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ERICSSON TELEPHONES LIMITED

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A Modern House Exchange

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and

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The House Exchange described has been designed to augment the existing range of key-telephone systems. It is particularly suitable for use in businesses where the calling rate between stations is high and where there is an immediate or future need for external stations or tie lines.

KEY telephones are becoming almost universal in every-day communications and form the basis of a wide variety of systems developed to meet the different requirements of private telephone installations. As a useful addition to the available range, a modern House Exchange has been introduced primarily for use in businesses and large private residences where the demand exists for a reliable system offering a high internal/external traffic ratio in addition to a comprehensive range of facilities. Designed in conjunction with the B.P.O., it employs press-key control throughout and basically provides access for a maximum of 11 telephone stations to 2 exchange lines, and communication between stations.

Although essentially an internal system with stations interconnected by multiple cable, it includes provision for 2-wire (non-multiple) stations and tie-lines in lieu of up to four internal (multiple) stations. This aspect of the system is of considerable significance to the

Figure 1—Multiple station telephone with associated wall-mounting terminal block

Figure 2—Non-multiple station telephone

expanding business with requirements for progressive and economical extension of telephone service to remote locations within the organization, or the integration of the House Exchange with an identical or similar system.

EQUIPMENT

Telephones

The telephones employed are of two types; multiple and non-multiple, as illustrated in Figures 1 and 2. Both present a neat and pleasing appearance approved by the Council of Industrial Design and are equipped with identical high-performance transmission circuits. The light-weight handsets and the instrument covers are moulded in a tough ABS copolymer and either telephone can be produced in a wide range of light-fast colours compatible with modern furnishing schemes. Other main features include convenient press-key array, simple lamp signalling (exclusive to multiple-station telephones) and straightforward internal layout, with easy access to all parts.

Relay Sets

A single Exchange Line Relay Set serves all stations. It accommodates answering and signalling apparatus and includes also a transistor device for current regulation of the station signalling lamps. With this device, maximum lamp life is ensured irrespective of the number of station telephones initially installed. The relay set (see Figure 3) has overall dimensions $12\frac{1}{8}''$ long, $7\frac{5}{16}''$ high and $8\frac{3}{4}''$ deep (308 : 186 : 222 mm) and is suitable for table or wall mounting.

Relay sets of similar size are employed for tie-lines and non-multiple stations and are provided on a one-per-circuit basis.

Auxiliary Units

One of the multiple stations (selected as ' The Main ') is equipped with a small desk-mounted auxiliary unit when non-multiple stations and/or tie lines are installed. This unit, equipped with lamps, buzzer and double-throw miniature switchboard keys, is used by the main-station attendant for the routing of certain calls via the tie-lines or to and from non-multiple stations. It is available in two sizes, catering for a single station or maximum of four (see Figure 4).

In a mixed-station installation, any other multiple station can be equipped with an identical auxiliary unit to provide 2nd-choice main-station working. With

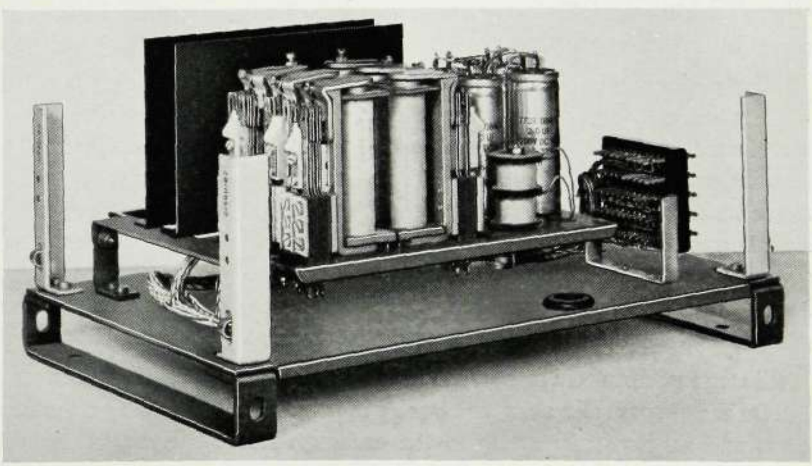

Figure 3—
The exchange line relay set with cover removed

Figure 4—
Auxiliary Unit for up to 4 non-multiple stations and/or tie lines

this arrangement, the functions of the 1st main station can be transferred to its subsidiary by operation of a changeover key in the auxiliary unit at the 1st main station.

Power

Operation of the system is from a 50V d.c. supply derived either from normal storage batteries or a mains-operated power unit.

SERVICE FEATURES

Exchange

Although the main station is usually responsible for answering duties and the routing of incoming calls to wanted stations, any multiple station can answer an incoming call if desired. This general-answering feature is of particular significance at installations where there are no non-multiple stations or tie-lines, since its adoption dispenses with the need of an attendant for centralized answering duties.

Outgoing exchange calls, on the other hand, can be established direct from both multiple and non-multiple stations, or any of these stations may be restricted access to the exchange via the main station during day service and allowed direct access at night. At these restricted stations the telephones are equipped with a ' restrict-access ' miniature relay unit (one per exchange line) directly controlled from the main-station instrument.

All stations, restricted or not, can hold an exchange call for the purpose of making an enquiry call on other lines, and subsequently return to the exchange-line conversation. In addition, an exchange call can be held pending its transfer direct to any unrestricted station or indirectly to a restricted station via the attendant. Both incoming and outgoing calls can be repeatedly transferred among the stations.

Audible indication of incoming exchange calls is given by the instrument bell at any required number of multiple stations within the loading limits laid down by an Administration (normally four). For flexibility of arrangement, each telephone incorporates bell ON/OFF keys which can be made operative by a strapping adjustment. At one selected station the exchange bell is permanently in circuit.

Series-secrecy is provided on exchange calls. This means that the first station in the multiple, when originating or receiving calls automatically disconnects succeeding stations from the seized line. Similarly, the next station in the multiple excludes stations of a lower priority, and so on.

Intercom

The heart of the system is the intercom circuit. It allows up to five two-way conversations to be held simultaneously, the maximum that can be provided in an equipment of this capacity. This is made possible by the provision of separate 2-wire transmission feeds for each station, the associated current-feed coil itself being contained within the instrument.

Calls between stations are non-secret. This feature, while presenting no inconvenience to most organizations, has the inherent advantage of simplicity which is exploited in the system design to provide a straightforward conference facility, enabling any multiple station to set up a call among a group of stations by sequential keying.

Intercom signalling at multiple stations is by the instrument d.c. buzzer and, at external stations, by the instrument a.c. bell which also serves to signal exchange calls under night-service conditions.

PRINTED WIRING

An interesting aspect of the multiple-station telephone is its use of printed wiring. Figure 5 shows the printed wiring of the basic transmission circuit on a synthetic resin panel. The components shown, i.e. the capacitor, resistors and induction coil, are soldered direct to this panel which also provides a convenient mounting for the jack-in line regulator and the ringer, both independently removable.

An additional printed-wiring panel is used in the intercom-key assembly to provide an unusual contact operation when an intercom key is depressed to signal the distant station. The panel, secured at the rear of the main-chassis bracket by four screws, accommodates 10 pairs of contact springs (one pair per key), individually clamped at one end by metal eyelets. Mounted at the free end of each spring is a moulded buffer which is engaged by the key plunger when fully depressed, thus moving the springs into contact with the printed wiring. With this arrangement, the need of conventional pre-tensioned ' make ' springsets is avoided and no spring tensioning is required, since adequate contact pressure is exerted by the forward projection of the plungers.

STATION LAMPS, SIGNALS AND SWITCHING KEYS

At multiple stations, visual exchange-line signalling and supervision are provided by two pairs of ' Exchange ' and ' Seize ' lamps. These are mounted beneath clear lenses integrated with a removable main key-switching panel (see Figure 6) in the sloping upper front of the instrument case. Each pair is associated with an exchange-line key and individually arranged in corresponding left and right-hand corners of the panel.

The seize lamp provides a steady-glow signal at the station occupying the related exchange line, whereas the particular exchange lamp emits three indications at all multiple stations :—

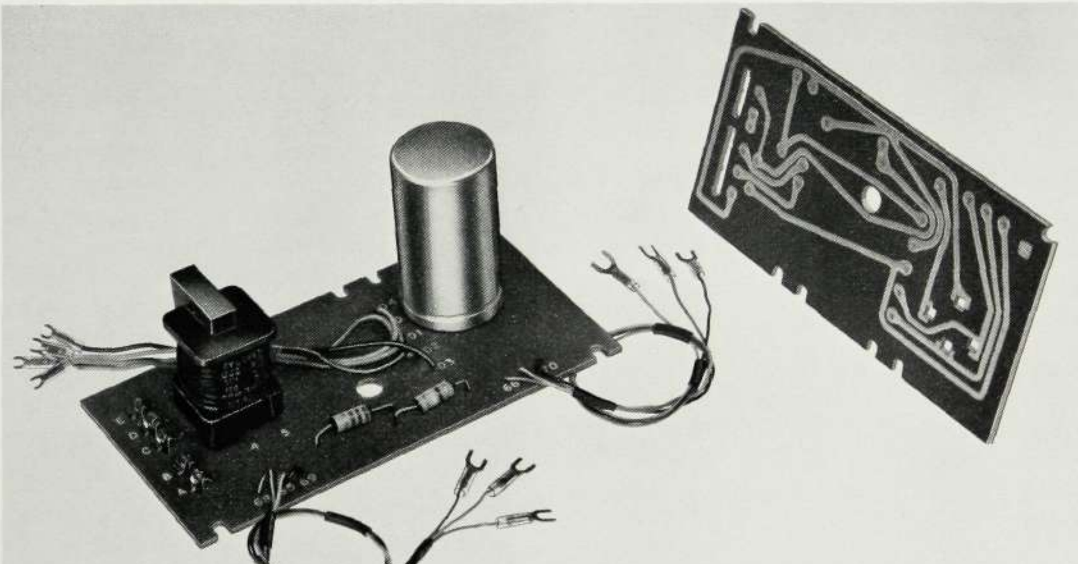

Figure 5—Synthetic resin panel carrying transmission components of multiple-station telephone

(a) A pulsating signal at ringing periodicity until the call is answered.

(b) A steady glow during an established exchange call.

(c) A ' wink ' when a station holds an exchange line while making a call on another line. This signal becomes steady when the user returns to the held line.

The keys in the panel number 15. Ten of these are allocated for intercom lines and, to assist identification, their press-buttons contrast in colour with the remainder. The intercom keys are arranged in two horizontal groups of five between adjacent designation strips carrying double-sided slip-in labels. To the left of these keys are the exchange and associated exchange-release keys and, at the extreme right of the panel, is the single conference key.

Ancillary operations are provided by keys between the panel and the handset cradle. The bell ON/OFF keys at each station take up the two inner positions, with snap-in dummy buttons either side. These dummy buttons are removable and can be replaced by ' Bar 1 ' and ' Bar 2 ' keys in the main station telephone for the control of stations restricted exchange-line access. At any other station these dummy positions may be occupied by ' Mon 1 ' and ' Mon 2 ' keys for monitoring.

There are only two keys associated with external-station telephones; ' Extension ' and ' Exchange '. External stations have no lamp signalling because of their connection by 2-wire lines.

Operation

Intercom Calls

Between Multiple Stations

Calls between multiple stations are signalled by buzzer on momentary overpress of the intercom key beyond its normal locking position.

At the called station the lifting of the handset completes the through connection and the call proceeds in the normal manner, with the intercom key at the calling station remaining in the locked position until the handset is replaced at the termination of the call or any other key is operated.

If the wanted station is engaged on an exchange call, either of two conditions is given during the overpress of the calling intercom key, dependent upon strapping arrangements in the equipment:—

(a) Buzzer signal at the called station; usually employed at stations where internal calls have high priority.

(b) Buzzer signal at the calling station, serving as a busy indication.

From Multiple to Non-Multiple Station

A non-multiple station is called in the same way as for a multiple-to-multiple station call. In this instance, however, a static generator in the non-multiple station relay set is activated to extend ringing current to the distant station's a.c. bell. Connection between the two stations is established when the called party lifts the handset and presses the locking extension key.

From Non-Multiple to Multiple Station

All internal calls from non-multiple stations are established via the main. As the extension key is pressed at the non-multiple station, a visual signal appears at the main-station auxiliary unit on a combined calling/supervisory lamp, particular to the calling line. At the same time the auxiliary-unit buzzer sounds continuously. Both indications continue to be given until the main station answers but, if the attendant is occupied with other calls, the audible signal may be disconnected by the ' Alarm off ' key.

After answering, the attendant proceeds to signal the required station. On reply, the called station is requested to operate the relevant key to establish connection with the waiting station.

Between Non-Multiple Stations

When more than one non-multiple station is installed, calls between these stations are also set up with main-station assistance. The attendant identifies the calling station by its glowing call-lamp and, after speaking to the caller, establishes connection with the wanted station from the main-station telephone. Subsequently, the attendant ' throws ' the connect key associated with each station in the auxiliary unit to complete the talking path between the stations. On termination of the call, both lamps light, whereupon the connect keys are restored to clear down the connection.

Among Stations (Conference Call)

Calls for the purpose of joint consultation among station users, can be set up from any multiple station by first calling the stations individually. The

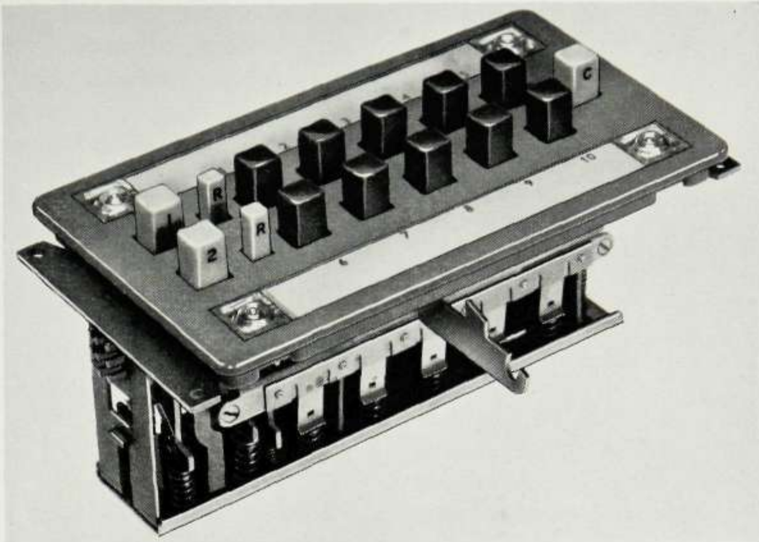

Figure 6—
The main key-switching panel removed from multiple-station telephone

conference key is then depressed, followed by all selected station keys. Replacement of the handset at the originating station restores all keys to normal.

EXCHANGE CALLS

Multiple Stations

An incoming exchange call is indicated by the appropriate visual signal at all stations and by the sounding of the instrument bell where connected. The call, normally answered by the main station, is accepted by lifting the handset and pressing the appropriate exchange key. At this stage, the audible signal is disconnected and all associated exchange lamps glow steadily. Simultaneously, an identical signal appears on the station-seize lamp in the answering-station telephone (see ' Transfer ' multiple-to-multiple station).

Outgoing calls from unrestricted stations are originated by employing the same key procedure as for an incoming call; corresponding lamp signals are given on seizure of a free line and during progress of the call.

If a call is to be allowed to a restricted station by the main station, the attendant informs the caller of the particular line to be seized, and momentarily presses the bar-key of the allocated line. The restricted station, in turn, presses the appropriate exchange key. Owing to operation of the bar-key, the add-on relay in the restricted station's telephone actuates to give access to the exchange line. The act of seizing the exchange line causes the relay to lock in the operated position and remain held until the restricted station terminates the call.

Non-Multiple Stations

Calls from a non-multiple station are initiated in a similar manner to multiple-to-exchange calls. If the station is unrestricted, the momentary depression of the non-locking exchange key causes the adjacent extension key to operate and lock. Because of these combined key functions, relays are operated in the non-multiple station relay set to switch the calling station to line and connect the steady-glow signal to all multiple stations.

Incoming exchange calls during day and night service are described later, under respective headings ' Transfer ' and ' Night Service '.

ENQUIRY CALLS

If a station speaking over an exchange line desires to make an enquiry call on another line, either to a local station or via the other exchange line, the relevant intercom or exchange key is operated. Either action restores the exchange key originally operated to the hold position and applies a hold condition to the exchange line. Simultaneously, the wink signal appears at the corresponding exchange lamp. After completion of the enquiry call, the exchange conversation is resumed by a second depression of the restored exchange key.

When an enquiry call is made over an exchange line connected to a distant operator-attended telephone installation, the operator can be re-called by over-pressing the exchange key from its locking position.

Transfer Calls

Multiple-to-Multiple Station

After the wanted station operates the relevant exchange key, the lamp signal reverts from wink to steady, thus indicating to the transferring station to complete the transfer.

Should the transferring station be ahead of the wanted station in the exchange-line multiple and fail to replace the handset, the exchange line will remain in the held condition, so preventing transfer. As a reminder of this, the station-seize lamp at the leading station continues to glow until the handset is replaced to complete transfer of the call.

If the main or any other unrestricted station is talking on one line when a call comes in on the second line, the station may accept the call by depressing the second exchange key, thus restoring the first exchange key to the hold position. This call may then be transferred to another station, the called party being requested to pick up the second exchange line. When the usual lamp-signal change occurs, i.e. from ' wink ' to ' steady ', the transferring station operates the release-exchange key associated with the second line to restore the relative exchange key and allow the called station to take over the call. This additional key operation by the transferring station is necessary in this instance, since normal completion of transfer by replacement of the handset would result in loss of the call on the first exchange line. Meanwhile, the first exchange key remains in the hold position and, by again fully depressing this key, the transferring station may resume conversation on the exchange line.

To and From Non-Multiple Stations

During day service, incoming calls for non-multiple stations, whether barred or not, are dealt with at the main station. The non-multiple station, after acknowledging the calling signal from the main, takes over the incoming call when the appropriate test and transfer keys are consecutively operated in the main-station auxiliary unit.

With a call established on an exchange line, a non-multiple station may re-press the non-locking exchange key to hold the line and simultaneously call the main station. On reply, the main station can be requested to signal the wanted station for the purpose of setting up an enquiry call or to take over the call. Alternatively, the external station can revert to the exchange line by re-pressing the exchange key a third time.

If an exchange call is accepted from a non-multiple station when the other exchange line is also in the held condition (i.e. both lamps winking) the attendant first operates the auxiliary-unit test key particular to the calling external station. This action causes the appropriate exchange-line ' test ' lamp to light in the unit, thus identifying the line to be picked up.

Tie-Line Calls

Outgoing tie-line calls from stations are established similarly to station-to-station calls. Incoming calls on the other hand are dealt with at the main station and signalled by lamp and buzzer in the auxiliary unit, call-transfer being accomplished in the same manner as for non-multiple/multiple station calls.

The possible absence of through clearing facilities at the distant installation is catered for by a clearing signal that appears on the auxiliary unit on replacement of the handset at the called station. On sight of this signal the attendant breaks down the connection by momentary operation of the tie-line release key.

Incoming exchange calls to the H.E. system can be extended over the tie-lines by a transfer key in the auxiliary unit. This same key is also used for the transfer of outgoing calls originated by the main station on behalf of the distant tie-line caller.

For connection of tie-lines to non-multiple station, non-multiple/non-multiple procedure applies.

Night Service Calls

Since all stations with full facilities have direct access to exchange lines and common signalling of exchange calls is provided, night service is automatic at these stations.

When non-multiple stations or certain tie-line circuits are installed, night service connection is by the ' throwing ' of keys in the auxiliary unit. By their operation, incoming ringing is repeated to connected stations by the transistor generator in the appropriate relay set (i.e. non-multiple or tie-line), this signal being concurrent with the audible and visual signals given at all multiple stations.

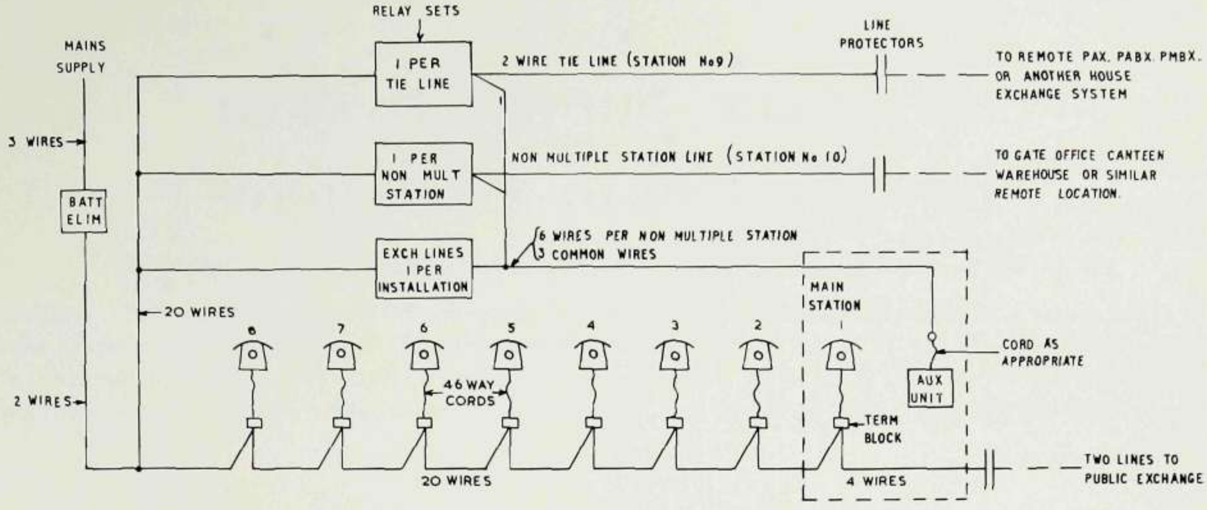

Figure 7—
Typical installation catering for 2 public exchange lines, 8 multiple stations, 1 non-multiple station and 1 tie line

Any or all of the non-multiple stations or tie-lines may be allowed incoming night-service calls on either or both exchange lines by simple re-arrangement of wire straps in the equipment.

MONITORING

When a monitoring station wishes to listen into an exchange call, the appropriate monitor key is operated to extend the station to the beginning of the exchange line multiple.

Miscellaneous

INTER-STATION CABLING

Connections between multiple stations are made at the cabling terminal block associated with each instrument, and require a total of 41 conductors. The cable employed is tapped in to all intermediate stations, terminating finally in the Exchange Line Relay Set.

At installations fully equipped for four non-multiple stations, an additional 39 wires are required. These are routed between the auxiliary unit and the corresponding relay set, seven of the wires being particular to each relay set.

Tie-lines are connected in a similar manner to external 2-wire lines.

Figure 7 shows a typical 2 + 10 installation.

LINE LIMITS

The system is suitable for connection to exchange lines of up to 1000-ohm loop resistance. When a non-multiple station is installed, the combined resistance of the exchange and the 2-wire line must not exceed this figure.

For maximum local-signalling performance between multiple stations it is recommended that the total length of multiple should not exceed 440 yards using $6\frac{1}{2}$ lb/mile cable.

Conclusion

The new H.E. system will undoubtedly fulfil an urgent need in the medium-size organization when it is important to reduce operating attendance to the minimum. This is a significant aspect of the system, but perhaps its most striking is its ability to provide flexible communication services for businesses of diverse geographical layout.

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A Power Supply System for Electronic Exchanges

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The diverse supply voltages required by electronic exchange equipment can be provided by d.c. to d.c. converter units powered from a single negative d.c. source as provided for conventional Strowger exchanges. This article, after briefly discussing the suitability of d.c. to d.c. converters for this application, outlines the switching characteristics of various types and concludes with a description of a new design employing transformer and semiconductor switching devices.

IN electronic exchange practice most of the circuits are divided into sections or ' security blocks ', such that should any block fail, the exchange will not be put entirely out of service but only suffer a reduction in the grade of service. Consequently, each security block must be equipped with its own individual supplies. Each supply must have a sufficiently smoothed and low impedance output and also be adequately protected against fault conditions.

These power requirements, and particularly those of the fully electronic exchange where increased diversity of supplies is anticipated, can be fulfilled by use of a d.c. to d.c. converter unit. Essentially a high-power oscillator, its principle of operation is to effect d.c. to a.c. inversion and transform the derived a.c. voltage to the desired level; at this stage, rectification and filtering take place to provide an isolated d.c. output.

Because of this principle the d.c. to d.c. converter offers a number of advantages. The sole need of a d.c. supply for operation of the converter enables it to be used directly with a single negative d.c. source as provided for the conventional Strowger exchange. This is a significant aspect since it permits an electronic exchange to work in conjunction with or in place of its electromechanical counterpart without the need of additional battery supplies. Equally important from a circuit design standpoint is the ability of the converter to provide any number of different and isolated supplies from the single d.c. source. For this reason the design of circuitry to be served within a security block is not restricted by supply voltage considerations. In addition, since high output efficiency is possible, a converter can be designed to operate close to the maximum output. Although this arrangement has the limitation of making protection against a small overload more difficult to achieve, it offers considerable advantages in permitting losses to be confined mainly to the transformer core, rectifier and filter. Finally, and of the utmost importance in telephone practice, there is the expectation of high overall efficiency and reliability which can be realized by suitable choice of switching devices for the converter design.

DESIGN CONSIDERATIONS

Since sine wave converters are approximately 30 to 40 per cent larger and heavier than square wave converters and have a lesser efficiency, square wave switching is usually chosen. Another choice which the designer has to make is the type of switching to be used to chop the d.c. to a.c. prior to voltage transformation and rectification. This can be by means of a mechanical vibrator or semiconductors in the form of transistors or controlled silicon rectifiers. Although mechanical switches have been used, their application is usually restricted to low power supplies and they have the disadvantage of short life. Replacing mechanical switches with semiconductor switches considerably extends the life and enables greater power outputs to be obtained. Controlled semiconductor rectifiers also have their drawbacks since they present circuit complexities in the form of firing circuits and require commutating capacitors because this type of rectifier can only be turned off by ensuring that the anode becomes negative with respect to the cathode.

Thus, taking into account output power requirements, simplicity and cost, switching transistors are preferred as the switching element. Transistors do however have the restrictions of maximum emitter current and maximum collector-to-emitter voltage (e.g., when the primary source is above about 30 volts)

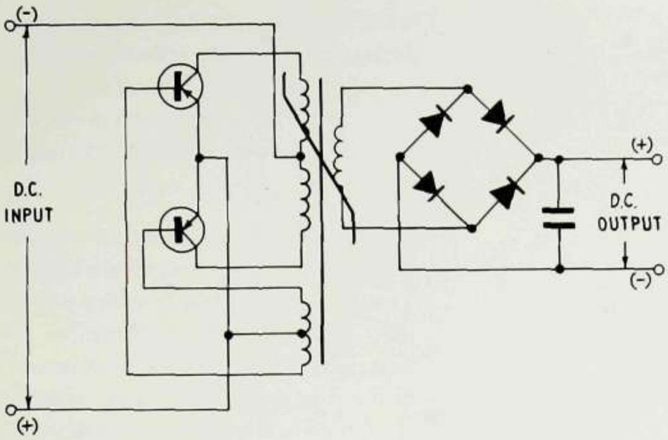

Figure 1a—
A single saturating square-loop transformer in a push-pull or bridge circuit

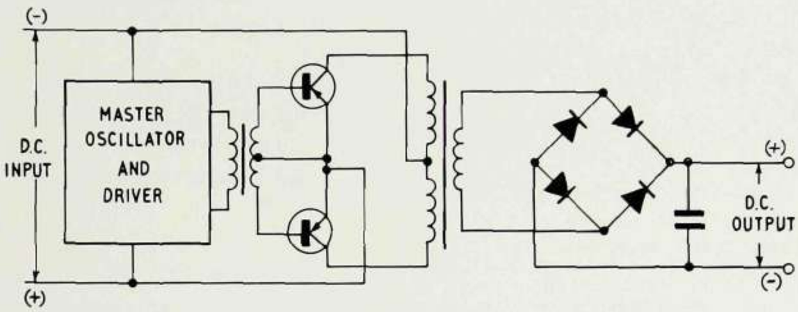

Figure 1b—
A separate oscillator driving the switching transistors with a linear output transformer

Figure 1c—
A self-oscillating switching circuit with a linear output transformer and a square-loop driving transformer

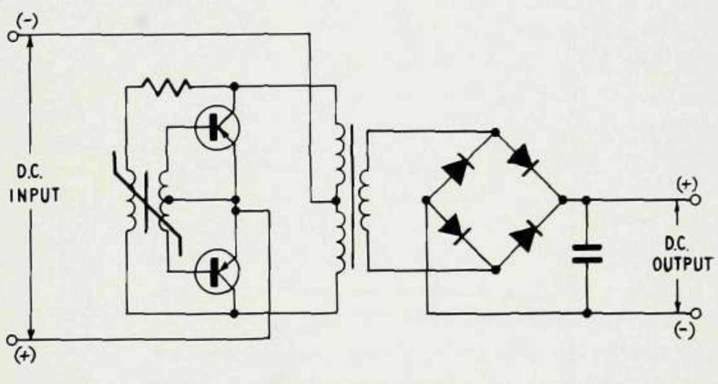

Figure 1—Three types of converters, using transistors as switching elements

when used in push-pull circuits. The latter restriction can be overcome to a certain extent by using bridge-type circuits in which two transistors are always in series across the primary source supply at any one time.

Converters employing transistors as switching elements may be of three types:—

(*a*) A single saturating square-loop transformer in a push-pull or bridge circuit (Figure 1a).[1, 2, 3]

(*b*) A separate oscillator driving the switching transistors with a linear output transformer (Figure 1b).[4]

(*c*) A self-oscillating switching circuit with a linear output transformer and a square-loop saturating transformer (Figure 1c).

Technical and cost considerations based on device limitations and circuit complexities led to the last type of circuit being selected for the new design.

Although most frequency ranges available for switching have some limitation, the frequency of 1500 c/s was chosen because it permits the use of reasonably sized core-components without introducing excessive core losses. Further, by employing square

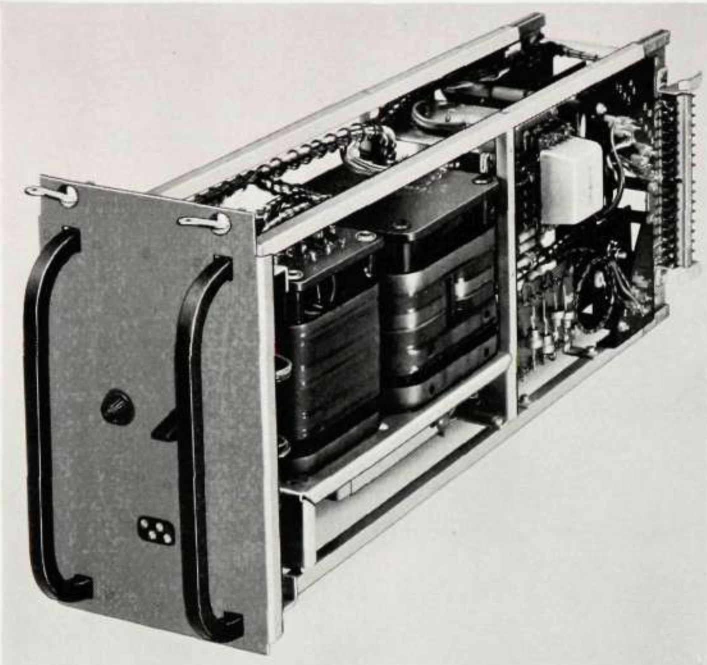

Figure 2—A typical converter unit

wave switching, any harmonics generated (i.e. third, fifth, seventh, etc.) fall outside the telephone speech pass band. The output filtering problem is also reduced to providing the desired output impedance.

The tolerances of the output voltages of the d.c. to d.c. converter are slightly greater than that of the primary source. The equipment must therefore be designed to tolerate these variations. If the tolerances of the output voltages are too wide for convenient equipment design, the outputs must be stabilized or the converter made self-regulating.

Since the d.c. to d.c. converters will probably be mounted in jack-in units and each converter requires protection and filtering circuits, it is advisable and

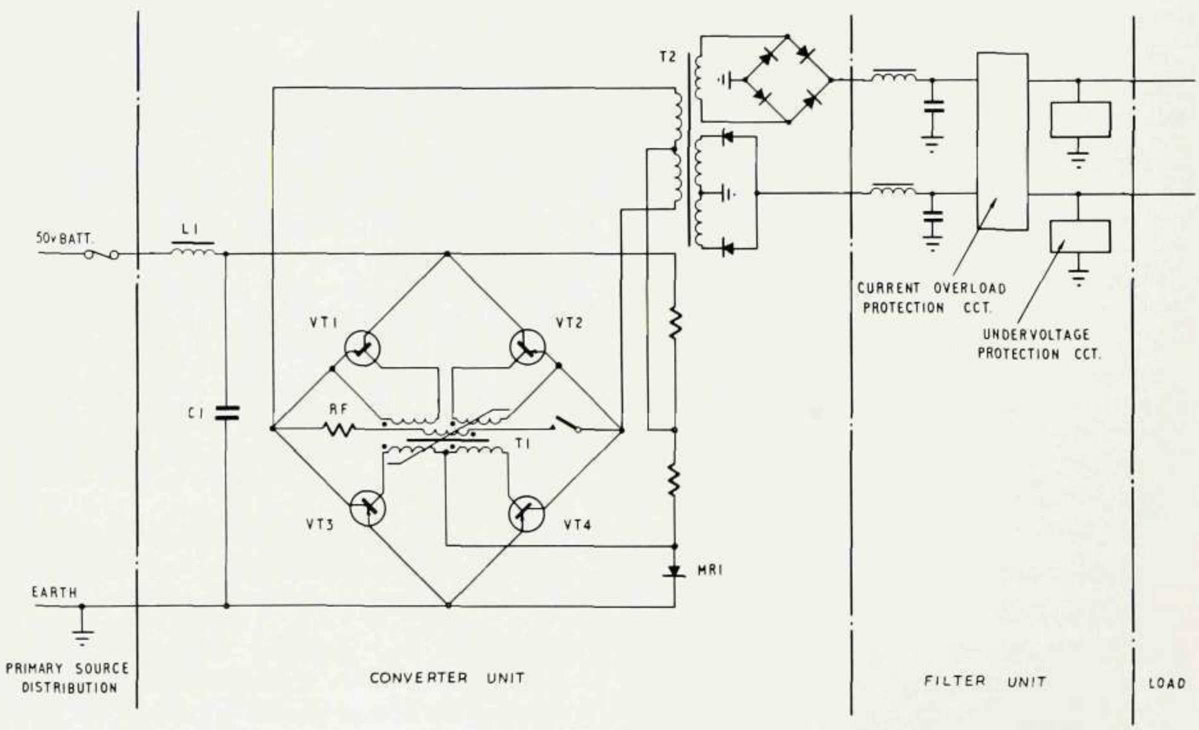

Figure 3—Basic circuit of a d.c. to d.c. converter power supply system

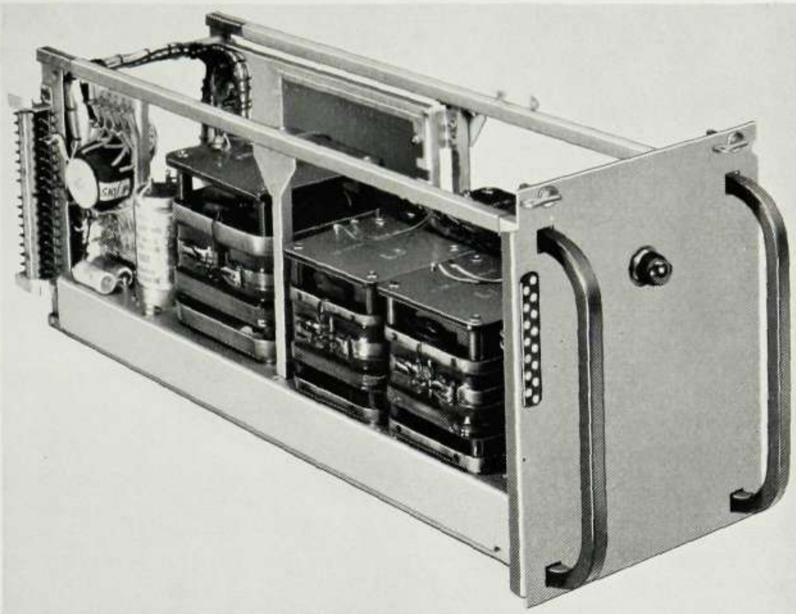

Figure 4—The filter unit

convenient from size and weight considerations to provide two separate units. These are the Converter Unit and the Filter Unit.

The Converter Unit

This unit contains an input filter, starting circuits, switching transistors, square-loop driving transformer, linear output transformer and rectifiers.

A typical converter unit is shown in Figure 2, having five isolated outputs and a total output power of 120 watts.

In push-pull converters the peak voltage applied to the transistors when in the cut-off state is twice the supply voltage. This limits the maximum primary supply voltage but on the other hand it is desirable to use a high primary supply voltage (the standard being —50 volts) because of the primary supply distribution problems. To accommodate these conflicting requirements a bridge circuit, as basically shown in Figure 3, is used.

The phasing of the secondary windings of the saturating transformer T1 is such that diagonally opposite transistors conduct together. When VT1 and VT4 are bottomed, the supply voltage will appear across VT2 and VT3 which are cut off.

Upon switching on, one pair of transistors (say VT1 and VT4) will conduct due to circuit asymmetry and the conductive bias supplied by the starting diode MR1. The emitter potential of VT1 falls towards the —50 volt supply and the collector potential of VT4 approaches earth. This change in voltage across transformer T1 primary is fed back to the bases of VT1 and VT4; a cumulative action occurs until VT1 and VT4 are bottomed and VT2 and VT3 are cut off. When the primary current of transformer T1 increases sufficiently to saturate the core, the voltage across the primary falls. This fall in voltage reduces the base drive, and the collector currents of VT1 and VT4 begin to decrease, causing the polarities in the windings to reverse. This action continues until VT2 and VT3 are bottomed and VT1 and VT4 are cut off. The frequency, which is nominally 1500 c/s, is governed by the feed back resistor RF and the inductance of the driving transformer primary winding. The drive to the transistors is always in excess of that which is required for maximum collector current. Thus the peak collector current of the transistors is determined by the load current and the magnetizing current of the output transformer.

After voltage transformation by the linear output transformer the output voltages are full-wave rectified before distribution to the Filter Unit.

An input filter consisting of capacitor C1, inductance L1 and the battery capacitance attenuate voltage transients on the —50v line to about 200μV (psophometrically weighted).

When the start key is operated, the primary circuit of the driving transformer is completed and the switching action commences. The protection circuit is inhibited for a period of 100 m.s. so as to allow the output voltages to rise to their nominal levels. After this period, if a fault occurs in the load, the protection circuitry open-circuits the primary circuit of the driving transformer, and the converter stops oscillating.

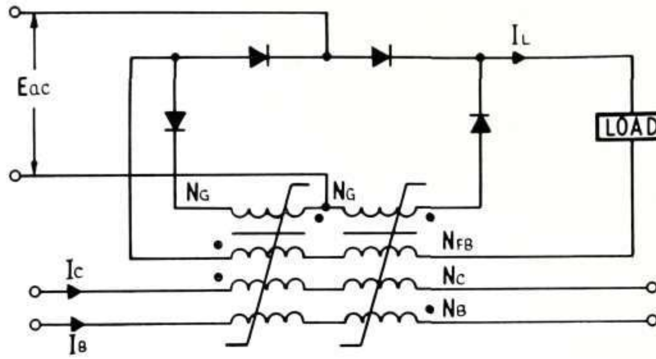

Figure 5a—Basic circuit of bistable magnetic amplifier

The Filter Unit

This unit provides smoothing and protection facilities for each of the rectified converter-unit outputs and is shown basically in Figure 3 and in assembled form in Figure 4. To provide a sufficiently low output impedance to cope with the load variations, the filters are designed to resonate at approximately 25 c/s and the output impedance falls from 10 ohms at this frequency to 1 ohm at 250 c/s and 0·2 ohm from 1·5 to 200 kc/s.

Low voltage protection is by means of a relay for each supply line. When the unit is switched on and the voltage rises to 80 per cent of its nominal value the relay operates. When all undervoltage relays have operated, a slave relay switches resistors into circuit in series with the undervoltage relays. Thus the undervoltage relays can be identical and by the choice of the series resistor, they can be arranged to release at between 60 and 70 per cent of the nominal voltage to which they are connected. In the event of an undervoltage the converter is switched off.

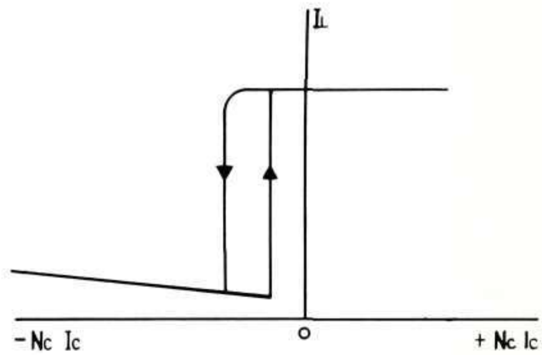

Figure 5b—
Characteristic of the bistable magnetic amplifier

Current overload protection is provided by a full wave self-saturating bi-stable magnetic amplifier.[5, 6] The amplifier input is a control winding per supply line while the load is a relay in the protection circuitry. A d.c. bias is derived from a zener diode and resistor chain between —50V and earth, and the gate voltage is supplied from the converter output transformer. A simplified circuit of the magnetic amplifier is shown in Figure 5a. With a full-wave self-saturating magnetic amplifier the application of additional feedback, proportional to the load current, gives a bistable characteristic, the curve of which is shown in Figure 5b. The control ampere-turns add algebraically. If a bias winding is added to the circuit, the curve of Figure 5b may be effectively moved to either left or right of the NcIc = 0 point. In the application considered, the characteristic curve adopted is shown in Figure 5c. It can be seen that if the control

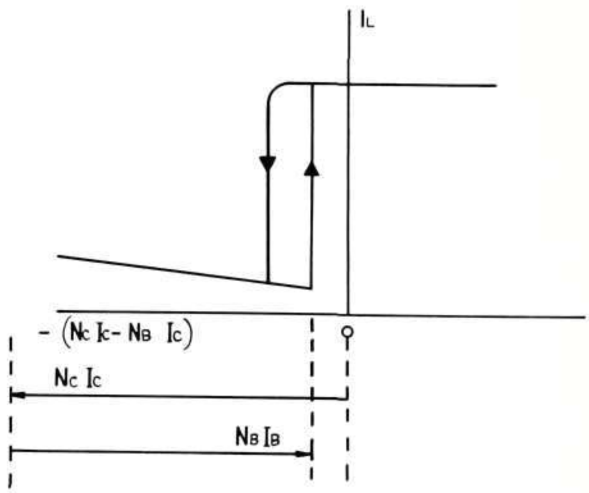

Figure 5c—
Characteristic of the bistable magnetic amplifier showing control and bias ampere-turn polarities

ampere-turns are equal to or less than the maximum predetermined value, then a relay, which is the load, will be energized assuming the bias ampere-turns are constant. Conversely, if the control ampere-turns exceed the specified maximum, the magnetic amplifier switches and the relay becomes de-energized. Hence the bias current determines the magnitude of the control ampere-turns at which the relay releases. The magnetic amplifier has a switching sensitivity of one ampere-turn and a speed of response of 3 or 4 cycles (approximately 2·5 m.s.). The relay is used to switch off the converter when an overcurrent fault is detected.

The protection circuit described above was found to be adequate in the majority of fault conditions.

Further Design Considerations

Design considerations included steps to reduce audio noise which, at 1500 c/s, can be particularly irritating. This noise, which is due to magnetostriction in both the driving and the output transformer, can be significantly reduced by encapsulating the driving transformer in silicone rubber and mounting the assembly on anti-vibration mountings. In the output transformer itself a reduction in audio noise can be obtained by using ' super finish ' ' C ' cores which are noise tested at a frequency of 1500 c/s and a flux density of 2 kilogauss.

For loads considerably greater than 5A it was found necessary to split the load and the supply feeding it into two or more parts. This limit on the maximum current per supply is due to hole storage in the diode rectifiers which at 5A could be as long as 30 μs. The effect of hole storage at an operating frequency of 1500 c/s can cause a fall of ten per cent in the output voltage. The only other remedy is better rectifiers (which are not yet readily available) or to reduce the operating frequency whenever this is possible bearing in mind that this will also increase the size of iron-core components.

Should the power supplies to a security block fail and the converter be switched off by its protection circuits, it is desirable that the fault should be located and repaired as quickly as possible. In the ideal case, individual indication should be given to show any fault on any output supply line. However, this would be uneconomic owing to the number of components required. The converters are therefore supplied with the minimum of indication and only a general alarm is given, but more comprehensive test equipment is provided on a ' per exchange ' basis. This test equipment comprises two units, ' Converter Test ' and ' Load Current Test ', either of which may be plugged into the same rack position as a Filter Unit.

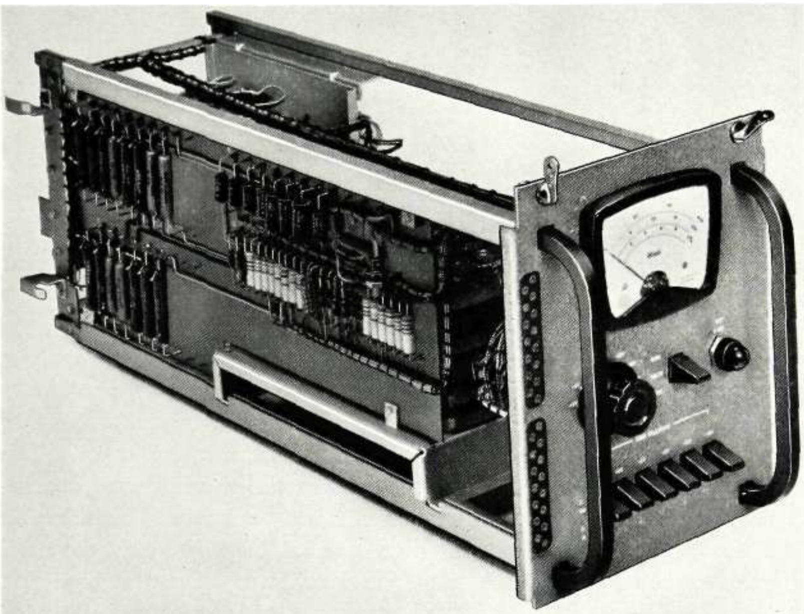

Figure 6— Converter test unit

The Converter Test Unit

Replacing a Filter Unit with the Converter Test Unit (Figure 6) disconnects the converter from the load and substitutes dummy loads. The unit contains filter circuits, dummy loads, voltage reference circuits and a voltmeter. The magnetic amplifier output is simulated by rectifying the gate voltage and feeding this rectified voltage into the protection circuitry. Output impedance conditions are maintained by employing individual filtering circuits. The converter

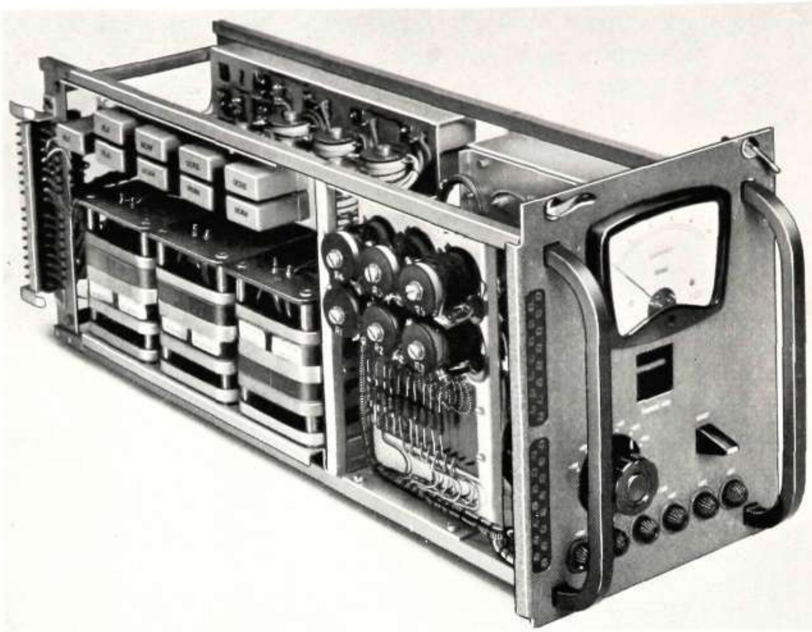

Figure 7—
Load-current test unit

output voltages are required to be within ± 5 per cent of the nominal value over a load current range of 10 per cent to 100 per cent of full load with a constant input voltage. Provision of alternate loads of 250 mA or 1A, which may be selected by a key, is calculated to give a load to each supply line within this prescribed range.

For direct voltage measurement the voltmeter has two calibrated ranges. With a three-position key in its normal position, all the output supply voltages and the −50V primary voltage can be selected by a rotary switch and measured. A reference voltage is also provided so that the converter output voltages can be compared with it, percentage errors being displayed on the voltmeter.

The Load Current Test Unit

This unit (Figure 7) measures and monitors the load currents and, in the event of a severe overload, switches off the converter and shows, by means of indicator lamps, on which supply line the fault was detected. The unit also contains filtering circuits. Overload protection is provided by overcurrent relays; the correct tripping current for these is automatically selected by appropriate routing of unit and rack wiring.

Under normal working conditions, the mean current can be measured by a meter.

Conclusions

The use of d.c. to d.c. converters provides a convenient and economic answer to the problem of power requirements for electronic exchanges. The transformer employed in the transistorized square-wave oscillator circuits is not critical and considerable freedom of design is possible. Since only the small feedback transformer needs to operate at high flux densities, high operating frequencies may be used without large core losses, the frequency being limited only by the rectifying efficiency of the rectifier diodes. The testing method described is one of many but is thought to be adequate bearing in mind that special test equipment must be kept to the minimum.

Because semiconductors and magnetic-core devices are employed as the main elements, the new design can be expected to operate with a high degree of reliability.

REFERENCES

[1]Urchin, G. C. and Taylor, W. O., ' A New Self-oscillating Square Wave Transistor Power Oscillator ', *Proc. IRE*, 1955, 43, p. 99.

[2]Pye, T. R., ' High Power Transistor D C Converter ', *Elect. and Rad. Eng.*, March 1959, p. 96.

[3]Jenson, J. L., ' An improved Square Wave Oscillator circuit ', *IRE Trans.*, Sept. 1957.

[4]Stephenson, W. L., ' A Four Transistor D C Converter Circuit ', *Mullard Tech. Comm.*, 1958, 4, p. 191.

[5]Dornhoefer, W. J., ' Self Saturation in Magnetic Amplifiers ', *AIEE Trans.*, 1949, Vol. 68, p. 835.

[6]Finzi, L. A. and Feth, G. C., ' Magnetic Amplifier in Bistable Operation ', *AIEE Trans.*, Nov. 1955, p. 592.

U.D.C.621.394.34(6)

Telex in Central Africa

This article describes the combining of Telex and Gentex service in a single integrated network. It discusses the planning considerations for the system and outlines the general features and circuit functions. In conclusion, reference is made to the factors that influenced installation and enabled the system to be brought into service on schedule.

THE phenomenal growth of Telex traffic in recent years is illustrated by the introduction of nationwide Automatic Telex networks in a number of countries throughout the world. Commercial development has been particularly rapid in Central Africa over the last decade and by 1958 the need for such a network to cover the whole of the then Central African Federation had become apparent. An initial survey of the requirements was undertaken at the request of, and in consultation with, the P. & T. Administration. Four Telex Automatic exchanges were subsequently designed and manufactured and these were opened for service in late 1961.

Exchange Sites

The two largest exchanges are installed, one at Salisbury, the capital of Southern Rhodesia and commercial hub of Central Africa; the other, at Bulawayo, a mining and industrial town some 100 miles from the border with Bechuanaland, on the main rail route to South Africa. The smaller exchanges are sited at Lusaka, the capital of what was formerly Northern Rhodesia (now Zambia), and at Kitwe, one of the main centres of this country's rich copper-mining district.

Influences on Planning

At the planning stage, several factors combined to prescribe, at least in part, the general features of the system. The most immediately evident of these was distance; as may be seen from Figure 2 Bulawayo is 270 miles from Salisbury, Lusaka further still, and the airline distance from one end of the system to the other is well over 500 miles. It was decided therefore to economize in line and switching costs by combining Telex with the Public Telegraph (Gentex) service in a single integrated network.

Another consideration was the type of Telex traffic to be expected and the form that further development would take. It is an inherent feature of Telex service that its value and appeal to the subscriber as compared

Figure 1—Salisbury Central P.O. accommodating one of the Telex exchanges

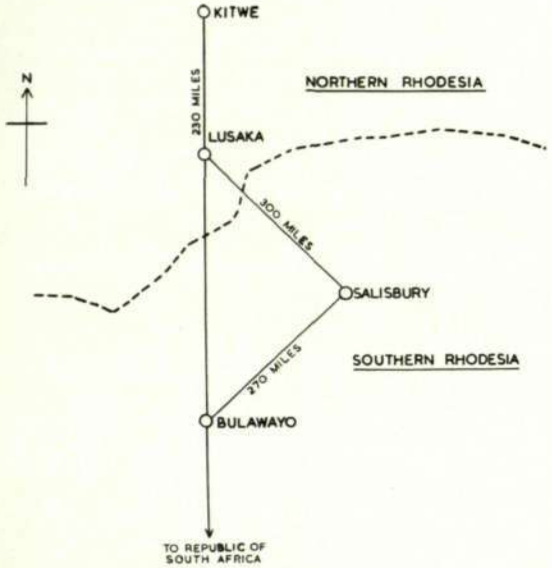

Figure 2—Telex/Gentex network in Central Africa

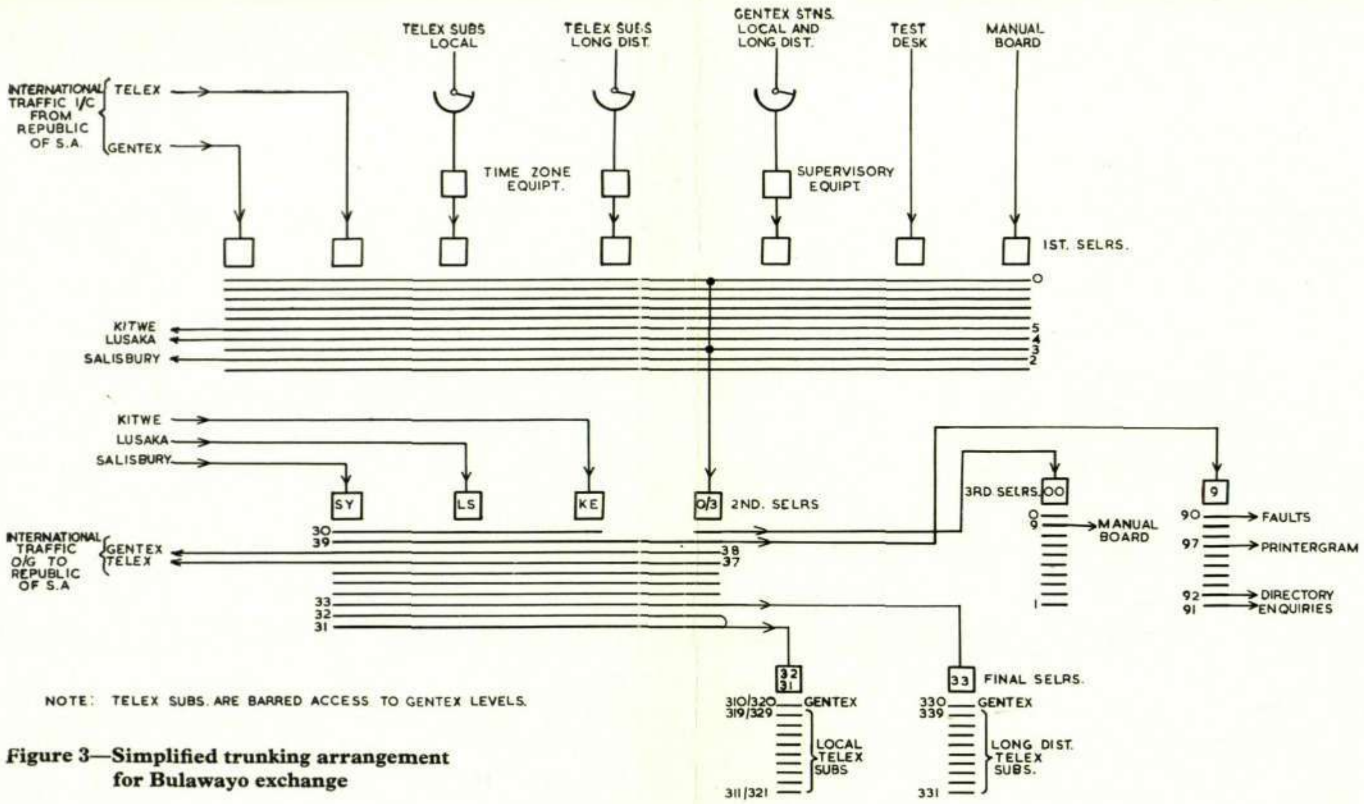

Figure 3—Simplified trunking arrangement for Bulawayo exchange

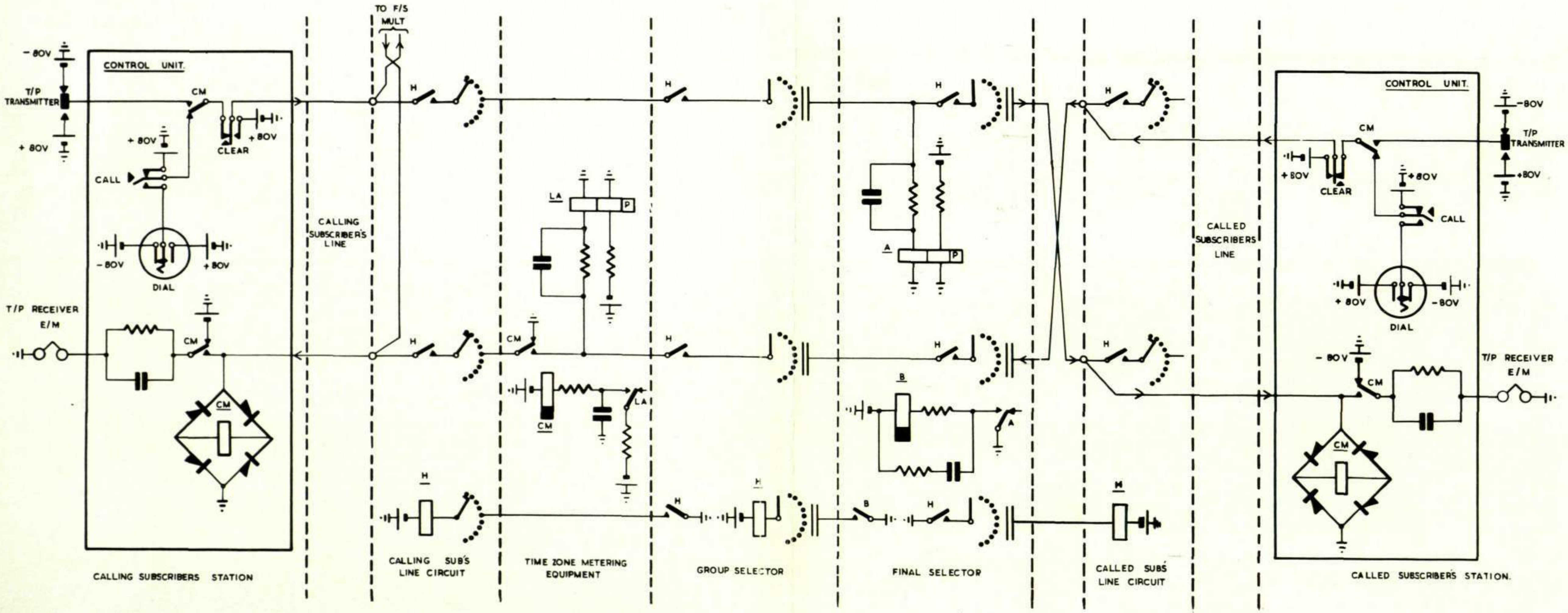

Figure 4—Basic signalling and supervisory elements

with other means of communication increase with distance. Surveys in established systems confirm that the preponderance of traffic is national rather than local and that a demand for international outlets invariably follows the inception of a national system. The essential aim of a world-wide subscriber-dialled network is realistic because the practical importance of time differences is less with Telex than with most other communications.

The adoption of a linked numbering scheme gives immediate benefit in the form of subscriber convenience and simplification of routing problems. When international outlets become available the advantages naturally accrue; an important one from the economic angle is the saving of capital cost in providing expensive registers for handling international traffic.

Telephone subscribers in Central Africa had already enjoyed for a number of years an efficient Subscriber Trunk Dialling system and in this progressive context similar facilities for Telex subscribers, capable of extension to the whole of the Federation were a natural and expected choice. Further, the strong community of interest with South Africa made it obvious that the network would not achieve full usefulness if isolated within the Federation boundaries; this trans-national outlet at least should be provided for initially.

A traffic count taken some months after the opening of the system showed that usage within the Federation had developed as expected, with a ratio of national to local traffic of more than 11 to 1. International traffic was exceptionally heavy, amounting during the period of the count to three times the national-plus-local traffic total.

General System Features

The four exchanges are directly connected together by v.f. links and can be considered as four zone exchanges with provision for the connection of satellite exchanges when expansion of the system calls for this. Figure 3 shows a simplified trunking arrangement for Bulawayo exchange. This exchange is chosen because it caters for all the international circuits coming into and leaving the Federation; in other respects the remaining exchanges are similar in trunking arrangements.

Outgoing and incoming trunks are shown as unidirectional, but actually both unidirectional and two-way trunks are employed dependent upon the traffic volume.

The step-by-step system is of the non-register type and employs pre-selectors and two-motion selectors. Battery-testing is employed on all switching circuits and this, in conjunction with the use of high-speed ' testing-in ' relays effectively prevents double testing, which must be rigorously excluded in Telex where messages are recorded in print.

Any Telex subscriber can obtain dial access to any other Telex subscriber but access to Gentex offices is barred; the latter, on the other hand, can dial any Telex station. Conventional printed service signals are employed as shown below.

Printed Signal	*Meaning*
MOM	Awaiting a free line or the attention of the called operator
OCC	Called subscriber engaged
NC	All junction outlets engaged
NP	Spare line or spare level
DER	Called line ' plugged out ' for faulty condition
ABS	Called line closed or on paper failure

Circuit Features

Figure 4 shows the basic signalling and supervisory elements, all switching being in the normal or ' Free Line ' condition.

Seizure

In the ' Free Line ' condition, a permanent ' start ' polarity (+ 80V) exists on both the forward and backward signalling paths. The calling subscriber initiates a call by depressing the call button on the control unit. This action inverts the above condition to ' stop ' polarity (— 80V) for seizure of the exchange equipment. Subsequently the Time Zone metering equipment returns a ' proceed to dial ' negative pulse on the backward signalling path to give a lamp indication to the caller and start his teleprinter motor.

The caller dials. In the explanatory figure, a 3-digit numbering is shown. The first pulse-train positions the 1st group selector while the second and third position the Final Selector wipers to the called subscriber's line. The calling ' stop ' (—ve) polarity is extended to the called station to operate relay CM, the contacts of which connect the teleprinter transmitter and receiver electro-magnet to the line. Another contact of CM (not shown) causes the teleprinter motor to start. The —ve ' stop ' polarity now encountered on the backward path is identified as a ' Call Connect ' signal to the Time Zone equipment which proceeds to transmit a ' WRU ' signal to the called station. This WRU signal triggers off the 'Answer Back ' of the called station's teleprinter which is returned over the backward signalling path and printed at the caller's teleprinter. Communication in both directions can now proceed.

It will be observed that during the ' idle ' condition, i.e. the period when printing is not actually in progress, a ' stop ' polarity is applied to both the forward and backward signalling paths.

Supervision

Supervision is effected by two polarized relays, namely relay A for the forward and relay LA for the backward path. Both of these are sensitive high-speed relays capable of responding to teleprinter signals whilst drawing a very small current from line.

Backward holding is employed. The whole connection is held under control of relay B in the final selector; this relay is in turn under control of A but has a release lag of some 400 m.s., sufficiently long to cover the largest aggregate of ' start ' (+ve) elements of any character.

Depression of the ' clear ' button by the calling or called party causes a change from ' stop ' (—ve) to ' start ' (+ve) polarity on the forward or backward path from the appropriate station. If the calling party clears first, relay A goes to its 'start' position, causing relay B to release after approximately 400 m.s. With the holding condition removed, the connection breaks down and all circuits revert to normal.

If the called party clears first, the 'start' polarity (+ve) received on the backward path causes relay LA to go to the 'start' (+ve) position, thereby disconnecting the holding circuit of CM in the Time Zone equipment. Relay CM releases after some 400 m.s. and its contact returns an earth on the backward path to release relay CM in the calling party's control unit. One contact of the latter relay extends a 'start' (+ve) polarity on the forward path, this causing relay A to go to its 'start' (+ve) positions. The connection therefore releases as described above.

Installation

Installation work was carried out by the P. & T. staff entirely without assistance and was completed on a particularly stringent schedule despite difficulties inherent in the simultaneous erection of four interconnected exchanges at the distances involved. The design of the exchanges which incorporate the familiar 2000-type switch and circuitry is very little different from that already well known to the P. & T. staff in automatic telephone exchanges undoubtedly assisted in the fulfilment of the programme to time; the small variations peculiar to Telex practice were quickly grasped.

Another contribution was the effort made to provide overhead ironwork and cabling in advance of the rack equipment, so that this could be installed and connected with minimum delay on its arrival at site. In some instances this was achieved in less than a day.

Where practicable the exchanges are located in, or near, the Telegraph office at each centre. At Salisbury this arrangement created a particular problem because although rooms were available for the exchange equipment and batteries there was no easy access to the Auto room for bulky items of equipment. The test desk, shipped in two 6 ft. sections was manipulated up the main semi-circular staircase, a difficult undertaking achieved however without incident.

Concurrently with the initial installation work preparation was made to modify existing manual Telex exchanges at Salisbury and Bulawayo to work into the system and to provide them with incoming and outgoing junctions to the automatic exchanges. Prior modification of the subscribers' teleprinters was also necessary and for this purpose a small pool of spare machines was used, the modified machines being returned to service with a temporary plug and cord conversion, removed on the cut-over to automatic.

Conclusion

Less than 10 months from the opening of the system, direct dial access was made available at the Salisbury and Bulawayo Telex switchboards to Johannesburg Telex subscribers and to manual Telex switches in the main South African centres. Likewise, the Telex Switchboard at Pretoria SA, was able to dial all Telex subscribers in the Federation.

Because the traffic-pattern of the system has been largely international in nature from the outset, it seems unlikely that changes following the dissolving of the Federation and the accompanying division of responsibility for telecommunications, will materially affect its future expansion.

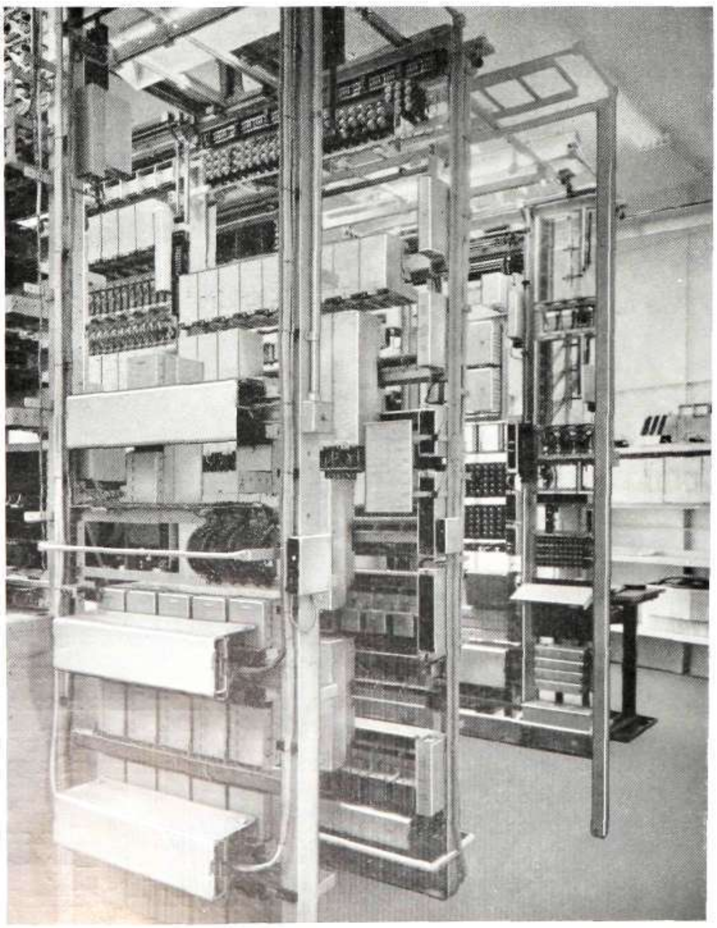

Figure 5—
Salisbury auto racks with meter pulse distribution in foreground, time zone equipment in the centre and MA1 and traffic recorder in background

U.D.C.681.124

An Electromagnetic Transducer Tachometer

H. L. Arnall and A. R. Wood, A.M.I.E.E.—Relay Technical Services Department

This article reviews the design features and many applications of this new instrument. Measurable speeds range from a few hundred rev/min or lower still with phonic wheel attachments, to well above any likely to be met in practice. The transducer can be used independently for time interval, torque and other measurements.

TECHNIQUES for indicating the speed of rotating machine parts are well established and the most common mechanical tachometers have been in use for many years. These sometimes have disadvantages both in their method of operation and installation. Mechanical linkage is often difficult to arrange, puts additional load on the moving member and limits the distance of the indicator. Initial cost may be low, but is offset by maintenance problems due to mechanical wear, particularly at high continuous speeds, whilst coupling slip may limit accuracy and reliability.

Optical devices, whether stroboscopic or photo-electric, need alignment and focussing and cannot always be brought to bear conveniently on the moving part. The incandescent sources have limited life, particularly if exposed to vibration or frequent switching; dust, dirt and lubricants may cause rapid deterioration of reflecting surfaces and lenses.

Most of these disadvantages are avoided by the use of electromagnetic transducers, which generate a train of electrical impulses whose rate is proportional to rev/min, provided only that there is a ferrous irregularity in the moving member or that one can be introduced.

The equipment to be described consists of such a transducer, together with a control unit and read-out indicator. The control unit develops a d.c. output proportional to the repetition rate of the transducer pulses; this output operates the read-out indicator.

Transducer

This is in effect a voltage generator and consists of a polarized electro-magnetic assembly encapsulated in epoxy resin (Figure 1).

Coils of very fine wire are wound on the pole pieces, which are joined within the assembly by the polarizing magnet, a bar of Alcomax III. A U-shaped magnetic circuit is thus formed, which is completed by the rotating member to be sensed. When any ferrous

Figure 1—Transducer

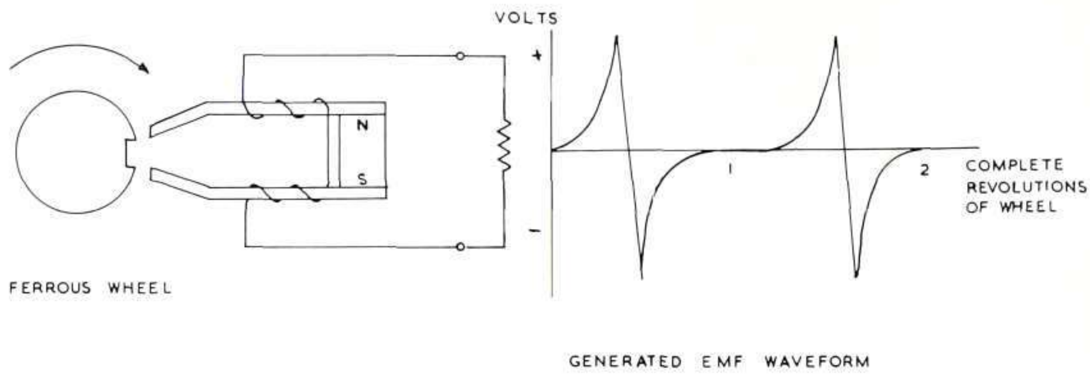

Figure 2—Generation of e.m.f. from shaft irregularity

irregularity passes the pole-piece ends, the resulting change in the reluctance of the magnetic circuit causes an e.m.f. to be induced in the coils. To ensure maximum e.m.f., the poles have a relatively wide separation and are brought into close proximity with the rotating member. Figure 2 shows a diagram of the magnetic and electrical circuits and a typical output waveform. The actual waveform and amplitude obtained will depend on factors such as the velocity, shape and proximity of the ferrous irregularity. Either projections (e.g. splines or gear teeth) or recesses (keyways or slots) may be sensed, the former usually giving the greater output. Where the rotating member is non-ferrous an insert must be provided; the head of an 8BA screw is usually adequate.

The medium between the pole pieces and the members need not of course be air; the method will work in gases and liquids and provided that the transducer can be brought sufficiently close, through non-ferrous casings. The sensing distance can be much increased by the introduction of a magnet mechanically balanced as the ferrous irregularity.

The relation between output voltage and shaft speed for various types of irregularity is shown in Figure 3.

CONTROL UNIT

In the control circuit, pulses from the transducer are fed via a diode into an amplifier, the positive-going component being amplified, squared and differentiated to provide trigger pulses for a monostable circuit. The effect of triggering is to put this circuit into a temporary, quasi-stable state of a duration dependent only on circuit constants. An output is only delivered while this state exists, and consists of a series of pulses of constant duration and amplitude, independent of the duration, amplitude or shape of the original transducer pulses. Their mean current value is directly proportional to the trigger pulse repetition frequency and thus to revolutions per minute.

The circuit is a four-transistor arrangement (see Figure 4), the first two transistors, X_1 and X_2 performing the amplifying and squaring functions. The squared pulses have an amplitude independent of the original pulses, but are still related to them in duration. It is to ' lose ' this dependence that they are differentiated. Two trains of ' spikes ' result, one positive-going and the other negative-going; both are in effect time markers describing the repetition rate of the transducer pulses but no other quantity.

The positive-going train is selected by means of a diode and applied to trigger the monostable circuit, consisting of transistors X_3 and X_4. In the stable state X_3 is cut off and X_4 fully conducting (bottomed); in the quasi-stable state the reverse applies. The duration of the quasi-stable state is determined accurately by the time constant (CR) of a capacitor and series resistors R1, R2, RV3, in the interstage coupling. Each time it occurs, therefore, a fixed amount of electrical energy passes through X_3 from the supply. The *total* amount of energy passing in a period of one second, in other words the average current, is thus a measure of the repetition rate of the transducer pulses. A milliammeter (the read-out indicator) in series with X_3 will thus give a linear indication of rev/min. The speed range to be covered is determined by a suitable choice of CR. RV3 is a preset component for calibration purposes.

The control unit operates from a 12V d.c. supply, obtained either from suitable a.c. mains via a built-in power unit, or from an external battery. The d.c. consumption is 18 mA. A feature of the mains unit is its intrinsic safety, the output current on short circuit being limited to 70 mA and the terminal voltage on open circuit to 15V. A transistor-type regulator is incorporated, with zener-diode reference.

The equipment, including mains supply components where required, is assembled on a printed circuit board and mounted in a cast-iron case 6 × 6 × 2 in. (15 × 15 × 5 cm approximately). Connections to the transducer and read-out indicator are made by two-point screened plugs and sockets, a spare socket being provided for a second read-out indicator if required. The a.c. mains supply cable is brought in through a cable gland.

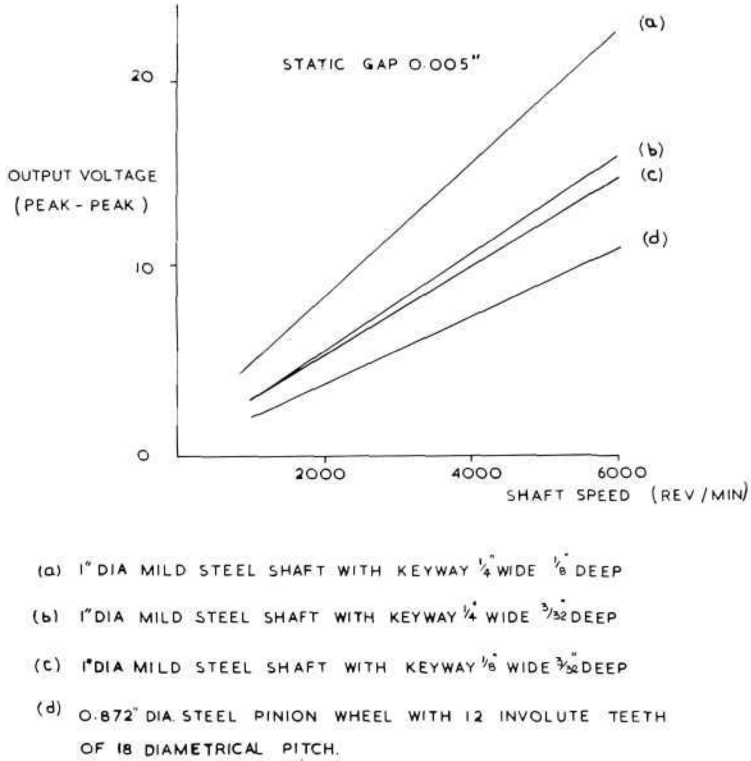

Figure 3—Typical output voltages

Figure 5 shows a complete tachometer equipment.

READ-OUT INDICATOR

This is a moving coil meter of 5 mA (full-scale) usually of the cirscale type with 240° deflection as this type of scale is generally associated with speed indication. The linear relationship between rev/min and current simplifies marking-off, and the equipment need only be calibrated at one point to give assured accuracy over the whole range.

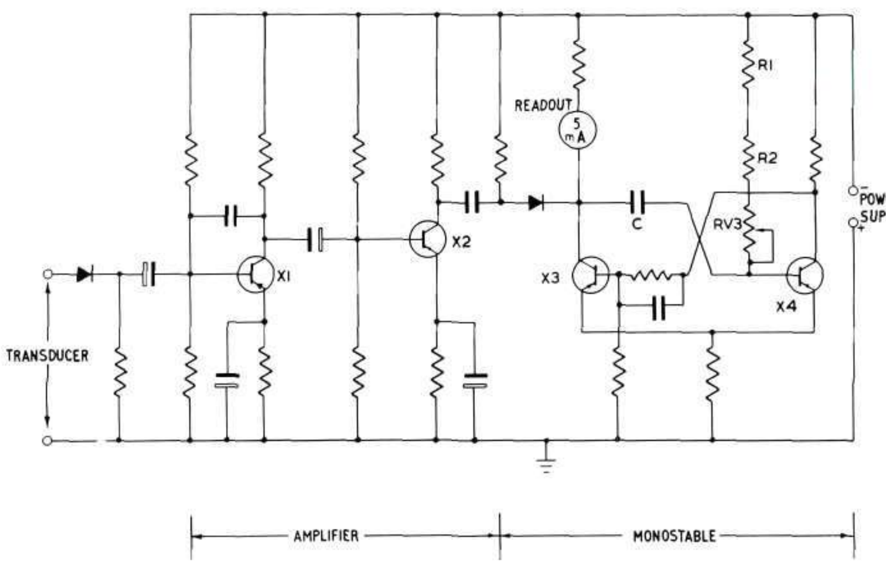

Figure 4—Simplified circuit of control unit

Operation

The read-out indicator can be installed in any convenient position with respect to the control unit, up to a distance of several hundred yards. The calibration is preset for the length of connecting cable specified and it is important that this length should not be altered after installation unless the equipment is recalibrated. There is no definite maximum limit to the transducer-to-control-unit cable length, but if very high rotational speeds are to be measured the effect of cable capacitance on pulse form and amplitude must be borne in mind.

A minimum transducer output of about 500 mV peak to peak is required, this being obtained at the lowest speed to be measured. At 1000 rev/min, for example, such an output would be obtained with a $\frac{1}{4}$ in. wide keyway or slot in the moving member and the transducer pole-faces about 0·03 in. from it.

Alignment of the transducer is important since it influences waveform as well as amplitude. A symmetrical output of high form factor is desirable, an example of this being shown in Figure 6. It is necessary to avoid the secondary double 'hump' waveform also shown; this may occur with certain shapes of ferrous irregularity but can be minimized by rotating the transducer slowly through 90° about its longitudinal axis until the best waveform is obtained. In the absence of an oscilloscope a useful guide in alignment is that if two rev/min readings (ratio 2: 1) are obtained in rotating the transducer, the lower one is correct.

To accommodate shaft speeds below the equipment range, multiple ferrous irregularities such as gear teeth may be made use of, or phonic-wheel methods employed. Such means will of course divide down the whole indicated range; for example, the equipment shown in Figure 5 will read 3000 rev/min maximum with two irregularities, 1500 rev/min with four, and so on. A divider of two can most conveniently be obtained, if the end of the shaft is accessible, by cutting a single diametric slot. Two slots at right angles will give a divider of four.

Some Tachometer Applications

The measurement of very high speeds often presents problems of accessibility and low available torque, and the tachometer is of particular value in this field. One particular example was the measurement of the speed

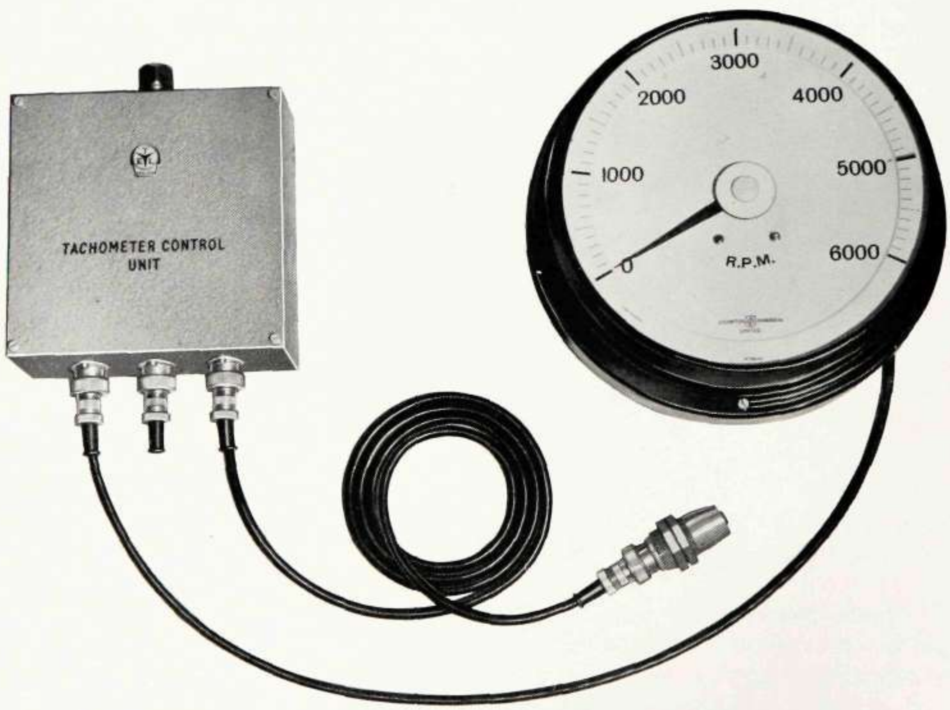

Figure 5—Complete tachometer installation

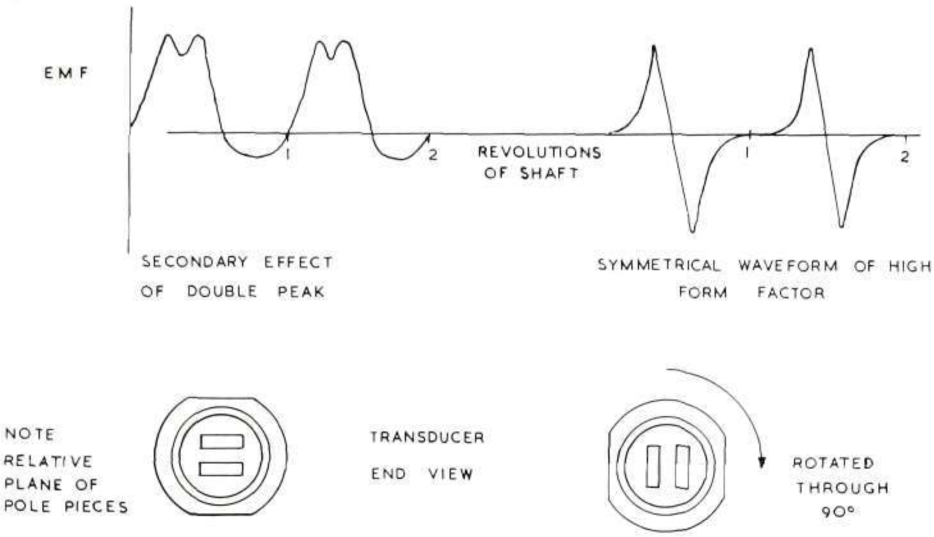

Figure 6—Transducer waveforms for different angular positions

of the compressed air turbine-operated type of dentist's drill. An adequate transducer output was obtained by replacing the dental burr with a magnet of similar dimensions. In applications such as this even the minute retarding effect of the transducer on the member—due to eddy current and hysteresis losses—may produce some slowing. This may be allowed for by moving the transducer away from the member and extrapolating successive readings to give the true no-load speed.

For general work including high speeds a multi-range equipment is an advantage. Figure 7 shows a five-range portable set with built-in read-out indicator. The different ranges are obtained quite simply by switching in alternative values of C and R in the time constant circuit, separate calibration presets being provided for each range. The ultimate coverage possible with this design of control circuit extends, as regards pulse rate, from practically zero frequency to well over 10^4 per second. Owing to meter flicker, however, there is a lower limit to the speed capable of being read, this being about 900 rev/min with a single ferrous irregularity and proportionally less with multiple irregularities. At the opposite extreme, speeds in excess of 5×10^6 rev/min (simulated by phonic-wheel methods) have been read.

The ' vehicle ' socket on the multi-range set permits the speed of internal combustion engines to be read directly. The transducer is dispensed with and connection made to the distributor or ignition-coil primary. The reading is divided by two for four-cylinder engines and three for six-cylinder. An alternative input circuit is incorporated between the ' vehicle ' socket and the control unit circuit.

Figure 7—Portable multi-range tachometer

For measuring diesel engine speeds the transducer is used and may be mounted, for instance, on the inspection cover of the flywheel housing with the polepieces near to the teeth of the starter ring, the number of teeth being counted and used as a divider for the indicated speed.

A special version of the equipment has been produced to measure the speed of the Rover gas turbine vehicle engine in road tests. This type of engine develops rotor speeds up to 70,000 rev/min; access to the rotor however is not practicable and the transducer is mounted adjacent to the alternator pulley. This has eight inserts and rotates to a maximum speed of 3060 rev/min, the control unit being so calibrated that full deflection is obtained on the read-out indicator at 24,480 pulses per minute, the scale being graduated 0-70,000 rev/min. The control unit shown in Figure 8 is of compact, light-weight design and has many other applications where maximum portability is required.

Figure 8—Lightweight control unit

In many situations, provision for a second read-out indicator has been found useful, for example, in marine installations where a small weatherproof indicator on the ship's bridge is used as repeater to a main indicator in the engine room.

Two transducers placed at a suitable distance apart along a power transmission shaft will provide a measure, by the phase difference of the pulses, of the shaft torque. This information could, with suitable circuitry, be displayed directly, or combined with the rev/min information from one transducer to give direct read-out of shaft b.h.p.

Conclusion

Many other uses will suggest themselves both for the complete equipment and the transducer alone—flow rate measurements, accurate time interval measurements (many commercial timers have inputs suitable for the transducer), the evaluation of tool cutting speeds and the stabilizing of speeds in mechanical systems where feedback information is conveniently derived and utilized in the form of tachometer pulses.

An accuracy better than 2 per cent is given, with complete reliability, in a variety of measuring conditions which together would probably defeat any alternative system—extremely high or very low speeds, remote indication, impossibility of mechanical coupling, restricted surroundings and adverse environments. In the majority of applications no marking of the moving member is necessary.

U.D.C.621.395.34

Abu Dhabi Petroleum Company Rurax Network

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This article, which describes the integration of four Rurax exchanges within a comprehensive communication network, emphasizes the adaptability of Rurax equipment to meet special requirements, particularly where environment is a major consideration.

SOME months ago the Company supplied four Rurax telephone exchanges to International Aeradio Limited for the Abu Dhabi Petroleum Company's communications network. This network is operated and maintained by International Aeradio Limited and is of primary importance in the smooth and efficient operation of the Abu Dhabi Petroleum Company's oilfield installations which are located in one of the most remote and inaccessible areas in Abu Dhabi, one of the Trucial Oman States. This region, which has been the subject of a number of newspaper articles and even television documentaries since the recent discovery of oil, consists almost entirely of scrub-covered desert and is subject to extremely high temperatures and occasional dust storms. Until oil was discovered the area was virtually uninhabited and water supplies, roads and communications were non-existent.

The four Rurax telephone exchanges form part of a comprehensive scheme for providing telephone, telegraph, mobile land, maritime and international communication together with ancillary air/ground communication and non-directional beacons for guiding aircraft. This scheme highlights the vital role that communications has to play in the operation of major industrial organizations, particularly where, as in this case, the operational area embraces a number of widely spread sites.

The project involves four permanent sites; the administrative headquarters of the A.D.P.C. in Abu Dhabi town, the main oilbase headquarters at Tarif, the oilfield area at Habshaan, and the oil loading port at Jebel Dhana. Habshaan is some 20 miles inland and the crude oil is pumped to Jebel Dhana and then via a submarine pipeline to offshore tanker berths. In addition to Jebel Dhana, Abu Dhabi and Tarif are also on the coast, Tarif being some 40 miles from Abu Dhabi and Jebel Dhana 20 miles from Tarif.

Obviously, in such a scheme, quite a number of factors influence the choice of the type of automatic telephone exchange equipment to be employed. The number of telephones required initially at each site was relatively small, but provision was necessary for expansion of the telephone system along with that of the oilfield installation. The switching system needed to be simple in operation, extremely reliable and easy to maintain. The operational environment necessitated equipment which was suitably protected against dust infiltration and the extreme climatic conditions.

Rurax equipment has an initial capacity of up to 50 lines and is capable of providing economic service for a small number of lines. The switching system has step-by-step control but uses only uniselectors in the finder and selecting stages. The equipment is constructed on the self-contained unit principle in totally enclosed dustproofed cabinets and can be easily extended in 50-line stages. These features, together with the high quality tropical finish, made Rurax equipment ideally suited to the requirements.

An essential feature of the telephone communications scheme is that, in addition to local calls, extensions should be able to dial calls direct to extensions connected to exchanges at the other sites. As Tarif is the approximate geographical centre of the scheme, direct v.h.f. multi-channel radio links are provided between this and the other three sites. Tarif is in fact the central exchange in a small star network and forms the tandem switching centre for calls between the outlying exchanges.

Each of the permanent sites has a Rurax exchange initially equipped for 25 extension lines with a wired capacity for 50. Each of the terminal exchanges is equipped with two bothway junction relay sets operating to the central exchange with wiring for 5. Tarif, the central exchange, is initially equipped for 6 bothway junction relay sets with a wired capacity for 15. In all cases, the junction relay sets are arranged for E & M operation in conjunction with 3825 c/s signalling employed on the v.h.f. radio links. In

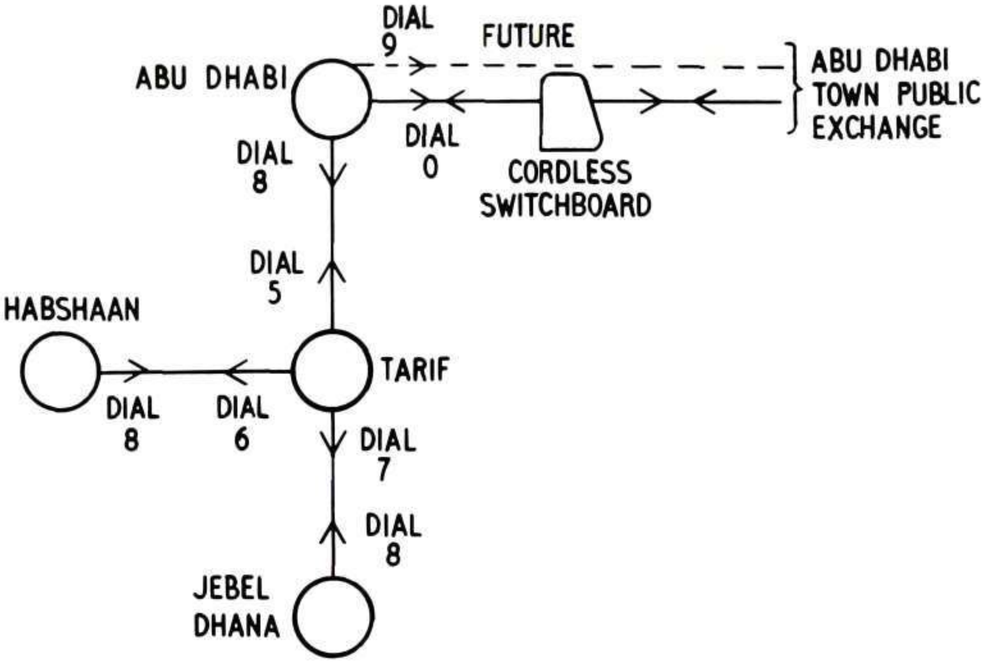

Figure 1—Abu Dhabi network showing junction and special service access digits

addition, Abu Dhabi, one of the terminal exchanges, has a remote cordless switchboard to provide manual connection between the oilfield network and the local public exchange and also to a h.f. radio link to Umm Said. The link from the cordless switchboard effectively makes the whole oilfield communications network a private automatic branch exchange in the Abu Dhabi public system. Provision is also made for future direct dialling from the network into the public system.

The basic equipment for a Rurax exchange of 50 lines or less is a single Line Unit and this normally accommodates all the necessary switching, junction and miscellaneous equipment. Group selectors are not usually introduced until the exchange extends beyond 50 lines, hunters being employed to provide access to and from junctions. However, to avoid using the local switching equipment on calls routed through the exchange, group selectors were introduced initially at Tarif. The local and incoming group selectors are mounted in a separate unit similar in construction to the line unit. As the wired capacity required for junction relay sets was in excess of that which the line unit could accommodate, a miscellaneous unit is also provided at Tarif. This, again, is of similar construction to the line unit. Thus, the exchange equipment for the terminal exchanges consists of one line unit together with an associated enclosed type M.D.F. unit. The equipment for the central exchange consists of a line unit, M.D.F. unit, group selector unit and a miscellaneous unit.

The diagram (Figure 1) shows the exchanges in the network together with the junction and special service access digits. Provision is made to bar selected extensions access to the junction circuits. This is done by means of a simple strapping connection on the associated extension line circuit. Successful junction calls are metered. Certain extensions and the cordless board operator are allowed to cut into engaged lines by dialling an additional digit on the receipt of busy tone. When the parties on the existing connection have replaced their handsets, the required line is automatically re-rung. This facility applies on both local and junction calls, consequently, the junction circuits incorporate a special discriminating element for recognizing and passing forward the priority condition. The junction circuits also incorporate an alternate testing feature, thus preventing, under fault conditions, the successive seizure of a faulty junction by a caller.

Conclusion

The Abu Dhabi Petroleum Company's oilfield network provides another outstanding example of the ease with which Rurax equipment can be adapted to meet the special requirements of a particular telecommunications system and its capability in providing reliable and efficient services under adverse conditions.

U.D.C.621.395.623.62

New Products and Developments

CAPSULE RECEIVER

This receiver was developed primarily as an alternative to the rocking armature receiver in the Etelphone and may be substituted for it directly without instrument modification or change in performance. Figure 1 shows front and rear views of the component.

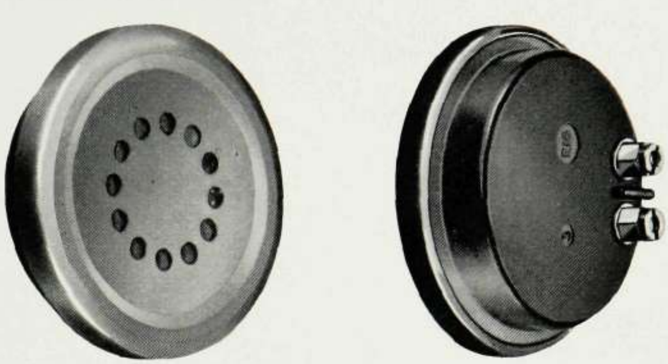

Figure 1—Front and rear views of capsule receiver

The driving unit (see inset illustration Figure 2) is a small electro-acoustic transducer based on hearing aid receiver practice. The annular magnet (*a*) is closed on its underside by a circular yoke carrying the polepiece (*b*). Yoke and polepiece are integral and of high permeability material.

A preformed coil on the polepiece forms a solid mass, completely impervious to moisture and atmospheric attack. No bobbin is necessary. A small aperture in the yoke provides a lead-out for the coil connections to the pressed-in terminal points in the receiver case.

An annular brass surround (*c*) is fixed to the magnet and stepped to provide a seating for the magnetic diaphragm (*d*) with concentric armature and aluminium diaphragm (*e*) attached.

The receiver case shown is a one-piece moulding with two concentric partitions, the surround of the driving unit being staked to the outer and the magnet housed in the inner partition.

The aluminium diaphragm is seated at its periphery on the case surround, thus bringing the magnetic diaphragm into its correct position on the driving unit. A polyester moisture-proof membrane is added and the receiver cap swaged over the case to complete the assembly.

The dimensions of the outer cavity in the case are chosen to give the required degree of acoustic loading; two small holes in the floor of the cavity also play a part in determining this.

Magnetization is adjusted for optimum performance, this coinciding with a minimum coil impedance of 150 ohms. No further adjustment or testing, other than in batch sampling, is needed.

The driving unit may be wound for other impedances as required and is

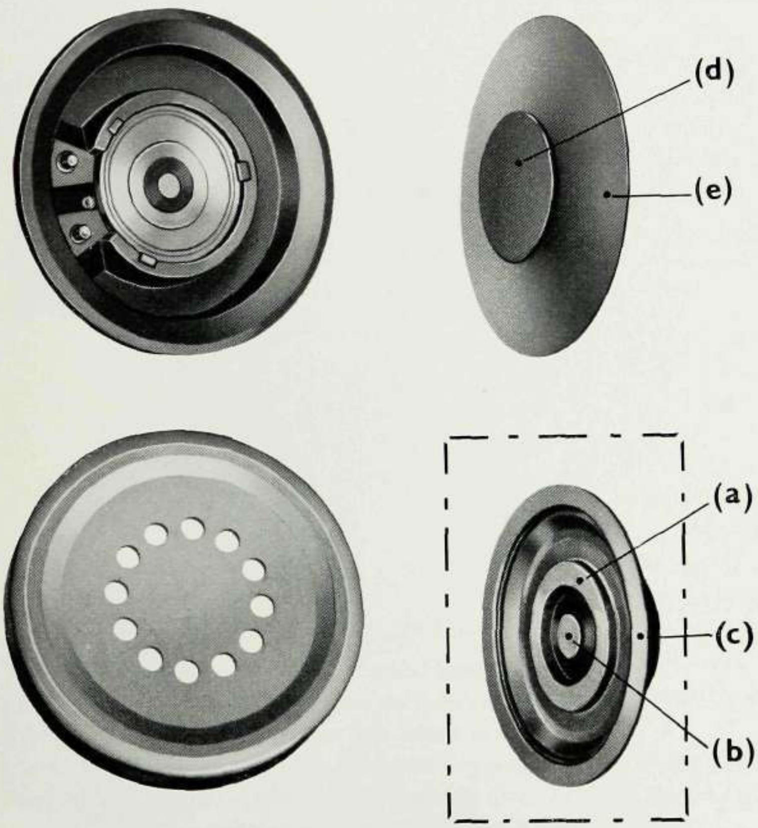

Figure 2—
Capsule-receiver components
(a) **Annular magnet**
(b) **Polepiece**
(c) **Brass surround**
(d) **Magnetic diaphragm**
(e) **Aluminium diaphragm**

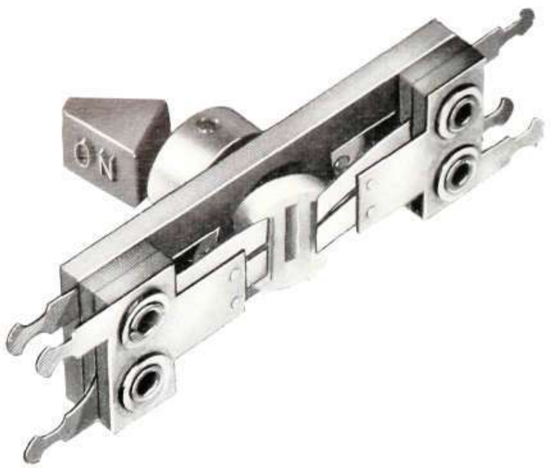

Figure 3—Minature toggle switch

equally suitable for use as a transmitter. Electromagnetic versions, e.g., for intercom systems with polarized receiver, can also be produced.

British Patent No. 932,276 and corresponding foreign patents

MINIATURE TOGGLE SWITCH

In this switch (Figure 3) a moulded toggle plate is supported across its under-surface by two pretensioned springs and is traversed across its upper surface by the lever-end.

With the lever at opposite ends of its travel, the plate is tilted by equal and opposite amounts. Deflections are correspondingly imparted to the springs so that one moves towards the switch baseplate and the other away from it.

Beyond the horizontal position of the toggle plate, spring pressure assists in completing the movement of the lever, resulting in a crisp snap action.

In either thrown position the tilt of the toggle plate causes it to rest at one edge upon a recessed area in the baseplate. Since the opposite edge rests on the lever end, the travel of the toggle plate, and thus of the springs, is accurately determined. Wander of the toggle plate in its own plane is prevented by ribs on the under surface, which engage the spring-ends.

The switch illustrated gives a 1 + 1 changeover action; in either direction of throw the springset approached by the lever-end completes its changeover before the opposite one commences. Twin silver contacts are employed, the ends of the moving springs being bifurcated.

Larger spring pile-ups can be accommodated in a switch of this design by comb or card operation of one or both moving springs.

The base plate and separators of the switch are of SRBP, the lever handle in coloured nylon and the toggle plate in Delrin. Springs are riveted in position; panel mounting is by means of a circlip on the metal pivot-housing. Tests on production samples have shown that an average life exceeding 100,000 operations can be expected.

British Patent Application No. 12973/64

TELESOCKET

This flameproof unit, illustrated in Figure 4, has been designed primarily for use in magneto, auto and auto-magneto Mine telephone systems. Installed at intervals of 200 to 400 yards along a main roadway it allows any authorised person with a plug-in portable telephone to gain speedy access to the colliery exchange.

Sturdily constructed in cast iron and heavy steel plate it includes horizontal entries for two special single-wire armoured-cable glands (see ‘Screw-in Cable Gland’ below) and a vertical entry for acceptance of the telephone socket. This entry is located on the underside of the unit to minimize the ingress of dust.

Removal of the cover with its synthetic rubber gasket reveals three $\frac{1}{4}$ in. holes in the baseplate for mounting purposes, and a 6-way porcelain terminal block for through and tie-in connections.

Figure 4—Telesocket

SCREW-IN CABLE GLAND

This gland (Figure 5) embodies the fixing principle of couplers having a captive threaded connector that rotates to make the union, the rest of the coupler remaining stationary. Its advantage over other screw-in glands is that no twist is imparted to the cable or junction box during installation.

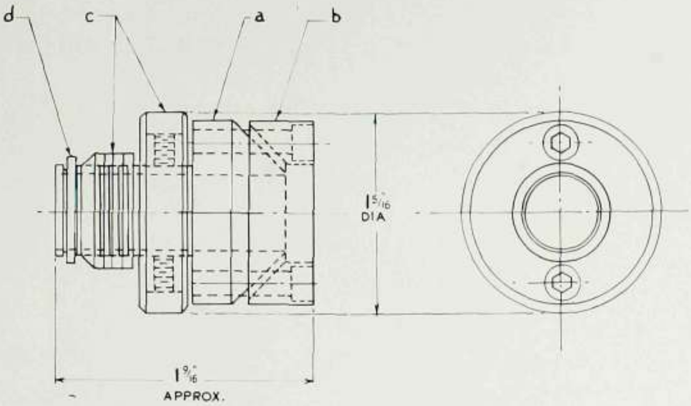

Figure 5—Screw-in cable gland (a) Heavy bush (b) Clamping collar (c) Connector (d) Spring collar

The stationary part of the gland consists of a heavy bush (*a*) and a clamping collar (*b*). The face of the bush is coned.

The inner sheathing and conductors of the cable are inserted through the bush, the armouring wires being splayed out over the cone and clamped by means of the collar. This presents a matching face to the bush and is attached to it by two Allan screws.

The connector (*c*), which rotates on the bush, consists of a heavy knurled flange of slightly larger diameter than the bush, and a concentric tubular projection, threaded externally with a $\frac{3}{4}$ in. (19 mm) conduit thread. A spring collar (*d*) engaging a groove in the end of the bush serves to retain the connector, but permits a small amount of lateral movement.

After the connector has been screwed into the threaded aperture of the junction or terminal box, the bush is locked to the connector by means of four Allan screws provided radially in the latter.

When engaged with these screws, the Allan key may be used as a tommy-bar to tighten the connector prior to locking.

British Patent Application No. 43289/64

**Figure 6—
Illuminated press key with button removed**

ILLUMINATED PRESS-KEY

This key (Figure 6) is suitable for general application in telephone switching, or for other purposes where the voltage is not in excess of 250 volts and current not greater than 250 mA a.c. or 100 mA d.c. (300 mA d.c. is permissible if the voltage does not exceed 100V). Silver contacts are normally fitted, but other types can be provided to special order. Operation is by frontal pressure on the button, which actuates the springs directly with a basic non-locking action.

No screws are employed in fixing the assembly to the panel. Flexure of the frame sides enables the frame ends to be snapped into the panel aperture, notches in the frame corners engaging projections in the aperture.

A pivot-pin for the button passes transversely through the frame sides, being so secured as to permit their flexure. The button moulding carries recesses for the pivot pin at the upper end and a projection at the lower end; this bears on the back of the panel, forming a stop. With the frame in position, the button is inserted through the aperture, projection first, and pressed so as to snap on to the pivot pin. The frame sides are now prevented from flexing inwards by the button, and the key is thus locked securely to the panel.

To release the assembly, the button is prised gently off the pivot pin, tilted forward to free the stop projection, and withdrawn. The frame sides can now be flexed inwards and the frame removed.

Illumination is by a barrel-type bulb mounted behind a lens in the button. The bulb holder is contained between the frame sides, a peg-and-slot mounting enabling it to be moved forward to permit lamp replacement from the front of the panel without removing the main key assembly. Button and lens are available in a variety of colours and can be marked as required.

Keys can be supplied with locking or non-locking actions and for mounting on panels of 0·048 in., 0·064 in., or 0·080 in. thickness, as specified.

Figure 7—
Single miniature-key unit

Figure 8—Single miniature-key unit designed for 8 + 8 changeovers (double throw) or 16 changeovers (single throw)

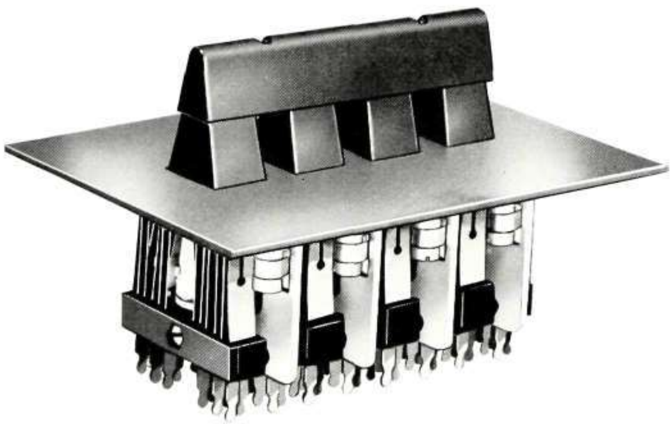

Figure 9—Multiple unit equipped with common-throw handle

Figure 10—Locking attachment for miniature keys

Figure 11—Key in one of the three locked positions provided by the locking attachment

MINIATURE KEYS

These keys were originally described in Bulletin No. 35 (July 1957). They have now been partially re-designed, with mouldings (of Delrin) replacing many of the metal parts, and the range of variants extended.

The double non-locking action is now obtained, like other actions, by means of a toggle instead of by springs in the lever as formerly (see Figure 7). Toggles are one-piece mouldings of similar design for all actions, the only difference being in the shape of the end which bears on the platform of the toggle-spring bush. This is V-shaped for double locking actions, half flat for locking/non-locking actions and full flat for double non-locking actions. The simplification in manufacture is particularly noteworthy in the second type, which replaces a three-piece riveted metal assembly. The new toggles are self-retaining, thus obviating the inter-toggle strap formerly necessary to prevent disengagement.

The lever assembly consists of two identical mouldings, which are placed on either side of the frame so as to engage the double pivot pin ends, and a rectangular moulded sleeve. This is a push-fit over projections on the above mouldings, serving as a strap to unite the assembly in the absence of the handle. The handle snaps over the assembly, its inside apex being a snug fit over the rectangular sleeve, thus eliminating shake.

Moulded bushes replace the brass inserts formerly employed to mount the pivot pins in the frame and act as distance-pieces between the lever sides.

The pin ends rest in curved slots in the lever; for a given direction of throw one pin bears under toggle-spring pressure against the inward end of its slots, forming a fulcrum, while the other pin slides. For single-throw actions the appropriate pair of slots is replaced by circular holes.

The toggle spring bush and integral platform is at present retained in metal but a moulded replacement is in process of tooling.

A version of the key is now in production giving eight changeovers. There is a single-throw locking or non-locking action. With the lever in the neutral position, four of the changeovers are operated and four non-operated; throwing the key reverses this disposition.

All keys are produced in single or multiple units of 2, 3 or 4 with one exception. This is shown in Figure 8. It is produced in single units only and is suitable for use in computers and a variety of control equipment, as well as in switchboards. The key provides $8 + 8$ changeovers (double throw) or 16 changeovers (single throw) and occupies a mounting space approximately equivalent to a normal 2-unit key assembly.

Individual or combined key operation is possible for the complete range. Figure 9 shows a multiple unit equipped with common-throw handle.

Locking Attachment

This simple, easily fitted locking device has a variety of uses, such as preventing accidental movement of keys from neutral or operated positions.

The attachment consists of the one-piece pressing shown in Figure 10 employed in conjunction with the special, pegged key-handle shown alongside. The key is first detached and the pressing positioned on the back of the panel so that two of the four corner-holes engage the key-mounting studs and the rounded V-shaped bracket projects through the panel aperture. The key is then re-attached with the existing handle removed and the lever in the neutral position. Finally, the special handle is pushed on; the bracket being flexed aside momentarily so that hole and peg engage.

Figure 11 shows a key in one of the three locked positions provided by the attachment. Movement from any position may be accomplished by a twisting action of thumb and forefinger.

British Patent Application No. 32021/64

DEMOUNTABLE JACKS

It is not uncommon for one or more jacks in a strip to receive much more use than the rest and so develop wear at a much earlier stage. With conventionally assembled jack-strips, the whole strip has to be replaced when this situation arises even though the majority of the jacks may be still unworn.

A moulded jack which may be individually withdrawn from or fitted into a strip has recently been developed and is shown in Figure 12. The jack body (*a*) is a one-piece moulding carrying channels at the tail end to receive the three strips forming the main conductors of the jack, and additional channels as required to receive subsidiary (springset) conductors. A moulded retaining piece (*b*) is a push fit into the assembly and carries channels and grooves on its underside to receive the upstanding edges of the conductors. Body and retaining pieces are of coloured glass-filled nylon.

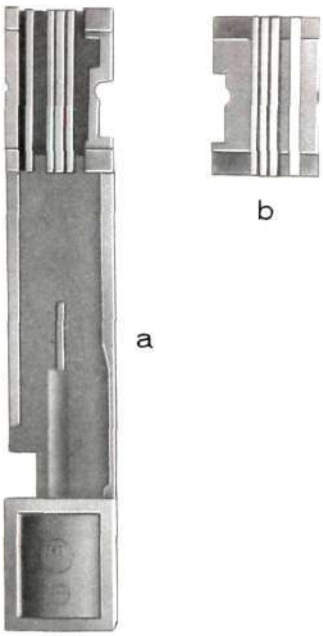

Figure 12—
Moulded jack on jack-strip
(a) Jack body
(b) Moulded retaining piece

The twenty-station metal carrier plate, shown in part in Figure 13 is pierced to give parallel rows of hooks and bar-ended tags. A jack is shown in position ready for locking to the carrier. A step in the base of the moulding, under the forward kink in the sleeve-conductor, is first engaged with the hook at the required station. The rear end of the jack is then lowered between the corresponding bar tags, a projection on the underside of the moulding entering the hole between the tags and assisting location.

The jack is locked by twisting the bar tags clockwise through 90° so that they engage the semicircular cut-outs in the retaining-piece (see upper illustration). A suitable tool consists of a rod with a diametric slot at the end. The floors of the cut-outs are contoured up slightly towards the 90° radius, so that the bars exert a compressive force on the retaining piece as they are turned. The jack may be released by twisting the tag bars through 90° anticlockwise.

A 'book end' moulding (not shown) is attached to each end of the carrier, preventing any sideways displacement of the front ends of the jacks, and also providing a means of clamping the jack strip to the switchboard framework. This moulding is locked in place by the end tag of the row and by the twin tags shown facing along the line of hooks. A projection on the moulding engages the circular hole shown on the carrier, assisting location.

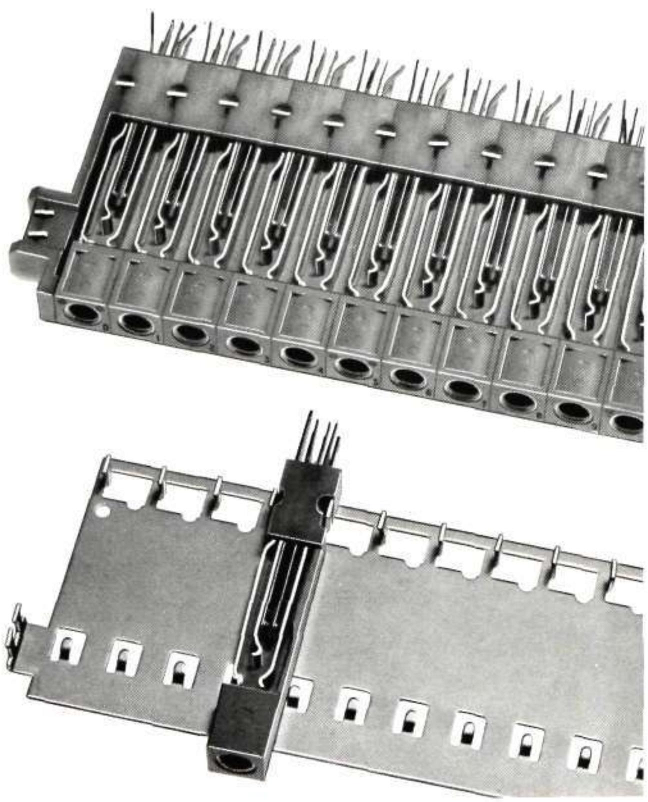

Figure 13—20-station metal carrier plate

British Patent Application No. 14910/64

Figure 14—Etelphone in case with stay fitting

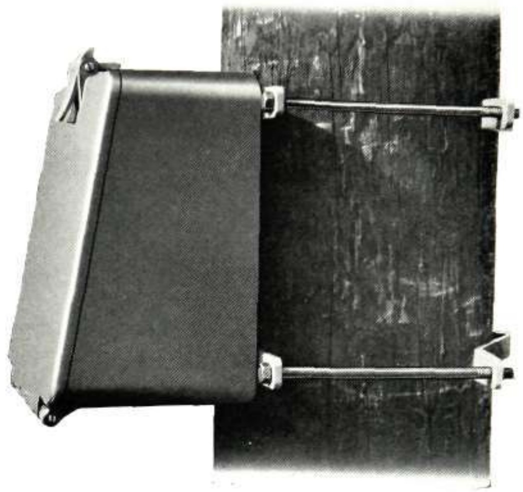

Figure 15—Pole-mounted Etelphone

WATERPROOF CASES FOR ETELPHONES

These cases are available in two forms; for Auto or CB Etelphones, and for Magneto Etelphones. Both forms are suitable for Wall or Pole mounting, pole fittings being included in the latter instance.

Construction is of LM6 cast aluminium alloy with stoved silver grey enamel finish inside and out. The lid is secured in the shut position by a cast gunmetal slam catch at the top. A compression gasket of synthetic rubber provides a completely weatherproof joint.

Cable entry is via a $\frac{3}{4}$ in. (19 mm) diameter hole in the base which may be fitted with a gland if required. An adjacent hole of similar size is plugged and may be used for external bell connection.

Instrument ringing signals are emitted through louvres in the base, these being backed by a perforated metal plate to exclude rain and snow. A lamp mounting with a strong glass dome can be provided on top of the auto telephone case if visual signals are required in addition to ringing.

A lid-stay can be fitted on the Auto CB Etelphone case so that the lid may be used as a writing table. The Magneto-Etelphone case is provided with two removable aluminium battery boxes, accommodated one each side of the instrument in the upper part of the case.

Figure 16—Magneto Etelphone case showing battery boxes

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