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A NEW 10 + 50 LINE PRIVATE AUTOMATIC BRANCH EXCHANGE

A. L. WEAVER — Exchange Systems Development Engineering Department

This addition to our range of standard single-unit P.A.B.X. equipments caters for requirements not exceeding 50 extension lines and 10 exchange lines. Used in conjunction with an associated cordless switchboard it offers a varied range of facilities. It can be provided with B.P.O. 2000 or 4000-type two-motion selectors.

NEW versions of private automatic branch exchanges that provide up-to-date facilities and features of durability to improve service and minimize maintenance are essential to the working efficiency of many modern business organizations.

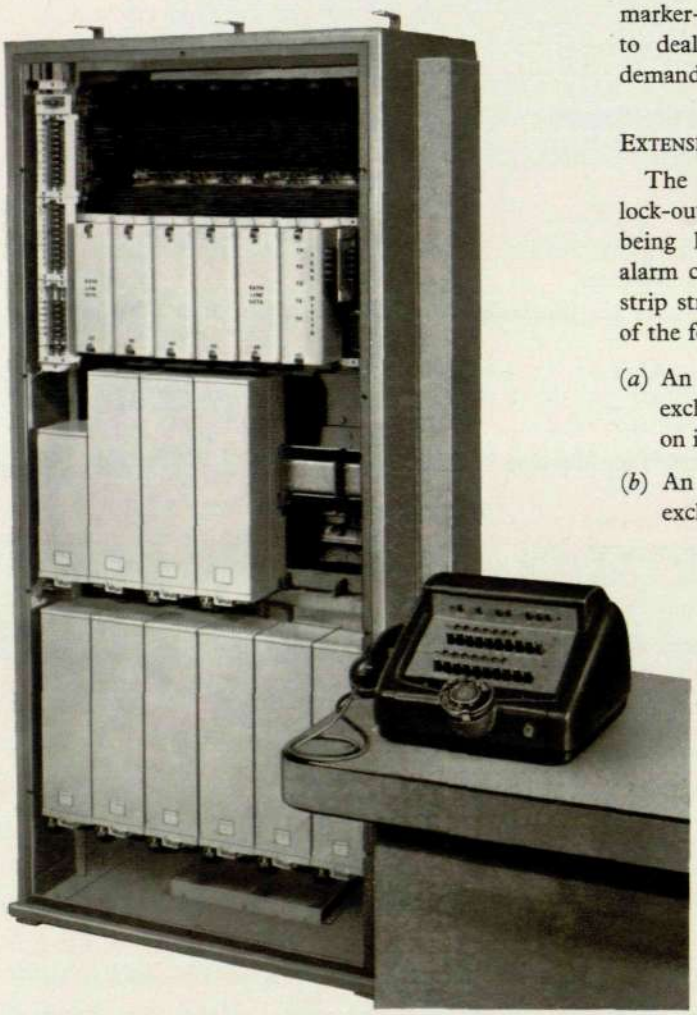

Fig. 1—General view of the P.A.B.X. Unit and switchboard

To augment our range of private automatic branch exchanges designed to fulfil such requirements, the Company has introduced a P.A.B.X. having capacity for 50 extension lines and 10 exchange lines. The equipment, as shown in Fig. 1, includes a small, attractive cordless switchboard coupled with a marker-switching arrangement to enable the attendant to deal with incoming exchange calls and other demands promptly and efficiently.

EXTENSIONS

The extension line circuits are provided with a lock-out facility to prevent switching equipment being held unnecessarily under P.G. or C.S.H. alarm conditions. By means of simple connection-strip strapping any extension may be placed in one of the following categories:—

(*a*) An extension having direct access to the public exchange and right-of-way (intrusion) facilities on internal calls.

(*b*) An extension having direct access to the public exchange but without right-of-way facilities.

(*c*) An extension barred from direct access to the public exchange but permitted to receive incoming or transferred public exchange calls. Outgoing calls are dependent upon the attendant or a direct-access extension.

(*d*) An extension fully barred from the public exchange.

A right-of-way extension is prevented from intruding on an extension engaged on a public exchange call. If required, this guard can be removed by a simple modification to the connector and call-back selectors.

When specified, a maximum of three extension lines can be connected via auxiliary equipment to convert them to manual extensions. All outgoing calls are routed by the attendant whose assistance is obtained when the handset is lifted. Calls to a manual extension are completed as for a normal extension.

Exchange Lines

The exchange line circuits are arranged for working to either automatic or C.B. public exchanges.

Direct access to the public exchange from an extension is gained by dialling a single code digit. If necessary, the exchange line circuits may be arranged in two groups with different access code digits for each group.

Incoming calls are normally answered and extended by the attendant. Rapid consecutive keying of extension numbers, together with 'camp on busy' and intrusion facilities ensures that operating time is kept to the minimum. Positive lamp signals enable the attendant to determine when the required extension is engaged on an exchange line, locked out, or when the number keyed is spare. Supervision is given until the connection of a call to an extension is established. Each exchange line circuit has an individual appearance to allow the state of unestablished calls to be easily observed. No clearing signal is provided as exchange calls are released automatically.

Outgoing exchange calls can be originated by the attendant and reverted to any extension not fully barred from the public exchange.

An extension engaged on an exchange call may make an enquiry call to another extension without being overheard by the public exchange subscriber. The repetitive transfer of an exchange call can be accomplished without the attendant's assistance. Attendant recall is also possible.

A guard against follow-on calls by barred direct-access extensions prevents dialling into an automatic public exchange after the exchange subscriber has replaced his handset. Through clearing permits the exchange line circuit to remain in the busy condition until the public exchange equipment has released.

Tie Lines

Direct access from all extensions to an external system, other than the public exchange, can be obtained by:—

(*a*) Utilizing a second group of exchange line circuits, incoming calls being answered and extended by the attendant as for public exchange calls.

(*b*) Replacing the second group of exchange line relay sets with tie line relay sets. Incoming calls are routed via an extension line circuit to allow direct 'in-dialling' to extensions. The attendant may originate a tie-line call and revert it to an extension in a similar manner to that adopted for exchange lines.

It should be noted that in either case the number of exchange line and tie line circuits that can be fitted is limited to ten. In case (*b*) the number of tie line circuits that can be fitted is limited to five (i.e. five exchange lines and five tie lines or six exchange lines and four tie lines, etc.).

Assistance Circuit

The assistance circuit provides a bothway link between extensions and the attendant. Extensions gain access to the circuit by dialling a single code digit, and the attendant may call an extension by means of the digit keys in a similar manner to that adopted for extending an exchange call.

When a fully barred extension is connected to the assistance circuit, a lamp indication is given to the attendant as a warning that the extension cannot be connected to the public exchange should such a request be made. If the circuit is engaged, a further lamp signal indicates when another assistance call is awaiting attention.

If tie lines with direct in-dialling are fitted, assistance calls can be made in the same way as if the tie line were a fully barred extension. Should the attendant need to originate a tie line call, this can be achieved directly via any free tie line circuit.

Night Service

Calls from the public exchange can be dealt with by either or both of the following schemes:—

(*a*) Incoming calls are indicated by the ringing of bells at selected points, and any extension not fully barred from exchange lines may answer by dialling a single code digit.

(*b*) The instrument bells of not more than two selected extensions ring when an incoming call occurs. When the call is answered, intrusion tone is superimposed on dial tone to indicate that the night answering code should be dialled to complete the connection to the exchange line.

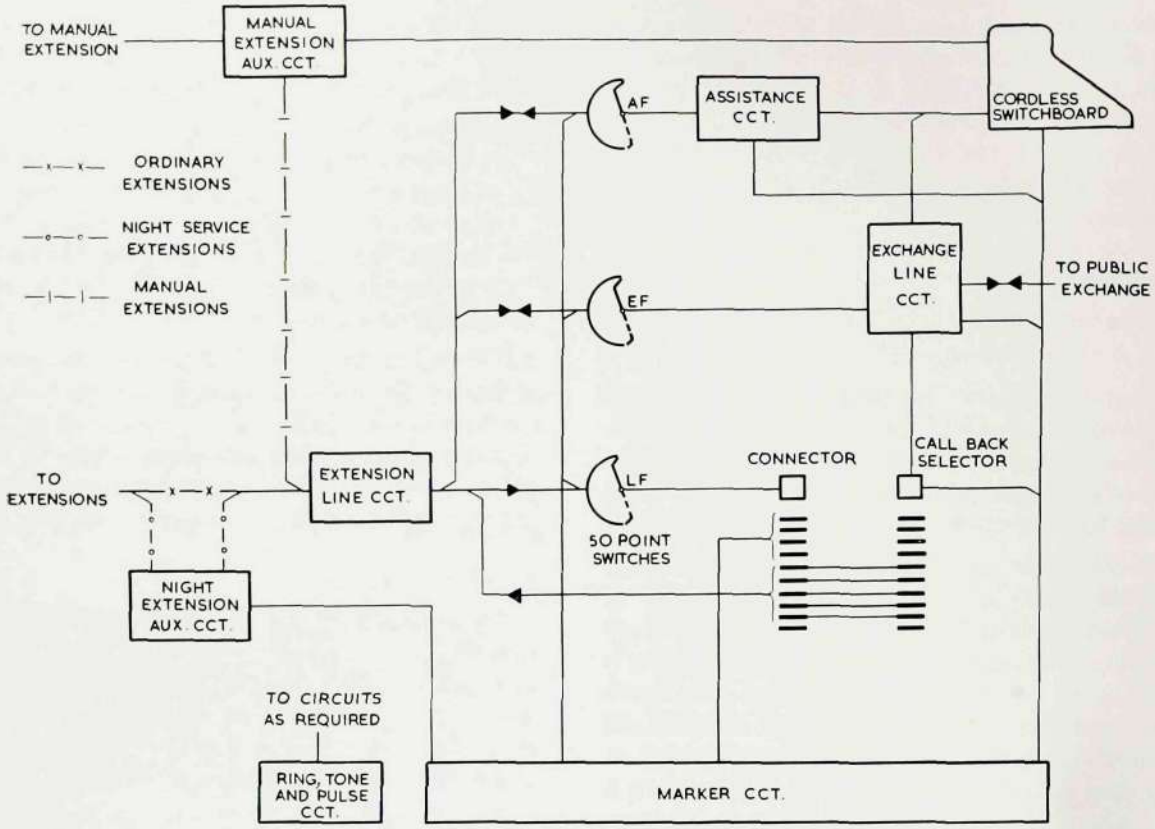

Fig. 2—Trunking Diagram

Should a night service extension be engaged when an incoming call occurs, intrusion tone is connected to indicate that an exchange call is waiting to be answered.

Numbering Scheme

Extension lines are numbered 20-69 with digits 7, 8, 9 and 0 available for allocation as access codes to:—

(*a*) Exchange lines.

(*b*) Tie lines or a second group of exchange lines.

(*c*) Assistance calls.

(*d*) Night service answering.

Operational Outline

The trunking details of the system are as illustrated in Fig. 2.

Extension to Extension Calls:—When an extension lifts the handset, a start signal is routed via the pulse circuit to cause the linefinder (LF), associated with a free connector, to self-drive to the relevant outlet. This arrangement enables the traffic to be distributed evenly over the connectors and also facilitates the passing forward of a start signal to an alternative circuit should any linefinder fail to locate a calling extension within approximately 5 seconds.

Dial tone is fed from the connector. Should the caller fail to dial or cause the inter-train pause to be excessive, the connector releases after approximately 20 seconds, leaving the extension line circuit locked out until the handset is replaced.

The dialling of two digits steps the connector to the outlet associated with the required extension. The line circuit is tested and, if engaged, busy tone is transmitted to the caller; if free, ring tone is returned and ringing current is applied to the called extension's line. If the called number is spare or locked out, the caller receives N.U. tone.

At the end of a conversation, if the caller replaces the handset first, the connector releases immediately and leaves the called extension line circuit locked out until the handset is replaced. Should the caller fail to replace the handset in approximately 20 seconds

after the called extension has done so, the connector releases, thus causing the calling extension's line circuit to be locked out until the handset is replaced.

A right-of-way extension may intrude on an engaged extension who is not connected to an exchange line by dialling the digit ' 1 ' on the receipt of busy tone. This causes a speech path to be connected to the engaged parties and intrusion tone to be transmitted to indicate the presence of the third party.

If a private conversation is desired, the engaged extensions may be requested to replace their handsets. The relevant extension is then rung automatically and the call proceeds normally.

Extension-originated Exchange Call:—Having removed the handset and received dial tone, the extension dials the relevant code digit to gain access to an exchange line circuit. The connector steps vertically and then automatically takes one rotary step into the level concerned. Provided no other type of call is being switched at this instant, the marker circuit permits the connector to mark the outlet on which the linefinder is standing. The marker circuit initiates a start signal via the pulse circuit to cause the exchange finder (EF), associated with a free exchange line circuit, to self-drive to the outlet connected to the calling extension.

At this stage, the marker circuit releases unless another call of this type is waiting to be dealt with, in which case the switching of this call takes place before the marker is released. The average time the marker circuit is engaged on switching any one call is 500 milli-seconds.

Meanwhile, the connector releases and the extension is connected to the exchange line circuit. If the public exchange is automatic, dial tone will be returned and the required subscriber's number may then be dialled.

Should a barred extension attempt to originate an exchange line call, N.U. tone is returned without seizure of the marker circuit. Similarly, busy tone is returned if an extension attempts a call when no free exchange line circuit is available.

Incoming Exchange Call:—When an incoming call occurs, a 'line' lamp associated with the circuit's position on the attendant's switchboard flashes to flicker earth, and a buzzer sounds. To answer, the attendant operates the appropriate ' speak ' key; the lamp continues to flash but the buzzer is disconnected. Having ascertained the extension required, the attendant keys the relevant number and this information is stored in the marker circuit. If no other type of call is being switched at this moment, the finder multiple is marked and the appropriate switch self-drives to the outlet concerned. Once this has been accomplished the marker circuit releases.

The required extension's line circuit is tested, and if this proves to be busy, the line lamp flashes to interrupted earth. Should the extension be already engaged on an exchange line, a subsidiary lamp glows steadily. In either case, the attendant is at liberty to intrude and offer the call without being overheard by the incoming caller. Intrusion tone is heard by the engaged parties whilst the attendant is connected.

If the extension agrees to accept the call, the attendant may inform the caller accordingly and then withdraw from the circuit leaving the call camped on busy. The line lamp continues to flash to interrupted earth until the engaged parties clear, at which stage the line lamp glows steadily, the called extension is rung automatically, and ring tone is returned to the caller, all of which would have occurred earlier had the required extension line tested free initially.

When the called extension answers, the line lamp is extinguished, thus indicating that the call has been completed. At the end of the conversation, clearing is achieved automatically, thus necessitating no further action by the attendant.

If during the course of an exchange call both the attendant and the extension are connected to the circuit (e.g. if the attendant introduces a call before withdrawing) intrusion tone is transmitted to indicate the presence of the attendant.

In the event of the attendant keying a spare number or the number of a locked-out extension, a ' number-unobtainable ' lamp, in addition to the line lamp, flashes to interrupted earth. This condition may be cleared by keying another number or momentarily operating the cancel key.

Should the attendant key a code digit, a spare first digit or the number of an extension line circuit allocated to a tie line, the number unobtainable lamp glows steadily and the line lamp flashes to flicker earth. Clearance of this condition can be effected by operation of the cancel key.

Attendant-originated Exchange Call:—Firstly, the attendant momentarily operates the exchange test key, which causes the line lamp of each busy circuit not already indicating a supervisory condition to glow. A free circuit may thus be chosen and the appropriate speak key operated.

The line lamp then flashes to flicker earth and if the public exchange is automatic, dial tone is heard and the required subscriber's number can be dialled. Thereafter, the call may be extended in the manner already described.

If the attendant wishes to release an exchange call without connecting it to an extension, this is accomplished by momentarily operating the release key prior to restoring the speak key.

Consultation Call:—If an extension during the course of an exchange call requires to consult another extension, a momentary operation of the instrument's transfer button causes the extension to be diverted to the call-back selector and a holding loop to be connected to the exchange line.

Dial tone is returned and the call proceeds as for an extension-to-extension call. Right-of-way is also available to extensions allowed this facility. Should any number other than that of an extension be dialled, N.U. tone is returned.

At the end of a consultation call, the originating extension again momentarily operates the transfer button to release the call-back selector and restore the connection to the exchange line.

' Fail to dial ' and C.S.H. ' time-out ' guards apply to the call-back selector, as for the connector, to prevent the selector being held indefinitely in these circumstances.

Transfer Call:—In the event of an extension requiring to transfer an exchange call, the extension to which the call is to be transferred is obtained as for a consultation call. Having achieved this, the original extension replaces the handset. This causes the marker circuit to be seized and the exchange finder to be self-driven to the outlet concerned. The exchange subscriber is connected to the new extension and the call-back selector and marker circuit release.

Special care has been taken in the circuit design to prevent an exchange call being lost owing to a fault or to mis-operation on the part of an extension during a consultation or transfer call. Should anything amiss occur, the exchange line circuit reverts to the incoming call condition and thus attracts the attention of the attendant or a night service extension.

Attendant Recall:—If an extension engaged on an exchange call wishes to recall the attendant, this can be achieved by a double operation of the instrument's transfer button. The call-back selector is momentarily seized and ring tone is transmitted to both the extension and the public exchange subscriber; the line lamp flashes to flicker earth and the buzzer sounds to attract the attendant.

When the attendant answers, ring tone is replaced by intrusion tone, the line lamp is extinguished and the buzzer disconnected. If only an enquiry is made, restoration of the speak key leaves the call in its original state. Should the extension request that the call be transferred, the attendant can do so.

If the extension replaces the handset before the attendant has taken any action, intrusion tone is disconnected and the line lamp flashes to flicker earth.

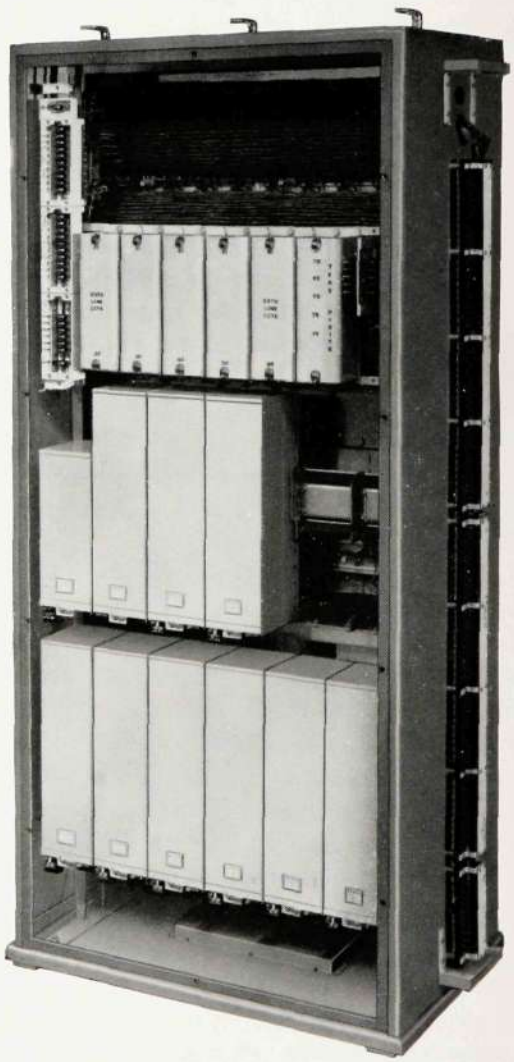

Fig. 3—Exchange Line relay sets in P.A.B.X. Unit. (Perspex door and cross-connection field cover removed)

In the event of an extension initiating a consultation or transfer call when the call-back selector is engaged, the call is directed to the switchboard for an attendant recall as previously described.

During night service the attendant-recall facility is, of course, ineffective.

Assistance Call:—As already explained, the assistance circuit serves as a link between extensions and the attendant. Within the limits of the facilities offered, it functions in a manner so similar to that of an exchange line circuit that further description is unnecessary except to explain the ' call-waiting ' feature.

If an extension dials the assistance code digit at a time when the circuit is engaged, the connector steps vertically and then automatically takes one step into the level concerned. The marker allows the connector to test free; ring tone is returned to the caller and the call-waiting lamp glows on the attendant's switchboard. During this period the marker is not prevented from dealing with other demands, but if another extension dials the assistance code digit, busy tone is returned.

When the attendant restores the ' assistance-speak ' key, the marker circuit controls the switching of the assistance circuit to the waiting caller. The connector and marker circuit then release and ring tone continues to be returned until the attendant answers.

During night service, N.U. tone is returned to any extension attempting an assistance call.

Exchange and Assistance Finder Safeguard:—The precautions taken to prevent a linefinder driving indefinitely under fault conditions have been described earlier. In the event of an assistance or exchange finder failing to find a marked outlet, the switch concerned is arrested after approximately 5 seconds and the following operations occur as appropriate:—

(*a*) If an extension is attempting to initiate an exchange call, the marker is released and the extension receives busy tone from the connector. The exchange-finder start arrangement is such that it is unlikely that the same finder will be seized on a second attempt.

(*b*) In the case of an exchange transfer, the extension to which the call was being transferred is locked out; the call-back selector and marker are released, and the attendant or a night service extension is called into the circuit concerned.

(*c*) If an extension is attempting an assistance call, the ring tone heard by the extension is disconnected and the marker released. The connector is eventually released under C.S.H. conditions unless the extension replaces the handset earlier.

(*d*) Should an exchange or assistance finder fail after an extension number has been keyed by the attendant, the marker is released and the number-unobtainable lamp on the attendant's switchboard glows continuously to indicate the failure. This condition may be cleared by a momentary operation of the cancel key.

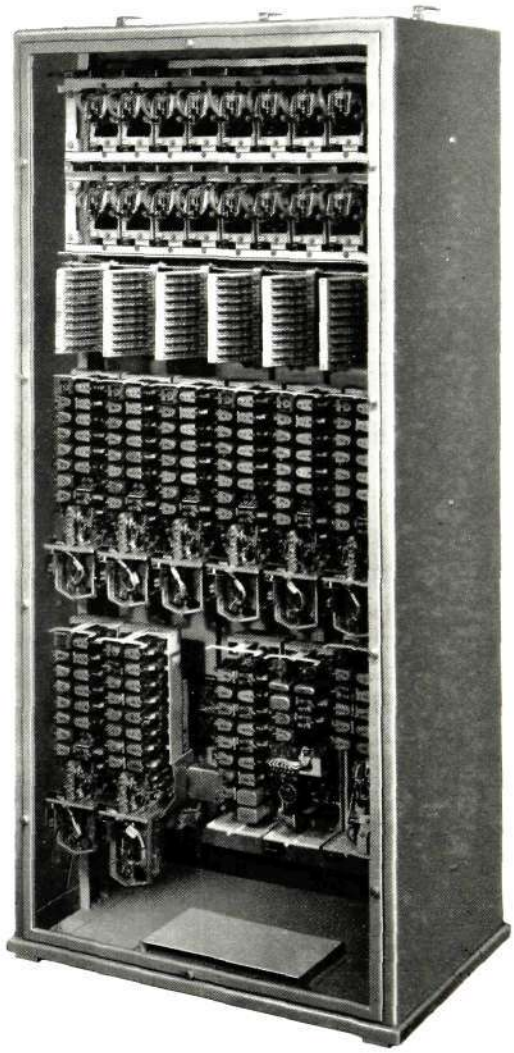

Fig. 4—Uniselectors, and two-motion selectors with covers removed in P.A.B.X. Unit (Perspex door on)

Fig. 5—The Attendant's Switchboard

RINGING AND TONES

Two transistor oscillators are provided, one being used for the 400 c/s tone requirements and the other for the generation of 25 c/s continuous-ringing current. Interruptions are controlled by means of interacting relays and a uniselector.

Dial Tone is provided by feeding continuous-ringing current via an attenuator network.

N.U. Tone is a continuous tone fed from the 400 c/s supply.

Busy Tone is fed from the 400 c/s supply via interrupter contacts which give tone periods of 800 milli-seconds ON and 800 milli-seconds OFF.

Intrusion Tone is also derived from the 400 c/s supply, but interrupter contacts control the tone periods to 60 milli-seconds ON, 340 milli-seconds OFF, 60 milli-seconds ON and 1140 milli-seconds OFF.

Ring Tone is provided by modulating the 400 c/s supply with the continuous-ring supply. The resultant tone is then interrupted 400 milli-seconds ON, 400 milli-seconds OFF, 400 milli-seconds ON and 2 seconds OFF.

Interrupted Ringing is provided for internal calls at the same intervals as Ring Tone.

Exchange Ringing is provided at the same intervals as Busy Tone and is applied in establishing exchange calls. In addition to indicating to an extension the nature of the call, it is also considered to be a more urgent calling signal.

VOLTAGE AND LINE LIMITS

The equipment is designed for an operating voltage of 50V but variation in voltage between 45 and 55V is permissible without operating reliability being affected.

Extension line loop resistance up to 800 ohms may be allowed with safety. The earth connection for an instrument transfer button may be obtained locally or by means of a third wire to the P.A.B.X. equipment.

Exchange and tie line loop resistance is independent of extension line limits.

ALARMS

Provision is made for alarms to be indicated on the attendant's switchboard. Lamp signals are used to discriminate between urgent and non-urgent alarms, and an audible signal is used in conjunction with the urgent alarm.

Fuse, release, and ring failures are classified as urgent alarms. The non-urgent alarm covers P.G. extension line faults and operates on a delay basis.

A mains-fail alarm can also be provided if required. The equipment does, however, allow selected extensions to be directly connected to the public exchange in the event of a power failure.

MOUNTING DETAILS

Every effort has been made to contain the equipment in as small a cubic capacity as possible consistent with giving easy access for maintenance purposes. As may be seen from Figs. 3 and 4, a double-sided cabinet of pressed-steel construction is used, the overall dimensions being 5′–9″ (175.3 cm) high, 2′–11″ (88.9 cm) wide and 1′–8″ (50.8 cm) deep. These measurements are inclusive and allow for the cross-connecting field cover being in position.

Fig. 3 shows the mounting arrangement of the extension line circuits, assistance circuit, marker circuit, and eight exchange line circuits with positions for a further two exchange line circuits. Fuse panels, heat coils and a routine test jack are also mounted on this face.

On the opposite side, as may be seen from Fig. 4, are the uniselectors employed as assistance, line, and exchange, finders. Below these are the extension line and miscellaneous connection strips, connectors,

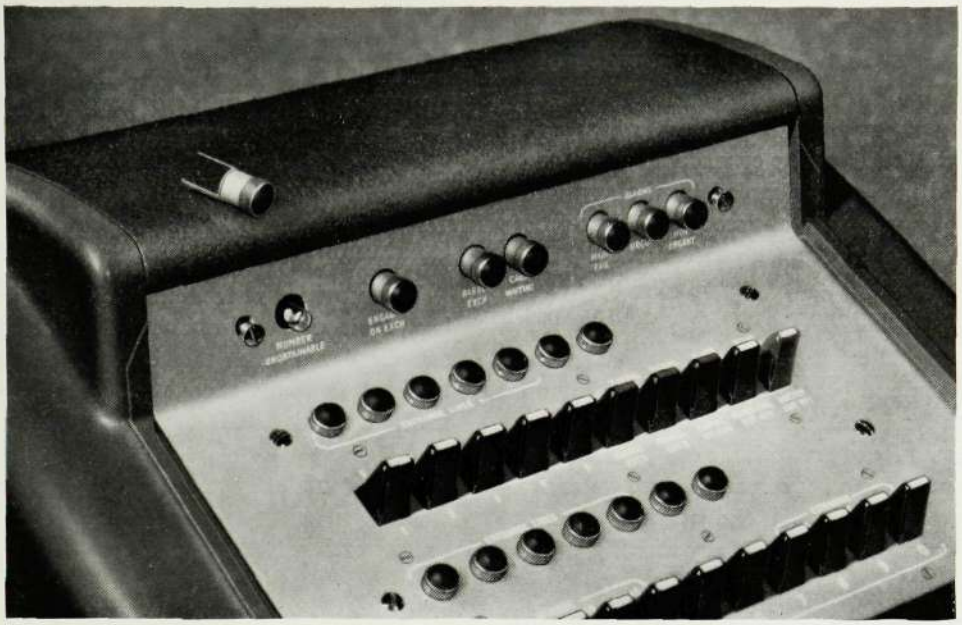

Fig. 6—Method of replacing a faulty lamp

and call-back selector. Also included at the lower right-hand corner are the relay sets accommodating the ringing and tone generating equipment and the manual extension auxiliary circuits. Selector and relay-set covers are provided, but are shown removed in Fig. 4 in order to give some idea of the amount of equipment used by the various circuits.

Perspex doors provide protection against dust and allow the functioning of the equipment to be observed. The cross-connecting field enables access to be obtained to extension and exchange line terminations for testing and re-routing purposes without disturbing the rest of the equipment.

The outer parts of the unit are finished in opaline green and the inner details in a light straw colour.

Attendant's Cordless Switchboard

Fig. 5 illustrates the attendant's switchboard. The shell is the same pattern as that adopted for our cordless switchboard described in detail in Bulletin No. 35. It occupies no more desk space than an office typewriter and is 13″ (33 cm) wide, 13″ (33 cm) deep and $8\frac{1}{2}$″ (21.6 cm) high.

The face panel has been carefully designed to keep operating procedure as simple as possible. At the top of the board may be seen the special supervisory and alarm lamps described earlier. The first seven keys on the upper row are double throw, each direction being associated with a lamp peculiar to an exchange line circuit, the assistance circuit or a manual extension. A further key is used for the control of manual calls, the other two keys being associated with alarms and night service working. At the bottom of the panel are the digit keys used for the completion of internal calls. The opposite throw of several of the digit keys is utilized for 'splitting', intrusion and other requirements. The dial is conveniently placed for the attendant to originate external calls.

The loosening of a captive screw on either side of a lamp strip (Fig. 6) enables the lamp assembly to slide forward, thus permitting a lamp to be removed without the need for a lamp extractor. In the event of the exchange line circuits being split into two groups, coloured lamp caps are fitted to distinguish the circuits associated with each group.

The switchboard is finished in two-tone grey which readily blends with most modern office furnishings.

Apparatus and Finish

Apparatus of proven reliability is used. It includes British Post Office standard type heavy-duty uniselectors, Type 4000 (or alternatively, Type 2000) two-motion selectors, and 'major' and 'minor'

relays, as well as 'twin' type line relays, together with the high-speed and thermal types required for special circuits.

The equipment has full tropical finish, whilst p.v.c. insulated wire is used for the connections; thus, with the additional protection afforded by the apparatus covers, and being totally enclosed in a dust-proof cabinet, the whole is adequately safeguarded.

Capacity and Equipment

P.A.B.X. 10 + 50 has capacity for 10 exchange line, 50 extension line and 7 connector circuits. The stock equipment is for 4 exchange lines, 30 extension lines and 4 connectors, together with the call-back selector, assistance circuit and other common items. Extension by the addition of line circuit and jack-in equipment is a simple matter as the unit is fully wired.

Power Supply

A mains-operated rectifier unit designed for wall mounting adjacent to the equipment unit meets the needs of most installations. If preferred, batteries and a suitable charger are supplied.

Conclusion

The provision of facilities of doubtful efficacy has been avoided. Well-established switching principles are employed and the exterior appearance has received as much thought in design as the most intricate circuit detail.

It is confidently anticipated that organizations which avail themselves of this new P.A.B.X. will be satisfactortly served for many years.

U.D.C.621.396.65

SINGLE-CHANNEL RADIO TERMINATING UNITS

W. E. HUNT, B.Sc. — Head Office, London.
J. E. DAVIES — Carrier and H.F. Development Department.

Fixed station single-channel radio equipment can be used to provide a reliable and economical junction or subscriber telephone circuit over short distances.

This article describes a number of terminating units suitable for connecting such radio circuits to different types of telephone exchanges.

THE use of a radio link to provide communication between two fixed points as an alternative to the installation of a physical circuit is now a well-established practice, and many types and arrangements of radio equipment are available and in use.

During recent years, there has been a growing demand to extend the facilities of radio links to provide a subscriber service to an exchange and also to provide a single junction facility between exchanges of various types.

Point-to-point radio circuits may operate on a simplex or duplex principle and generally depend upon loud-speaker calling. The most suitable radio equipment to operate into a telephone system is one of the duplex type, which provides separate go-and-return paths simultaneously.

Such an arrangement, however, requires a number of modifications ; in particular, facilities to convert from 4-wire radio to 2-wire telephone working, and also the provision of suitable signalling equipment to give the exchange calling and clearing arrangements.

It is for these reasons that differing types of terminating units have been designed, the variants being necessary to overcome either radio difficulties or to provide the particular types of service required.

CIRCUIT REQUIREMENTS

2W/4W CONVERSION UNITS

As connections to a telephone exchange are normally made on a 2-wire basis, it is necessary to fit hybrid transformers in the terminating unit to provide speech paths between the 2-wire telephone line and the 4-wire radio path. This arrangement automatically imposes limiting conditions on the maximum gain allowable in the radio path if ' singing ' is to be avoided.

Singing occurs round a 4-wire circuit terminated with 2-wire/4-wire hybrids when the total gain in the 4-wire path exceeds the total loss across the terminal hybrid transformers. Whilst the amplification provided in the transmitters and receivers can be stabilized and held within close limits, the attenuation of the radio path may vary between very wide limits for reasons well known to the radio engineer, and this factor must be allowed for in the initial planning of the circuit.

Reasonably stable circuits can be obtained using frequencies in the v.h.f. and u.h.f. bands with line-of-sight between the aerials. When greater distances are to be covered and frequencies in the h.f. band are used, it is necessary to provide additional equipment in the terminating units, in the form of singing suppressors, etc., to ensure stable operation in the face of the wide variation in the radio path attenuation.

SIGNALLING

The calling and clearing signals between a telephone and a switchboard or exchange are usually provided by the use of d.c. loops and low-frequency alternating currents ; the radio equipment, on the other hand, will only transmit voice-frequency signals and is not therefore capable of passing the type of signal required by the telephone equipment.

The terminating unit must therefore contain equipment for accepting the telephone signals and converting them into suitable radio path signals and *vice versa*.

The simplest form of signalling used over the radio path is effected by switching the transmitter on at one end and using the presence of radio carrier at the distant receiver to operate a relay which, in turn, sets up the desired signalling condition. Removal of the radio carrier can then also give a clearing signal.

Under favourable conditions this method can give quite satisfactory service, but should the radio path be subject to severe fading or prone to interference signals from other sources, false clears or calls may result.

To overcome this interference trouble, a very satisfactory solution is to provide a further signalling frequency within the pass band of the radio equipment so that calling and clearing conditions depend upon the presence or absence of both radio carrier and the voice-frequency tone signal. The use of this additional tone provides further facilities, as it may also be pulsed under the action of an automatic dial. In this case, the resulting pulses of tone passing over the radio link to the distant terminal can, after detection, set up the d.c. loop condition necessary for the operation of the switches in an automatic exchange.

TYPES OF TERMINATING UNIT

UNIT RTU 1

This unit is used to connect a radio terminal to any type of manual switchboard utilizing plug and cord connecting circuits. It consists of two parts, the first being a chassis unit $3\frac{1}{2}$ in. (8.9 cm) high, suitable for mounting on a standard 19-inch rack associated with the radio transmitter and receiver, and the second part being a set of components for inclusion in the switchboard. A power pack within the terminating unit provides all the necessary signalling currents, thus making it entirely independent of the exchange battery supply.

Insertion of a plug into the radio line jack on the switchboard operates a relay in the terminating unit which switches on the radio carrier to give a calling signal at the distant terminal.

As mentioned previously, this method of calling does demand a radio path having stable characteristics and freedom from interference to avoid false operation. Two forms of service can be provided by this unit ; the distant terminal may be a normal subscriber, in which case no modifications whatever are required ; if, however, a further RTU 1 unit is fitted at the distant terminal the circuit can provide junction facilities between two switchboards.

If the switchboard is to be supplied at the same time as the radio equipment it is possible to modify a cordless-type switchboard to provide the necessary terminating and speaking facilities as an alternative to the cord-type board.

UNITS RTU 5 AND 6

This pair of units is recommended when it is desired to provide subscriber service over a radio link affected by possible intermittent fades and/or extraneous interfering signals.

Both units incorporate a second signalling path using a frequency of 3825c/s, and switching only takes place when both radio carrier and this tone signal are present.

The 3825c/s tone can be switched on, off, or pulsed, and when used in conjunction with a suitable relay set it can give all the necessary signals required by a CB or automatic exchange. Provision is made within the terminating units to prevent the tone being heard by the subscribers and the tone detector being operated by speech currents.

The RTU 5 unit (Fig. 1) is fitted at the subscriber's terminal together with a normal 2-wire CB or automatic telephone instrument.

Fig. 1—Type RTU5 Subscriber's Unit

The RTU 6 unit is fitted at the radio terminal at the exchange end.

Each unit accepts the normal signals from the telephone equipment and converts them into the appropriate signals for transmission over the radio path, and *vice versa*.

The terminating unit consists of a chassis occupying a 7 in. (17.7 cm) panel position and can be supplied suitable for mounting on a standard 19″-rack, or fitted in its own casework. Fig. 2 shows an RTU 5 unit viewed from the rear and removed from its case.

A simplified schematic drawing of the subscriber's unit is shown in Fig. 3, and the following brief description is intended to show the general principle upon which these units function.

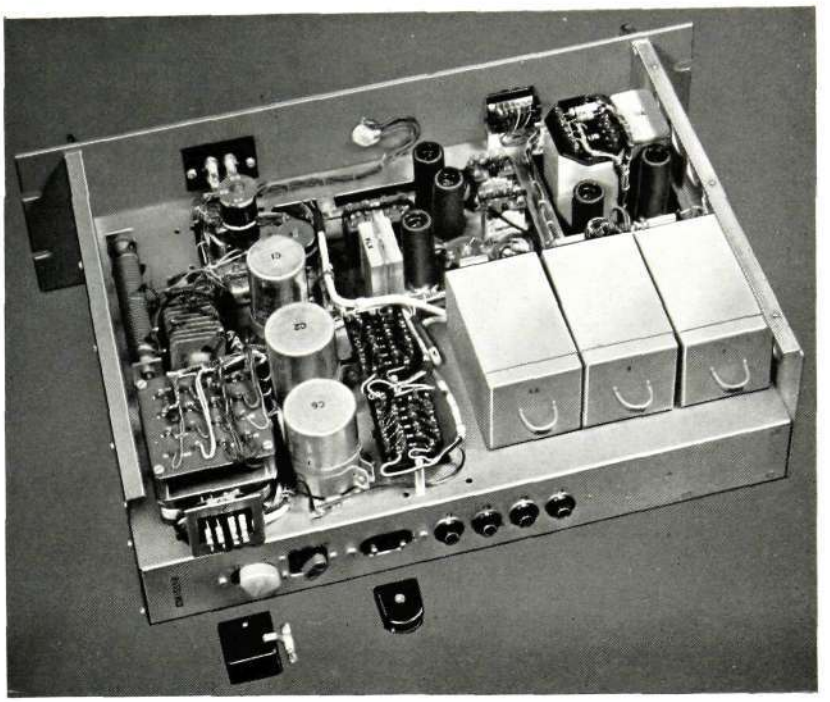

Fig. 2—RTU5 Chassis viewed from rear

The hybrid transformer UA serves to interconnect the 2-wire telephone line with the 4-wire radio circuit. The band-stop filter FU1 suppresses speech frequencies and their harmonics in the band 3775—3875 c/s, thus leaving a free path for the signalling tone and assisting the action of the guard circuit in the distant dialling receiver. The signalling tone is fed from the oscillator UC through a static modulator, which is keyed by the application of an earth from relay contact A2, and injected into the 4-wire transmit path via transformer T1. The variable attenuator UD makes it possible to adjust the signal level at this point to suit the input level required by the particular radio equipment being used.

A similar attenuator UE is used to adjust the level in the 4-wire receive path. The dialling receiver UB, tapped across the 4-wire receive path, accepts the pulses of 3825c/s tone and converts them to d.c. impulses which are passed via relay RX to the associated relay circuit. In the event of harmonics of speech corresponding with the signalling frequency, a guard circuit is provided to respond to the fundamental and prevent RX from operating to the false signal. This unit also includes a blocking amplifier to prevent outgoing speech currents or switching surges affecting the dialling receiver.

Outgoing Call

When the subscriber picks up his handset prior to making a call, the d.c. loop across the line causes a carrier to be transmitted, the receipt of which by the distant radio equipment switches on its transmitter, thus completing the radio path. This same operation seizes the exchange equipment and dial tone is passed back to the subscriber. The breaking of the d.c. loop by the dial contacts, operates a relay which keys the static modulator, thus transmitting pulses of tone over the radio link. These pulses of tone are detected by the distant dialling receiver and converted to the interrupted d.c. loop required to step the exchange switches. When the calling subscriber replaces his handset at the completion of the call, a pulse of tone is transmitted to operate RX in the dialling receiver at the exchange unit and cause the loop to the exchange to be broken and the call released.

Incoming Call

Interrupted ringing from the exchange is converted to pulses of tone by the distant exchange unit. This incoming tone operates RX in the dialling receiver which connects 50c/s ringing to the 2-wire line. The switching on of the transmitter and other circuit functions are as for an incoming call.

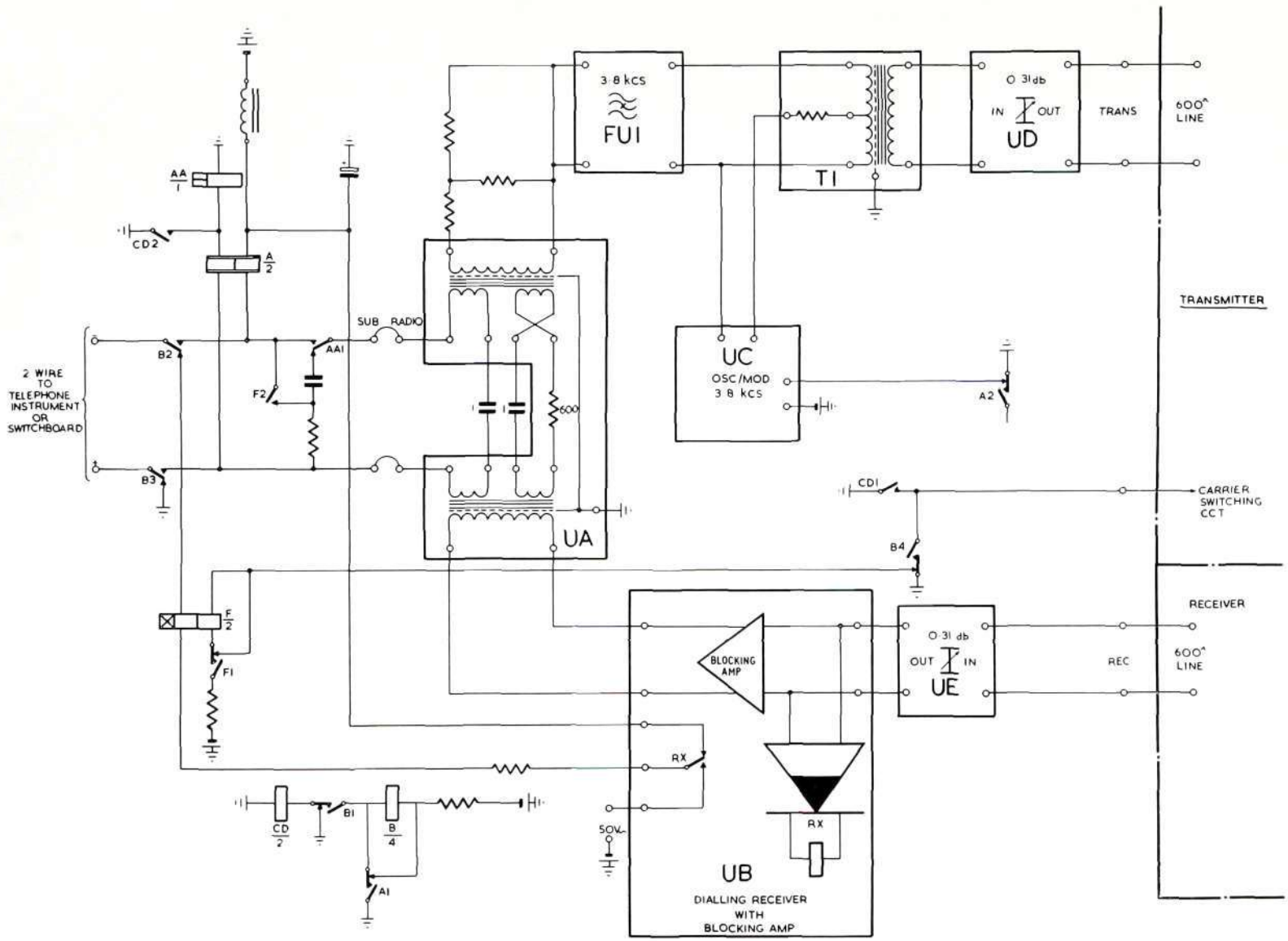

Fig. 3—Circuit Diagram of the RTU5 Subscriber's Unit

Fig. 4—RTU8 Unit with typical cordless switchboard

UNIT RTU 7

This unit utilizes similar principles to the RTU 5 and 6 and is used in pairs to provide a junction circuit between two CB or automatic exchanges ; one unit is necessary at each radio terminal.

As junction working between automatic exchanges is normally provided between selector levels, a bothway-junction relay set is also necessary at each exchange. In order to cater for the many types of automatic exchanges which may be involved, a universal relay set has been designed and is provided with a suitable wall mounting if it is not expedient to mount it on the existing racks.

Mechanical details are similar in principle to those of the RTU 5 and 6 units.

UNIT RTU 8

The units previously described are usually associated with radio equipment operating in the v.h.f. or u.h.f. bands where the radio terminals and any intermediate repeaters are within line-of-sight of each other.

For much longer radio paths it is usual to operate in the h.f. bands, and such circuits may suffer considerable changes in path attenuation. To provide a reasonable overall transmission equivalent, the gain in the radio equipment must be as high as possible, but should the loop gain of the four-wire path exceed the sum of the losses across the hybrid transformers, singing will take place.

For international circuits of this nature, there are available termination units complete with constant volume amplifiers, singing suppressors, expanders, etc., and such circuits are usually under the direct supervision and control of an engineer.

For shorter distances and circuits of a non-international nature, the use of this form of unit may not be considered justified and so a simplified version, type RTU 8 has been introduced (Fig. 4), incorporating singing-suppressors and using 2280c/s in-band signalling.

The singing-suppressor contains voice-operated switching circuits which ensure that only one path of the 4-wire radio circuit is open at any one time, thus preventing the singing conditions being set up. It is on this principle that the RTU 8 unit functions.

The principles of operation follow closely those of the previous units.

The RTU 8's provide facilities to operate into CB switchboards. Fig. 4 illustrates a typical cordless board suitable for this purpose.

A PRINTING RECORDER FOR USE WITH OBSERVATION EQUIPMENT

B. A. GREEN, M.I.Prod.E., M.I.E.I., and H. BLAKEY*

This article appeared in the current July issue of the Post Office Electrical Engineer's Journal and is reprinted by kind permission of the P.O.E.E.J. Authorities.

The printer described was developed primarily for use with meter-observation equipment. It is portable but requires an external control equipment and a 1-second clock pulse. It is intended to work without attention for long periods and has been designed to ensure ease of maintenance.

UNTIL recently most observation equipment, used either for verifying circuit operation or to collect statistical data, has involved the use of an operator. For some purposes automatic observation equipment would have given sufficient information, but the scope for such automatic equipment has not previously justified the development involved. However, the introduction of subscriber trunk dialling and the consequent registering of trunk-call charges on the subscriber's meter has increased the need for automatic observation equipment with printing recorders. The largest application of the printing recorder described in this article will be for checking the accuracy of the metering of customers' calls,[1] and it is this use which has determined the basic facilities. There is, however, a degree of flexibility in the design which will permit other applications, the most obvious of which is its use for traffic analysis.[2]

Fig. 1—The Printing Recorder

The machine, a general view of which is shown in Fig. 1 and with the cover removed in Fig. 2, is designed to provide a printed record of all events on the circuit to which it is connected and the times at which each event occurs ; for example, on an outgoing call the digits dialled and the meter pulses applied to the subscriber's meter are recorded, together with the week, day, and time of day, to the nearest second, at which each such event occurred. After printing, the paper tape moves upwards past the printing wheels and can, if required, be advanced manually by a knob on the outside of the case to enable the latest record to be viewed through the window at the front of the case. For special applications it is possible to pass the paper over a writing tablet positioned near the handle (Fig. 2). Manuscript entries can then be made on the tape before it passes back into the machine and on to the take-up spool.

All the printing operations are performed by electromagnets operated by an external control equipment, which must also supply the 1-second pulses for the timing mechanism. The machine is connected to its control equipment by a flexible cord.

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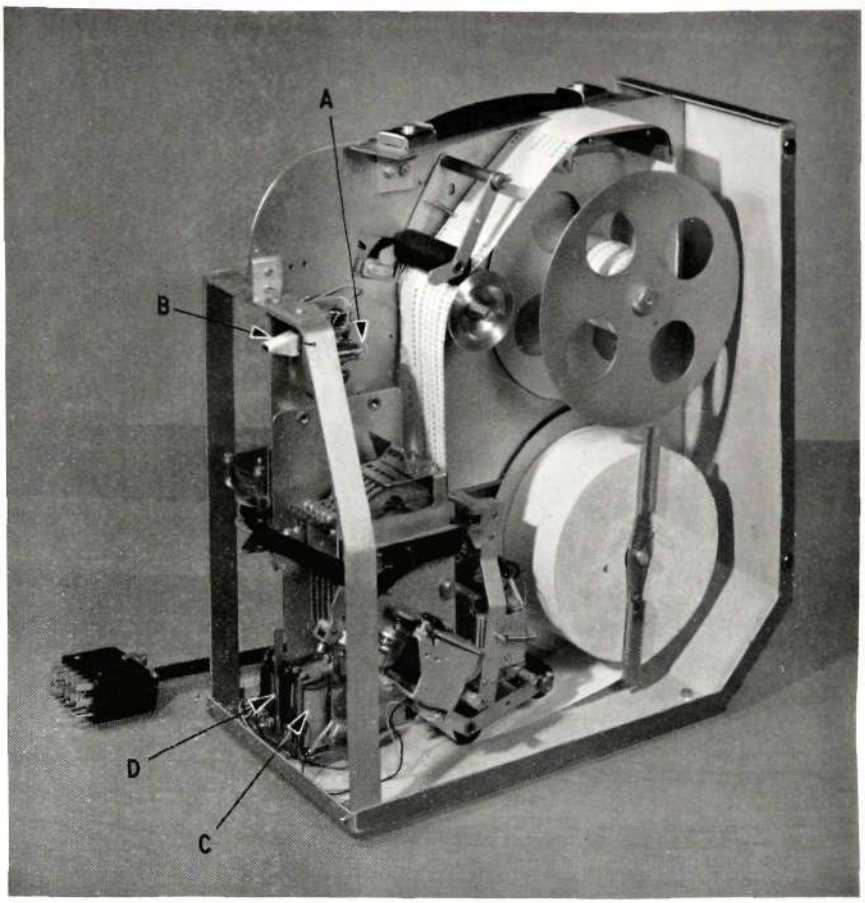
A lamp (A, Fig. 2) indicates that the equipment is in use and also illuminates the printed record. A key in front of this lamp (B, Fig. 2) disconnects the time mechanism when it is operated in one direction, and in the other direction it provides a local pulsing circuit. This facility is for synchronizing the printer with the exchange clock. When the cover is in position this key is not accessible.

The printer is 14 in. high with a base 13 in. x 7 in., and weighs about 29 lb. with a roll of paper fitted.



A. Equipment-busy lamp **B. Time synchronizing key**
C. Meter pulse sub-assembly **D. Digits-dialled storage sub-assembly**
Fig. 2—Printing Recorder with cover removed

Design Considerations

The size and general proportions of the machine have been largely fixed by the requirement that it should be portable and capable of holding a roll of 2-inch wide paper tape which can be transferred to a take-up spool within the case. The cover can be locked to prevent interference.

To keep down tooling costs many components already in production have been used and, to simplify both assembly and subsequent maintenance, the machine has been designed as a number of sub-assemblies which are individually mounted either side of a central plate. This central plate is supported on an L-shaped frame forming the base and back of the recorder. The carrying handle is attached to the central plate enabling the unit to be easily moved with the cover removed, and avoiding the distortion which might occur if it were fixed to the cover.

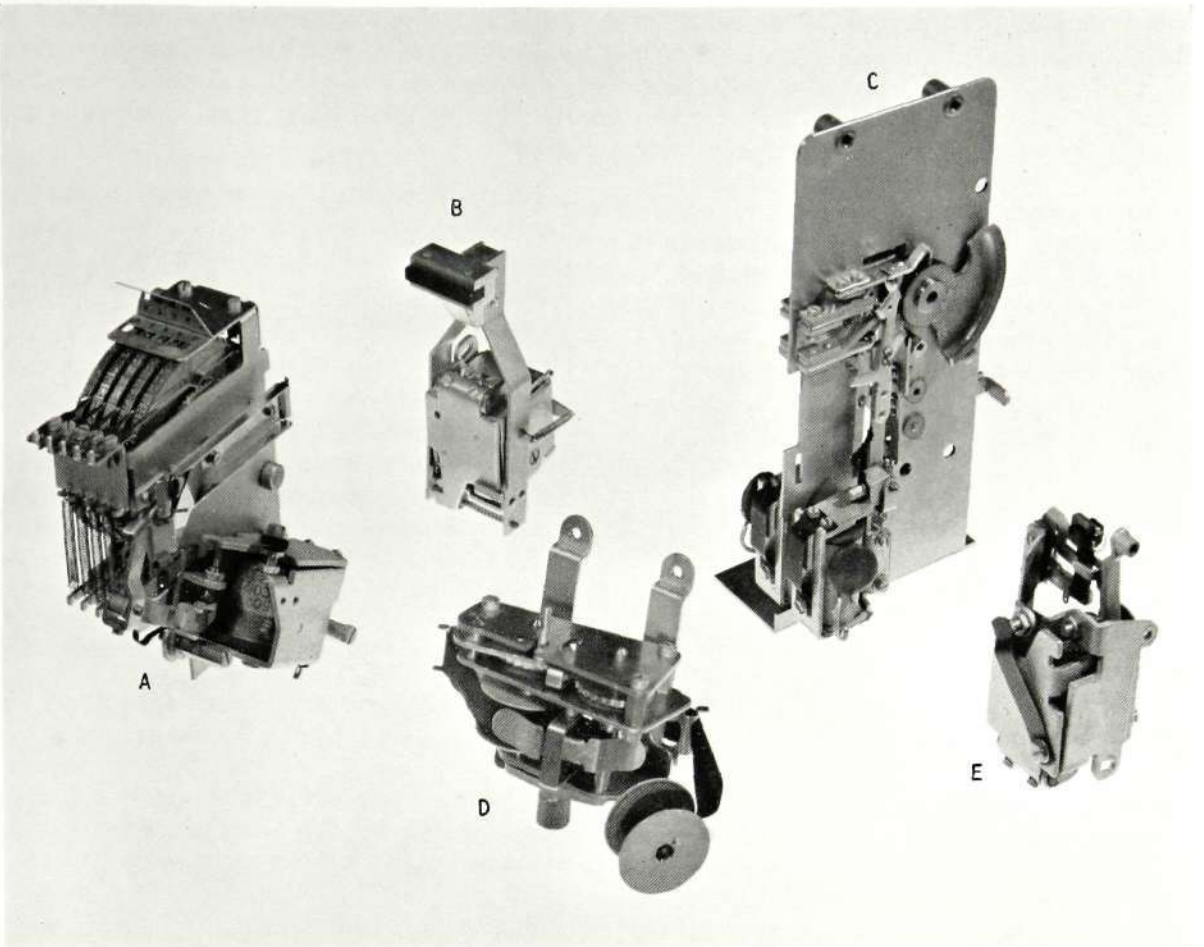
Mechanical Details of Sub-Assemblies

The Meter-Pulse and Digits-Dialled Storage Unit

The meter-pulse and digits-dialled storage mechanisms are shown as C and D, respectively, in Fig. 2. They are mounted either side of a verticle plate and the combined unit is shown separately in Fig. 3. Each consists of a ratchet and pawl mechanism operated by magnets which are basically the release magnet of the 4,000-type two-motion selector. Type sectors are fixed to the ratchets, and restoration of the type sectors to their normal positions after printing has taken place is by gravity.

The digit sector will print the characters—1, 2, 3, 4, 5, 6, 7, 8, 9, 0 and the metering sector will print F, M, 2, 3, 4, 5, 6, 7, 8, 9, 0, 11. The dash in the home position of the digit sector is used to indicate the beginning and end of an outgoing call. The F on the meter sector indicates that a call has not been metered and a single meter pulse steps the sector into the M position. Subsequent positions on the meter sector are used to indicate that multi-fee metering has been correctly registered.

Mounted on the vertical plate carrying these storage mechanisms there is a type-block with the letters I/C positioned so that it lies between the digit and



A. Date and time unit **B. Data and time printing-hammer unit**
C. Meter pulse and digits-dialled storage unit **D. Ribbon drive unit**
E. Individual track printing-hammer unit

Fig. 3—Main sub-assemblies of Printing Recorder

meter sectors. This is the abbreviation printed to indicate the beginning and end of incoming calls.

The Date and Time Unit

The date and time sub-assembly, complete with the 1-second magnet (which is basically a 4,000-type selector vertical-magnet assembly) is shown as A in Fig. 3. This sub-assembly is mounted on the plate carrying the storage mechanisms, an extension of the shaft carrying the type-wheels being located in a socket in the meter-pulse ratchet-wheel bearing to ensure correct alignment of all the type. The 1-second magnet operates the seconds wheel by a conventional ratchet and pawl mechanism. A snail cam on the side of the seconds wheel gradually lifts the minutes pawl during a period of 59 seconds. On the next 1-second pulse the pawl is released and advances the minutes wheel one step. Similar transfers occur between the remaining type-wheels in the unit. This method of gradually storing the energy helps to overcome the considerable load which is imposed when all the wheels have to move together once each week ; there are five type-wheels, which are used to indicate the week of the year, the day of the week, the hour, minute and second.

To facilitate the setting of the date and time wheels a stainless-steel mirror is fixed at an angle above the wheels so that the characters can be read from the front of the machine. To overcome the difficulty of seeing the type at the actual printing position the

reading is made at a position 90° in advance of the printing position where one type position on each type-wheel can be seen through a slot in a metal plate. The correction required to establish the time printed is a constant for each type-wheel and the appropriate correction factors are marked on the metal plate adjacent to each type-wheel. Thus, for example, if the seconds wheel is ready to print 25 the reading of the setting in the mirror shows " 40 minus 15 ". This reflection of the correction factor enables the actual setting at the printing position to be established without reference to a translation chart.

Individual type-wheels may be set by manually operating the transfer pawl levers to the full extent and then rotating the particular wheel to the required position.

The Printing Hammers and Magnets

The printing hammers, which are plastic faced, carry the paper and ink tape on to the type. This gives a much more simple construction than the alternative method of holding the paper stationary against a platen and moving the type to make the impression.

The date and time printing hammer is a modified 4,000-type selector magnet with a special armature (B, Fig. 3). The hammer has considerable inertia to give a sharp impression over the full width of the type-wheels. The hammer is pivoted on the armature so that it hits the paper on overthrow and rebounds after printing. This results in the hammer being in contact with the paper for a minimum period and almost eliminates the possibility of a smudged impression due to the 1-second wheel moving during printing. The other three printing hammers do not have this overthrow feature and are of a simpler and lighter construction, and their magnets are standard 4,000-type selector vertical-magnet assemblies (E, Fig. 3).

The Paper-Advance and Type-Ribbon-Advance Mechanisms

Separate magnets are used for the paper-advance and type-ribbon-advance mechanisms. The ribbon-advance mechanism uses a 4,000-type selector magnet, but the paper-advance mechanism is basically that of the P.O. Type 2 uniselector. Both mechanisms are reverse acting so that movement of the paper or ribbon takes place on release of the magnets.

The paper take-up spool is driven by a spring belt from the paper-advance mechanism. To counteract the effect of the gradually increasing diameter of the take-up roll, a slipping clutch is provided between the spindle and pulley wheel.

The ribbon drive (D, Fig. 3) is a compact unit which is located on the opposite side of the machine to the printing wheels. The ribbon is self-reversing and is kept taut by a leaf spring which also acts as a ribbon guide. This unit is a well-tried one, which is already in wide use in time-recording clocks produced for other markets by the developing manufacturer.

MOUNTING

The printer has been designed for use either as a portable item or for rack mounting in exchanges. In the latter case the printers will stand on open trays mounted on a rack, and the cut-away bottom corner (shown in Fig. 2) provides a space for the cords to run behind the machines to the jacks.

APPENDIX

In the above article the printer's particular application to meter observation equipment has been described and mention made of its further use in traffic analysis. It may be of additional interest to note here, however, that because of the printer's modular design the separate units shown can be replaced by other units to suit special requirements.

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2. *Ellis, D. R. B. Equipment for the Provision of Statistical Data Concerning Subscriber-Dialled Trunk Calls. (Also in the above issue of the P.O.E.E.J.).*

U.D.C.621.318.5

THE MULTIPLE RELAY UNIT

B. A. GREEN, M.I.Prod.E., M.I.E.I. — Apparatus Development Engineering Department

The development of reliable relays offering the advantages of low manufacturing, operating and maintenance costs and also economy of space, is one of the constant aims of this Company. With new design procedures and manufacturing methods these desirable objectives have been attained in the Multiple Relay Unit described. The unit comprises five relays mounted on a common base of small dimensions.

RELAYS, because they are so frequently used in telephone circuits, are one of the most important components in electromechanical switching systems. For this reason and to meet customers' many requirements, it is logical that considerable development work should be directed towards the improvement of relays, taking advantage of improved designs, new materials, and better manufacturing methods as these evolve. Since in the design of modern signalling equipment many circuit requirements can now be met by relays having not more than six contact units, and space conservation, like economy in cost, is very desirable, a 'five-in-one' general-purpose unit has been developed, known as the Multiple Relay Unit, and illustrated in Fig. 1. It occupies the space $4\frac{1}{2}''$ x $3\frac{5}{8}''$ x $1\frac{1}{8}''$ (114 x 92 x 28 mm.) and comprises five relays mounted on a common base to form an integral unit. With this arrangement substantial economies in manufacturing, operational and maintenance costs are obtained.

To achieve the economic objective without loss of reliability, an exploratory survey was made of all existing relays to establish a satisfactory basis for the new design. From the data gained it was realized that any real economy could be derived only by the attainment of the following desirable features:—

(*a*) An improved magnetic circuit.

(*b*) A simplification of parts.

(*c*) A reduction in adjusting effort and in the number of parts.

(*d*) Improved manufacturing procedures and processes.

(*e*) The avoidance wherever possible of existing design features known to cause difficulty during manufacture and service.

(*f*) The elimination of variable dimensions resulting from additive piece-part assemblies, e.g., contact spring insulation, lifting pins and studs.

The above requirements have been met by a basically new approach in relay design, as may be seen by reference to Fig. 2, illustrating the individual parts, the sub-assemblies and the order of assembly.

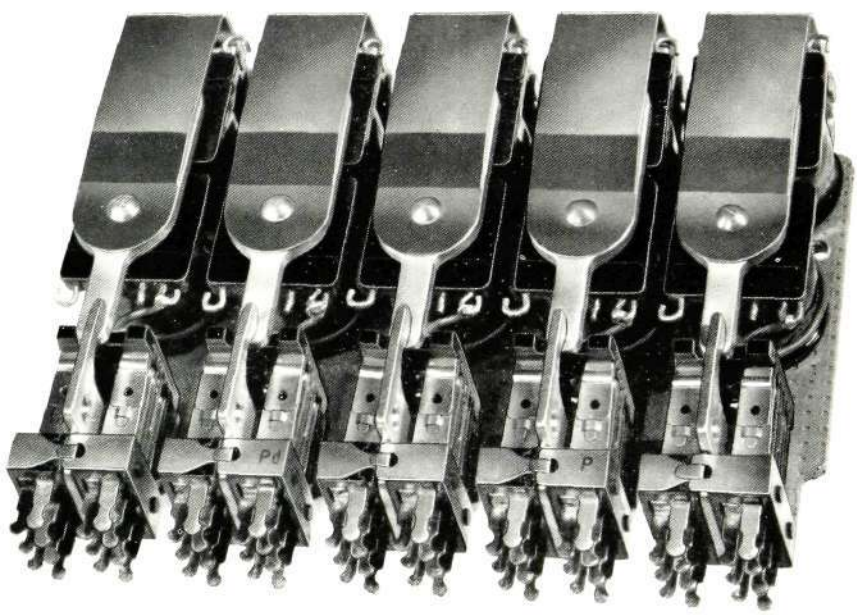


Fig. 1—The Multiple Relay Unit

Welded Core Irons

Instead of following the conventional practice of connecting core irons to a yoke by means of a screwed bolt, the two core irons of each relay are welded to a metal base plate. Located with great care to obtain mechanical symmetry, the core irons are accurately machined to close limits. This one-piece construction minimizes the reluctance of the magnetic circuit, improves the efficiency of the relay and contributes to lower power consumption.

Coil Bobbin

The moulded one-piece coil bobbin, because of its cylindrical core, provides precise and uniform winding space. All wiring connections are made external to the coil winding, two U-shaped, rigid moulded-in tags being provided for this purpose. External circuit connections are made to the outer looped tags and internal wiring terminations to the short inner tags; the provision of the latter eliminates the need for the threading of coil-wire ends as occasioned with the usual type of tag. Routing grooves or channels are provided in the coil cheek to protect these leads from the pressure of the coil winding and prevent contact with other turns of the winding. A further feature of the wire-end channel is that the separation between the inner end of the winding and the subsequent turns increases with the height of the winding and so reduces the risk of breakdown caused by the potential difference between ends of the winding.

In assembly, the coil windings and bobbins are located over the respective core irons and firmly retained in position by an S-shaped resilient clip. When in position, this clip exerts pressure in a groove around each core and is also under tension between the cores. To prevent rotary movement of the coil assembly a projecting stud in each bobbin cheek locates within a hole in the base.

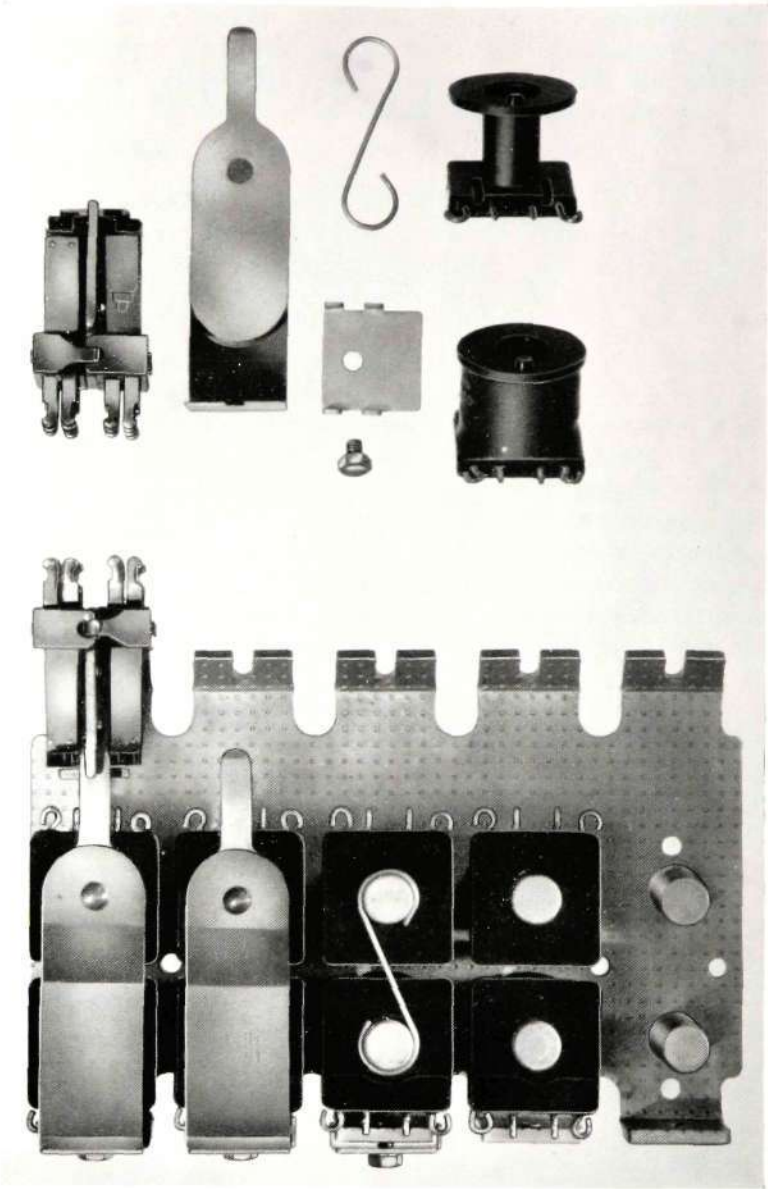


Fig. 2—Component parts and order of assembly

Armature Assembly

The armature assembly of the configuration shown in the photograph (Fig. 2), provides the return path of the magnetic circuit and is pivoted on a bevelled core iron remote from the springset assembly. An L-shaped pre-tensioned suspension spring of phosphor-bronze supports the armature and is connected to it by a rivet, forming also a residual stud. The other end of the suspension spring is secured to the upturned end of the base by means of a U-shaped clamp. To limit the upward movement of the

A. Complete springset assembly

B. Springset operating comb

C. Springset bracket

D. Single springset bank assembly

E. Separate halves of spring-bank strap

F. Springset insulating blocks

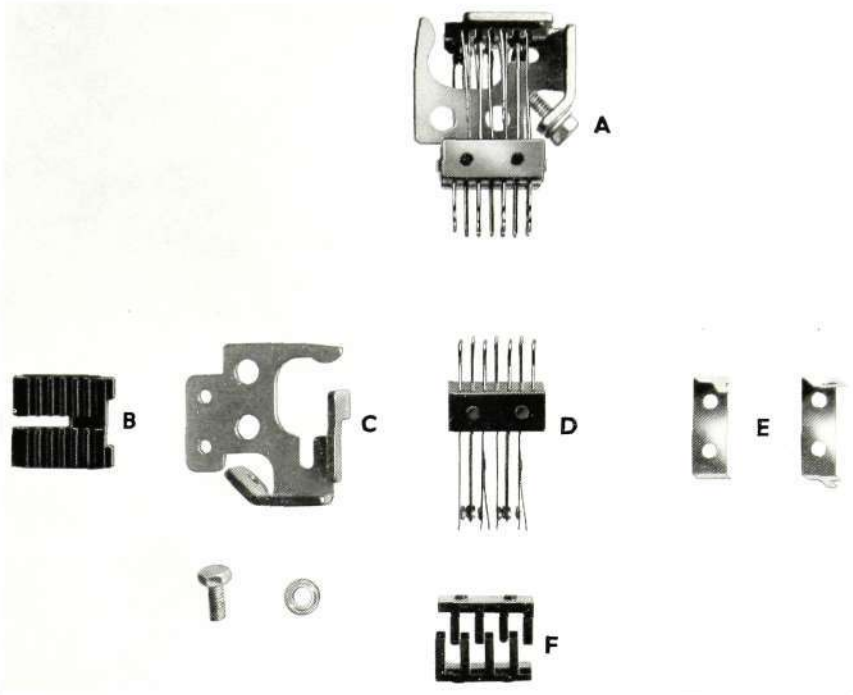


Fig. 3—Springset assembly and breakdown of parts

armature, the free end of the armature locates against a back-stop afforded by the overhanging arm of the springset bracket.

Springset Assembly

A complete springset assembly is shown in the upper part of Fig. 3 and individual parts beneath. Each of the two springsets is formed by a combination of fixed and moving springs located within the slots of two inter-locking plastic blocks, projections on which engage in holes in the springset-mounting bracket to ensure correct and consistent relationship between the height of the core irons and the spring positions. The insulating blocks of both springsets are securely clamped together by a metal strap. With this method of construction, the many separating and insulating parts required in other relays have been avoided, and the risk of insulation breakdowns is considerably reduced by the absence of metal inserts through the spring bank.

Comb Plate

Mounted astride the springset bracket, an inverted U-shaped comb plate of insulating material with a regular slotted face is so arranged that the slots are directed towards the free ends of the contact springs. All moving springs fit within the slots so that, on the operation of the armature, the comb plate moves and causes each moving spring to engage or disengage a fixed spring.

Other Features

Armature travel is fixed and accurately determined during manufacture by ensuring correct distances, relative to the base plate, for the armature back-stop and also the core-iron faces. Thus the need for bending or ' setting ' armatures to suit the dimensions of individual magnetic circuits is avoided.

The effects of small variations in spring thickness and in the spacing in the insulating blocks has been overcome by the use of bent off-set lugs in each spring. These projections, as shown in Fig. 4 are compressed by the insulating blocks during assembly to provide firm positioning of the springs. This close control of contact position during manufacture reduces to a fractional amount the number of relays that may require adjustment.

The regular spacing of the comb plate enables the accommodation of any combination of standard contact units up to a maximum of six springs each side of the spring-set mounting plate. Contact operation of typical contact units is illustrated in Fig. 5 and types of springs used, in Fig. 6. Because the moving

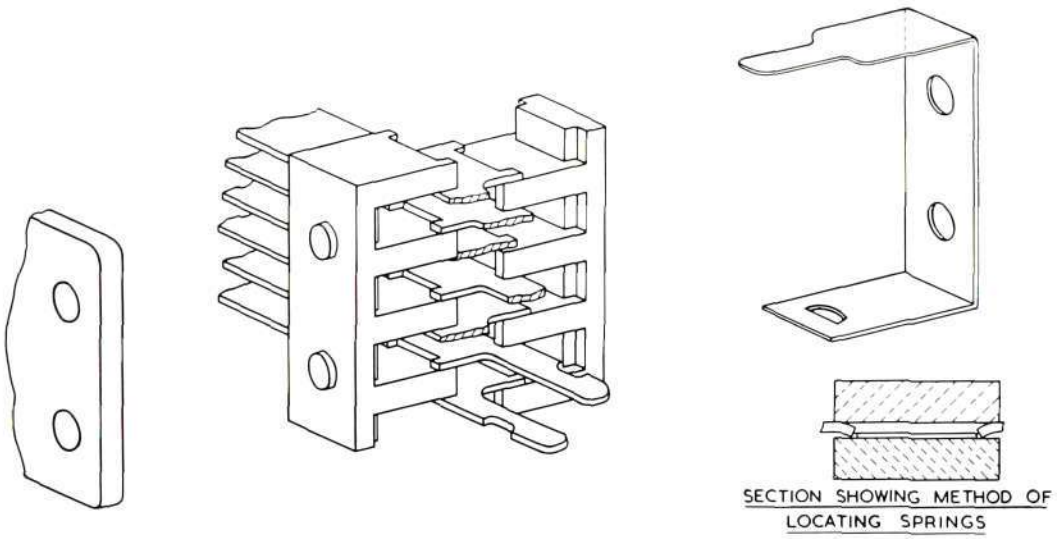


Fig. 4—Location and assembly of contact springs

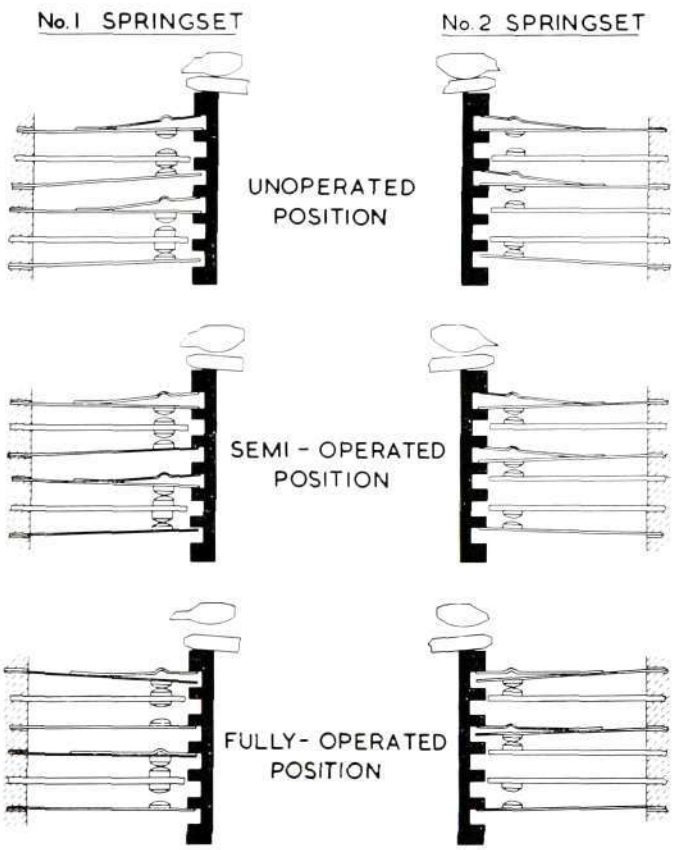


Fig. 5—Contact operation of typical Contact Units

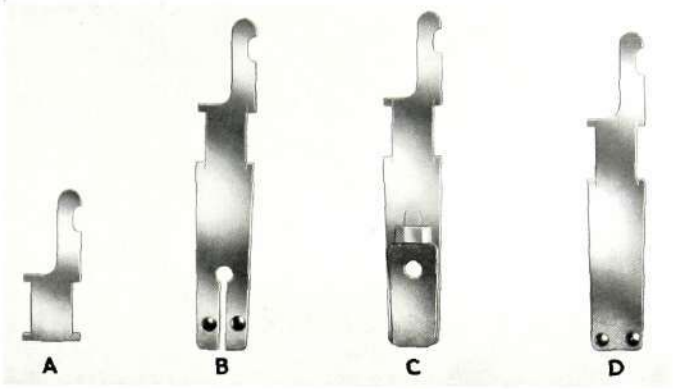
springs are thinner than the fixed springs (0.016″), tags 0.010″ thick are associated with the moving springs to maintain the uniform spacing of the insulation blocks and also provide a more substantial soldering point. For the moving spring of a 'make' contact unit, a leaf spring is used in conjunction with an indented thin moving spring, as shown in Fig. 6, to provide additional contact pressure and to limit, by its damping action, contact bounce.

By further reference to Fig. 6, it may be seen that the twin contacts of the moving spring are split. This feature enables the fingers of the moving spring contacts to exert independent pressure on the undivided contacts of the fixed spring.

To suit particular circuit requirements the contacts, similar in form to those of the B.P.O. 3000-type relay, are available in silver, palladium and platinum.

Facilities and Applications

The construction of the unit permits the quick removal and replacement of coil, armature and springset assemblies without



A. Moving spring soldering tag. B. 'Break' action moving spring. C. 'Make' action moving spring. D. Fixed spring.

Fig. 6—Types of Contact Springs

the need for any re-adjustment of the relay or the complete withdrawal of either of the base-fixing screws.

Simplicity in mounting the unit is afforded by means of four tapped holes in the base plate. This arrangement enables the unit to be mounted direct in any convenient space, or fixing details to be fitted by the user to suit his particular requirements.

The provision of two independent coils allows considerable flexibility in the winding arrangements to meet such conditions as series or parallel windings, balanced windings with high-insulation requirements, differential windings and other features. When sensitivity is not of major importance a relay can be operated on a single coil.

Operating characteristics may be further altered by changing the normal armature of electrical quality steel for one of hardened steel. A relay with this type of armature (a 'remanent' relay) will remain operated until released by a reverse pulse of current and is particularly suitable for use in data-storage circuits; it can also be used with advantage in alarm circuits or as a control switch operated and released by pulses from a time control to switch a supply on and off at predetermined periods.

Advantages of Manufacturing Processes

Contributing to the achievement of the several advantageous design features described are the economic processes employed during manufacture. For example, the welding of core irons has been developed into a rapid process by the use of precise jigs, accurate weld-current and timing control. Because the core faces are circular, the centreless-grinding technique is used to control accurately and economically the relationship between core faces and welding jigs. The availability of stable plastic materials, made possible by controlled moulding processes, has contributed considerably to the mechanical and dimensional stability of the coil bobbin, lifting comb and springset insulating blocks and, consequently, to the consistent performance of the Multiple Relay Unit as a whole.

U.K. Patent Applications *15595/8; 9870/59; 28589/59*
Australian Patent Application *48700/59*
New Zealand Patent Application *123497/59*

U.D.C.621.395.334.2:621.395.34:622

AUTO-MAGNETO PARTY-LINE WORKING IN MINES

E. WOODWARD — Special Projects Development Engineering Department

The equipment described has been developed to meet requirements for the improvement of Colliery communications between mine and surface telephone networks. The article outlines the need for quicker communication in the modern colliery, and attention is drawn to some limitations of existing equipment. A description is given of the general features and function of this Company's new party-line equipment, and the circuit operations of each facility are described in detail. The article concludes with a brief description of the operation and adaptability of an associated Emergency Control scheme.

WITH the demand for coal continuing, greater inroads are being made into existing underground networks, and mines are becoming deeper and more extensive. Modern machinery is being increasingly used to achieve greater output from coal-faces and to transport this coal promptly to the surface. The full benefits to be derived from mechanization of coal mining, however, are dependent upon maintaining a smooth flow of coal from the mine. Any prolonged breakdown of a machine, for example, a conveyor or haulage motor, will utimately result in an accumulation of coal at the face and enforced cessation of operations at this point. To minimize the effects and duration of such occurrences and to ensure the safeguarding of personnel wherever possible, quick and efficient telecommunication is essential among working groups of men within the mine, and between these groups and surface locations.

The provision of suitably designed automatic telephones in recent years has assisted in the improvement of communications between the mine and the surface, but for economic reasons their use has been restricted to underground administrative personnel. To provide these single-line instruments for individual use throughout the mine would not only incur considerable expense in cabling and protection devices, but would deny to the underground worker a long-established means of communication more suitable to mine working methods : party-line working.

This facility of the intrinsically safe magneto system—widely employed in mines—enables more than one telephone to be connected in parallel on a line to serve a group of men working as a separate team or supporting unit at coal-faces, loading points, and places on the haulage system. Communication between parties on the same line is simple ; calling is by a hand generator, and ringing codes are established for each instrument. A drawback of the system is evident, however, when one group wishes to communicate with another or with a surface extension. Such calls must first be routed via a manual switchboard located either on the surface or underground. The switchboard, according to the activity of the particular colliery, may be manned permanently or by a person having additional duties to perform. The part-time operator may be an attendant in the time-office, lamp-room, or power-house ; if underground, he may be a nearby haulage hand. Because of these varying local procedures and the necessary time spent on manual connection of calls, the speed of communication between underground and surface extensions is limited. In the new auto-magneto party-line system of working to be described, this bottleneck in communications has been eliminated ; no switchboard being necessary. Up to four dual-purpose party-line instruments, each having a generator and dial, may be connected to a line to permit essential local party-line working and full communication within the colliery network. From any instrument, access can be gained over tie-lines via the surface private automatic exchange to other collieries, headquarters, or mine rescue stations.

In common with all apparatus for use in mines, the equipment has been designed to conform with safety regulations as laid down and enforced by the Ministry of Power. Since the greatest hazard in a mine is the danger of fire and explosion, considerable attention has been directed to the elimination of all incendive sparking that could result from induced or contact voltages. Each party line, therefore, by which a dangerous condition could be introduced

into the hazardous area, is electrically isolated from the surface telephone network by safe auto-magneto link circuits located in the P.A.X. outside the danger area.

Delay circuits are provided on a basis of one per five link circuits to give discrimination between hand-generated code-ringing signals and the long ringing signal required to gain access to the surface P.A.X.

Transmitter current for the instruments is supplied via the link circuits from an approved 24-volt source derived from two batteries operating on a charge/discharge basis. This feature excludes the need for local batteries hitherto essential in the intrinsically safe magneto system, thereby affording the advantages of reduced maintenance and ample power for signalling and transmission.

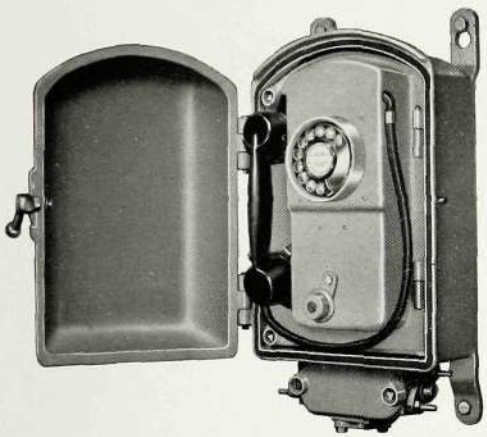


Fig. 1—The safe Auto Magneto Telephone

The safe auto-magneto instrument is illustrated in Fig. 1. It is housed in a grey-enamelled cast iron case, and all components are secured to a hinged inner door easily removable for maintenance purposes. On party-line working, satisfactory operation is possible over a 300-ohm loop resistance. The telephone circuit used is the latest as adopted by the Post Office, and provides transmission superior to that of the conventional magneto telephone instrument used in mines.

General Operation of Equipment

As in the magneto system, the hand generator is used for making local party-line calls. It is also employed to send a long ring of approximately four seconds duration to actuate a delay circuit and enable the party line to be extended to the surface automatic exchange. Dial tone is returned to the calling party and the required number is dialled as in a purely automatic system.

During an incoming call to the party line, the bells of all the telephone instruments ring in unison with the code of the wanted telephone. The first extension to answer, trips the ringing and is connected to the incoming call.

When a conversation is in progress between extensions on the same party line, the line is not busied, so as to permit calls of possibly greater importance originated from other party-line groups and surface extensions to enter the line. Once the line has been reached by the incoming caller, the wanted party-line extension in the group is selected by the dialling of an additional digit via an auxiliary connector in the P.A.X. A coded tone, identifying the extension, is transmitted to the engaged parties and ring tone is returned to the caller. The incoming call cannot proceed until both the engaged extensions replace their handsets, after which, automatic coded ringing is applied to the line. Should the call be for one of the two extensions previously engaged in conversation the called party can answer immediately by again taking up the handset without waiting for the ringing signal.

Equipment

All surface equipment is accommodated in totally enclosed units with dust-proof covers. Figure 2 shows a typical 100-line P.A.X. and associated miscellaneous apparatus units (M.A.U.'s) with covers removed.

Provision is made in the M.A.U.'s for up to 20 auto-magneto relay sets or, when exclusive automatic instruments are employed, 20 auto-auto relay sets. In the partially equipped M.A.U.'s shown in Fig 3, the left-hand unit comprises equipment for 15 auto-magneto link circuits and the other, equipment for 5 auto-auto link circuits. If necessary, an auto-magneto relay set may be used for exclusive working by a simple re-arrangement of wiring on the shelf jack.

The link relay sets—a general view of the auto-magneto type is given in Fig. 4—are jacked into pre-wired positions. To avoid the possibility of danger resulting from wiring faults, the connecting wires in the safe and unsafe sections of the link circuit are in separate cable forms. This applies both to the wires within the relay sets and on the rack.

B.P.O.-type relays with tropical finish are employed throughout to ensure long life under adverse climatic conditions.

Circuit Detail

Outgoing Call

Figure 5 shows the circuit of the auto-magneto link. It illustrates how the bridge circuit of the link is used for calls in both directions. When a party-line extension originates a call, relay A operates via F2, AC1, LS2 and the loop provided by the instrument. Contact A1 prepares the seizing loop to the exchange and subsequently repeats dialled pulses forward. Contact A2 operates relay B. Relay BA is operated at B1, and B3 prepares for the operation of relay AC on the commencement of ringing from the hand generator. The loop to the automatic equipment is further prepared by contact B4, and relay LS is prevented from bridging the line by the BA1 contact.

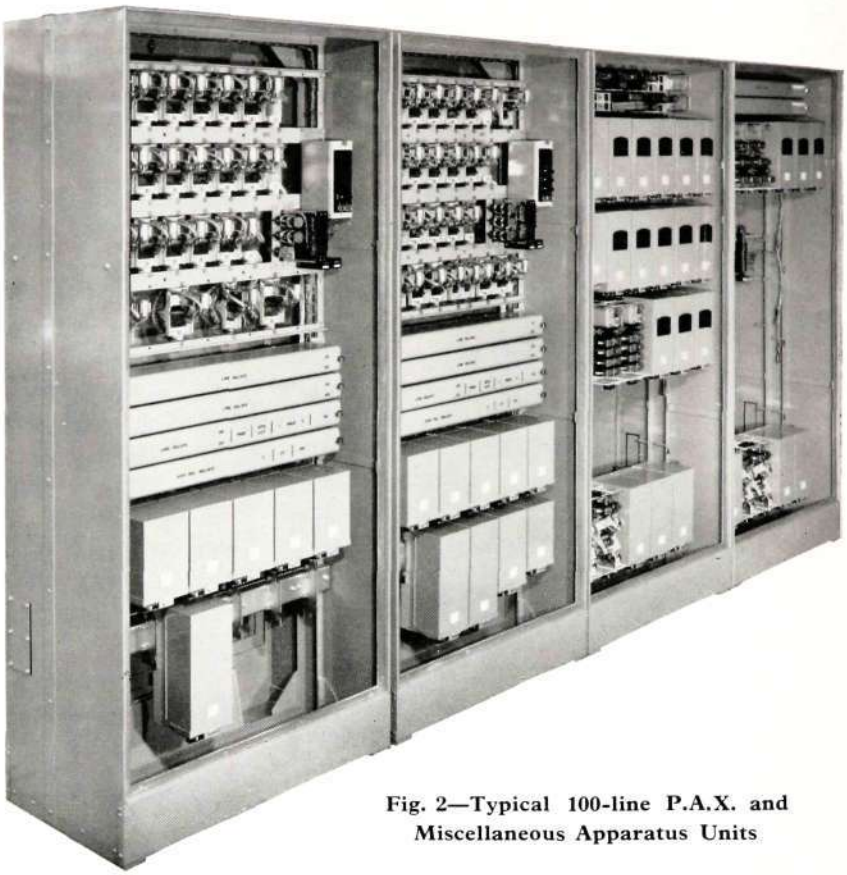


Fig. 2—Typical 100-line P.A.X. and Miscellaneous Apparatus Units

When the hand generator is first operated, relay A is released by the opening of the generator cut-out springs to cause relay AC (fast operate) to operate at A2 normal, and prevent the loop over the primary winding of transformer T1, relay A, and the supply battery from shunting the generator output. With relay AC operated, the load on the generator comprises three ringers and the LS relay. Relays, B, AC and BA subsequently release.

During the period of approximately four seconds ringing, relay LS operates and holds. Contact LS2 maintains the circuit of the LS relay and also the disconnection of the loop via the transformer winding. Relay LC is operated from the earth at LS1 and this earth is extended via MR6 to the delay circuit. After the elapse of approximately four seconds, a delay-pulse earth is returned via LC2 to operate relay LD.

On the completion of the ringing, relay LS releases and LS1 removes the start earth to the delay-start common and releases relay LC. Contact LS2 now completes the loop between the caller's instrument, and relay A re-operates. Relay B operates via FF4. Contact B1 operates relay BA and provides a holding circuit via LD4 for relay LD, maintained operated by its slow-release feature after the release of LC2.

With relays A, B, BA and LD operated, the loop to the automatic exchange is completed ; initially over resistor R1 and subsequently through the transformer/rectifier arrangement, inserted to minimize induced voltage surges in the telephone side of the link circuit.

Dial tone is received and the required number is dialled. Relay A responds to the dialled pulses and, at A1, repeats them to the P.A.X. Upon the first release of A2, relay CD operates via LD2. Satisfactory dialling performance is achieved by the insertion of the non-inductive loop through resistor R1 on the closure of the CD1 contact. Resistor R1 also serves to lessen induced surges in the secondary circuit. Relays B and CD hold during the pulse train owing to their slow-release features. During inter-train pauses and also after the completion of dialling, relay CD releases to remove the R1 shunt across the transmission bridge. Tones are returned to the caller according to the condition of the called extension's line.

The call is released on the replacement of the calling extension's handset.

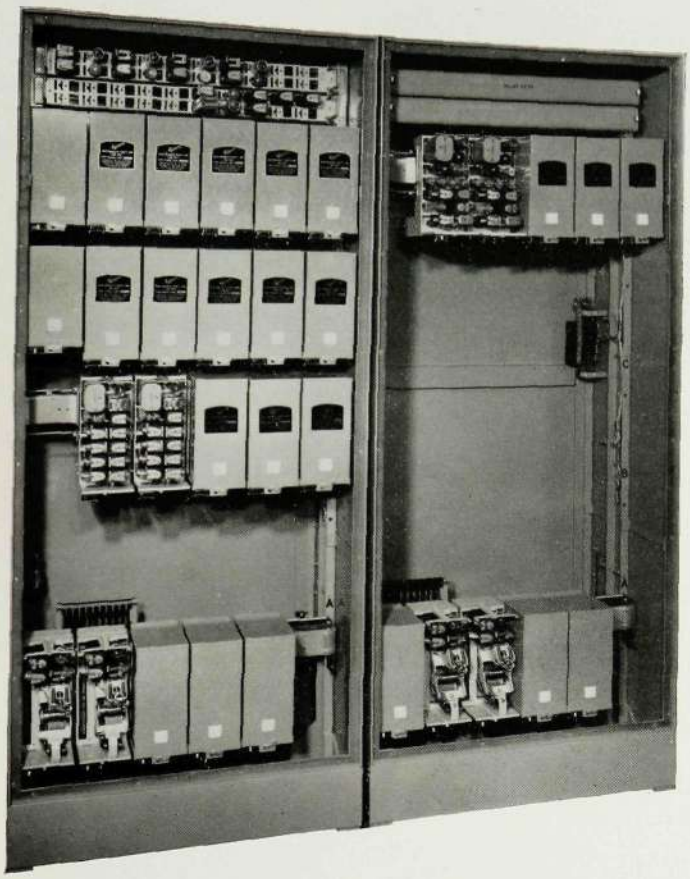


Fig. 3—Enlarged view of Miscellaneous Apparatus Units

Calls between parties sharing the line

On the removal of the calling party's handset, relays A, B and BA operate as previously described. When the code of the wanted telephone is rung, relay LS responds to the short bursts of ringing. Relays A, B and BA function as before, with AC operating during the commencement of each ringing pulse to remove the low impedance shunt across the transmission bridge circuit. The code-ring pulses are extended to the delay-start common at LS1, but as these are of less than four seconds duration, the delay circuit does not complete its function to enable relay LD to operate.

At the end of the code-ring train, relay LS releases and relays A, B and BA re-operate. Connection is established when the called party lifts his handset.

When the call is completed, the last party to replace his handset releases the circuit.

This type of call does not entail the use of P.A.X. connector circuits ; therefore any number of inter-party-line calls can be made without degrading the service provided by these connectors.

Incoming Call from Auto Exchange (Party Line engaged)

Relays A, B and BA are operated during the inter-party-line call. On an incoming call, relay F responds to the exchange code ringing, but safe ringing is prevented from being extended to line by BA2 operated and the d.c. loop maintained via BA1. Relay FF operates over F3 and locks via FF2 to earth on the P-wire of the connector. Contact F4 extends intrusion tone to the secondary winding of T1 through B4, A1, LD3 to earth, and this tone is induced in the primary winding to inform the engaged parties of the incoming call.

Following the replacement of both handsets by the engaged parties, relays A, B and BA release and the coded ring of the wanted party is passed to the line through the safe transformer.

When the called party answers, relays A, B and BA re-operate and relay LD is operated via FF1 ; the ringing is tripped, and the connection completed.

Incoming Call from Auto Exchange (Party Line free)

The operation of the circuit is as previously described except that the earth return for the intrusion tone is disconnected at B4 and A1 to prevent the application of tone.

EMERGENCY CONTROL

To permit information concerning an underground emergency to be received at the surface without delay, an instrument is provided capable of

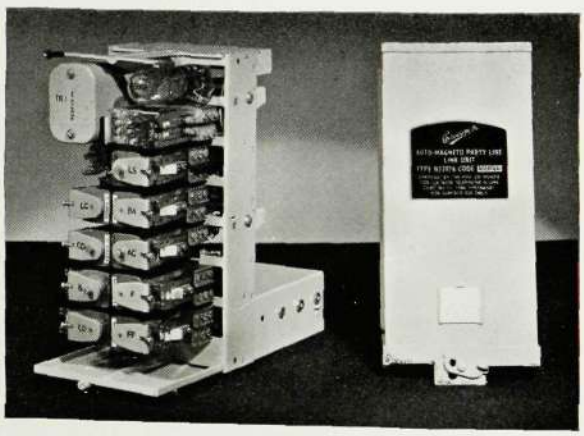


Fig. 4—Auto/Magneto Relay Set

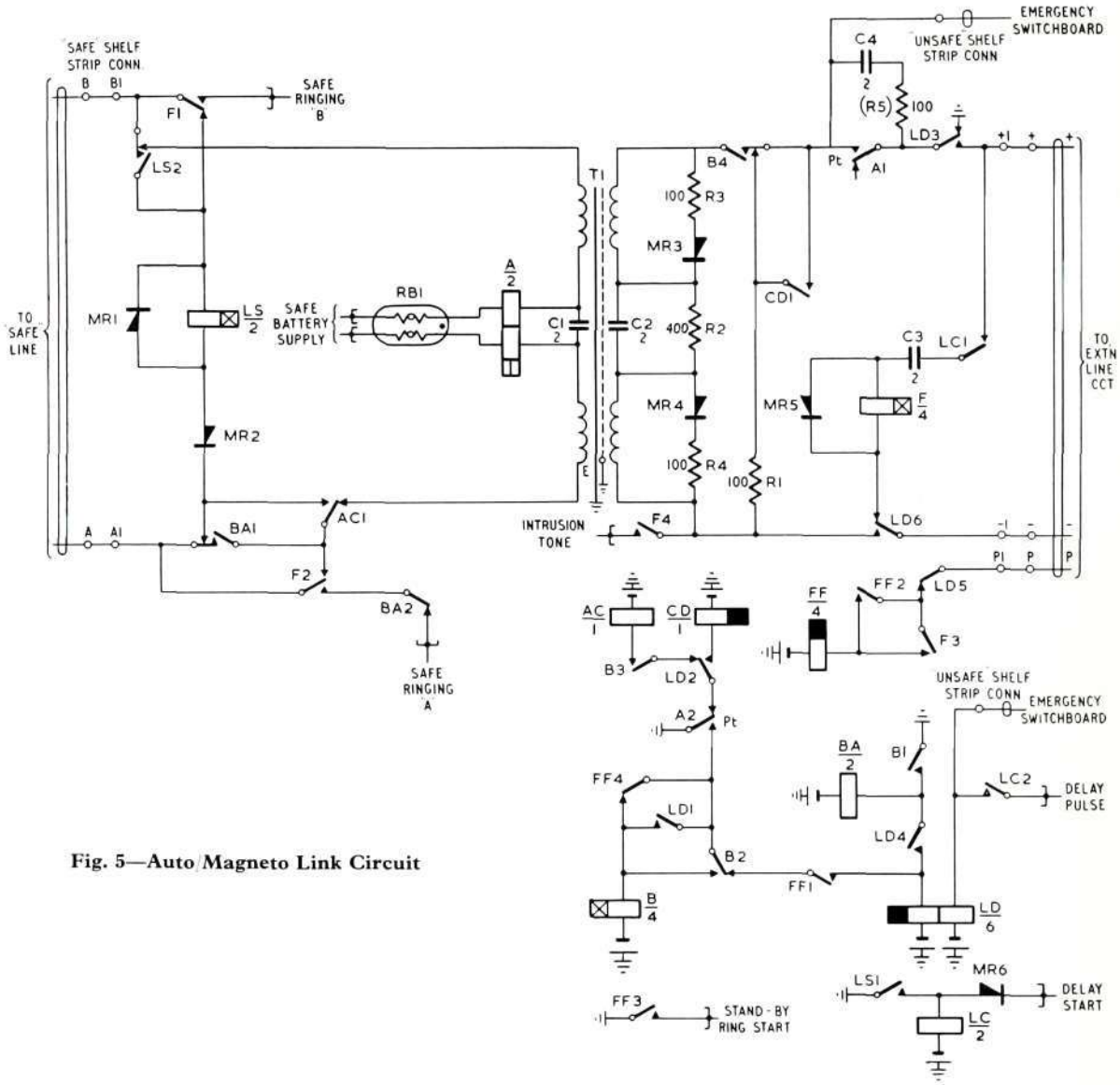


Fig. 5—Auto/Magneto Link Circuit

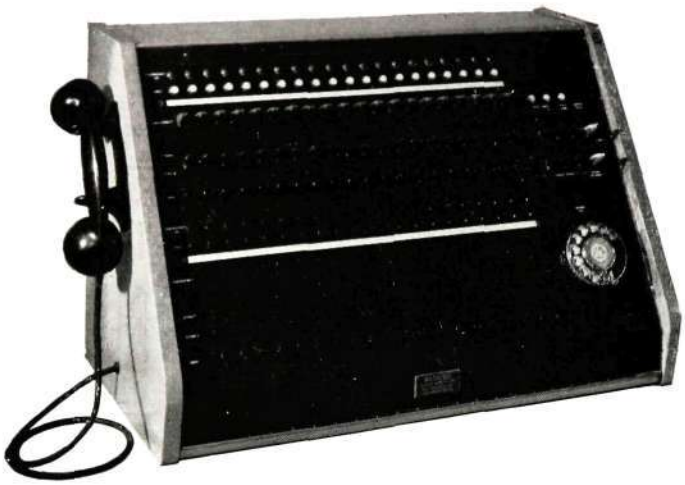


Fig. 6—Emergency Control Switchboard

receiving incoming calls only. The instrument may be positioned at any location on the surface where there is a 24-hour attendance and calls to this emergency telephone can be made by dialling 999.

Should the information received warrant Emergency working, underground lines can be switched over from the P.A.X. to a desk-type switchboard (Fig. 6) by the operation of an ' emergency on ' key associated with each line on the switchboard. This operation causes a red lamp, particular to each line, to glow, and the relevant line circuit to be busied at the P.A.X. to prevent intrusion from extensions unaffected by the emergency.

To enable any person in the immediate vicinity of a switched extension to instantly differentiate between an emergency calling signal and the signals received under normal conditions of working, an extended ring of approximately ten seconds duration is applied to the line on the operation of the relevant switchboard ' ring ' key.

A white ' calling ' lamp glows immediately on the lifting of any telephone handset on the party line and the controller responds by throwing one of two ' connect ' keys to speak. The call may then be extended, as required, to the G.P.O. system for outside assistance, or to any underground or surface instrument.

In an emergency, because all underground lines can be controlled via the switchboard, the essential requirement of maintaining communication with and within the mine is met, even in the improbable circumstance of a break-down occurring at the P.A.X.

Conclusion

The availability of the equipment described, designed to ensure safety, efficiency, simplicity of operation and easy maintenance, will undoubtedly fulfil the urgent need for improved service in the modern colliery. By its application the complete integration of surface and underground telephone networks is achieved and centralized control of the colliery made possible. A feature of considerable merit is that safe automatic working can now be introduced into a mine as requirements demand, without sacrifice of essential local party-line working or the need for, and economic disadvantage of, providing additional underground lines.

The equipment has now been installed in several collieries in Great Britain and has proved completely satisfactory.

U.D.C.621.395.92:621.395.61

AN AMPLIFIED TELEPHONE HANDSET

W. G. Soar — Audio-Frequency Research Department

The new amplified Etelphone-type handset described has been developed to assist the telephone user who is hard of hearing. Requiring no separate batteries, the handset can be readily interchanged with the normal handset of many existing telephone instruments without modification of the telephone circuit.

MANY subscribers with impaired hearing will welcome the availability of a new light-weight telephone handset which, incorporating a transistor amplifier, provides a high standard of amplified reception. The handset has been designed to replace the Post Office Repeater Telephonic No. 17A—a valve amplifier housed with its attendant battery supplies in a separate wooden box situated near an associated special telephone instrument. This instrument had a gain control mounted on a bracket at the rear, h.t. and l.t. switching contacts added to the switch hook springset, and a separate bell-set. The whole formed a bulky piece of apparatus requiring frequent maintenance visits for battery replacements.

The new model is built into the Etelphone, the entire amplifier fitting in the hollow handle of the handset (Fig 1). No auxiliary supplies are needed ; power to operate the amplifier is derived from the telephone line current. The only evidence that this is not a normal telephone handset is the projecting edge of a miniature gain control situated at the receiver end. The instrument circuit does not require modification, the amplified handset being connected into the circuit in the same manner as a normal one. Merely changing the handset transforms an ordinary telephone into an amplified telephone. The absence of any large additional equipment will appeal to deaf users who wish to conceal their disability. The lower initial cost, absence of batteries and less frequent maintenance should result in lower rental charges. The amplifier uses all the advantages offered by transistors, i.e. small size, low operating voltage, low power consumption, high efficiency and reliability.

Investigation showed that the maximum useful gain that could be put into the receiver circuit was approximately 20db at 1000c/s. More gain caused instability leading to oscillation and, consequently, a target gain of 20 db was adopted.

The amplifier, the circuit diagram of which is shown in Fig. 2, uses a single transistor with grounded emitter, base bias provided through R4,

Fig. 1—Complete Handset with Amplifier alongside

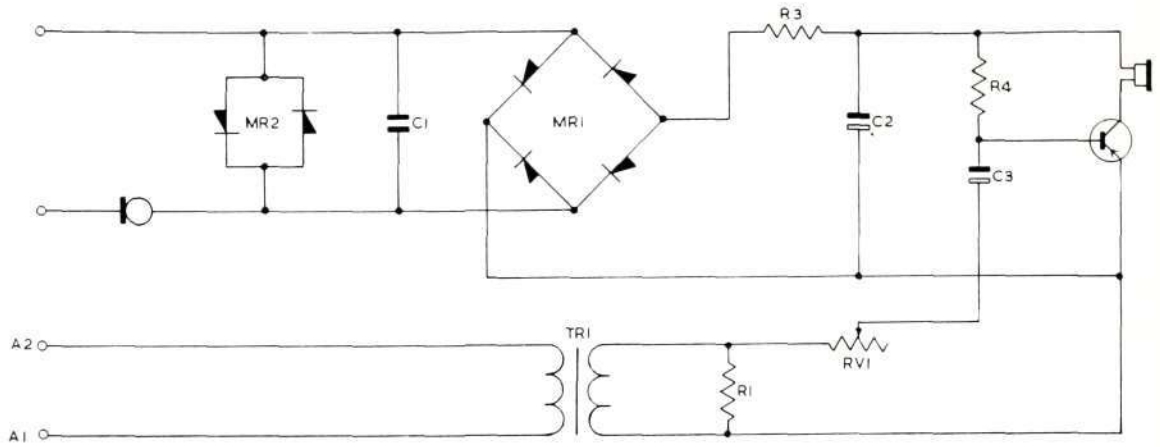


Fig. 2—Circuit diagram of Amplified Handset

and the telephone receiver as the collector load. The received signals appearing at terminals A1 and A2, pass through T1, RV1 and C3 to the base of the transistor. A terminating resistor R1 provides a correct impedance match through T1 at A1 and A2 for side-tone balance.

Power to operate the amplifier is derived from the telephone line current which passes through MR2 and the transmitter. The rectifier arrangement MR2 has a non-linear current/voltage characteristic which tends to reduce the voltage change produced across it by variations of current through it (Fig. 3). Two units are combined back-to-back to cater for either direction of line current. Placing MR2 in series with the transmitter introduces a transmission loss of about 4 db. This loss is reduced to less than 1db by C1, a large capacity, non-polarized capacitor placed in parallel with MR2.

The voltage developed across MR2 is applied to the amplifier through the bridge rectifier MR1 to ensure correct polarity of the amplifier supply voltage. Resistor R3 and capacitor C2 form a filter circuit giving decoupling from the line additional to that provided by C1.

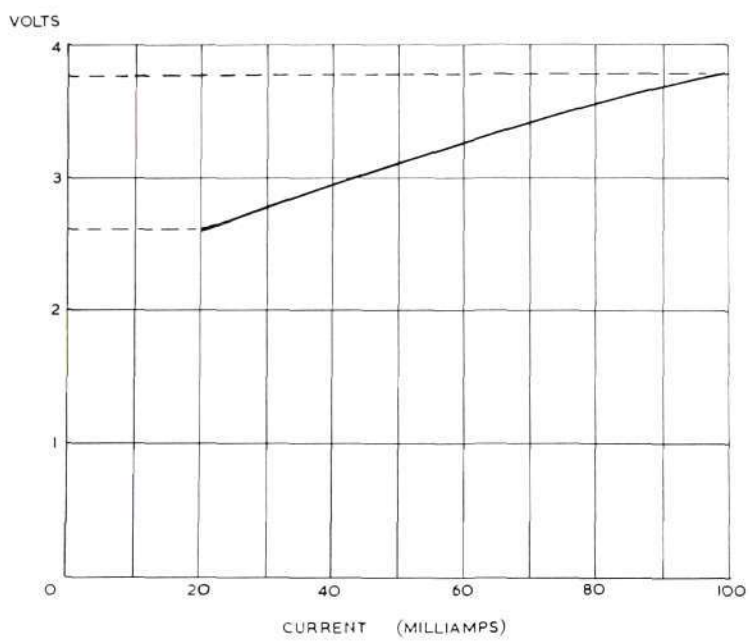


Fig. 3—Current Voltage characteristic of MR2

The gain control RV1 is series connected to prevent complete signal cut-off in the minimum position. It has a semi-logarithmic law to give a smooth control range of 30 db, i.e. from full gain of 20db above normal to about 10db below normal listening level.

To prevent acoustic shock to the user, the maximum output power developed by the amplifier is limited to a little over one milliwatt, corresponding to a sound pressure of 200 dynes per square centimetre from the receiver.

Amplified handsets of this type are made for both local-battery and central-battery working and are supplied as part of the telephone or as a separate item. They are available in the full range of Etelphone colours.

UK Patent No. 803396.

U.D.C.621.395.61

MECHANICAL FEATURES OF THE PLAN-ETELPHONE

W. SINCLAIR — Apparatus Engineering Department

A natural corollary of the recently designed and world-wide accepted Etelphone (described in detail, Bulletin No. 38, Jan. 1959), has been the demand for a telephone instrument having the same pleasing contemporary appearance, wide colour range, and efficient transmission performance, but with incorporated features to meet the varying requirements of customers desiring extension facilities, including those of the recognized extension plan arrangements.

The Company therefore has introduced this new telephone—the Plan-Etelphone. This instrument, now being produced, has a flexibility in application that enables all extension requirements to be confidently fulfilled. The article describes the mechanical features of the telephone, and the auxiliary components utilized in various extension plans.

IN the late nineteen-thirties, in conjunction with the British Post Office, the Company developed key-switching units suitable for plan-working application, and since this time has been closely identified with plan-type instruments. The knowledge gained in this field, through the years, has now made possible the introduction of a new telephone—the Plan-Etelphone. This instrument, incorporating the best of accumulated ideas and experience, and satisfying the demand for a modern ' plan ' telephone of high performance, is shown in Fig. 1.

BASIC TELEPHONE

To avoid the necessity for a multiplicity of different types of instruments to cater for the variety of extension plans, and yet provide a versatile and economical unit suitable over a wide range of application, maximum flexibility in use is essential. This has been achieved by the provision of a basic instrument that can be readily adapted to meet any facility by the use of suitable 'add-on ' units.

CONSERVATION OF SPACE

In order to maintain the established layout of the ringer, the dial, capacitor and induction coil, as in the Etelphone instrument, and also provide accommodation for, and the highest degree of accessibility to, other components within the dimensional limits imposed, maximum space utilization has been necessary. This objective has been realized by the use wherever possible of components of small bulk, without degradation of performance and reliability.

SPRINGSETS

To keep the variety of component parts to the minimum, a springset assembly, of a new miniature

Fig. 1—General view of the Plan-Etelphone instrument

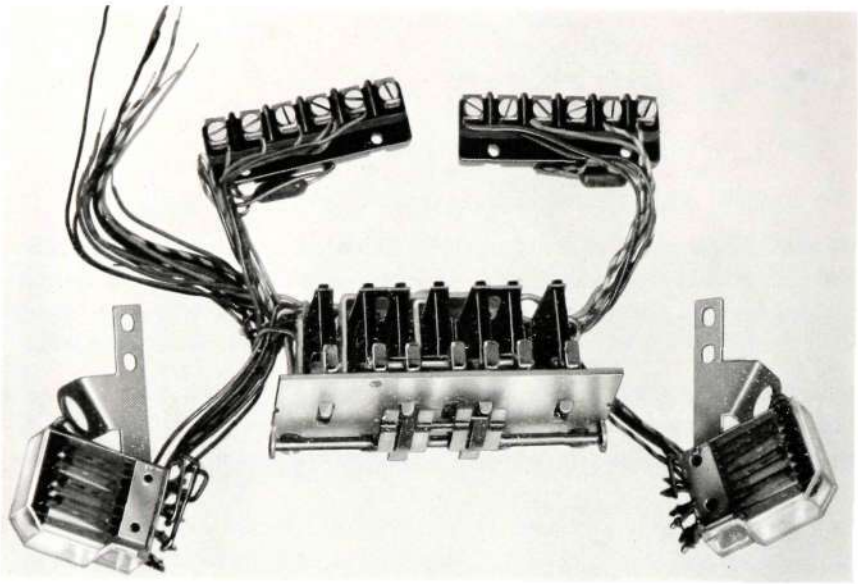


Fig. 2—A typical 4-button key-switching unit complete with associated wiring and terminal strips

form, has been adopted for cradle-switch application and also for use in the key-switching units to be described later.

These assemblies, comprising springsets of a type similar to that employed in our new B.P.O.-approved cordless switchboard and other equipments, have suffered no loss in reliability or performance through size reduction. Special attention has been devoted in the design of the twin-contact phosphor-bronze springs to ensure their satisfactory operation within safety margins comparable with larger springsets of earlier design. High contact pressures have been maintained, insulation between springs increased, and uniform movement of springs made possible by comb-plate action.

Protection to all springs against dust and damage is afforded by transparent covers.

Key-Switching Units

These consist of springsets, and spring-loaded plungers with or without latching devices, mounted on a slotted metal plate forming the front of the fixed main bracket.

A key-switching unit has capacity for 56 springs arranged in eight banks of seven springs. The banks can be disposed in single or double units, the springset assembly itself being secured to the plate by means of a single screw.

Where a large number of contact springs is employed in a predetermined switching arrangement, as typically shown in the key-switching unit illustrated in Fig. 2, the springs are permanently wired to auxiliary terminal strips for connection to the telephone circuit. For simple switching requirements, however, the flexible connecting leads are terminated with spade tags to permit single or double-bank springsets to be connected in circuit as requirements demand, using spare terminals provided in the base of the instrument for this purpose.

Normally the springsets are evenly distributed between plungers, but various plunger extension arms can be added to increase the number of springs operated by any single plunger.

Plungers can be locked in the operated position and also extended by again pressing the associated press-button. This overpress facility enables secondary switching functions to be accomplished without additional press-buttons (i.e. ringing etc.). Release of locked plungers is effected on the operation of another button or by replacing the handset.

A feature, novel as well as advantageous and typifying the versatility of the key-switching units, is the provision made for a fifth plunger in the central position of a 4-button switching unit. This extra plunger can be operated by either or both of the central press-buttons when a common or late switching operation is necessary.

By arrangement of individual latch plates a sequence of locking can be obtained, the second button operated being released when further pressure to the first button is applied.

Alternative Latch-Plate Assembly[1]

If it is desired to rearrange switching needs *in situ*, it is convenient to use a complete latch-plate assembly as shown in Fig. 3. It consists of a number of stainless steel latch-plates for engaging the plungers and

[1] *Acknowledgment. This latch-plate was designed in conjunction with the B.P.O.*

is mounted on a main plate, which pivots at its lower end across the front of the fixed main bracket. On loosening each screw and by moving these latch-plates into any of three different positions, various switching functions can be obtained. The positions of the latch-plates (identified by numbers in the illustration) give the following conditions :—

1. Locking, and releasing any other latched plunger.
2. Non-locking, and releasing any other latched plunger.
3. No action.
4. Locking, and releasing any other latched plunger (as in 1).
5. Cradle-switch release of any latched plunger.
6. No cradle-switch release.

One facility this type of assembly cannot provide, is the consecutive locking of plungers described above.

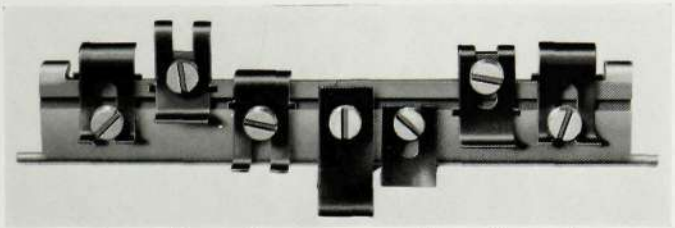


Fig. 3—Alternative latch-plate assembly

Additional Termination Points

The high complement of springs permissible in the key units necessitates termination points other than those provided in the basic instrument. Either two or three 6-way terminal strips may be fitted. When requirements are met by two terminal strips, these are fixed either side of the fixed bracket. If the number of springs employed justifies the use of three, these are accommodated together between the arms of the bracket.

Press-Buttons

The press-buttons, of contrasting colour to the instrument case, shaped at their finger-ends to provide an easy finger action, are positioned in line between rectangular holes in the top of the instrument case. To hold a button captive, yet not restrict its sliding movement, a metal pin is passed through a vertical elongated hole in the button, and pressed at its ends into grooves inside the case.

Another type of button is illustrated in Fig. 4. It provides a locking action independent of the internal mechanism. Held in position by a metal pin as before, this button—as may clearly be seen from the part-transparent model illustrated—incorporates a hooked latch, this being controlled by a sliding cap in the top of the button. When the button is pressed down, a movement of the cap to the ' on ' position causes the latch to engage the fixing pin and prevent the button returning to the normal position. Release is effected by again pressing the button and switching the cap to ' off '.

For simple switching requirements (i.e. non-locking ring buttons) two buttons can be accommodated in the space occupied by the normal button, thereby enabling twice the number of switches to be individually operated. A typical key arrangement showing the ' two-in-one ' button is given in Fig. 5.

When less than four press-buttons are required the rectangular holes are closed by ' snap in ' dummies.

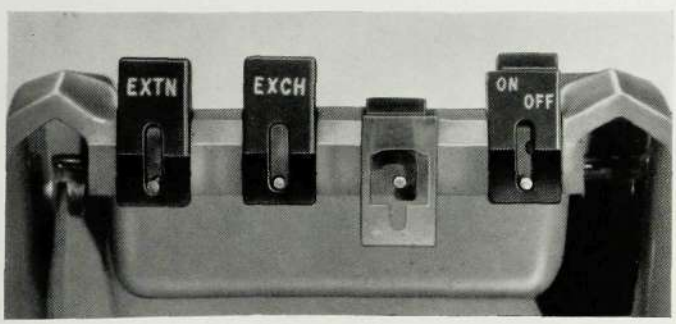


Fig. 4—Combination of ordinary and independent-action buttons

Lamps

In the instrument, provision is made for mounting two miniature screw-lamp fittings, with white flexible reflectors, on extension arms of the cradle-switch springset brackets.

When low-consumption lamps are fitted, effective illumination is obtained through transparent lenses inserted in holes pierced in the face of the instrument near its upper corners.

The translucent quality of the material forming the case has enabled an alternative indicator to be designed for lamps of higher wattage. This indicator is shown in Fig. 6. Its simple construction has been achieved by

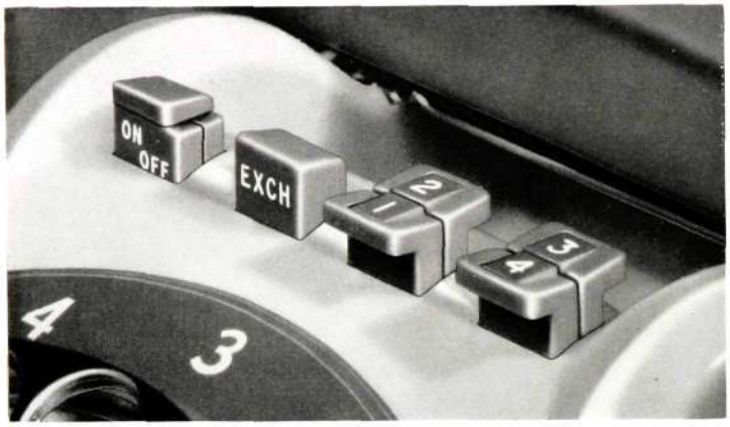


Fig. 5—Typical press button arrangement showing 'two in one' buttons

reducing the thickness of a circular section of the case to a degree sufficient to ensure adequate penetration of light in the immediate area facing the lamp. Because of heavy pigmentation, black instrument cases cannot be provided with this facility.

It is of interest to note here, that the lamp unit positions can be alternatively used to accommodate press-buttons should space for this purpose be required (i.e. operator recall, etc.).

Shared Service Adaptor

This adaptor, used for automatic separate-metering shared service lines, is usually mounted under any of four key-unit press-buttons. Alternatively, it may be mounted in place of either of the lamp units.

Local Battery Adaptor

An adaptor, consisting essentially of a choke coil, may be added in the instrument (without dial), to convert it to a local-battery instrument. An additional cradle-switch contact unit is included as part of the unit.

D.C. Buzzer and Transistor Oscillator

Both of these assemblies may be mounted at the rear of the fixed bracket. The buzzer, small but robust, is mounted on an extension of the cord-securing bracket and secured by means of two screws.

The transistor-oscillator (operational details are given in Bulletin No. 40, Jan. 1960) is also mounted on the cord-securing bracket. The frame of the oscillator unit has two extensions that clip inside and against the walls of the instrument base to prevent any movement of the assembly.

External Components

Because of the large number of components required in the various extension plans, it is clearly impracticable to mount them all in an instrument of reasonable dimensions. In some extension plans either an additional bell or buzzer, or both are necessary, and these are, therefore, mounted externally. Fig. 7 shows both components housed in a plastic-moulded case.

The ringer is of the latest type, and the same as used in the instrument. To permit ringing discrimination between the two, different sets of tone gongs are provided.

Desk Terminal Block and Cord Terminations

On a normal single-line instrument with two or three cord-termination points, disconnection or connection of the cord is a simple matter, but with the addition of more complex switching the number of conductors obviously increases. Therefore, with ten, twelve or more connections to be made in extension plan arrangements it is important that some arrangement be made to ensure the correct location of the terminations. To this end a new design of connecting tag has been developed for the desk cord conductors. The tags, together with their associated screws, are made captive on a plate of insulating material to maintain a permanent relationship between connections. The screws clamp the tags to metal bushes in the terminal block, (Fig. 8)

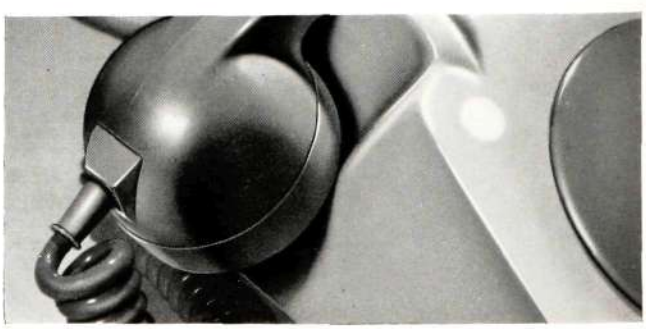


Fig. 6—New lamp indicator (on a CB telephone)

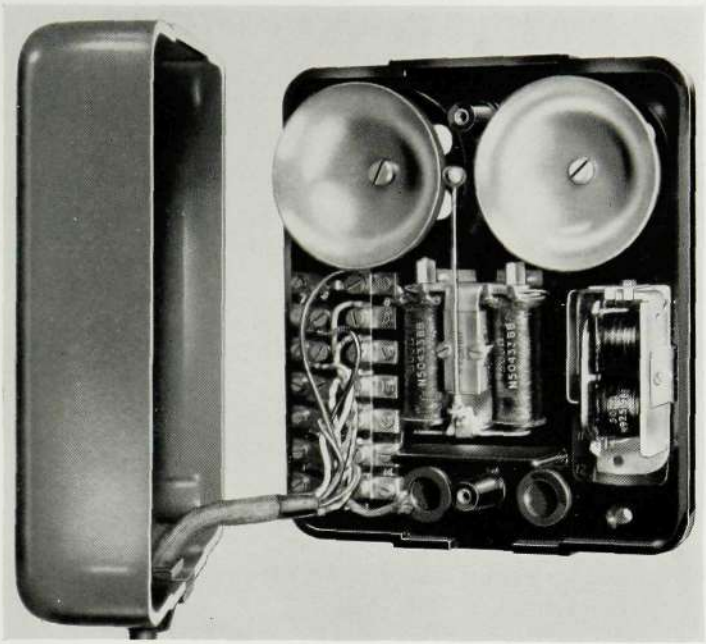


Fig. 7—Ringer and A.C. buzzer in plastic-moulded case

thus holding the insulating plate in position and also providing high contact pressures and reliable low-resistance connections This method of termination permits the removal or replacement of an instrument without disturbing the local wiring or the need for skilled labour.

Fig. 8—Desk terminal block and cord terminations plate

OTHER FEATURES

The Plan-Etelphone is treated to withstand wide extremes of temperature and humidity.

The facility to lock the cradle-switch actuating bracket in the ' handset on ' position by means of a latch spring on the fixed bracket, is included in the instrument (a feature of the Etelphone).

CONCLUSION

The Plan-Etelphone is undoubtedly a considerable improvement on previous types, and will, it is expected, have wide appeal. It is extremely compact yet easy access to all components has been maintained. The mechanical design ensures a high standard of operational reliability, greater convenience in use, and reduction in maintenance costs. A further contribution by the design is that no unsightly appendages are necessary to meet particular applications; all extension plan requirements can be met without alteration of the instrument's pleasing lines.

A subsequent article will detail facilities and circuit arrangements relating to the extension plans.

Patent Applications: 31433/60.

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