working surfaces of the mechanism can be troublesome. Particles chafed from the working surfaces migrate to the contact gaps where they become compressed, and not only cause resistance difficulties, but form pads and thereby upset the dynamic performance of the oscillatory system. Generation occurs at points in the moving system where pressure and 'rub' occur, including that at the contact tips themselves. Design should aim therefore at eliminating unnecessary actuating points and should limit any controlled friction that may be provided to 'damp' contact bounce. Contact striking forces should be carefully chosen in relation to the materials used, as there is an optimum level above which little is gained in the quality of contacting, and below which contamination rapidly increases.

Contact materials are continually under surveillance, particularly in regard to modulator requirements. Gold, and gold alloys, operating at comparatively low striking pressures in dry air, are at present the most satisfactory and are largely responsible for the longevity of present-day modulators. Of these materials, gold alloys are the more usual choice owing to their greater hardness enabling them to resist mechanical wear better.

The question of ambient contact atmosphere is one which is affected by a number of considerations, both technical and economic. A chopper sealed in a clean dry atmosphere or gas and designed for optimum performance under these conditions has better prospects of attaining a longer initial run before failure occurs than an unsealed one. When failure does occur, however, the cost of replacement or repair is comparatively high, even though, as is often the case, the actual cause of failure may be trivial. Alternatively, a chopper properly housed in a dustproof container, as in the type described below, while capable of giving an initial run of some thousands of hours, can be cleaned and adjusted on site, with an attendant saving in cost. Users generally prefer the latter arrangement, which is proving quite successful in applications where large numbers of choppers are used, in computers and the like.

Chopper Type 'D'

This is a plug-in- micro-signal chopper particularly suitable for use in high-impedance circuits where low noise level, high sensitivity and dependable operation are essential requirements.

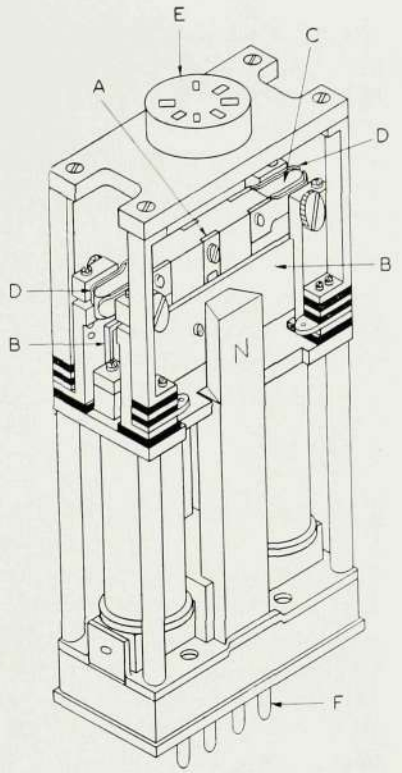
Based on the design of the well-known E.T.L. polarized relay it employs an armature assembly comprising a vibrating contact carrier mounted above two radiometal armatures and arranged between four stationary-contact pillars. The armatures, as indicated in Figure 3, are interposed between the pole-pieces of an electromagnetic and polarizing magnet system and the complete armature assembly is mass and geometrically balanced on a torsional suspension to eliminate pivoting trouble, thus ensuring satisfactory operation of the chopper in any position.

The vibrating carrier, moulded in ceramic and of high dimensional stability, carries four movable springs constructed entirely of gold alloy. This use of contact material for the springs is an interesting feature since it enables the conventional-type built-in contact to be dispensed with, without degradation of contact efficiency. Furthermore, because of the reduction in the number of automatic

processes required in production of the new contact spring, the always sought lower cost and economy of manufacture are obtained. Each spring is fixed at one end and so shaped that, as soon as it engages its associated fixed contact, full pressure is exerted. The spring flexes on impact and the spring compliance is regulated by the friction between the shaped portion of the spring and the carrier moulding against which its free end is tensioned. Thus, with this contact arrangement, the attractive performance feature of virtually bounce-free operation is provided.

Figure 3—General layout of Chopper Type 'D'

A. *Torsional Suspension*
B. *Armatures*
C. *Vibrating Contact-Carrier*
D. *Movable Contacts*
E. *B7G-Valve Socket*
F. *12-pin Connector*



To minimize electrical noise the movable springs are located well clear of the magnetic field and, as may be seen by further reference to Figure 2, all coils and connecting leads are heavily screened. In addition, the leads for the driving and contact systems are segregated, the leads being divided into two groups for separate termination to a top B7 G socket and to the lower 12-pin plug, or vice versa. This alternative means of connection not only permits considerable flexibility in both circuit and mechanical layout of the chopper's associated components but, more important, allows the chopper to be connected into circuit with the minimum length of external leads; an essential requirement in high-gain and low-signal amplifiers.

Because of the effective screening and the very low driving power requirements of the chopper, the noise level is reduced to the negligible proportions of 8 to 15μV measured at a frequency of 50 c/s. Moreover, despite any impedance that may be applied across its contacts, the noise level remains substantially unaffected.

Coils are series connected and the standard winding of each is 250 ohms for 6.3-volt, 40-60 c/s working with drive power approximating 16 mVA. Since the efficiency of the magnetic circuit permits the use of electromagnet cores of very small cross-sectional area, windings within the resistance range of 1 to 6,000 ohms can be accommodated on each core to suit various voltages and drive frequencies between 10 and 100 c/s.

Contacts may be single-pole double-throw (s.p.d.t.) or double-pole double-throw (d.p.d.t.) and can be arranged with break-before-make or make-before-break actions with closures of 48% and 51% of the cyclic time respectively. Asymmetry of contact dwell in each contact unit is within 4% of the other for both s.p.d.t. and d.p.d.t. versions.

Designed to withstand extreme temperatures between −40° to +85°C, this chopper occupies the small space of 2.56″ x 1.56″ x 0.844″ (65 x 40 x 21 mm approx.). It plugs firmly into a 12-way jack having 0.468″ fixing centres for convenient chassis mounting, or inclusion in equipment employing relay-set plates. While the contact pins are sufficient to hold the chopper in a vertical position, mounting in any other plane or in situations where abnormal vibration is present necessitates a spring clip, which is located in the jack and passes over the dustproof cover and top connector plug to retain the chopper in position.

The high degree of reliability of this chopper is emphasized by its capability to operate without attention at recommended loadings of 1V/10mA or 10V/1mA for 360 million operations—a very large number by any standards, corresponding to 50 operations every second for 2,000 hours.

As with any device, definition of life expectancy depends upon application. Should the chopper, for example, be used for loadings as high as 50 volts 500mA the expected life is approximately halved, nevertheless, this can usually be indefinitely extended by careful, periodic maintenance.

Patents *U.K. No.* 695664, *Canadian No.* 508542, *Australian No.* 162814, *Nederlands No.* 84803, *Sweden No.* 148503.

U.D.C.621.395.658:621.395.44

A LINE CONCENTRATOR USING CARRIER

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The high cost of telephone line plant required to connect remote subscribers to the exchange, highlights the need for a scheme that provides for plant reduction without affecting subscriber service. The flexible, easily maintained concentrator system described, allows substantial plant economies to be made, since it provides automatic service for 22 subscribers over four carrier links on one open wire bearer. Each concentrated-line user has all the facilities enjoyed by a directly connected subscriber.

IN sparsely populated areas, the joint use of one pair of wires by several subscribers has ever been an attractive proposition on economic grounds. Party line working, despite its complexities and restrictions, still continues to provide a useful service in situations where secrecy between subscribers is not essential and where distances are great and costs of line plant consequently high. A more recent development in this field was the Line Connector or Concentrator,[1] which provides 22 auto telephone subscribers with individual service over 4 physical lines. This equipment has found a useful place in telephone networks where shortage of cable pairs has been a problem and where, on a short term basis, it has been more economical to provide a Line Connector rather than the extra 18 subscribers' lines.

[1] *Bulletin No. 36, pp. 40-45, January 1958*

The popularity of the Line Connector has led to the development of the Carrier Concentrator which enables service to be given to 22 auto telephone subscribers using four carrier links.

The use of carrier increases the working range of this equipment to distances approximating 200 miles over open overhead lines, depending upon the gauge of wire used. It also enables one open-wire pair to provide communication for 22 subscribers in place of four open-wire pairs normally required between the exchange and the Concentrator. Depending on the distance involved, the cost of carrier equipment can show considerable savings over the cost of the provision of equivalent line plant.

DESIGN CONSIDERATIONS

In the design of the new Concentrator the main considerations taken into account were as follows:

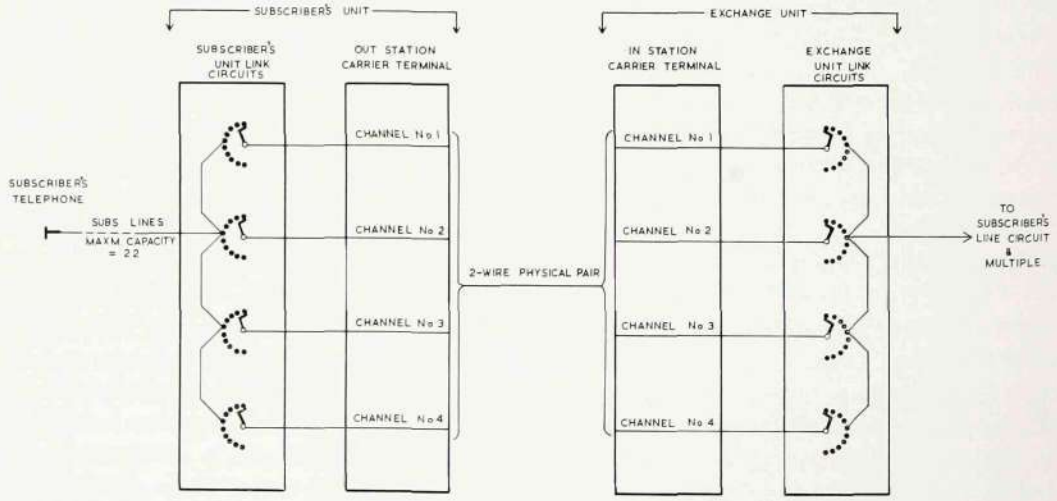

Figure 1—Trunking Arrangement of Carrier Concentrator

(*a*) Subscribers connected to the Concentrator to enjoy full facilities as offered to any ordinary subscriber in the network.

(*b*) Both carrier and switching equipment to be economic, robust, easy to install and capable of long usage with the minimum of maintenance. In particular, the outstation equipment should be as small as possible consistent with reliable operation.

(*c*) Transistor circuits to be used throughout and to operate at ambient temperatures up to 50°C.

(*d*) Low-voltage operation of the outstation to permit use of small battery accumulators if necessary.

(*e*) Provision for battery charging over the phantom of the single physical pair used for the carrier channels.

(*f*) Since the number of subscribers in an area suitable for service via a Concentrator approximates twenty, the Concentrator should serve 22 subscribers, this number being equal to the maximum available outlets on a 25-outlet single-motion switch.

(*g*) Four link circuits to be provided to carry the estimated traffic and ensure an acceptable grade of service.

Trunking Arrangement

Figure 1 indicates the trunking arrangement of the Concentrator. Essentially the system consists of an 'out-station' unit and an 'in-station' unit connected together by four carrier channel links. Each end of the link is connected to the wipers of a uniselector, the bank contacts of which are connected at one end to the subscribers' lines, and to the exchange-line circuits and the associated final selector multiple at the other. Calls to and from the subscribers are connected by causing the two uniselectors to step in unison until the appropriate contacts are reached.

Mechanical Layout

Figures 2 (*a*) to (*c*) show the physical layout of the subscribers' unit of the Concentrator. The equipment is completely enclosed by a lift-off cover which ensures the exclusion of dust.

The four carrier circuit panels are mounted at the top of the unit. Each panel approximates 20″ x 7″ x 3½″ (51 x 18 x 9 cm) and accommodates a maximum of nine plug-in units interconnected by a main printed-wiring card with associated leads terminating

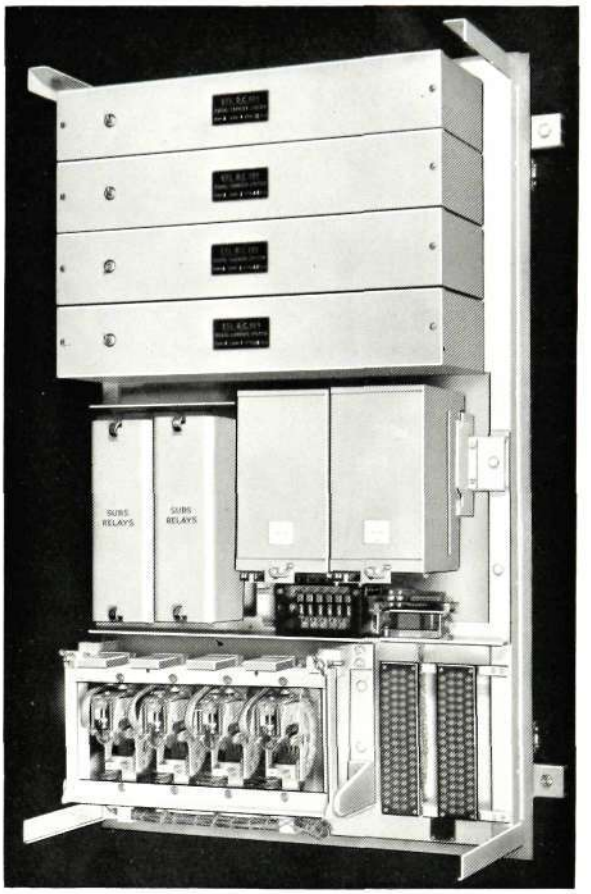

Figure 2(*a*)—Typical Subscribers' Unit fully equipped

on an individual tag panel. Cable entry is provided in the rear of each panel. The plug-in feature of the equipment enables personnel unaccustomed to carrier equipment to maintain the apparatus by a process of substitution, faulty units being returned to the base workshop for detailed attention.

The link circuit relays and switching equipment are mounted in jack-in relay sets incorporating two circuits per base, while the associated uniselectors are mounted on a hinged 'gate' below. Adjacent to the gate, provision is made for the subscribers' cable terminations and a cross connection field for change of location of subscribers. Mounted immediately above the cable termination blocks is a transistor ringing unit.

For the exchange unit (not illustrated) no special layout has been planned, since the Concentrator can be connected to any type of automatic exchange and therefore the equipment would be arranged to suit the existing equipment of the exchange.

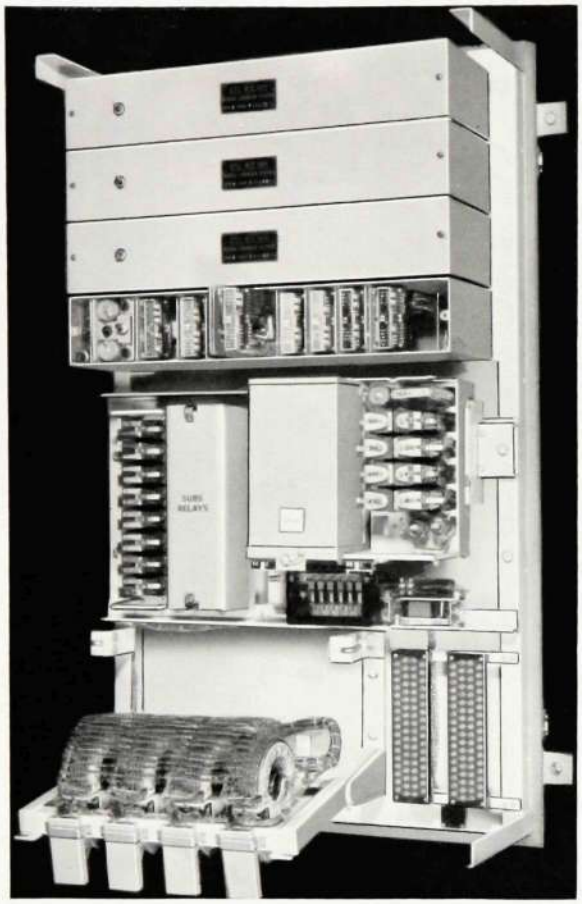

Figure 2(*b*)—View of Subscribers' Unit with some equipment covers removed, a carrier transmit plug-in unit partially withdrawn and hinged gate down

CIRCUIT DESCRIPTION OF SWITCHING EQUIPMENT

Subscriber-to-Exchange Call (Figure 3)

When the Concentrator subscriber lifts the handset to originate a call, a telephone loop is completed between the A and B wires to cause the earth detectors at all free links to respond and the 'go' carrier to be transmitted.

At the Exchange unit an allotter circuit allocates a free link and the appropriate FL relay is operated together with relay RLA. Contact RLA 1 completes a local loop at the exchange unit to operate relay ST. A 'start' earth extended to the 'M' lead via ST1 causes the 'return' carrier to be switched on to operate the high-speed relay HS and relay A at the subscribers' unit.

On seizure of the free link at the Exchange unit, relays ST, PA and STA operate in sequence. Relay P is operated at 10 i.p.s. and the 'return' carrier is pulsed at this frequency by the action of contact P1.

At the subscribers' unit, a conventional impulsing circuit comprising A, B and CD relays accepts the pulses to cause the S switch to step in unison with the J switch at the exchange end. Immediately the S switch steps off normal the 'go' carrier is switched off. This state continues until the calling subscriber's line loop is detected by the earth detector via arc S4, whereupon the 'go' carrier is again transmitted to the exchange unit where earth is applied to the E lead via ON1 operated, to hold relay PA and maintain the 'return' carrier on. This causes the S and J switches to stop driving.

Relays KA and CD release, the calling subscriber's K relay operates and CD releases relay B. On the release of relay KA the loop is extended to the subscriber's exchange line circuit, and earth is returned on the P-wire to operate relay H. This relay releases STA and all other relays including FL. Relay FL released permits another FL relay to operate and allocate another free link to deal with the next call. Thus, during the call, only relays K, A and HS in the subscribers' unit and relay H in the exchange unit are operated. The call proceeds as

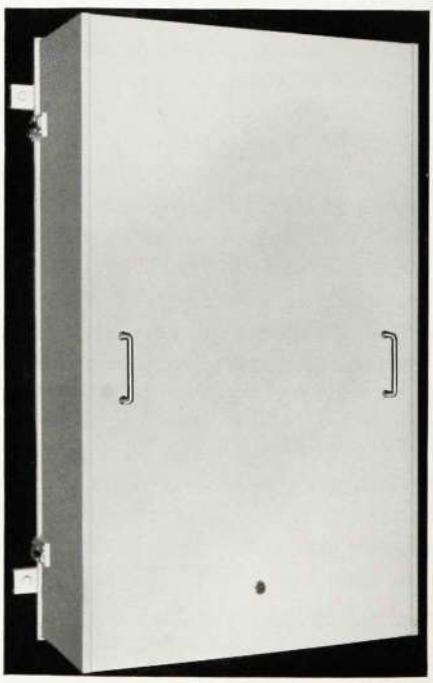

Figure 2(*c*)—Unit enclosed by dust-proof cover

for a normal call, dialled pulses from the subscriber's dial causing the 'return' carrier to be switched on and off. This results in loop disconnect pulses being transmitted by RLA1 to the exchange switching equipment.

Exchange-to-Subscriber Call. (Figure 4)

A call to a Concentrator subscriber proceeds in the normal manner at the main exchange and the subscriber's final selector is seized. An earth is applied to the P-wire and extended via the diode D1 into the pre-allotted free link 'M' lead (FL operated) to switch the 'return' carrier on.

At the subscribers' unit, relays A and B operate as before. An earth is applied by contact BI to cause the earth detector to operate and switch the 'go' carrier on, relay ST operating at the exchange unit to the loop supplied when the 'go' carrier is switched on.

With the start relay already operated, the S and J switches step in unison in the manner described for a subscriber-to-exchange call. In this instance, however, the required subscriber is recognized by a level sensitive detecting relay ET. Contact ET1 maintains the 'return' carrier, and holds PA. Relay KA releases and H operates to the earth on the P-wire to cause all other relays to release in sequence.

During the stepping of the switches, relays B and CD in the subscribers' unit hold, but when the called subscriber's line is found, A holds and CD and B release slowly.

At the Exchange end, with H and KB operated, ringing is applied to the 'M' lead (transformer feed) to cause the 'return' carrier and hence the HS relay to respond to ringing frequency. Relay A holds during the full cycle of ringing but RR responds to ringing current only. Contact RR3 causes the transistor ringer to generate ringing current during the main exchange ringing periods and this is applied to line at the proper interrupted frequency (at RR1 and RR2) to ring the called subscriber.

When the called subscriber answers, the loop operates the earth detector equipment to cause the 'go' carrier to be switched on. Relay FA in the Exchange link operates and FA1 trips the exchange ringing. Relays KB and FA release and the line is extended at KB2. Both calling and called parties are connected through and conversation may proceed in the normal manner.

Release

The circuit has been designed for calling party release, relay H being the controlling relay. If the concentrator subscriber is the called party, relay H is controlled by the P-wire earth applied under control of the main exchange calling subscriber. On the other hand, if the Concentrator subscriber is the calling party and clears down first, the 'go' carrier is switched off to disconnect the holding loop for the exchange equipment. When the exchange equipment releases, earth is removed from the P-wire to release relay H. With the release of relay H the return carrier is switched off, the uniselector switches are 'homed', and the circuit is returned to normal.

Carrier Equipment

The basis of the carrier equipment is the RC 101 Rural Carrier System,[2] which is fitted for this application with special signalling units in place of the standard types. These enable each carrier circuit to fulfil the requirements of a link between the two sets of Concentrator switching equipment.

Junction working over a carrier circuit is normally achieved in the RC 101 system by using an 'E & M' signalling unit in conjunction with an external relay set at each terminal. The details of these relay sets vary according to the particular type of exchange equipment with which the carrier installation is to be used.

With the Carrier Concentrator the exact requirements are known and it is possible to design signalling units to operate directly into the switching equipment with a consequent saving in space and expense.

The carrier circuits are 2-wire for speech and subscriber-exchange signalling, but 4-wire for Concentrator switching purposes.

Signalling

Subscriber-to-Exchange Call

The subscriber end of the link employs Signalling Unit Type 4, shown in Figure 5 together with external connections to indicate its function. An earth applied to the 'B' lead, via contacts in the switching equipment, causes the 'go' carrier to be transmitted to line. This is effected electronically, with negligible distortion, by using the voltage drop across one coil of relay RLA and a resistor to bias a previously non-conducting germanium diode in the

[2] *Bulletin No. 42, pp. 39-46, January 1961*

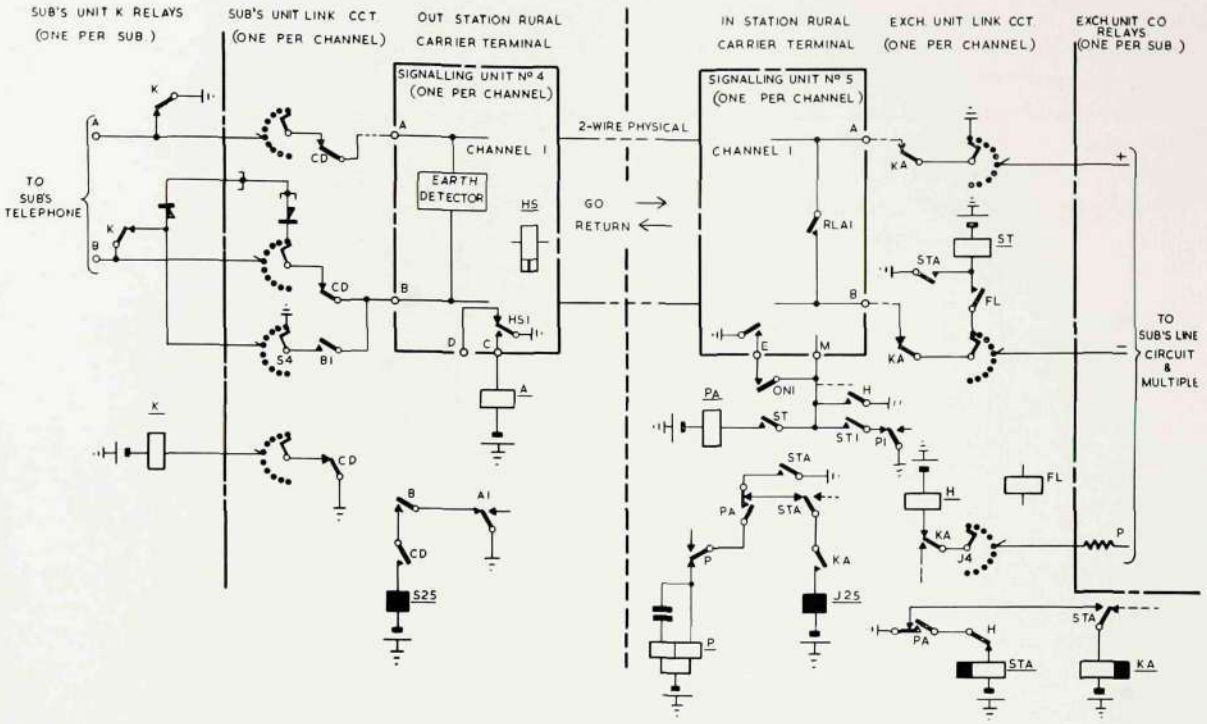

Figure 3—Simplified schematic for Subscriber-to-Exchange call

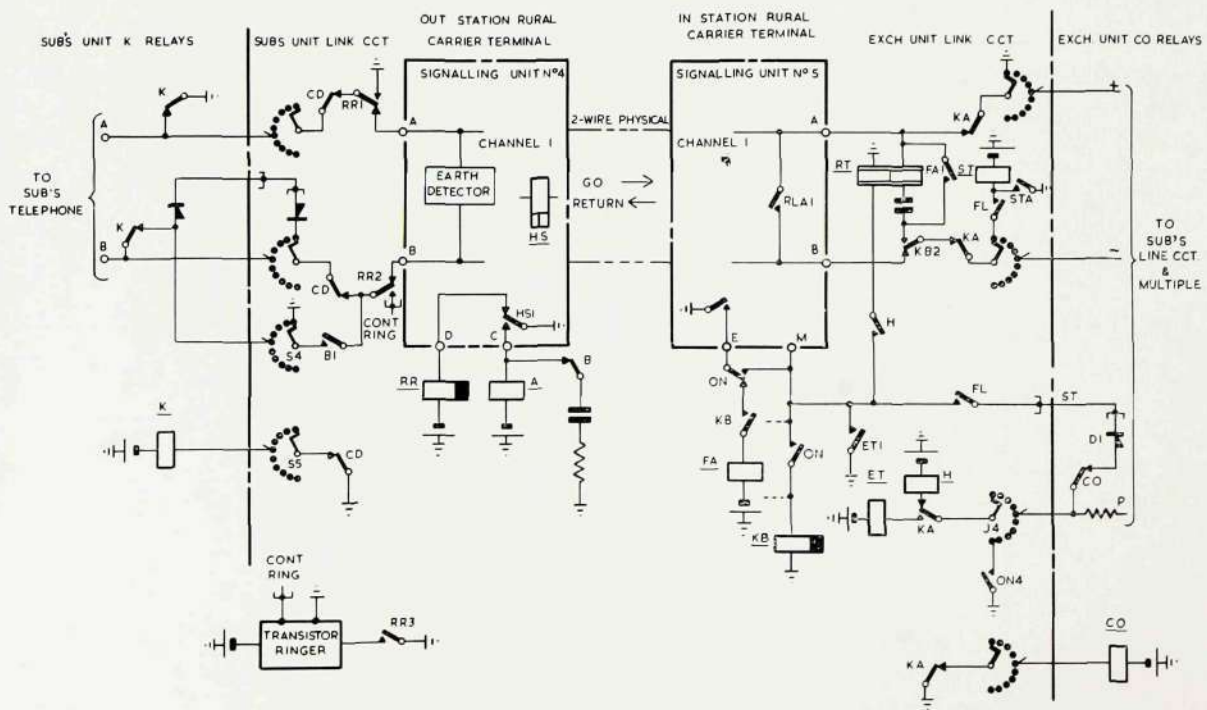

Figure 4—Diagram illustrating Exchange-to-Subscriber call

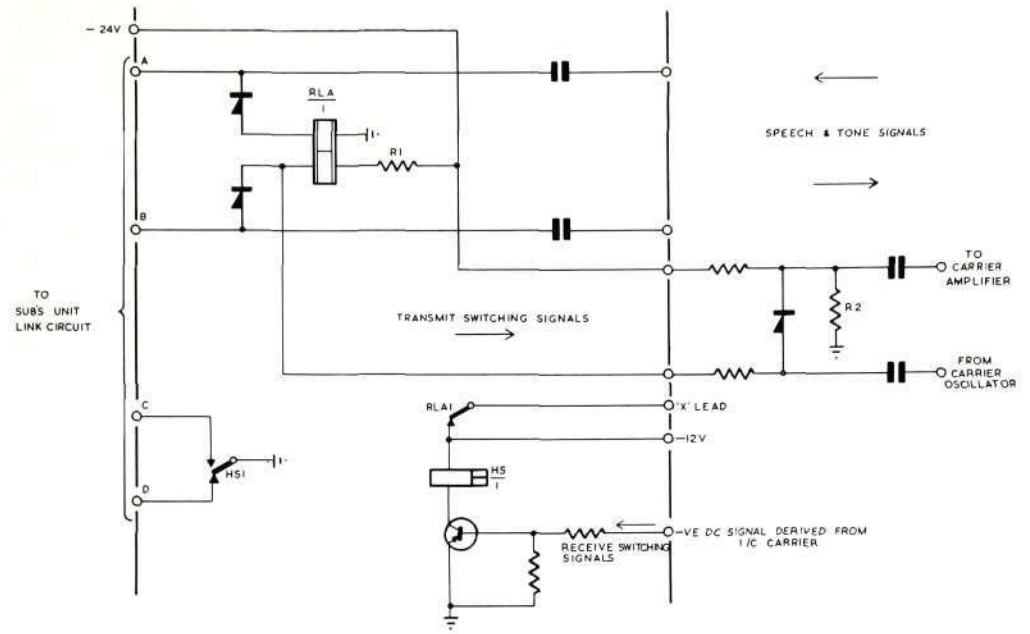

Figure 5—Out-station Signalling Unit (Type 4) basic circuit

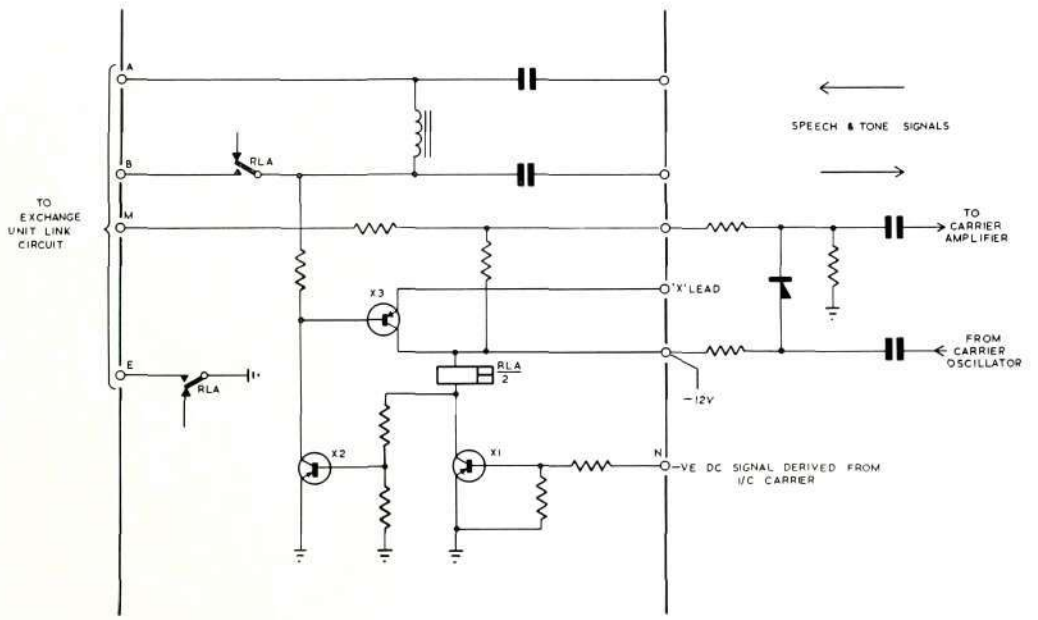

Figure 6—In-station Signalling Unit (Type 5) basic circuit

forward direction. This diode is interposed between the carrier oscillator and the modulated amplifier and forms part of the standard RC 101 equipment. The above components constitute the 'earth detector' depicted in Figures 3 and 4, and either a direct earth on the 'B' lead as received from the switching circuits, or an indirect earth via the subscriber's line when the subscriber's handset is removed, will result in a voltage drop across RLA and R1.

At the exchange or in-station terminal the received carrier is selected from any other signals on the line by a bandpass filter and then amplified and rectified. The direct current obtained is applied to the input N of the receiving part of Signalling Unit Type 5, shown in Figure 6. The incoming carrier results in a potential at N negative with respect to earth, and this causes the transistor X1 to conduct, operating relay RLA. Transistors X2 and X3 are used to switch on the 12V supply to units in the carrier equipment (powered via X in Figure 6) which remain quiescent between calls to conserve current. The relay is a high-speed type with two changeover contacts, both of which are required for use in conjunction with the automatic switching equipment. The employment of X2 and X3 instead of a relief relay saves space and expense.

When RLA operates, an earth is applied by one of its contacts to the E lead. The application of this earth, within about 5 mS of the application of the earth to the 'B' lead at the out-station, enables the switches at each end to step as described under Switching Equipment.

An earth applied to the 'M' lead at the exchange terminal causes current to flow through R1, the voltage drop across which biasses the carrier gating diode 'on' as at the subscriber terminal. The return carrier is therefore transmitted to line and at the receiving (subscriber) end is amplified and rectified. The resulting direct current is injected at point N on the Signalling Unit Type 4, operating relay HS via X2. Contacts of HS provide an earth to operate the concentrator switching equipment. This earth is applied and removed in synchronism with the earth imposed on the 'M' lead of the exchange signalling unit. The switches at each end are thus enabled to step in unison as explained in the description of the switching circuits.

After the exchange switching equipment has been seized, dial tone, busy tone, etc., modulate the return carrier and are detected in the normal way to be heard by the subscriber.

When the subscriber dials, the loop current is used to bias the gating diode on and off. The interruptions caused thereby in the 'go' carrier are reproduced at the exchange terminal as interruptions of the d.c. loop presented to the exchange switching equipment (Figure 3, contact RLA1). The function of the signalling units may therefore be summarized as the provision of earth-connect E and M signalling conditions at the exchange terminal for operation of the Concentrator equipment, and loop-dialling conditions for application to the exchange switching equipment.

The signalling unit at the subscriber's end also provides, via RLA, a means of feeding microphone current to the subscriber's line.

During the call, the 'go' and 'return' carriers are amplitude modulated by speech signals in the usual way. A limiter in the Rural Carrier equipment restricts the maximum modulation depth to approximately 70%, thus ensuring that excessive speech signal levels cannot interrupt the carrier and disconnect the call.

Exchange-to-Subscriber Call

Application of an earth to the 'M' lead on Signalling Unit Type 5 switches on the 'return' carrier, and the Concentrator switching equipment operates at both ends via the carrier circuit as previously described.

When ringing signals are applied via a transformer to the M lead, the carrier gating diode is biassed 'on' and 'off' at the ringing frequency. The resultant intermittent carrier signal causes the HS relay in the out-station signalling unit to respond in a similar manner. An intermittent earth is applied via an HS contact to the switching equipment which generates ringing current for application to the subscriber's line.

When the subscriber's handset is removed, the loop current switches on the 'go' carrier as for a call originated by the subscriber, and the call proceeds in the usual way via the carrier link.

The speech signals in each direction cause amplitude modulation of the appropriate carrier, in the normal manner.

Use of Physical Line

The use of the physical line for one of the link circuits is not very attractive as it would require different treatment from that applied to the carrier-borne circuits for switching purposes.

It is sometimes possible to charge the out-station battery over an earth-phantom circuit employing the physical line, provided a sufficiently low resistance line is in use. A special Line Unit is then fitted within the carrier equipment, containing a simple low-pass filter to enable the d.c. phantom connection to be made.

The physical pair may also be used, via the above filter, as an engineering or order-wire circuit.

Power Supplies

The switching equipment in the exchange unit is designed to operate at a nominal 50 volts and the subscribers' unit at 24 volts with permissible voltage variation of ± 4 and ± 2 respectively.

The basic carrier equipment operates from 12 volts and this voltage may be derived from the 50-volt or 24-volt switching equipment battery by a regulator unit, which also serves to decouple the carrier equipment from ripple or noise voltages. Current consumption in each carrier panel is 40 mA during a call, but only 10 mA between calls and for this reason a simple voltage-dropping resistor cannot be used. Alternative operation from a.c. mains voltages of 90 to 120 and 200 to 250 at 40/60 c/s is possible by substituting an a.c. power unit for the regulator unit.

Since each panel accommodates its own plug-in or regulator unit, failure of a unit affects only the associated link circuit.

Conclusion

The new Carrier Concentrator offers a satisfactory solution to the problem of providing telephone service in locations where a low calling rate prevails and where conditions are dominated by economic and practical considerations. The telephone service the Concentrator provides is comparable in both feature and quality to that of a direct exchange line. Moreover, because of the use of standard switching equipment and plug-in carrier units, maintenance requirements are reduced to the minimum, a major consideration when skilled labour is not available. Important too is the system's flexibility made possible by its low power requirements and the ease and rapidity of its installation. For example, the Concentrator may be utilized to provide fully automatic service to blocks of residential flats as an alternative to a p.a.b.x., or used to serve housing estates or any exchange fringe area where the cost of providing line plant would be prohibitive. In addition, by its use, the installation of small unattended rural community exchanges may be avoided, seasonal traffic conditions catered for, or temporary service given for mobile exhibitions or when plant alterations are in progress.

U.D.C.621.395.61

THE 'ETELUX'

A NEW SMALL-SIZE TELEPHONE

The article describes a new telephone set recently developed by the Company to meet the increasing demand for a versatile instrument of small size, light weight and pleasing appearance.

Named the 'Etelux', and available in a range of attractive light-fast colours, this easy-to-handle, compact telephone has a flexibility of design permitting the provision of all types of conventional service for both residential and business subscribers. Equally suitable on table or wall, the new set may be used as a simple extension instrument with or without ringer, or may be connected directly to auto/cb exchange lines or 2-party lines including those with party identification facilities; (e.g. Dial Message Rate, Auto Ticketing, 2nd-Tip Party etc.). The transmission performance conforms with B.P.O. and international standards, and the components used throughout are designed to give efficient trouble-free service under temperate or tropical conditions. Dial illumination is provided as an optional extra.

AMONG the many factors that contribute to the popular acceptance of a modern telephone, attractive appearance and convenience of use stand in prominence. To an Administration, an instrument incorporating these features must be suitable for table or wall use, easy to install and maintain, in limited space if necessary, and have a high standard of transmission efficiency over short or long lines. Furthermore, the basic design must enable optional features to be added to meet a subscriber's particular needs. From the user's standpoint, the telephone must be available in a range of colours to suit personal tastes, and small enough to be placed in a position where space may be limited. In particular, the instrument must be easy to operate wherever installed, or even when held in the hand.

These points were kept in mind in designing the Etelux. The end result has been a small, lightweight, efficient telephone set of distinctive appearance and flexible design, suitable for all conventional types of service. Because of its small size, it is ideally suited for convenient use on small desks and tables or when mounted on the wall. A typical location is shown in Figure 1.

The carefully selected soft-tone colours in which the Etelux is offered to meet the varying requirements of different decorative schemes are:

AQUA JADE LIGHT IVORY ALICE BLUE
ROSE GREY DUSKY PINK

The new set is approximately one third the size and less than two thirds the weight of a conventional table instrument. These considerable reductions are due largely to the use of reinforced plastic for the outer shell and base, the avoidance of any metal chassis for component mounting, and the application of standard but lightweight components. An additional and important influencing factor was the decision to provide the ringer assembly as a separate unit to give the telephone greater flexibility of use.

External Design

In the design of the Etelux, both external appearance and ease of use have received as much specialized attention as the instrument's technical performance. The low aspect and simple lines of the set are emphasized by the smooth blending of handset, dial and cover, and by avoiding the total concealment of the base when the cover is in position. To simplify cleaning, all exposed surfaces of the instrument are smooth.

The cover and cradle is a one-piece moulding of a plastic copolymer (acrylonitrile–butadiene–styrene), a tough yet lightweight scratch-resistant material,

Figure 1—The Etelux on a bedside table

incorporating the important characteristic of good colour stability and capable of withstanding very rough usage without damage. The wells formed in the cover are so designed as to provide a stable rest position for the handset, and the slightly recessed areas at the front and rear of the cover provide an effective handhold for lifting the telephone complete. When lifted, the set may be held comfortably in the palm of the hand, the handset removed and a number conveniently dialled.

The lightweight and comfortable handset is moulded of the same material as the cover and conforms in general shape and features to that of the Etelphone, with the exception of the mouthpiece. This has the usual acoustic cavity and customary annular pattern of holes, but has no lip; this ensures that the handset falls into the correct position in the cover wells when it is replaced after use. The transmitter capsule is of the immersed-electrode carbon granule type, and the receiver capsule of the rocking-armature pattern. These components, combined with others in the telephone circuit give a transmission performance equal to B.P.O. and international standards.

The cover fits closely to the base by concealed mating surfaces and is secured by two captive screws in metal inserts in the cover moulding. When the screws are released, the cover can be lifted clear to reveal all components on the base, as shown in Figure 2, thus simplifying adjustment and maintenance.

Internal Design

The Base

The base, insert-free and with an area little more than half that of a standard instrument, is moulded in a tough resilient grade of polystyrene. Its exposed portion is finished in a light beige colour, blending well with the instrument's colour range. Terminal strips, provided in ribs moulded into the base, are distributed around the inside edge of the base for ease of access. Simple 'break-ins' at each end provide choice of entry for the line wiring.

Because of the light weight of the telephone, special attention had to be paid to prevent the instrument from slipping during dialling. This

Figure 2—Interior view of the Etelux, with dial removed from its mounting.

difficulty was overcome by covering the underside of the base with a neoprene mat, moulded with a waffle pattern on its bottom surface. In addition to resisting the movement of the telephone, the mat also serves to prevent damage to polished surfaces on which the telephone may be standing.

Cradle-Switch

A simple design of cradle switch is employed. The switch consists of a spring-loaded plunger bracket and an associated comb-operated springset, both arranged on a common mounting plate riveted to the base. The plunger bracket, pivoted on two uprights of the mounting plate, has on its transverse bar a lower projection bearing directly against the contact-operating comb of the springset when the telephone is idle. At each end of the transverse bar, two arms extend in the horizontal plane and are so shaped at their ends as to firmly engage the slots formed in the underside of a single clear plastic plunger. This operates with an adequate margin of safety on contact of earpiece or mouthpiece when the handset is replaced, and slides freely within the limits allowed by its elongated slot which moves about a metal guide pin inside the cover. A liberal plunger slot in the cover well and sufficient restoring-spring pressure eliminate any possibility of plunger sticking, and ingress of dust through the slot is minimized by projecting flanges on the plunger which bear against the inner surface of the cover when the handset is removed.

The cradle switch springs are nickel silver, with twin palladium contacts, and the specified pressures are ample to ensure reliable connection. Protection of the contacts from dust is provided by a transparent clip-on cover.

Dial

When the instrument is assembled, the dial is slightly recessed in the cover. Because of this,

the needed mechanical protection of the dial is automatically obtained, inadvertent rotation of the finger-wheel minimized, and a more streamlined appearance secured. A further contribution from the appearance standpoint is the pleasing silver-gilt finish of the plastic finger-wheel.

For convenience of viewing and ease of use, the dial is offset at a slight angle and, on a table set, the designations on the number plate are positioned above centre since the dial is normally seen from a relatively low angle. Conversely, when the set is converted for wall use, the dial characters are arranged below centre.

To ensure reliable operation, the dial mechanism and springsets are protected by a transparent cover, and palladium is used for the pulsing contacts to avoid high contact resistance.

When required, low-voltage dial illumination can be provided. This is a useful feature allowing easy location of the instrument in the dark or the set to be used in conditions of half-light where it is difficult to read the dial characters. The illumination is provided by a small flash-light type bulb, mounted on a hinged trap in the base and positioned beneath the number-plate in the region underneath the 8 and 9 holes of the finger-wheel. The lamp is readily replaceable by the subscriber, since the hinged trap is easily raised, being designed to accept the tip of the finger or a small coin.

The number-plate, uniformly lit over its entire area, is a relatively thin piece of plastic, painted translucent white and having black moulded-in characters on the back to prevent defacement by use. Subdued illumination is provided when the telephone is idle, but on removal of the handset the light is intensified to full brilliancy. A slide switch, placed conveniently to hand in the base, enables the user to switch the subdued light on or off to suit personal preference.

Power for the lamp is obtained from a 6-volt transformer plugged into the mains. This transformer, because of differing voltage supplies and outlet sockets at subscribers' premises, is not supplied with the instrument, but may be purchased locally where conditions and requirements are known.

Auxiliary-Services Key

Provision is made for the inclusion of a press-key adjacent to the dial-light switch so that a number of special service features can be added according to the needs of the subscriber. The key, similar to the dial-light switch but with a non-locking action, may be employed for party-line working or to provide operator re-call or transfer facilities.

Transmission Components

The transmission components on the base comprise an induction coil, capacitors and resistors. Because of the sensitivity of the transmission circuit an auto regulator unit and click suppressor are also included.

The regulator unit, clearly seen in the right-hand corner of the base (Figure 2) enables the installer to adjust the line current for best transmission whether the line is short or long, thus ensuring all-round efficiency on both local and long-distance calls. The printed-wiring layout of the unit is connected to the telephone circuit by a single lead of the handset cord and by four terminal screws which also serve to retain the unit in position. With this method of fixing, the need for plug-in contacts is avoided and thus the electrical efficiency of the regulator is unaffected by adverse atmospheric conditions.

When the regulator is not required, it is a simple matter to withdraw the device and terminate the handset-cord lead to another terminal provided for this purpose.

The click suppressor, consisting of a simple rectifier arrangement, is connected across the receiver circuit to prevent any risk of an acoustic shock to the user, arising from the inevitable pulses of energy applied to the line by switching operations.

Wiring and Cords

The telephone is wired with p.v.c.-insulated wire in various colours, allowing ready identification. With the exception of stranded wire used for connections to the dial, all other terminations are made by $6\frac{1}{2}$ lb/mile wire.

Both the line and handset cords are designed for long and trouble-free service even under tropical conditions. The extensible handset cord is of the 'soft-pull' type and capable of extending six feet without exerting considerable pull on the telephone. It has, in common with the line cord, spade-shaped tags for easy termination or removal, and p.v.c. insulated leads covered overall with an outer layer of clear plastic insulation. The leads are marked at regular intervals throughout their

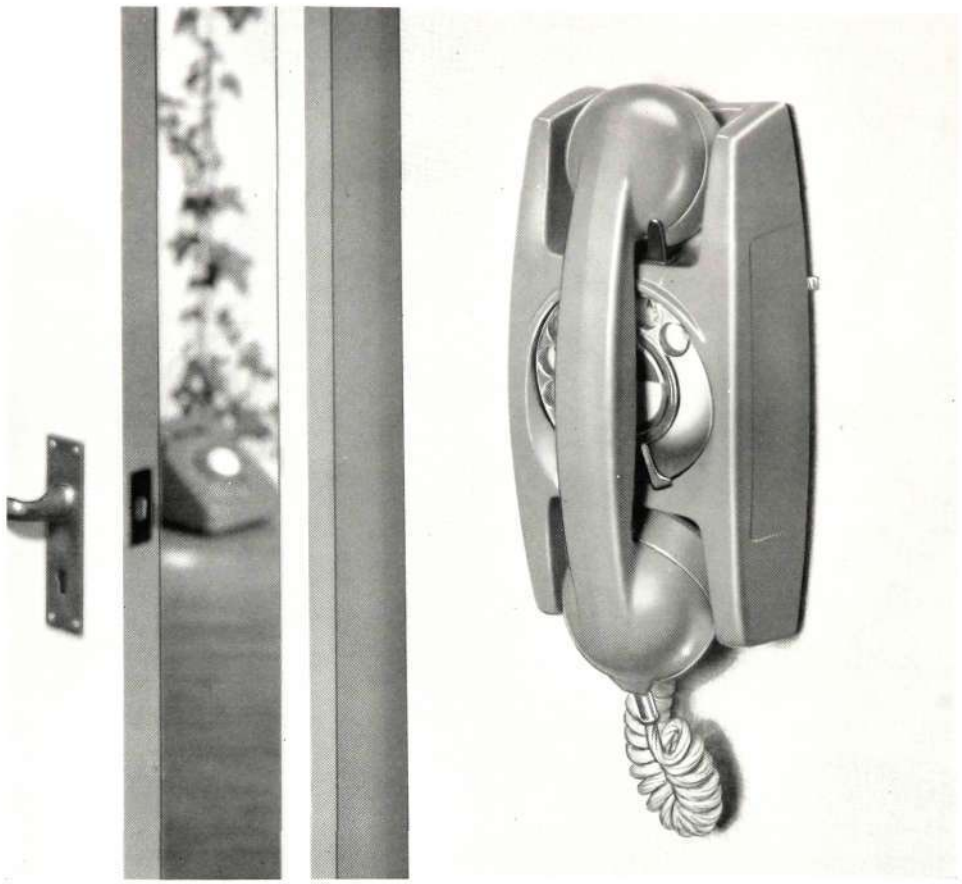

Figure 3—General view of Etelux, wall mounted

entire length with individual identification colours and these, visible through the transparent outer covering, present an unusual but very attractive appearance.

Connections of the line cord to the incoming line are made via the terminal strip in the ringer unit. Alternatively, when the instrument is used as a simple extension and the ringer unit dispensed with, connections are completed at a small, unobtrusive terminal box moulded in reinforced polystyrene.

Cord anchors hold the cords at their entries in the telephone, handset, and ringer unit or terminal box, thus preventing strain on the conductors.

Ringer Unit

The ringer unit designed for use with the Etelux has overall dimensions 6 ins. long, $3\frac{1}{2}$ ins. wide and $1\frac{7}{8}$ ins. deep (152 x 89 x 48 mm.) and consists of a single-gong ringer assembly, together with a 7-terminal connecting strip for the termination of line cord, line wires and lamp leads. The terminal strip is arranged above the ringer; both units are mounted on a rigid zinc-plated metal baseplate and enclosed by a robust plastic cover (coloured beige) secured to the base by a captive screw.

Twin coils are used in the ringer, each coil being of a value permitting the same ringer and telephone to be used for individual or 2-party lines, including those requiring party identification facilities. Simple adjustment of strapping in the telephone introduces the appropriate arrangement. Where party-line working is not required, coils of various standard resistance values may be fitted to suit an Administration's particular needs.

When the instrument is for party-line application, the ringer can be supplied biased to prevent the bell from tinkling when dialling is in progress on the partner telephone. A feature of the bias spring is that its adjustment is not restricted to the usual choice of a given number of positions, since the spring is so

arranged as to permit its movement by finger-tip pressure to any position between the non-bias and full bias locations. Thus, exact bias can be applied.

To permit the loudness of the bell to be adjusted to a suitable level, for reasons of convenience or where noise must be kept to the minimum, ringing-volume control is provided by an adjustable lever located at one end of the base.

Wall Mounting

The Etelux as a wall-mounted telephone is shown in Figure 3. Its conversion from table to wall use is a simple matter, requiring the fitting of a cradle bracket to ensure stable vertical hang-up, and the changing of the dial number plate for another to give increased visibility of the dial characters. For dial-light telephones a wall-fixing bracket is also required.

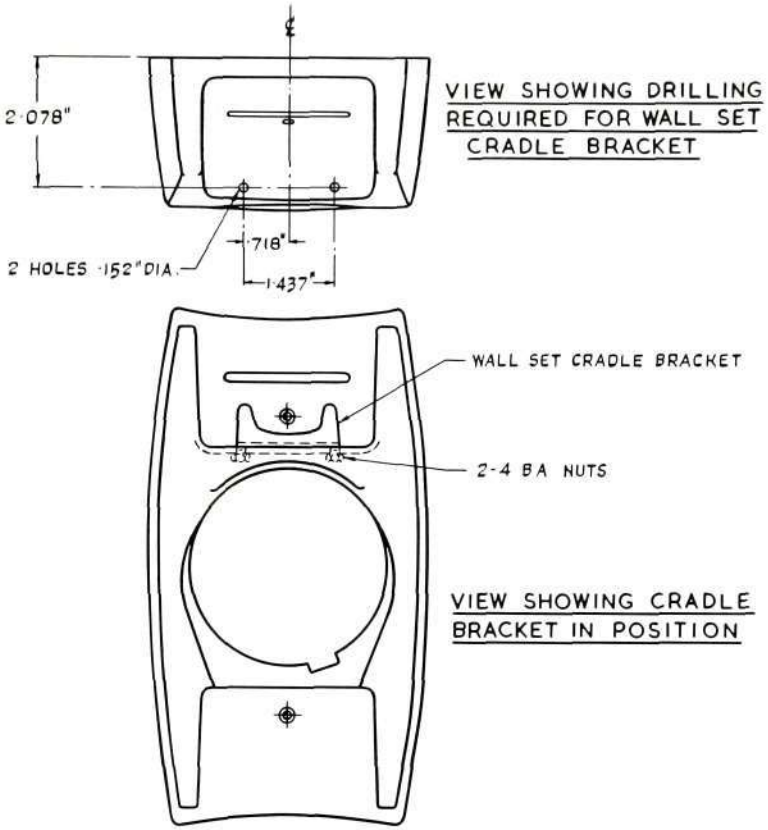

Figure 4—Fixing details for cradle bracket on wall version

Instruments can be supplied complete as wall telephones or, alternatively, to suit Administrations wishing to stock table instruments only, and subsequently convert as requirements demand, the appropriate parts can be made available to allow conversion operations to be done at some convenient central location. With the set of parts, a simple template is included to facilitate the correct drilling of the two holes necessary to accommodate the cradle bracket, as shown in Figure 4.

When a dial light is included, the instrument is mounted on a double folding bracket, hinged at its lower end. By releasing one small captive screw in the apex of the mounting, the bracket can be opened out to bring the telephone forward and provide easy access to the base for replacement of the dial lamp in the event of failure.

Conclusion

The Etelux is a further step forward to the improvement of the telephone, particularly from the standpoint of appearance and its capability to make the chore of telephoning as effortless as possible. The high degree of flexibility maintained in its basic design must also be considered a major contribution to this end.

While it is not possible at this early stage to assess the full appeal of the new instrument, several Administrations, after proving the instrument to their own satisfaction by extensive field trials, have already decided to adopt it to meet the special requirements of discriminating subscribers. Because of this, it is confidently felt that similar decisions will be made by other Administrations in the near future, thus proving beyond doubt the popular acceptance of the Etelux.

Design Registrations:—U.K. No. 902938, South Africa No. R421/61.
Design Applications:—Australia No. 42817, Canada No. D28435, New Zealand No. 9040.