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FACILITIES OF PLAN-ETELPHONES

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This article follows the description of the mechanical features of the Plan-Etelphone (Bulletin No. 41) and describes the facilities of some of the many new extension plan arrangements made possible by this versatile telephone.

ALTHOUGH the P.B.X. provides increased communication facilities for the subscriber, there are many situations where a simple extension is inadequate and the P.B.X. too elaborate or unsuited to particular needs. Intermediate requirements over the years have therefore been met by a variety of extension plans which, in general, serve a smaller number of extensions and exchange lines than the P.B.X. Intercommunication between telephones is sometimes provided, but the primary purpose of the plan arrangements is to allow a number of extensions to receive and originate calls on one or two exchange or P.B.X. lines.

The recent introduction of the Plan-Etelphone seen at the head of the article has now made possible the improvement of this type of service. The simple mechanical features of the telephone (described, Bulletin No. 41) have considerably subscribed to the straight-forward switching functions and the logical positioning of visual signalling lamps, thus providing the ease of operation essential to any efficient telephone system.

With the plan arrangements the standard facilities can be expanded by adding extra keys and ancillary items where space is available. By use of these modules the extension plans offer various grades of service each geared to a different level of communication requirements.

In developing the extension plans certain specific classes of service were particularly in mind, but the circuits were arranged to be flexible enough to meet any demand likely to be placed on a telephone of this type and size.

Because of the diversity of plan arrangements, it is clearly outside the scope of this article to deal with all aspects of plan working. The intention, therefore, is to describe some of the more popular types available and the variety of facilities they afford.

Plan-Etelphone, Type 2 (Fig. 1)

This is a simple extension plan consisting of a number of parallel extensions on an exchange line, with one telephone, designated the 'main', serving as the answering station for incoming calls. Because of its simplicity the plan provides neither secrecy nor intercommunication between instruments.

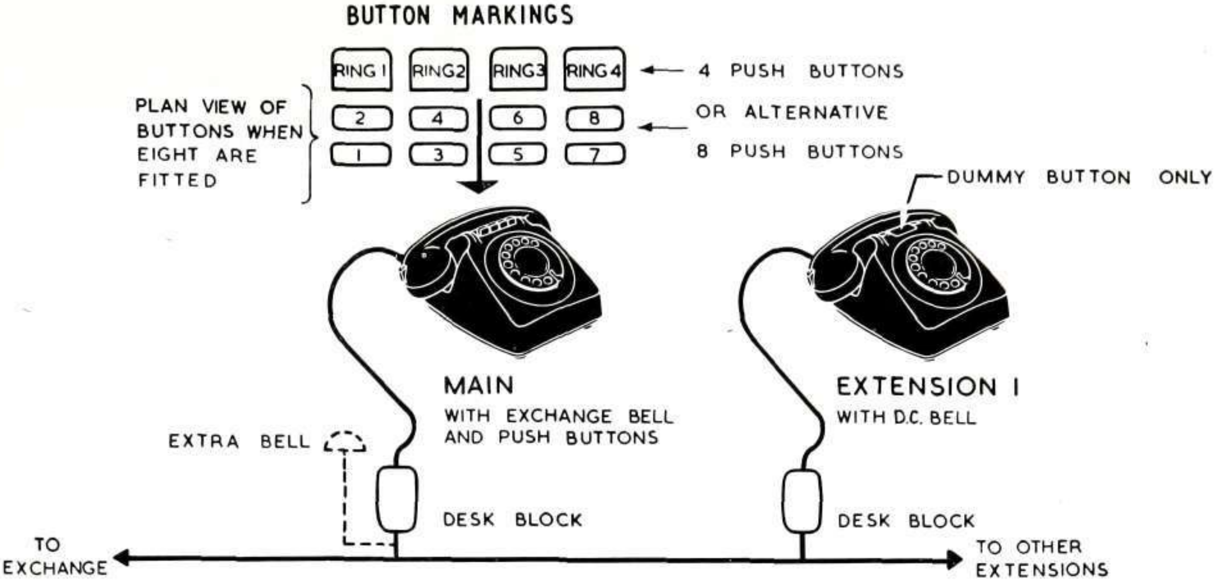

Fig. 1—Simple plan arrangement with one main telephone and a maximum of eight extensions connected to one exchange line (Type 2)

As shown, only the main telephone includes push-button keys. Each is non-locking and up to four standard or four 'two-in-one' buttons (Total 8: see Bulletin 41, pp. 71/2) or any combination of the two types can be accommodated in the telephone.

An incoming exchange line call is signalled on an a.c. bell in the main telephone and from this instrument the wanted extension is called by pressing the appropriate 'ring' key. This action causes the d.c. bell to ring in the selected extension telephone and, upon the extension user lifting the handset, connection to the exchange line caller is completed.

From any extension outgoing calls are established in the usual manner following the lifting of the handset.

A feature of the plan is the use of exchange line potential for the ringing of extensions, dispensing with the need for any local battery.

Plan-Etelphone, Type 6

It is quite common to find extension plans used on P.B.X. extension lines. In the arrangement shown in Fig. 2, a single telephone with three push-button keys is connected to two P.B.X. extension lines, which may be either internal or external.

The first line is used for incoming and outgoing calls via the P.B.X. operator, and the second line for originating an enquiry call on the P.B.X. system.

Outgoing calls on the first line are originated by lifting the handset and established in the normal manner.

Audible indication of an incoming call is given by the a.c. bell in the telephone and the call is answered on removing the handset, no key operation being necessary.

A user, speaking over line 1, can make an enquiry call by operating the 'enquiry' key to the locked position, thus connecting the telephone to line 2 and applying a hold condition on line 1. On conclusion of an enquiry call, the non-locking 'release' key is pressed to restore the 'enquiry' key and cause the telephone to be reconnected to line 1. To ensure that the instrument is always returned to normal should the user fail to return to the first line, the 'enquiry' key is also arranged to be released when the handset is replaced.

If the P.B.X. operator wishes to trunk offer whilst the user is engaged on the enquiry line, ringing is applied over line 1 and received on a separate bell-set positioned near the telephone.

A non-locking key provides the operator-recall facility.

A variant of the above plan is Type 15 (not described), which permits an incoming call to be received and held on either line and is not restricted to P.B.X. use.

Plan-Etelphone, Type 3

This plan uses one exchange line to serve two telephones interconnected by an external line and located, for example, in a shop and associated warehouse.

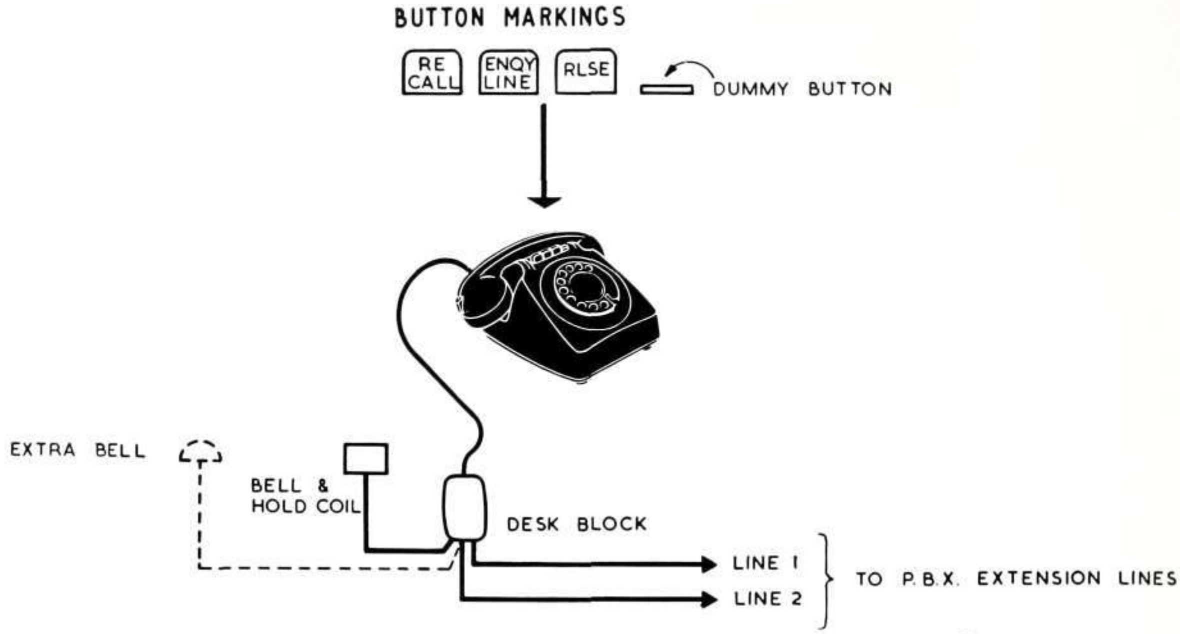

Fig. 2—Single telephone connected to two P.B.X. extension lines (Type 6)

Incoming calls are normally answered at the intermediate telephone but may, if the intermediate is unattended, be received at the extension, both bells ringing simultaneously in this instance.

An exchange line call may be held at the intermediate and an enquiry call made to the extension. The intermediate user may then return to the exchange call or transfer it to the extension.

Outgoing exchange line calls can be made direct from the intermediate telephone. Extension-to-exchange calls, however, are switched via the intermediate, and visual indication that the line is engaged by the extension user is given by an 'exchange line' lamp above the dial in the intermediate telephone. Conversation between the extension and exchange parties may be made secret or non-secret from the intermediate station by appropriate terminal strapping.

The extension telephone is provided with one non-locking key for signalling the intermediate station. The intermediate telephone has four locking keys for switching, and release of any one from the locked position is effected on the depression of any other key. Besides providing a locked condition, the two inner keys are arranged to perform an additional function for use in calling the extension, either key, when overpressed, operating an auxiliary springset common to both. This facility avoids the provision of a separate 'ring' key.

Inbuilt transistor ringing units provide ringing current for signalling between instruments and replace the inconvenient hand generator used on earlier systems of this type.

Other features available on an optional basis are P.B.X. recall, additional parallel extensions and external bells.

It is of interest to note here, that similar facilities are included in the Plan-Etelphone, Type 7 (not described), designed for an internal line and providing d.c. signalling between instruments.

Circuit Operation

A simplified schematic of Type 3, shown in Fig. 3, serves to illustrate the operation of the system.

Extension to Intermediate

After removing the handset, the user momentarily presses the non-locking 'ring' key KR in the extension instrument to apply ringing current from the transistor ringing unit to the a.c. buzzer at the intermediate instrument. The attendant at the intermediate replies by pressing the 'extension' key and removing the handset to complete the speech path between instruments.

Extension to Exchange

Should access to the exchange line be requested by the extension user, the 'extension-to-exchange' key KEX is operated to switch the extension loop across the exchange line via KEX 1, KEX 2 and the S relay. Relay S operates to the exchange battery and the exchange line lamp glows steadily on the closing of contact S1.

At this stage, the attendant may withdraw from the circuit by replacing the handset, and the extension user can proceed with the call in the usual manner. During dialling, no bell tinkling in the intermediate is possible owing to the action of contact S2, which disconnects the bell in addition to providing a low impedance speech path through capacitor C1.

Overhearing of the call is prevented (if required) by a key contact of KEX (not shown), applying a short circuit across the intermediate telephone receiver.

Incoming Exchange Calls

Ringing current from the distant exchange operates the bell at the intermediate telephone. The attendant replies by removing the handset and pressing the 'exchange' key KX to connect the telephone to the line. Relay S operates as previously described, but contact S1 is made ineffective by KX 4, which prevents the completion of the 'exchange line' lamp circuit.

To hold the line and speak to the extension, the 'hold and extension' key KH is pressed by the attendant to switch resistor R1 across the line and also to release the locked KX key.

By overpress action of the KH key the auxiliary springset KR is operated and the a.c. bell in the extension instrument rung.

If the exchange call is accepted by the extension user, the 'extension-exchange' key KEX is pressed and the KH key automatically released to complete the transfer of the exchange call to the extension. The intermediate telephone handset may then be replaced.

If the exchange line call is refused, the attendant returns to the exchange line by again operating key KX; the 'hold and extension' key KH restores to normal.

Intermediate to Extension (Intercom. Call)

An extension is called for purely intercommunication purposes by overpressing the 'extension' key

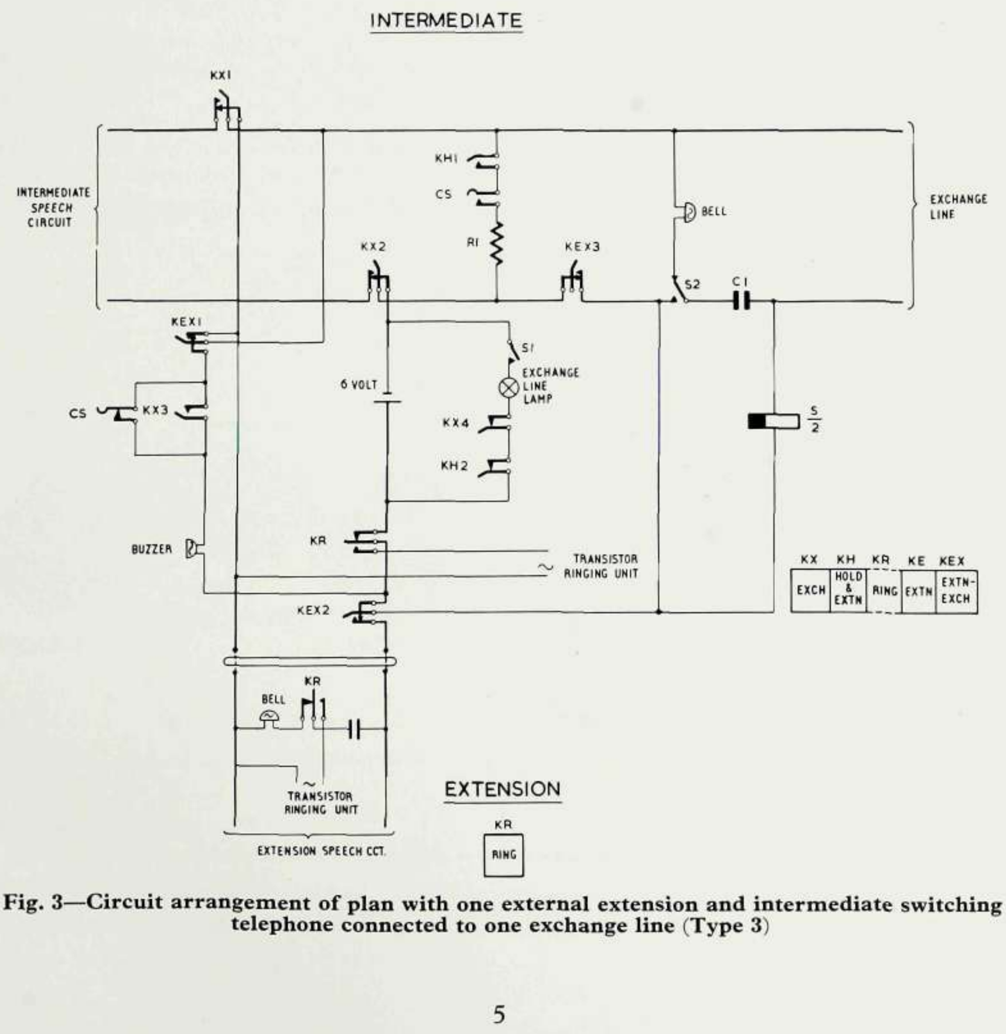

Fig. 3—Circuit arrangement of plan with one external extension and intermediate switching telephone connected to one exchange line (Type 3)

(KE). By this action the auxiliary springset KR is operated and the extension instrument bell rung. Both parties are connected when the extension user lifts the handset.

Intermediate to Exchange

Connection to the exchange from the intermediate telephone is established on lifting the handset and pressing the 'exchange' key KX, as for an incoming call. Contact KX3 prepares the buzzer circuit to enable the extension user to signal the intermediate while the exchange call is in progress.

SECRETARIAL SCHEMES

Among its other uses the Plan-Etelphone is well suited to secretarial service where a secretary, say, in an outer office can filter calls through the switching telephone to one principal or more.

PLAN-ETELPHONE, TYPE 1

An example of one of the several secretarial arrangements available is the Plan-Etelphone, Type 1, given in Fig. 4. It is based on one exchange line and provides for one secretarial telephone and up to two extension telephones.

With this arrangement, outgoing exchange calls can be made direct from any instrument or obtained via the secretary's telephone (intermediate). Secrecy from the intermediate is optional on extension-to-exchange calls.

Although answering duties for both extension users are usually performed at the intermediate telephone, an incoming exchange call can be directly received and answered at an extension telephone without the need for any intermediate switching. A manual lock-and-release key positioned next to the 'ring' key in each extension telephone, when switched to 'on,' causes the particular extension's exchange bell to be series connected with that of the intermediate telephone; both bells respond to incoming ringing. This is a useful facility if, for example, the secretary is absent for certain periods throughout the day, or the extension is to be attended after working hours.

No key operation is necessary on direct exchange calls from an extension. Seizure of the exchange line (if free) is immediate on removing the handset, and visual indication of this action is given by an 'exchange line' lamp in the intermediate telephone. Providing the plan is not arranged for secrecy, the extension may call the secretary into the extension-to-exchange connection by pressing the 'ring' key. On operation of the buzzer in the intermediate telephone, the secretary responds by taking up the handset and listening to, or participating in the conversation as required.

An intercommunication call from an extension to the intermediate is originated on operation of the 'ring' key only, and established following recall by

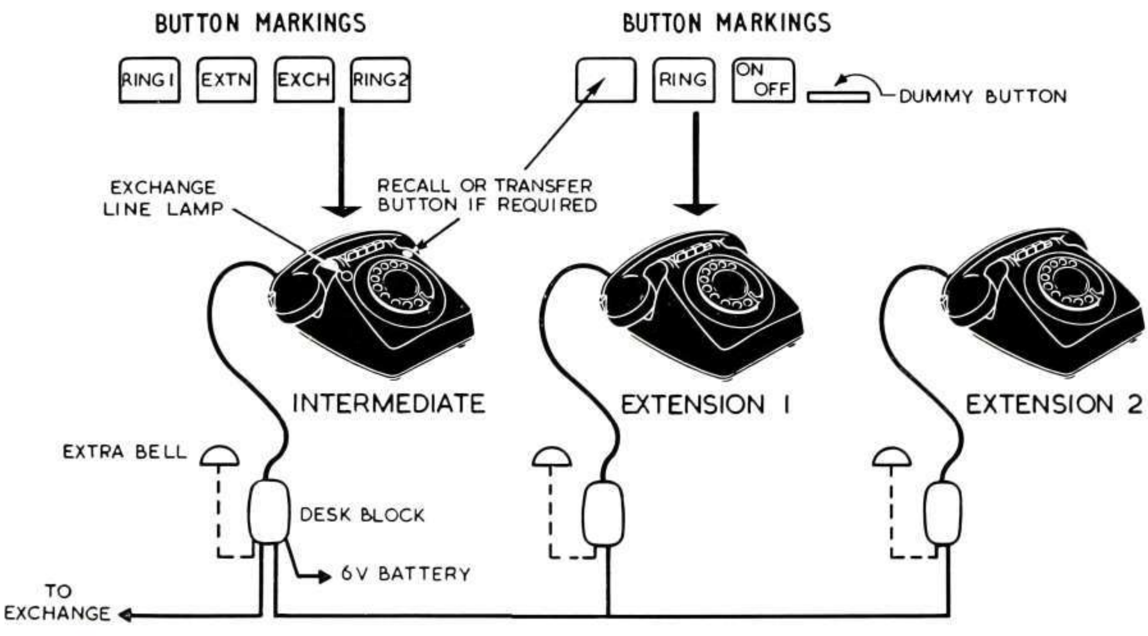

Fig. 4—Secretarial service with one exchange line serving two principals and a secretary (Type 1)

the secretary. When two extensions are fitted, the secretary is called by 'code-calling'—pressing the 'ring' key in a predetermined pattern of long and short rings. This method enables the secretary to determine the calling line and recall by pressing the appropriate 'ring' key and also the 'extension' key.

The secretary originates and receives exchange calls by operation of the 'exchange' key. During an exchange line call, a signal from an extension can be acknowledged or an enquiry call made by pressing the 'extension' key as previously described. Because the 'exchange' key is also operated at this stage a hold condition is applied to the exchange line while the secretary speaks to the extension. Dependent upon instructions received from the extension user, the secretary may proceed as follows:—

(*a*) Replace the handset to release all keys and automatically transfer the exchange call to the extension user.

(*b*) Repress the operated 'exchange' key to reconnect her telephone to the exchange line.

PLAN-ETELPHONE, TYPE 4

The variation shown in Fig. 5 provides secretarial service for one secretary and one principal.

The secretary's telephone comprises the same number of push-button keys as in the Type 1, including two with overpress action for use in sounding the extension instrument buzzer. The extension telephone has an extra key and, in common with the secretary's telephone, incorporates an 'exchange line' lamp.

Intercommunication is possible between the principal and secretary, and incoming exchange call procedure is as adopted in Type 1, with the secretary normally answering and filtering exchange calls to the principal's telephone. Exchange calls can be established direct from each instrument, but in this arrangement, because the extension is positioned between the secretary's telephone and the exchange, the principal has switching priority. A further feature is that the principal, in addition to the secretary, can make enquiry calls.

Extra facilities can be included in this plan, for example, recall, transfer, call-back or right-of-way, and any two can be provided by overpress on a suitable button and/or extra push button.

PLAN-ETELPHONF, TYPE 8

This secretarial scheme is based on two exchange lines. Despite the additional switching involved,

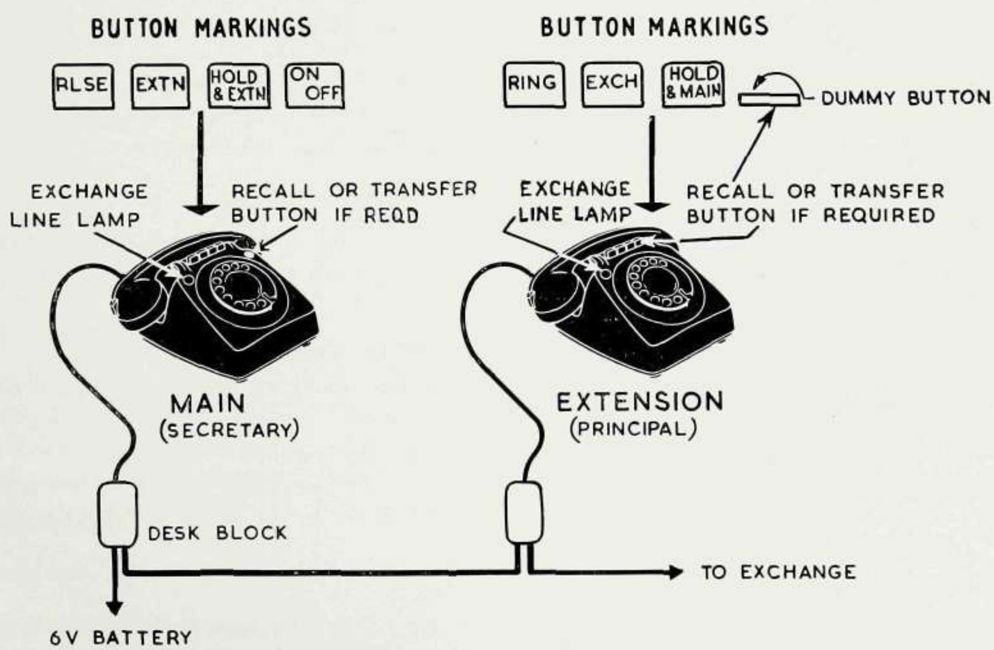

Fig. 5—Secretarial service, including bothway enquiry facility, with one exchange line serving a principal and secretary (Type 4)

the circuit arrangement is such that the number of push-button keys required is only three per telephone.

Among the facilities afforded are:—

(*a*) Exchange line calls are signalled and filtered at the intermediate (secretary's) telephone before being offered to the extension user (principal).

(*b*) In the absence of the secretary an incoming call signal is diverted to the extension.

(*c*) The secretary can take part in, or listen to a through conversation or be excluded at the discretion of the principal.

CIRCUIT OPERATION (Fig. 6)

Extension to Exchange

Following the lifting of the extension handset the locking 'exchange' key KB is pressed to switch the extension directly to the filter line. Should the principal not require his conversation to be overheard by his secretary, the locking 'exchange secret' key KC is operated when the call is established, to release key KB and isolate the intermediate telephone circuit at contact KC4. The call proceeds as normal and, on completion, the handset is replaced to release the operated key.

Extension to Intermediate

To call the intermediate, the principal operates the non-locking 'ring' key KA, and battery is extended via contact KA1 to operate the buzzer in the intermediate instrument.

The secretary replies by lifting the handset and operating the locking 'extension' key KB to cause the speech path between instruments to be completed via key contacts KB1, KB2 (intermediate telephone) and other series connected contacts. Replacement of the intermediate instrument handset at the conclusion of the call restores the operated key KB to normal.

Exchange Call (Secretary's Line)

The exchange line is seized by simply removing the handset.

Intermediate to Extension

To call the extension, the 'extension' key KB is overpressed, after removing the handset, to operate an associated springset unit KBC1. If the principal is not engaged on the filter line, the buzzer sounds in the extension instrument and both parties can converse upon the principal lifting his handset.

Should the principal be engaged, the 'exchange' key KB will be operated or the 'exchange secret' key KC. The action of either KB3 or KC3 therefore prevents the operation of the buzzer in the principal's instrument. The buzzer in the secretary's telephone, however, is sounded via contact KB3 or KC3 operated, to give warning that the extension is engaged.

Enquiry Call

To answer an incoming exchange call on the filter line, the locking 'answer filter' key KD is pressed by the secretary to connect her telephone across the line via key contacts KD2, KB1, instrument loop, KB2, KD1 and key contact KC4 in the extension telephone.

The incoming call may be held on operation of the 'extension' key KB to the locking position, to cause a holding loop to be switched across the line via KB3 (x). The principal may then be called by overpressing key KB as previously described, key contacts KB1 and 2 preventing the exchange party from overhearing the conversation.

On conclusion of the enquiry call the secretary may perform any of the following operations:—

(*a*) Replace the handset to release keys KB and KD, after the principal has accepted the call and pressed his 'exchange' key KB or KC.

(*b*) Repress the 'answer filter' key KD to release key KB and connect her telephone to the exchange line as instructed by the principal.

Secretary Absent

Before leaving the instrument telephone unattended, the 'absent' key KA is pressed and locked. Key contact KA1 applies a short circuit across the bell in the intermediate instrument, and exchange ringing is diverted to the bell in the principal's telephone.

CABLING

Cabling requirements obviously vary with the type of plan, the facilities provided and the disposition of the telephones. Indication of the number of conductors between an extension telephone and the

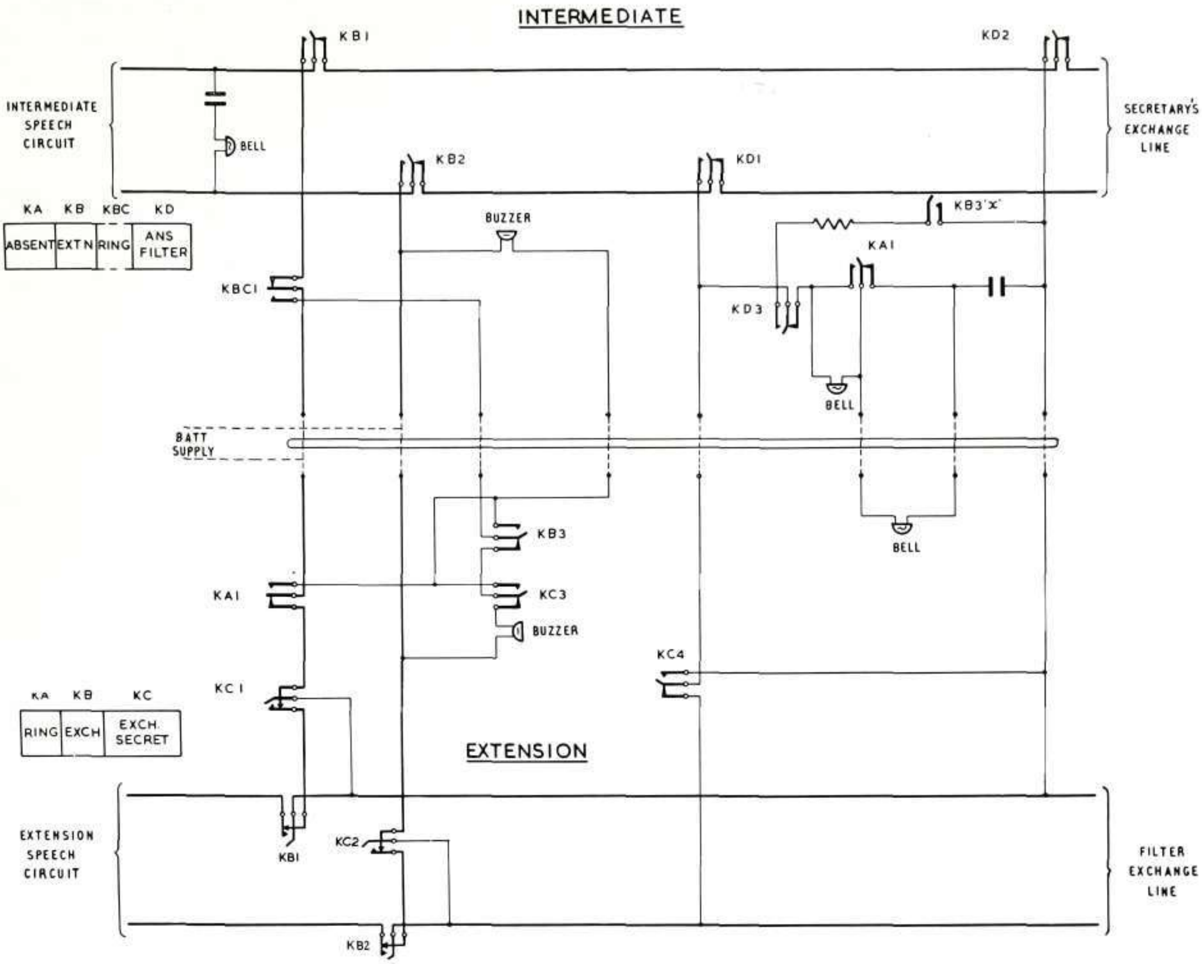

Fig. 6—Circuit arrangement of secretarial service with two exchange lines serving a principal and secretary (Type 8)

intermediate (or main) station is given below for the plan arrangements in the order described.

Plan-Etelphone, Type 2—4 wires

Plan-Etelphone, Type 6—none

Plan-Etelphone, Type 3—2 wires

Plan-Etelphone, Type 1—6 wires (1 Extension)

Plan-Etelphone, Type 1—7 wires (2 Extensions)

Plan-Etelphone, Type 4—10 wires

Plan-Etelphone, Type 8—8 wires

An internal extension is usually located within the same building as the intermediate (or main) telephone. Cable length between the two instruments is governed by a loop resistance of 40 ohms which allows, for example, 2500 ft. of 1-pair 20 lb/mile cable to be used, if necessary.

External Extension Resistance

An external extension is connected by a 2-wire line, which can be up to 1000 ohms loop resistance from the main exchange; the intermediate being situated anywhere between the extension and the exchange.

Power Supply

Excluding plan arrangements requiring no separate local battery for operation (e.g., types 2 and 6), the various plans are arranged to work from a 6V d.c. supply. This may be conveniently taken from a dry battery or, dependent on the type of plan, a power feed or power unit.

U.D.C.621.395.345

A THREE-DIGIT ELECTRONIC DIRECTOR

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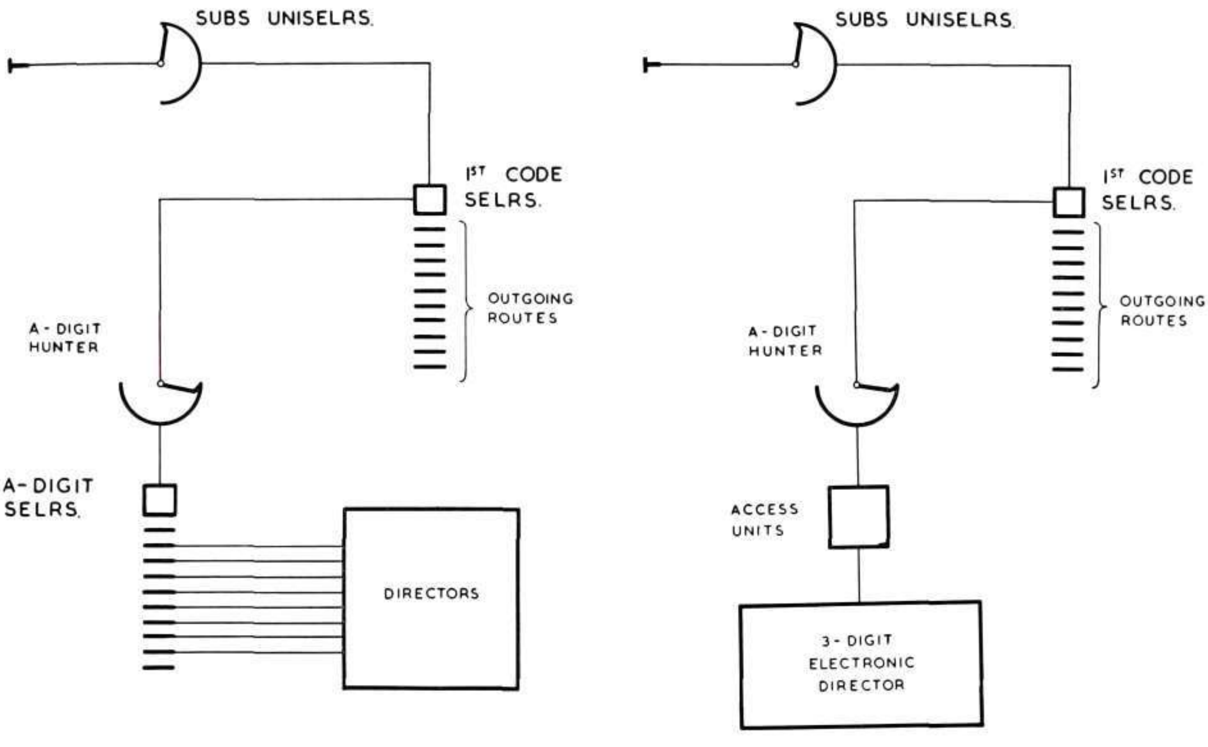
The electronic equipment described provides the same facilities as the existing electromechanical A-digit Selector and BC Director used by the B.P.O., but is considerably smaller and requires the minimum of maintenance. Size reduction has been obtained by the use of transistors and time-sharing techniques. 'Square-loop' magnetic cores are employed for the data storage and logical functions and the translation field is so arranged as to permit translation changes to be readily made.

A THREE-DIGIT electronic director has been developed to provide the same facilities as the electromechanical A-Digit Selector and BC Director in present use by the Post Office. In the electronic equipment, the storage, logical and switching functions are carried out by 'square loop' magnetic cores; transistors provide the current to operate the cores and are also used for the amplification of pulses where necessary. No thermionic valves or cold cathode tubes are employed. By the use of time-sharing techniques a substantial reduction in the size of the equipment as compared with its electromechanical counterpart has been obtained, and the low voltages and currents required by transistors and magnetic cores have resulted in a low total power consumption. The life of square-loop cores is indefinitely long, and transistors also will give long service when operated under proper conditions. In designing the circuits account has been taken of the particular necessity for a low fault rate in common equipment, and this, together with the use of reliable components, gives rise to an expectation of a long life for the electronic director and the minimum of maintenance requirements.



(a) **Electromechanical A-Digit Selectors and Directors** (b) **3-Digit Electronic Director**

Fig. 1—Basic Trunking Arrangements

The basic arrangement of the electronic director compared with the existing A-Digit Selector and BC-Digit Directors is shown in Fig. 1. In the electromechanical circuit (Fig. 1 (*a*)) the subscriber by lifting his handset causes his uniselector to search for a free first code selector. If a selector is available, it is seized and in its turn searches via its associated A-Digit Hunter to seize the first free A-Digit Selector; dial tone is then returned to the subscriber. On receipt of the A digit, the A-Digit Selector wipers step to the appropriate level and then cut into the bank to search for and seize the first free director. This director then accepts the B, C and numerical digits.

Fig. 1 (*b*) gives the arrangement for the electronic director. The equipment is seized via access units connected to the outlets of the A-Digit Hunters. When a free access unit is seized, dial tone is returned to the subscriber and the director receives and stores the dialled A, B, C and numerical digits. The number of access units is approximately the same as the number of A-digit selectors for the same traffic.

Functional Outline

Fig. 2 is a block diagram of the electronic director. There is a central data store consisting of a group of registers, the number depending on the traffic carried by the exchange. Each register is directly connected to an access unit.

The contents of each register are read out in turn and presented to the In and Out Computers; this operation is controlled by the Main Sequencing Matrix which applies scan pulses $Ro_{(1)}$ to $Ro_{(n)}$ to the registers in succession. These scan pulses are shown in Fig. 3; it will be seen that each register is scanned every $16\frac{2}{3}$ milliseconds. This period is suitable for sampling the subscriber's loop via the In Computer and also for timing and controlling the pulses returned by the Out Computer via the access units to the first code selectors.

The incoming dialled digits are stored in the register under control of the In Computer and the three code digits are presented to the decoders and translator. The Out Computer accepts the routing digits as these are produced in turn from the translator, stores them and arranges for them to be pulsed out; these are then followed by the numerical digits.

The functions and contents of the blocks are:—

(*a*) *The Store*

Each register consists of a column of 2 mm ferrite square-loop cores which hold information in a '2 out of k' code, k being the number of cores associated with each counter or logical unit in the In and Out Computers. The number of cores in a register is approximately one hundred and therefore in a hundred-register system the store would consist of a wired matrix of 10,000 cores. This would be constructed in practice as four matrix planes each of 50 x 50 cores.

(*b*) *The In Computer*

This comprises several functional units as follows :—

(i) The Make Length Counter (MLC) which detects the loop-disconnect pulses from the subscriber's line during dialling. It provides two separate output signals, one representing dial breaks and the other indicating the inter-train pause.

(ii) The Incoming Distributor (DR), which in conjunction with the Digit Control (DC), routes the successive incoming dialled digits to the appropriate digit counter stores. It also provides a control signal such that when all three incoming code digits A, B and C are complete in their counter stores they are presented to the Translator.

(iii) The Incoming Digit Counter Stores CDA, CDB, CDC for the code digits and ND1, ND2, ND3 and ND4 for the numerical digits.

(*c*) *The Decoders and Translator*

These comprise:—

(i) The first decoding matrix of square loop cores (M1) to which is applied the received A and B code digits.

(ii) The second decoding matrix of square-loop cores (M2) to which is applied the output of the first decoding matrix and the received C code digit. Each combination of the A, B and C code digits is represented by a separate output from M2.

(iii) The Translator, which receives the outputs from M2 and translates them into the required routing digits.

(*d*) *The Out Computer*

This comprises:—

(i) The Phase Counter (P), which controls the sequence of pulsing out of the routing and numerical digits.

(ii) The Pulse-Out Digit Counter (D), which counts out the digit to be transmitted and controls the Pulse-Out Relay circuit.

(iii) The Pulse-Out Relay circuit.

(iv) The 100 millisecond Counter (C), which controls the timing of the digits pulsed out.

(v) The Intertrain Pause Counter (ITP), which provides the necessary pauses between trains of digits and also maintains control over the pulsing out of the digits.

(vi) The Normal Release circuit.

(vii) The Forced Release Counter.

(*e*) *The Pulse Generator*, which provides the controlling pulses for the equipment.

(*f*) *The Main Sequencing Matrix* (MSM), which provides the scan pulses to the registers and access units.

(*g*) *The Access Unit*

This provides the parallel-to-series and series-to-parallel conversion required by the electronic director so that it may work into the electro-mechanical exchange. It also provides the necessary terminations and conditions for the +, —, P, PU and FR wires forwarded by the A-digit hunter.

OPERATION

Information relating to the progress of calls is stored in the 2 mm ferrite cores which make up the register columns. The columns of cores are subdivided into groups of k cores and the corresponding group of k cores in each register column is associated with a counter in the In or Out Computer.[1]

It is convenient for the purpose of explanation to consider the operation of one particular register 'r'

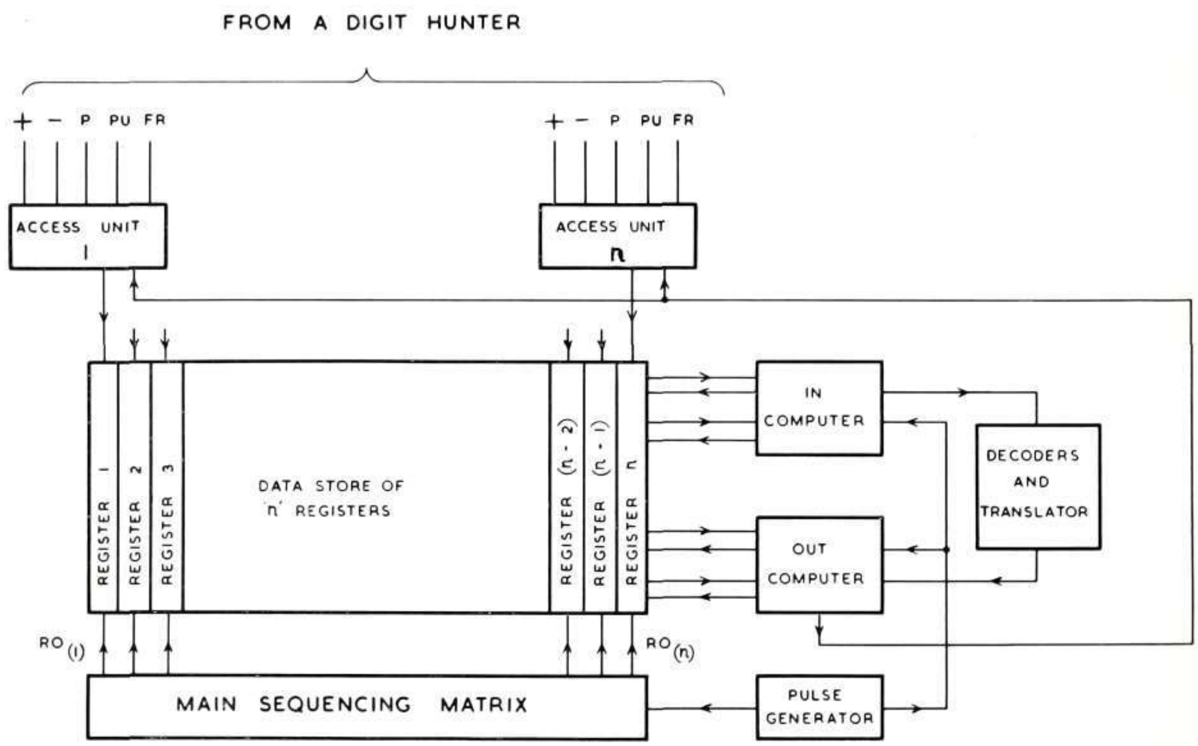
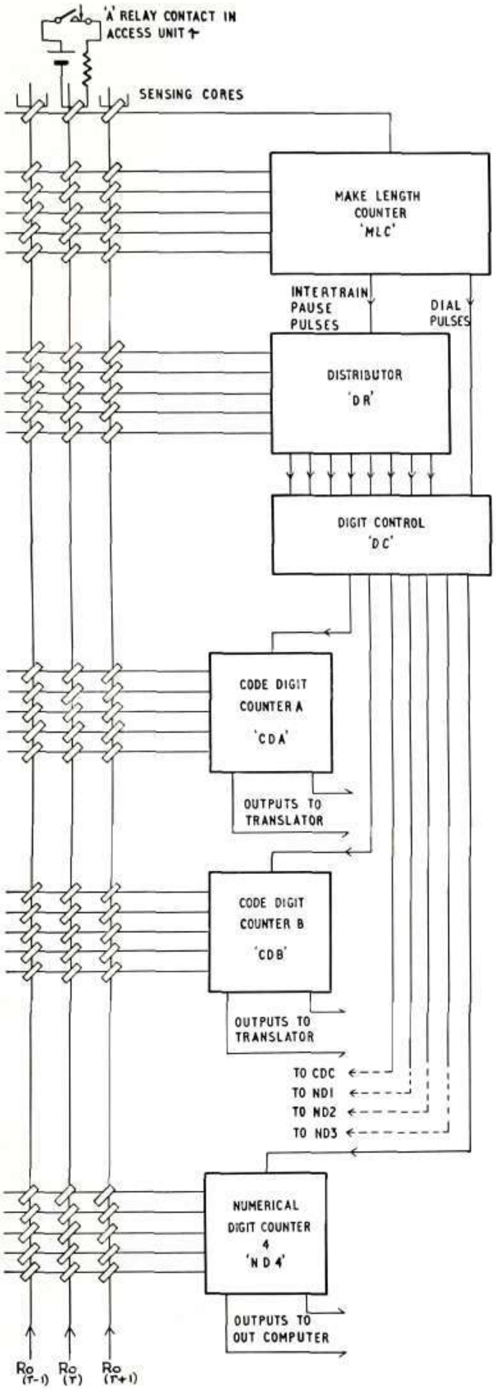


Fig. 2—Block Diagram of Electronic Director

1 LOUGHHEAD, W. A. E., KAPOSI, A. (Mrs.), MATTHEWS, G. A., and WOODWARD, J. A.: 'A combined Counter and Decoder using Transistors and Magnetic Cores', Proceedings I.E.E., Paper No. 2908E, International Convention on Transistors and Associated Semiconductor Devices 1959. (Part B, Supplement No. 18, P.1244).

during a call, it being understood that the other registers are independently operated on by their respective scan pulses, which occur in between the successive scan pulses $Ro_{(r)}$ of register r, (see Fig. 3).



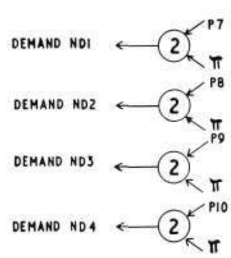


Fig. 4—The In Computer

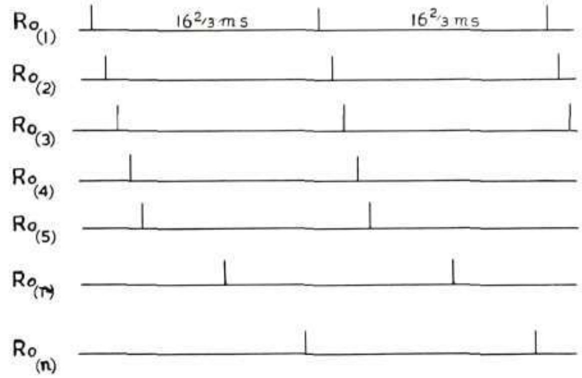


Fig. 3—Register Scan Pulses

The In Computer

When a subscriber seizes the access unit associated with register r, the PU wire is extended to an A relay in the access unit thus indicating the state of the loop. While the loop is made, a bias is applied to a sensing core associated with the A relay (see Fig. 4), and when the scan pulse $Ro_{(r)}$ is applied to the register no output is obtained from the sensing core and hence there is no input to the MLC (see Figs. 5 (*a*), (*b*) and (*e*)).

When the loop is broken during a dial impulse, the A relay releases and bias is removed from the sensing core. Outputs are obtained from the sensing core by the scan pulses $Ro_{(r)}$ and are passed to the MLC which produces a single output to indicate one dial break (Fig. 5 (*c*)). When the loop is made again the inputs to the MLC cease and after a fixed interval a separate single output is produced from the MLC to indicate the intertrain pause (I.T.P.), (Fig. 5 (*d*)). In this manner the incoming dial impulses and the intertrain pauses are converted into pulses which occur at the scan time of the register.

The Distributor, in conjunction with the Digit Control, organises the routing of the incoming code and numerical digits to their respective digit counter stores. The Distributor steps on one position for each received I.T.P. pulse from the MLC, thus indicating the particular digit completed and the following digit in the process of being pulsed in; the logical operations involved in the functioning of DR and DC are carried out by magnetic core circuits.

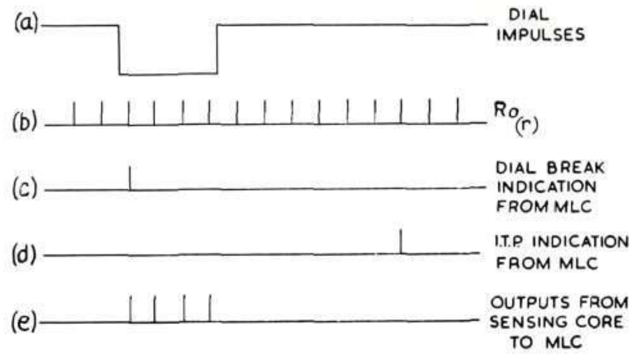


Fig. 5—Recognition of Dial Impulses

When the A, B and C code digits have been received and stored in the CDA, CDB and CDC counter stores they are presented continuously to the translator at the $Ro_{(r)}$ pulse time.

The Decoders and Translator

A simplified diagram of the decoders and translator is shown in Fig. 6. The first decoding matrix M1 consists of a wired array of square-loop metal tape cores. The simultaneous application of the stored A code digit to the selected column and the stored B code digit to the selected row causes the core at the intersection of the row and column to switch and produce an output. This output is applied to a column in the second decoding matrix M2 which is a further wired array of square-loop metal tape cores. Simultaneously with the application of the A and B code digits to M1, the stored C code digit is applied to the selected row of M2 so that the core at the intersection switches and produces an output from M2 which represents as a pulse on a single wire the three code digits stored in the CDA, CDB and CDC counters.

The outputs from M2 are connected to the translator consisting of an array of uncut C cores. The material of these cores does not exhibit a square hysteresis loop and is of the type normally used for small power transformers. In Fig. 6 the array is shown as consisting of three rows of cores numbered 1 to 0. (The purpose of the 'β' and 'code only' cores will be explained later). Each row represents

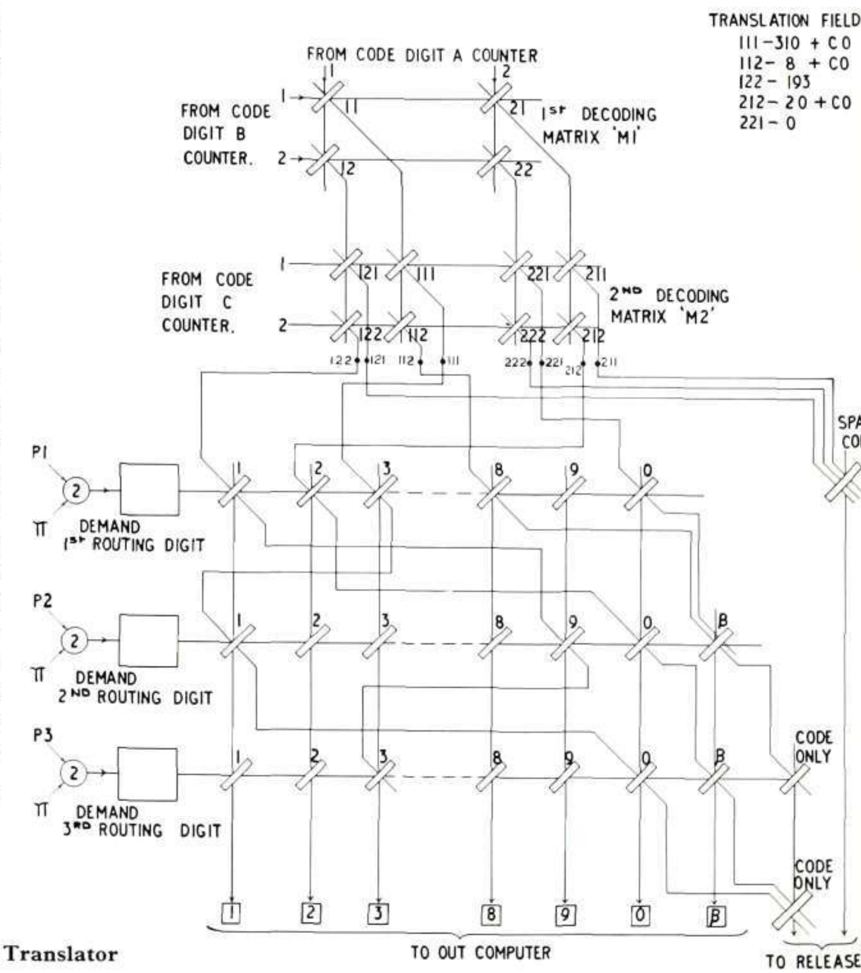


Fig. 6—The Decoders and Translator

one routing digit. Every core is provided with an output winding, and each column of similarly-numbered cores has its output windings connected to a common output point. This is represented in the diagram by the single vertical line through each column of cores.

The selected output of M2 is available on a single wire threaded through one core in row one of the translator, one core in row two, one core in row three and finally terminated at earth. Each routing digit (or row) is demanded in turn for the purpose of pulsing out; this demand is initiated by the Out Computer.

The selected output wire of M2 has a current pulse produced in it when its associated core in M2 switches. This current pulse tends to induce a pulse in the output windings of the translator cores through which the wire is threaded. The induced pulse is made available at the common output point associated with the core in the row demanded, thus representing the routing digit, but no output pulse appears in the output circuits of those rows not demanded.

As an example using Fig. 6, suppose that the code digits dialled and stored were 122. Core 12 in M1 and core 122 in M2 would switch. Because the output wire of core 122 is threaded through core 1 of row 1, core 9 of row 2, and core 3 of row 3, the rows can be demanded in sequence and the routing digits 1, 9 and 3 made available in turn to the Out Computer for pulsing out.

The translations can be changed by simply re-threading the wires through the appropriate translator cores. It is of interest to note that the potential of these wires is normally earth and changes by only a fraction of a volt during the pulse. Ignoring barred codes, M1 would be a 10 x 10 matrix of 100 cores providing 100 separate outputs to M2, which would be a 10 x 100 matrix of 1000 cores thus giving 1000 separate outputs to the translator.

There are no intermediate stages of amplification between M1 and M2 or M2 and the translator. In practice there are six rows of cores in the translator providing up to six routing digits.

The Out Computer

The timing of the digits pulsed out by the director over the + and — wires is controlled by the C counter (Fig. 7) which generates pulses (C1-C6), $16\frac{2}{3}$ m/s apart, each pulse recurring every 100 milliseconds. The control of the pulsing-out procedure is carried out by the ten-state P counter; the outputs P1-P6 of this counter initiate the demand for routing digits and a further four outputs P7-P10 initiate the demand for the numerical digits.

Initially the I.T.P. counter generates a signal which normally indicates the end of each I.T.P. period; this signal is called epsilon (ϵ). The epsilon signal is and-gated with the C counter output C6 to produce a signal termed pi (π). Initially the P-counter is in state P1 and this is and-gated with the π signal (Fig. 6) to produce a further signal which demands the first routing digit. This demand is applied at the scan time of the register, and when the three code digits have been dialled, the demand signal results in the appearance of a pulse at one of the translator output terminals. This pulse constitutes the first routing digit.

The 1-0 output pulses from the translator are applied to the pulse-out counter D (Fig. 7) and each pulse can set the counter to the corresponding one of its ten active states. Thus the first routing digit pulse sets the D counter appropriately; at the same time a signal alpha (α) is produced (see Fig. 7), which is an indication that a routing digit has been demanded and stored in the D counter. The signal α steps the P Counter from P1 to P2 and also causes the I.T.P. counter to cease producing further ϵ signals and to produce instead, on a separate lead, a 'commence pulse out' signal gamma (γ). This occurs every $16\frac{2}{3}$ milliseconds and the C1 signal from the 100 millisecond counter occurs every 100 milliseconds. The γ and C1 signals are applied to an and-gate, and the gate output pulse, occurring every 100 milliseconds, steps the D counter towards its 'home' state and also operates the Pulse-Out Relay Circuit. This process continues until the home position of the D counter is reached, indicating that the first routing digit has been completely pulsed out. The output from the home position of the D counter combines in an and-gate with the output C6 from the 100 millisecond counter to provide a signal to the I.T.P. counter As a result the signal γ ceases and it is arranged that $16\frac{2}{3}$ milliseconds later the I.T.P. counter will commence to count eight 100 millisecond periods; this is controlled by the counter input which itself occurs once every 100 milliseconds. When the I.T.P. period is complete, the signal ϵ reappears and the input and and-gate of the I.T.P. counter is inhibited.

The next time the output C6 of the 100 millisecond counter appears it combines as before with the signal ϵ to produce the signal π; this combines with P2 to demand the second routing digit. The process continues until all the six routing digits have been pulsed out.

The P counter is then at position P7 and this, together with the signal π, demands the first numerical digit from the ND1 counter. The D counter is set in the same manner as for a routing digit and the pulse-out procedure continues as before until the four numerical digits have been pulsed out.

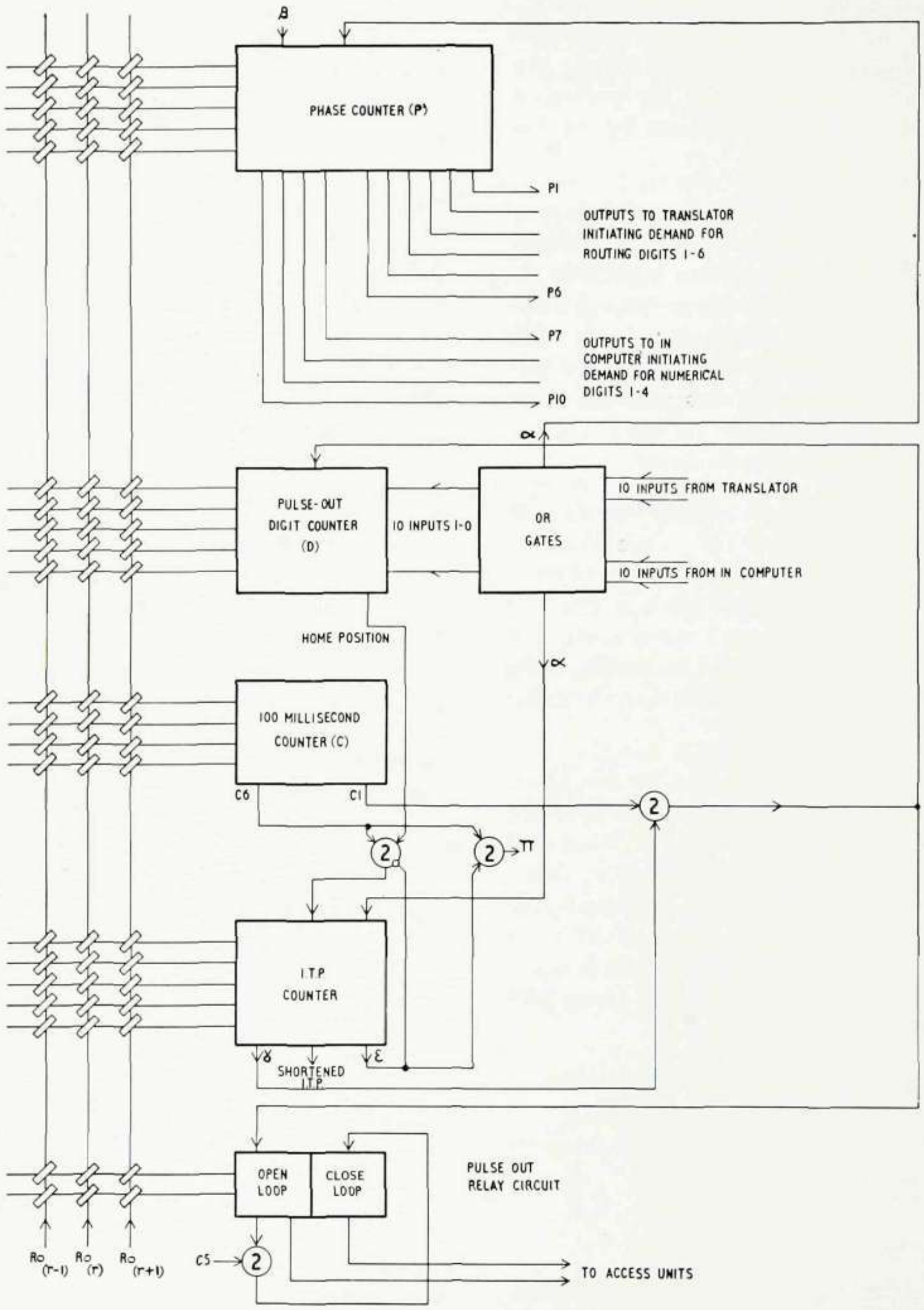


Fig. 7—The Out Computer

Some translations may of course have less than six routing digits. For example, in Fig. 6, the code 212 has only two routing digits, 2 and 0; the translation wire is threaded through core 2 in row 1, core 0 in row 2, core beta (β) in row 3 and then terminated to earth. The output from core β is demanded and is derived in the same manner as for a routing digit; its function is to advance the P counter to state P7 in one step so as to initiate the demand for the first numerical digit. This enables a positive indication to be given that there are no more routing digits and at the same time reduces the delay which would otherwise occur before the numerical digits were pulsed out.

If the dialled digits represent a 'code only' call, then the translation wire, after being threaded through the appropriate cores in the rows (which may include β if there are less than six routing digits), is passed through the 'code only' core prior to termination to earth. The output of this core initiates release of the director. The Pulse-out Relay Circuit, as previously stated, receives a signal every 100 milliseconds during the pulse out period. An 'open loop' signal is produced which operates the pulse-out relay in the access unit associated with the register. This 'open loop' signal is also applied to an and-gate. This gate also receives the C5 signal from the 100 millisecond counter. As a result, the gate generates an output signal $66\frac{2}{3}$ milliseconds after each 'open loop' signal; the gate output operates on the Pulse-Out Relay Circuit to produce a 'close loop' signal which releases the pulse-out relay in the access unit. The make and break periods on the + and — wires are therefore accurately timed during pulsing out.

Normal release is effected in two ways:—

(*a*) By combining in an and-gate:—

(i) The output from the P counter indicating that all routing and numerical digits have been pulsed out.

(ii) The shortened I.T.P. of 400 milliseconds.

(*b*) By combining in an and-gate:—

(i) The 'code only' core output.

(ii) The output from the P counter indicating that all routing digits have been pulsed out.

(iii) The shortened I.T.P. of 400 milliseconds.

The output of either of these two gates is arranged via suitable circuits to operate the release relay in the access unit. This relay operates to disconnect the P wire and thus releases the director and access

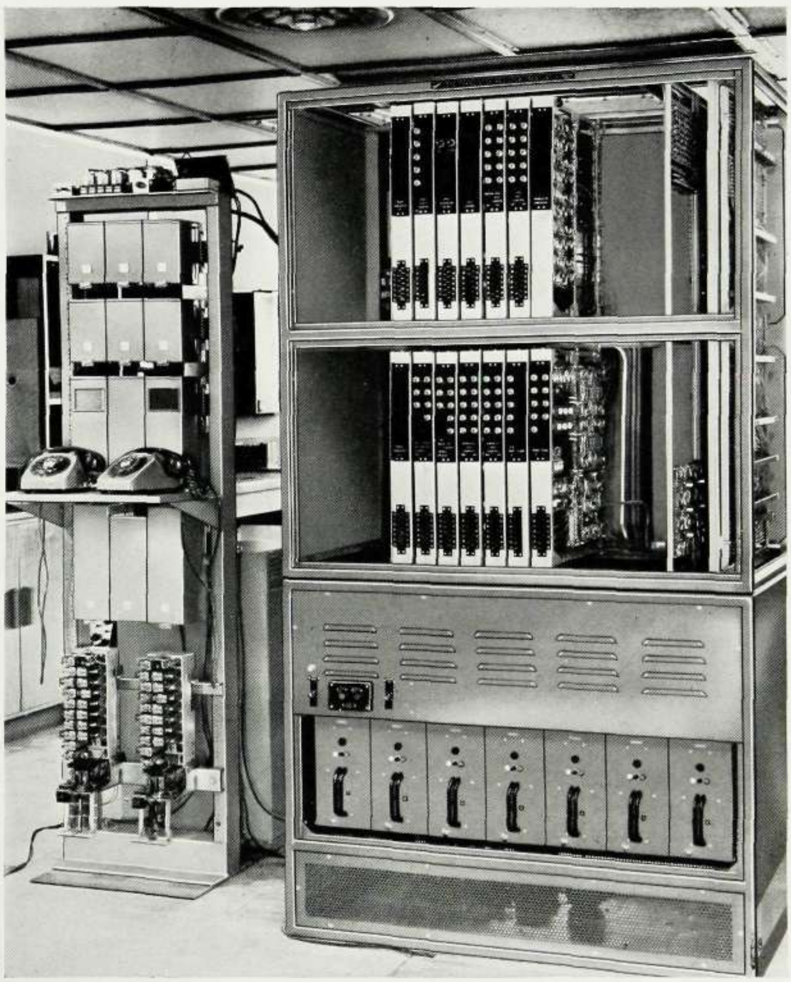


Fig. 8—Front View of Electronic Director

unit. Arrangements are incorporated to guard against premature reseizure of the access unit.

Forced Release is effected if the register is held for more than 30—60 seconds from seizure. The output of the Forced Release Counter is arranged to operate the forced release relay in the access unit. An external clock pulse occurring every 30 seconds is used for time-out and a further clock pulse occurring every second is necessary so that the + and — loop may be opened for one second before earth is connected to the FR wire in the access unit.

The Pulse-Out, Release and Forced Release signals are common to all access units (see Fig. 2). The association of one particular access unit with a register is achieved by and-gating via square-loop cores the scan pulse Ro($_r$) with the appropriate one of the above signals.

Construction

An experimental model of the electronic director is shown in Fig. 8. This is a front view with the covers of the top cubicle removed.

The director, with the exception of the access units, is mounted in the top cubicle. The In and Out Computers, Main Sequencing Matrix and Pulse Generator are mounted on swinging frames. All circuits are wired in and no plugs or sockets have been used. Maintenance is carried out *in situ*, test switches and monitor points being provided on the front of the frames. The power consumption of this upper cubicle is about 80 watts.

The power supply units are contained within the lower cubicle and receive their input from batteries.

On the left-hand side of the director is a rack which for demonstration purposes contains two handsets with associated first code selectors, A-digit hunters, access units and display units. Also mounted on the rack is an electro-mechanical routiner which operates into the director via four access units.

Fig. 9 is a view of the right-hand side of the upper cubicle showing the translation field fully wired for a typical London Director Exchange.

Fig. 10 is a rear view of the upper cubicle. In the centre may be seen the data store (or registers) which in a fully equipped 100 register scheme would contain 10,000 cores arranged as four planes of 50 x 50 cores. The experimental model has been equipped with 10 registers which is sufficient for trial purposes. The connections from the backs of the swinging frames to the store can be seen, and on the left is shown the rear view of the decoders M1 and M2 together with the cable form connecting the outputs of M2 to the translation field.

Tests

After a brief trial period in our laboratories, which established that the experimental director was

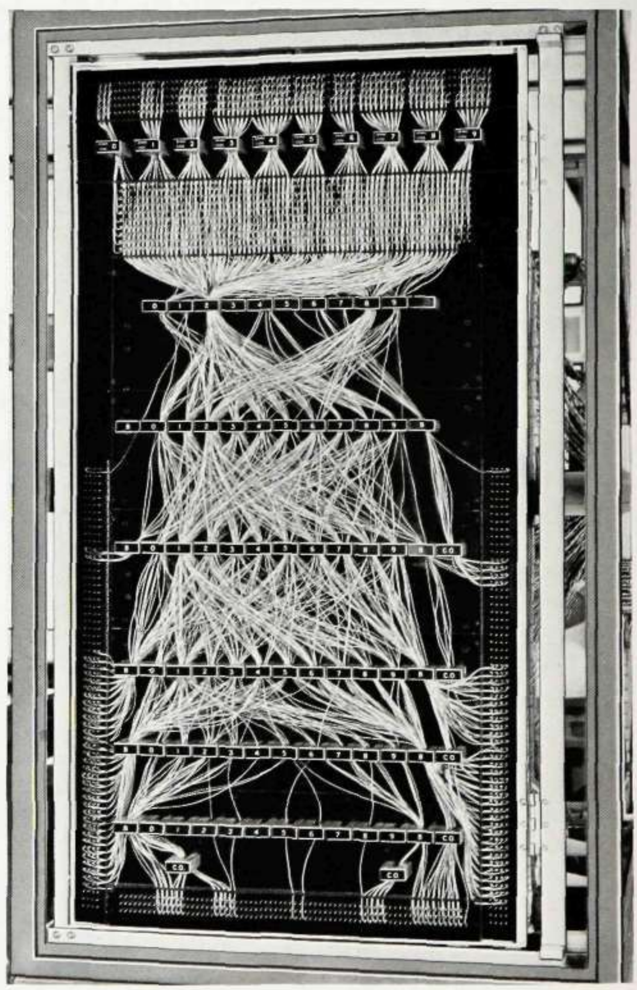


Fig. 9—View of Electronic Director showing Translation Field at the side of the Top Cubicle

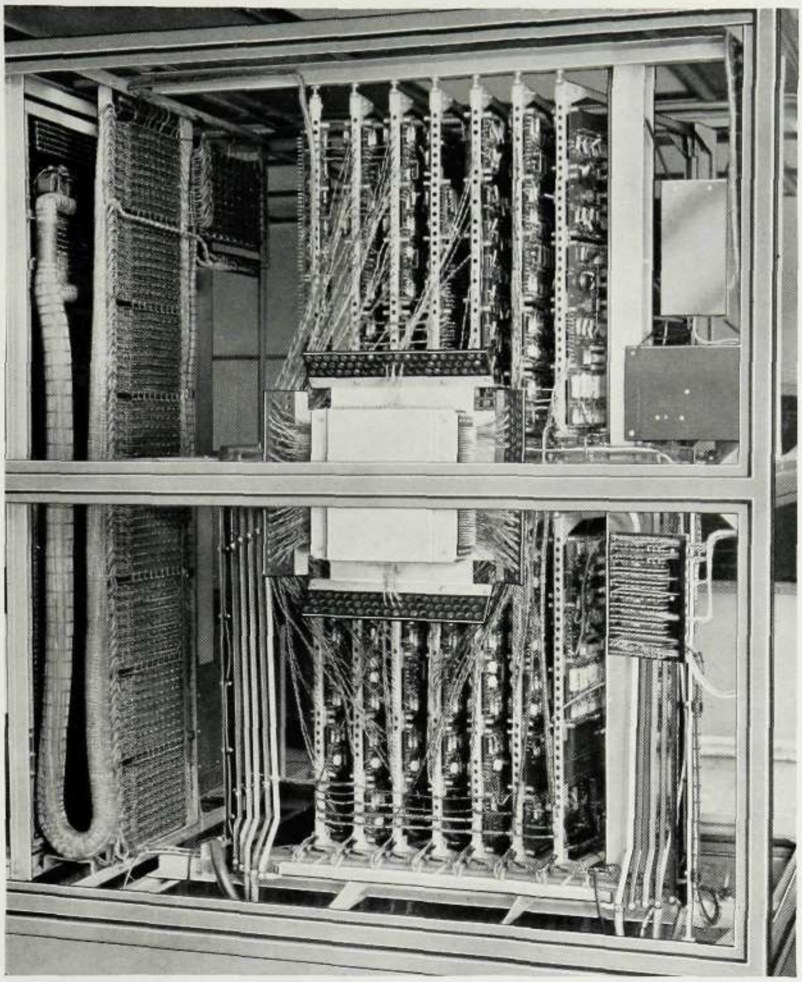


Fig. 10—Rear View of the Top Cubicle of the Electronic Director

operating correctly, the equipment was sent to the Post Office T.P.D. branch electronics laboratory for further tests. Installation proved to be very straightforward; the director was functioning within 24 hours of its arrival, and the fact that no faults had developed during transit gives some indication that the method of construction is satisfactory for this type of equipment. In particular, it is considered that no doubts need be entertained as to the robustness of the square-loop cores and their windings and terminations.

Tests in the Post Office laboratories have been in progress since August 1960. It has been established that the temperature rise in the equipment is less than 5°C in the upper cubicle; the design is such that the internal air temperature can reach at least 45°C before any danger of misoperation arises. The fault rate over the period of the test has been very low; only one component failure (of a miniature electrolytic capacitor) has been reported, and no design faults or logical failures have occurred. Tests of operation have been made in the presence of severe pulse interference such as is experienced in the vicinity of electro-mechanical switching equipment, and the results have been satisfactory. A trial on public traffic in a London exchange has now been arranged.

CONCLUSION

Experience with the electronic director acquired so far indicates that, while offering all the facilities of the existing electromechanical equipment, it will exhibit a very low fault rate and so require little maintenance. Its design gives expectation of a long life, and power consumption and space occupied are substantially reduced as compared with the directors now in use. The form of the translation field is such that translations can be easily and quickly changed, and it is known that facilities such as acceptance of voice-frequency keysending and ability to operate with multi-frequency signalling can be readily added. Estimates of cost indicate that the equipment will probably be economically attractive.

ACKNOWLEDGEMENT

The author wishes to acknowledge the work of his associates in the sections of the Electronic Switching Division in which the electronic director was developed, and in particular the major contributions of Mr. G. A. Matthews.

U.K. Patent Applications:— 23358/57, 40396/58, 17808/59, 1660/60, 5563/60, 15857/60, 15859/60, 18205/60, 28594/60.

U.D.C.621.394.34

Architect's illustration of the Fleet Building, Farringdon Street, London, E.C.4

FLEET EXCHANGE AND THE TELEX SERVICE

FLEET Exchange, the largest automatic telex exchange in the world, was inaugurated on the 12th December 1960 by the Postmaster-General, the Rt. Hon. Reginald Bevins, M.P., in the new Fleet Building, London. Its opening completes the B.P.O. programme for the conversion of Britain's inland telex service to automatic working, thus permitting all telex calls between subscribers to be established without the aid of a manual switchboard operator.

Designed by the Post Office, and manufactured and installed by the Company, the exchange is the last of twenty to be introduced throughout the country. Apart from its size, it differs from all other exchanges in the network, having been designed to contribute not only to the inland service, but to serve as a centre for internationally-routed traffic. Because this traffic amounts to more than half the entire volume of paid traffic in this country, the Fleet Exchange is a particularly important unit in the telex system.

International calls addressed to countries possessing automatic telex systems will be completed by fully automatic procedure. This type of service will be introduced in relation with West Germany, Belgium, Austria, Switzerland, the Netherlands, Norway, Denmark, France and Sweden in May this year, and will be extended to further countries. Fleet exchange will not, however, be fully self-contained until 1962/3, when an international cordless switchboard will be installed to handle the small amount of traffic to those European countries still operating manual systems.

At present, more than half of the 6,700 telex subscribers in this country are dispersed throughout London and the Home Counties and served by the Fleet Exchange. The exchange, occupying two stories of the Fleet Building, has an installed capacity for 5,000 subscribers' lines and is designed to accommodate a maximum of 15,000 lines. Equipment quantities include a total of 331 equipment racks and some 10,000 jack-in items.

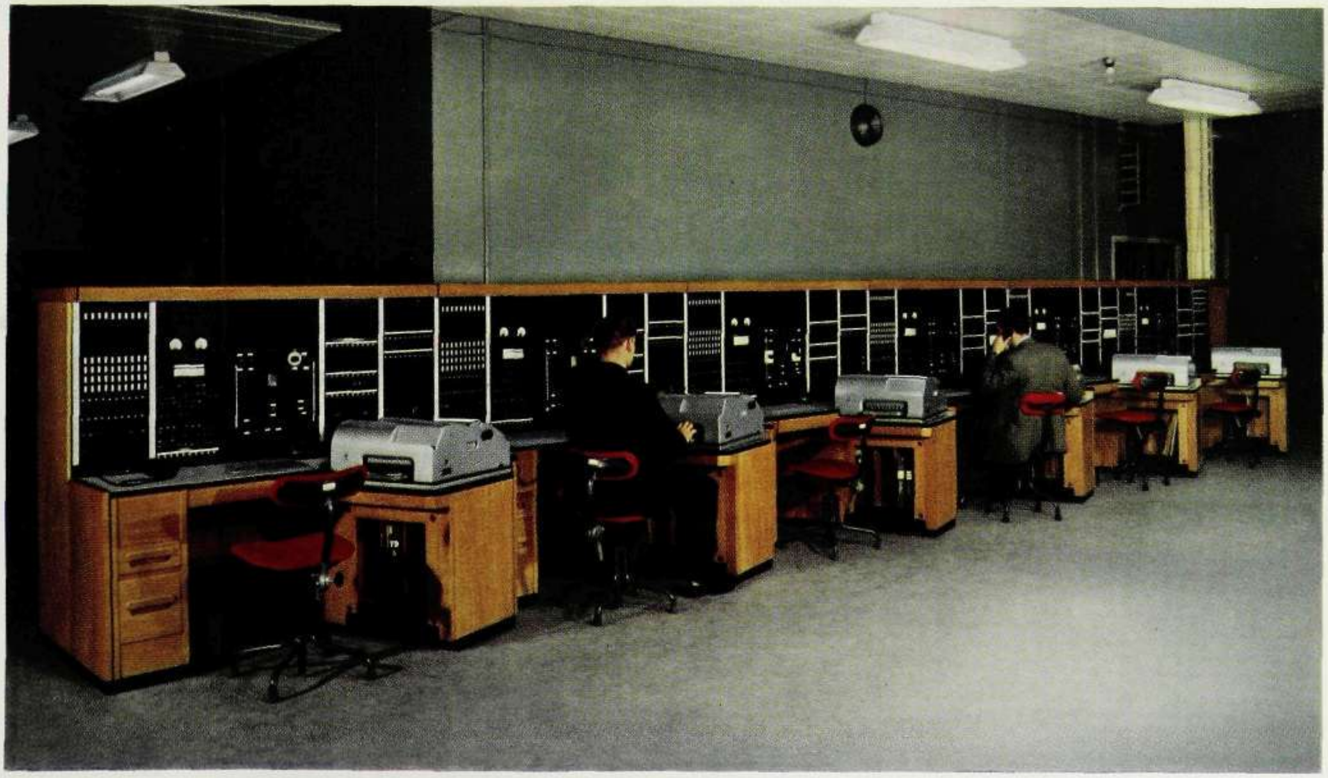
As may be seen in the coloured illustrations of the Fleet telex exchange, a notable feature of the equipment is the new colour scheme adopted for standard use in telex exchanges. The cream colour finish, used for both the exchange equipment and cabling, enhances the appearance of the equipment; with associated fluorescent rack lighting, a pleasing and airy atmosphere is created and maximum acuity of light provided.

A 15-position test desk provides accommodation for the maintenance control and trunk test and includes six positions for international circuits. Each position is equipped with a teleprinter for use in testing and communicating over the telegraph network. Telephone facilities are also provided. The suite, finished in medium oak, is housed in an imposing switchroom.

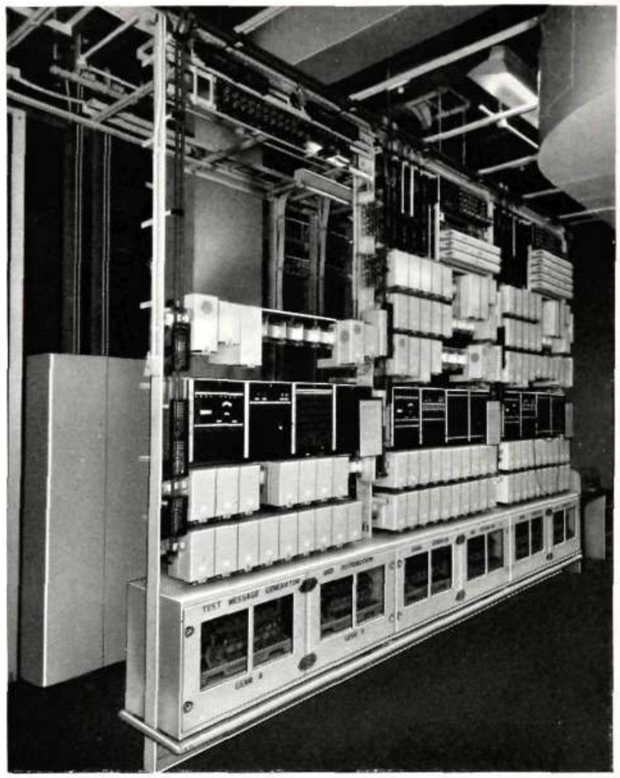
Because of the increasing demand for telex service and the rapid progress made in this field by continental countries, it was essential that the Fleet exchange, on which the introduction of the whole automatic system depended, be brought into service as quickly as possible. The fact that the scheduled ready-for-service date was not only met, but improved, despite difficulties encountered through concurrent building operations, reflects great credit on all concerned.

Owing to the complexity of the project, transfer operations were completed in three stages extending over a period of four weeks. The first stage (12th November 1960), involved the transfer of certain international dialling-in circuits and also approximately 900 subscribers previously served by a field-trial exchange at Shoreditch, London. The transfer of subscribers in the Home Counties was successfully accomplished on 3rd December 1960, and all remaining London subscribers seven days later.

Test Desk (International Suite)



Service Signal Generating Equipment Racks



Below: **Teleprinter and Dialling Unit as installed in subscribers' premises**

System Outline

The Fleet Building exchange, as all others in the network, uses electromechanical switching principles similar to those employed in an automatic telephone exchange. The telex system is, however, completely separate from the telephone cable network, although full use is made of the telephone network for routing telex circuits. Multi-channel voice-frequency telegraph systems, which enable up to 24 telegraph channels to be provided on one circuit are used for inter-exchange trunk connections and for subscribers' long lines.

Calls to any subscriber on the internal system are, in general, established by dialling the directory number of the wanted subscriber, although in certain cases the dialling of an additional digit is necessary.

For international calls, the called subscriber's number will be preceded by either a 3 or 4-digit code.

Connection to the called subscriber is indicated by the answer-back code of the wanted subscriber being printed by the calling teleprinter. The answer-back code is usually an abbreviated name of the firm or business concerned, including its location. The message transmitted by either party is recorded on both machines. Frequently, however, the caller transmits his message without requiring any co-operation in the called office, since the system is designed to permit the reception of messages in offices which may be temporarily understaffed. This facility is of considerable importance to users within the inland network and of particular worth in business relations between Britain and a foreign country distant from each other in time.

To cater for busy or similar conditions which may sometimes make it impossible to complete a particular connection, short-code service signal texts, agreed internationally, are printed by the calling teleprinter to indicate why the called subscriber cannot be connected. After the printed indication, the connection is automatically released.

Call Rates

The charges for calls are based on a metering system similar to that used in the telephone trunk dialling system. For inland telex calls, there are four rates giving 60, 30, 20 or 15 seconds for 2d., according to the distance. For charging purposes, the distances are measured from a selected point in each of the fifty or so charging areas into which the country is divided.

Call charges for dialled international calls will be bulked with charges for inland calls, each country dialled having a particular and uniform tariff rate.

Subscriber's Station Equipment

A typical subscriber's installation, comprising a page teleprinter and dialling unit is illustrated. The dialling unit, of B.P.O. design and Company manufacture, contains relays and other equipment required for the transmission of signals and dialling pulses between the subscriber's set and the exchange. Supplementary printer devices can be used for the preparation and automatic transmission of perforated tapes. Meters can also be included to record the sum total of the units charged and the charge for the last call made.

Conclusion

The flexibility brought to the telex service by the Fleet Exchange will, undoubtedly, prove attractive to many progressive business concerns. The system offers a swift and expedient means of long-distance telecommunication and possesses the advantage over the telephone in so far as it allows communication to proceed even in the absence of an operator at the receiving station and provides a record of all messages sent and received.

Acknowledgement

Acknowledgement is due to the Post Office for permission to publish the article and for kindly providing the photograph of the Fleet Building.

The teleprinters shown in the photographs were manufactured by Messrs. Creed & Co. Ltd., Croydon, England.

General View in one of the Apparatus Rooms

U.D.C.621.395.342.21

RURAX IN THE SUDAN

A. Foster — Circuit Development Engineering Department

The Gezira cotton-growing area of the Sudan accounts for nearly half the nation's income. Because of the extreme importance of this product to the country's economy, development is rapidly going ahead to double the area under cultivation.

A speedy and efficient telephone system is essential to such an area where the continuing development plays such an important part in providing a better livelihood for millions of people.

The conditions of isolation of the plantations and sparsely populated areas, which make a reliable telephone system so important, also add to the difficulties of providing an efficient and economic service.

Rurax equipment, with its flexibility, proven reliability and complete range of facilities, has been chosen to fulfil these requirements.

THE area of land contained by the Blue and White Niles as they draw together to meet at Khartoum is known to the Sudanese as El Gezira, meaning The Island. This used to be an ironic title, for less than 40 years ago it was more or less an extension to the neighbouring Sahara desert. There were no palm trees, foliage, or vegetation of any description. Today, El Gezira, far from being an ironic title, is a symbol of intelligent development and creative engineering. It has been transformed from an 'island' to a vast sea of cotton.

Many famous people have been associated with the development of the Gezira, but it was Sir William Garston who first saw its possibilities as a land of promise. He suggested that if only a dam could be thrown across the Blue Nile somewhere near Sennar, enough water could be trapped to nourish this barren land and make it into a fertile plain.

Before any work of this nature, involving millions of pounds, could proceed, experiments were carried out by a small company, formed in London, called the Sudan Experimental Plantations Syndicate. These experiments were undertaken on the banks of the Nile and were concerned chiefly with mixed farming and a small area devoted to cotton. These experiments failed and hopes began to fade. However, the syndicate in London was reorganized and the experiments were altered to the production of different strains of Egyptian cotton. Yields proved so encouraging that sufficient confidence was felt to continue with the proposed Gezira plan.

Although plans were completed for a dam to be built some 60 miles south of Sennar, the 1914-18 war intervened, and it was not until after the war that the British and Sudanese combined to put this great project into being. It took eight years to build and cost nine million pounds. One huge canal, 60 miles long, was cut through the land to carry water outwards from the dam and then a great spiderweb of minor channels from the main artery completed the work.

The opening of the dam made possible a cotton growing area of 500,000 acres. To-day, with additional canals, there are one million acres under cultivation.

The Gezira is a success and one of the chief reasons is that type of crops, agricultural methods and organization, were fully tested before they were brought into the scheme proper.

Planning the Network

With the continuing development and modernization of the area it became apparent that the existing manually operated telephone system would also require modernization.

Such a system can only give a reasonable service for 24 hours a day by employing four or five skilled operators to staff each exchange. This is uneconomic, particularly on these small exchanges. If economies are made at the use of part-time operators, the consequent inefficient operation and restricted hours impose definite limitations on the utility of such a system. Moreover, the manual system does not provide the secrecy so highly valued in these small communities. Because the service offered is not sufficiently attractive to secure the maximum number of subscribers, the full sources of possible revenue are not drawn upon.

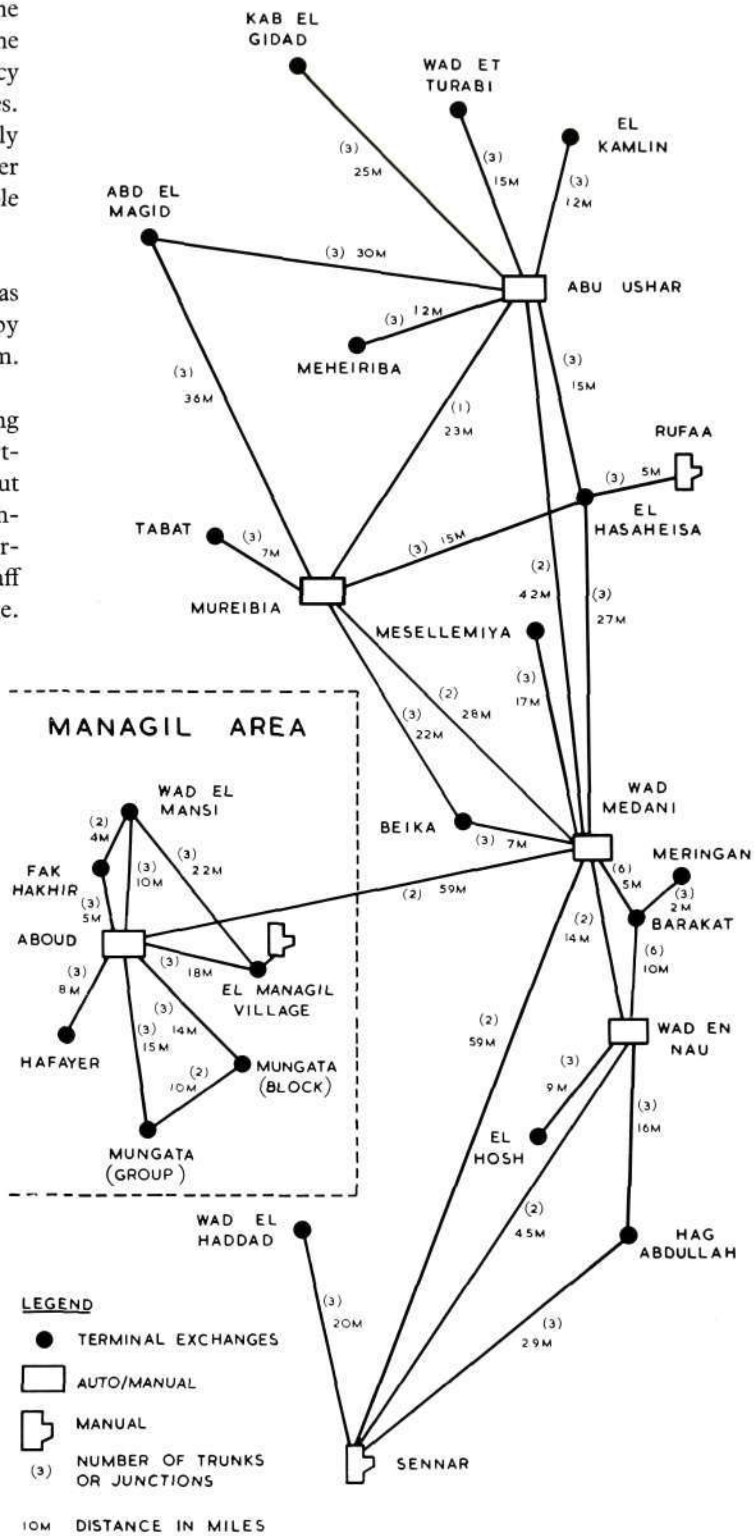
From an economic point of view, here was an area which could benefit enormously by the automatization of the telephone system.

Various types of automatic switching equipment are employed by the Department for their larger main exchanges, but the nature and amount of equipment involved make it necessary to have air-conditioned buildings and a permanent staff of maintenance engineers at each exchange.

These conditions would not be applicable to the Gezira, as the exchanges required here would be small, many of them initially serving 50 lines or less, and it would not be economic to air condition the buildings or provide maintenance staff at each exchange. The automatic equipment must therefore be extremely reliable and, because of the scarcity of capable technicians, straight-forward and simple in operation. It would also have to meet the severe demands imposed by nature in the form of high tropical temperatures and, in this particular part of the Sudan, severe dust storms.

The Sudan P. & T. Department's engineers were attracted by the switching methods, facilities and general construction of Rurax equipment but, like the civil engineers of earlier years, they did not intend going ahead with a scheme of this nature without ensuring that the equipment would meet all the requirements demanded of it.

A 50-line Rurax exchange was therefore provided for them to carry out field trials, and this exchange was



Trunk and Junction Network of the Gezira and Managil Areas

installed some four years ago at Jebel Aulia, the location of the only dam across the White Nile. It was located in a non-air-conditioned building as a test for future exchanges in the proposed network.

Planning of the Gezira network proceeded and, meanwhile, the exchange at Jebel Aulia continued to give excellent service despite the conditions to which it was exposed.

After a period of some 18 months, the full requirements for the network had been ascertained and the proved suitability of Rurax equipment was instrumental in obtaining the contract for this Company.

Illustrated are the initial installations for the Gezira, together with a further network since ordered for the Managil area. This latter area represents the first stage of a five-stage development plan, intended to double the total area of land under cultivation within the next few years.

As most of the line routes follow the canals, the illustration also gives some idea of the canalization system on which most of the exchanges are sited.

It will be seen that, at present, the network comprises some 20 Rurax terminal exchanges and 4 Rurax Auto-manual exchanges. These latter exchanges located at Abu Usher, Mureibia, Wad En Nau and Aboud have sleeve-control type manual boards and, in addition to providing auto service for local subscribers, act as trunk switching centres. This flexibility of Rurax equipment is shown in this network. It allows a high degree of standardization within the network which is clearly advantageous from the point of view of spares and maintenance, etc.

The Rurax Exchanges

Although articles on Rurax equipment have appeared in previous Bulletins, it is perhaps opportune at this stage to summarize the features which made this equipment particularly suitable for an application of this kind.

Construction is on the self-contained unit principle, the basic equipment being a 50-line unit. All units are enclosed in metal cabinets, sealed against dust. The wiring is insulated with p.v.c. and the equipment is fully tropicalized.

A special feature of the exchange is its adaptability. Equipment installed initially to serve 50 lines or less can be extended easily by stages to serve a normal maximum of 350 lines, or more than this number if necessary.

Experience has shown that a large percentage of faults in an automatic switching system is of a mechanical nature. For this reason, Rurax has been designed to use only uniselectors and relays for switching purposes.

The uniselectors employed are the British Post Office No. 2 type. These are heavy-duty uniselectors and are of a very rugged construction, designed to give a life up to about 100 million steps. Besides being probably the most reliable of all forms of electro-mechanical switch, they are designed with the minimum number of adjustments and are easy to maintain.

Rurax, therefore, has an obvious advantage over other systems using more complicated switching mechanisms, and this advantage has been achieved without forgoing the step-by-step principle of switching, which results in a more straightforward and easier-to-maintain system than others using registers, by-paths or common control equipment. A linefinder system is employed. On the 50-line exchanges the linefinders are connected directly to the connectors (final selectors). In such exchanges the connectors are arranged to absorb the first digit when a local subscriber's number is dialled and to switch the call to junction hunter switches if the first digit dialled indicates that a junction or special service is required. When an exchange extends beyond 50 lines, single-motion group selectors, mounted in separate units, are interposed between the linefinders and connectors. The absorbing feature is strapped out on the connectors and thus the introduction of group selectors does not affect the numbering of the original subscribers. As the junctions can be reached from the required level of the group selectors, junction-hunter switches are not required.

Facilities

The exchanges incorporate all the facilities essential to the provision of an efficient service requiring the minimum of attention.

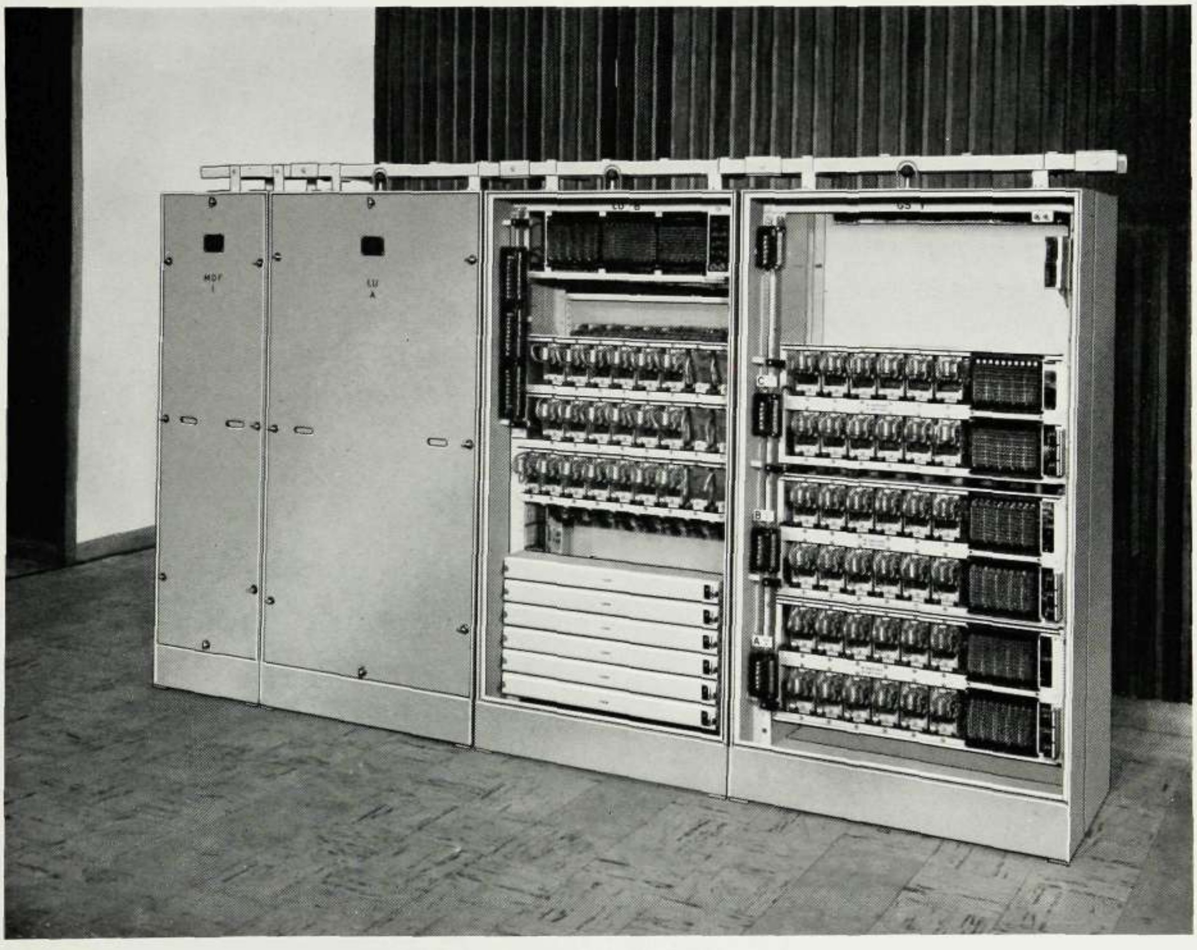
To guard against unnecessary engagement of a connecting link, a forced release condition is incorporated in the group selectors and connectors. This facility causes the link to be disconnected after a predetermined length of time if any of the following conditions persist: (a) earth fault or permanent loop on a line, (b) subscriber fails to dial after lifting handset, (c) subscriber fails to replace his handset at the end of a call. Under such conditions the associated line circuit is locked out of service and presents an engaged condition to incoming calls. This feature ensures that external line faults, etc., do not cause a degradation of service.

Any alarm condition arising at the exchange, immediately causes a junction to be automatically taken into use to transmit a calling signal to the parent exchange, where the operator receives a distinctive tone signal indicating the nature of the fault. The junction is released for normal use when the operator removes the answer plug.

A trunk-offering facility is incorporated to allow the parent exchange operator to break into an existing conversation on the Rurax and offer an important call to an engaged subscriber. If the call is accepted, both subscribers are requested to replace their handsets and the required subscriber is automatically re-rung and the connection completed.

On this particular network, certain subscribers are not allowed to have long distance calls extended via the manual board. The dialling of local calls is permitted, but discrimination between these subscribers and ordinary subscribers is made by means of a short burst of tone when the operator answers a call originated by a restricted subscriber.

The trunk and junction lines between exchanges usually comprise one or two physical pairs, any additional circuits being provided by the use of carrier channels. Jack wiring for the trunk and junction circuits is therefore arranged to permit either physical or carrier-type circuits to be jacked into any position.



View of a Typical 100-Line Rurax with doors removed from Line Unit 'B' and Group Selector Unit

In the rural areas of the Sudan, local calls are not metered, subscribers being charged on a flat rate basis. Because of this, multi-party line working (i.e., more than two parties on a line) can be employed without the complication of selective metering equipment.

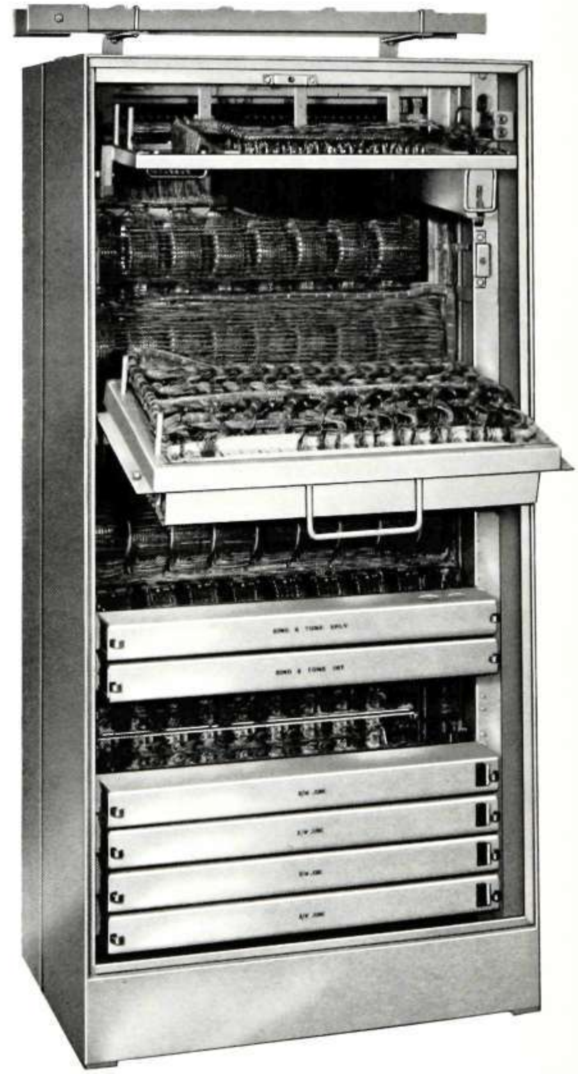
Party line working can be an important factor in contributing to the growth of telephone services in sparsely populated areas. Multi-party lines make service economically feasible for the greatest number of people by reducing appreciably the outside and inside plant cost per subscriber. These economies become obvious when it is seen that a single pair of conductors may be extended several miles and then be connected to a maximum of 10 subscribers' telephones. Such a line is terminated at the Rurax on a single set of line equipment through a single set of protective facilities.

In the Gezira, this facility is particularly useful for serving the canal control points where, in many cases, up to four telephones are connected to one pair of wires running along the canal route.

Whilst providing a marked saving in equipment, party line working does raise the problem of providing some means of party selection so that a particular subscriber in a group of subscribers can be informed of an incoming call. It is necessary to provide also a means of establishing a connection between one party line subscriber and another subscriber on the same line. These facilities are an integral part of the system and have been incorporated in the design of the connector circuit to enable any line to be used as a party line without the need for any additional equipment.

There are several ringing schemes available for selecting the required party on a line, the most economical and reliable being the code-ringing system used for this network. Some of the subscribers were already familiar with this system as it has been employed on the old manual exchanges, although perhaps operator errors and lack of dexterity may have caused some confusion at times. Selection of the required party on a line adds an extra digit to the numbering scheme outlined earlier, thus giving each exchange a 4-digit numbering scheme. As explained previously, on a 50-line exchange the first digit dialled is absorbed in the connector and, in an exchange exceeding 50 lines, this digit serves to route the call to the required 50-line group. The second and third digits position the connector on the required line, whilst the fourth and last digit selects the appropriate ringing code of the called party.

The exchanges use a divided code-ringing system requiring five different signals for a 10-party line. The party-line subscribers' telephone bells are connected between one line and earth. On a two-party line, one bell is connected to each line, and on a ten-party line, five bells are connected to each line. Codes 1 to 5 cause the ringing signal to be sent out on one line, whilst codes 6 to 0 cause the same ringing signals to be switched to the other line. Thus, a two-party line would have last digits of 1 and 6 and only the bell of the required subscriber would be rung.



Rear View of 50-Line Unit with doors removed and hinged gate open

Revertive calls (i.e., calls between subscribers on the same party line) are made by the calling party dialling the directory number of the required subscriber.

The caller receives the busy tone signal, since he has, in effect, dialled his own line, but when the handset is replaced, arrangements are made in the connector to hold the connection and transmit the called subscriber's ringing code. Should the calling subscriber's bell be connected to the same line as the called subscriber, he will also receive this ringing signal. If the bells of the called and calling subscribers' telephones are on opposite lines, a special revertive ringing signal is passed back to the calling subscriber. This signal is essential to enable the calling party to determine when the call has been answered. Connection is completed upon the calling party lifting the handset.

THE TRUNK NETWORK

It has been shown that automatic switching improves the service and enables economies to be made in the cost of handling traffic in a local network. By its adoption time is saved and the number of operators reduced. In the Gezira, for example, the installation of eighteen Rurax exchanges will replace the services of eighty operators.

Whilst a fully automatic trunk network would dispense with the need for operator control and is the ultimate aim of all Administrations, the cost and complications involved in its provision would be very considerable. An operator trunk dialling scheme permitting phased development towards this end has therefore been introduced. In this system, automanual exchanges have been provided with through-dialling facilities and sufficient direct trunk interconnections to allow any originating operator to dial any subscriber within the network. It can readily be seen that, at this stage of the development of the country's telecommunications system, it is the most economical and suitable means of establishing long distance calls.

The trunk lines and cables form a large percentage of the total cost of trunk switching. The presence of an operator at the originating end of a long-distance call produces a valuable smoothing effect upon the traffic. With a completely automatic scheme, originating traffic from subscribers is pure chance distribution, and such traffic, applied direct to a trunk line system, would require a more lavish provision of trunk lines to give the same quality of service.

On the later exchanges for the Managil, a degree of inter-exchange dialling has been introduced so that calls between adjacent exchanges do not have to employ the longer trunk lines via the parent exchange. For administrative purposes, the junction circuits employed on these routes are arranged to register automatically the number of calls on each circuit, the total occupancy time, and to limit any call to nine minutes duration. Suitable warning tones are provided to indicate when this time limit is approaching. The junction circuits are also arranged to prevent restricted subscribers using these routes.

Rurax exchanges are also employed in other parts of the Sudan. One 50-line exchange is in service at Gebeit, a small town situated on the railway line in the Red Sea Hills. Another 50-line exchange is situated at Zeidab, the location of one or two private cotton growing schemes. A third 150-line Rurax, which has been used for exhibition and demonstration purposes, is installed at Berber.

Since the war, great strides have been made in the telecommunications field, and automatic telephone equipment has been introduced in the main cities and towns of many underdeveloped areas. There is, however, a certain reluctance to introduce automatic switching to the rural and sparsely populated areas of these countries because of the doubts about both the economic and maintenance aspect.

The Sudan Posts and Telegraphs Department believed that with modern switching techniques these doubts were without foundation and, as a result, some of their small communities already have the benefit of the automatic telephone, whilst others, like the people of the Gezira and the Managil, are eagerly awaiting its introduction.

U.D.C.621.395.342.21

THE 'MINIRAX'

H. G. LAMBERT and M. V. DUNN, Bach. Eng. (India) — Circuit Development Engineering Department

A small telephone exchange has been developed for operation in rural areas where battery charging facilities are not available locally. It has capacity for twenty subscribers' lines, and three bothway junctions, which may be associated with physical or a combination of both physical and carrier circuits. The exchange is self-contained and the authors describe its facilities and construction, together with the arrangement for charging the local exchange battery over a physical junction.

THE Company's 'Rurax' (Rural Automatic Exchange) equipment meets a variety of particular requirements and adequately fulfils the demand for an efficient 24-hour telephone service in many of the remote areas of the world. A principal factor restricting the introduction of a similar service to the more sparsely populated and isolated rural fringe areas has been the problem of providing a suitable power source for exchange battery charging. In these areas a mains supply is often not available and to provide a locally-generated source would be uneconomic, bearing in mind that these communities are very small and widely dispersed, for example, on plantations, stations or farms.

A satisfactory solution to this problem has been obtained by the development of the Minirax, a small-capacity exchange, complete in every detail and requiring no particular site accommodation or local mains supply for its successful operation. By its use, the needs of small and isolated groups are served with the same efficiency as are the needs of Rurax subscribers.

As its name suggests, the Minirax is a miniature rural automatic exchange. It is designed for unattended operation and primarily for use as a small dependent exchange serving twenty subscribers. The exchange provides fully automatic local service and direct bothway working over three junctions to a parent exchange—manual, auto-manual or automatic. Junctions may be physical or a combination of both physical and carrier.

Power is derived from a 24-volt 8 a.h. local battery, trickle charged over a physical junction terminated at the parent exchange. Full use is made of the junction for traffic purposes as charging is only operative when the junction is free from calls.

Special attention has been directed to the provision of equipment with low power consumption and minimum maintenance requirements, thus ensuring trouble-free service in areas where regular visits by skilled personnel are often impracticable.

NUMBERING AND TRUNKING

A 2-digit numbering scheme (20 to 39) is used for local subscribers' lines. Access to the parent exchange is gained by dialling a single digit (9).

In the trunking arrangement shown in Fig. 1, twenty subscribers are connected to an equal number of line circuits. Each of the four connecting links provided, consists essentially of two single-motion selectors of similar type, one being a 25-point linefinder and the other a 25-point connector switch, arranged to function as a combined group and final selector. Subscribers' line circuits and junctions are terminated on the linefinder bank contacts and multipled to corresponding bank contacts of the connector switch.

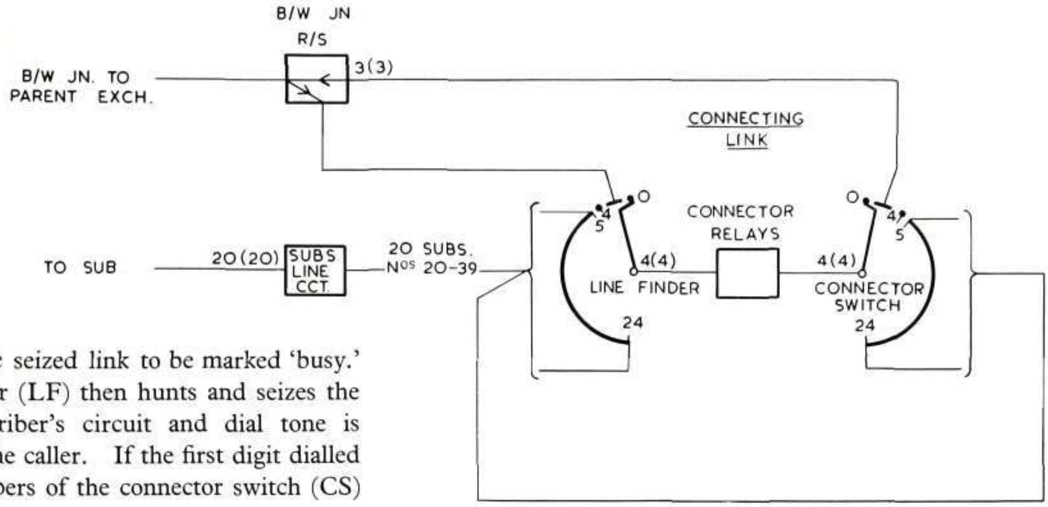
Although a connecting link is normally associated with both local and junction traffic, a particular link can be restricted, by simple adjustment of strapping, to incoming junction calls only. This allows access to the Minirax should all other connecting links be engaged by local subscribers.

OPERATION OF CONNECTING LINK (Fig. 2)

Local Calls

When a caller lifts the handset to initiate a call, the LR relay operates and an earth is applied to all connecting links. A free link is seized and the 'start' earth extended to operate the associated SC relay

Fig. 1—Basic Trunking Diagram



and cause the seized link to be marked 'busy.' The linefinder (LF) then hunts and seizes the calling subscriber's circuit and dial tone is returned to the caller. If the first digit dialled is '2', the wipers of the connector switch (CS)

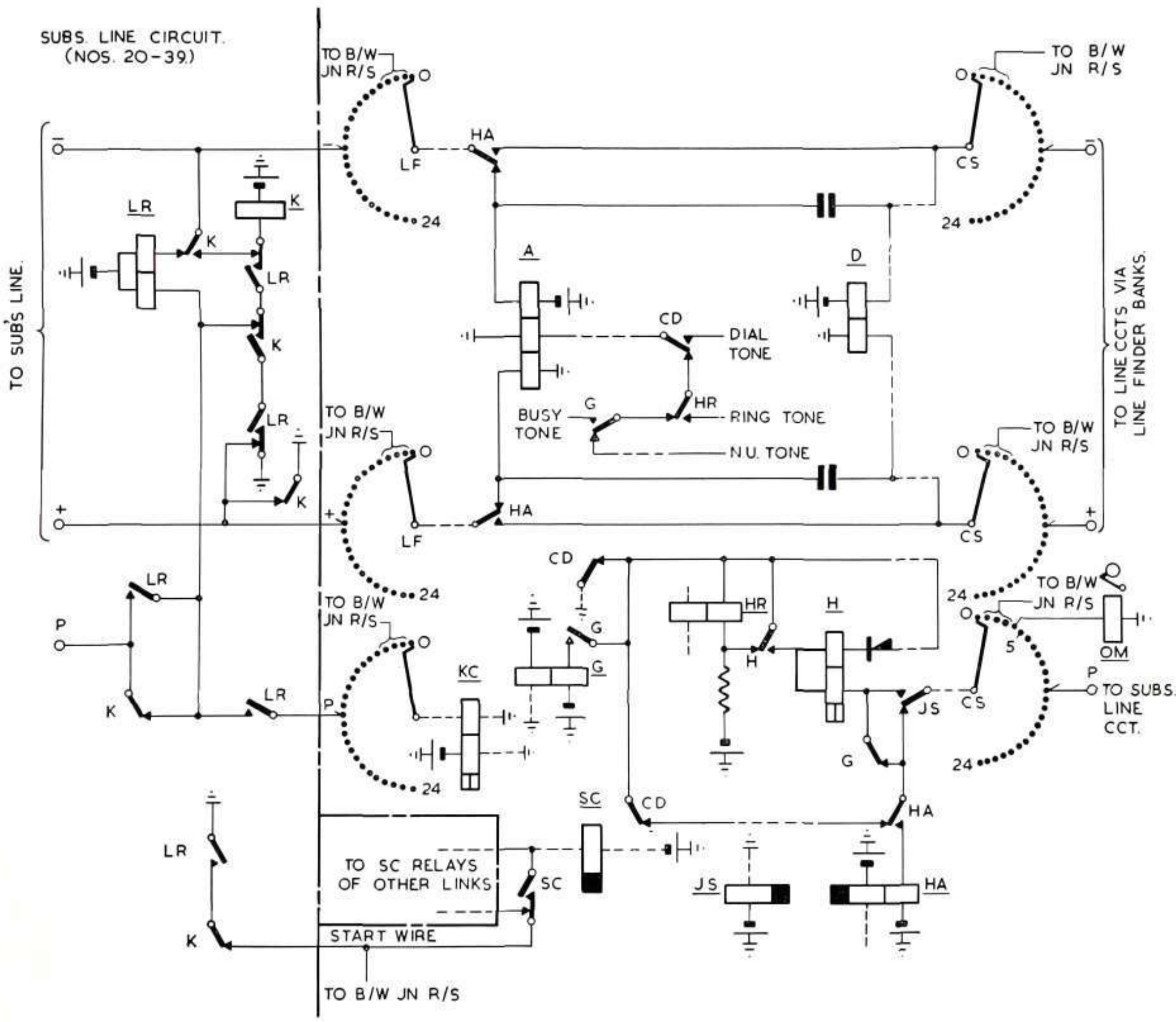


Fig. 2—Simplified Diagram of Connecting Link

step to contact '2', and, subsequently, self-drive to contact '4'. Similarly, upon the dialling of digit '3', the wipers take a corresponding number of steps and then self-drive to contact '14'.

At this stage the connector switch is again under control of the subscriber's dial. Following the dialling of the second digit, therefore, the connector-switch wipers are stepped to the wanted line and the conditions of the line tested.

Two relays test the P-wire of the called subscriber's line in turn, relay G testing in the operated condition followed by the high-speed relay H, released. If the called line is engaged, an earth is present on the P-wire and relay G remains operated, causing busy tone to be returned to the caller. Should the called subscriber number be spare, N.U. tone is returned, since the absence of earth potential on the P-wire causes the release of relay G, and relay H to remain unoperated.

When the called line is free, battery potential on the P-wire causes the release of relay G, and relays H and HR to operate. Interrupted ringing is then applied to the called line and ring tone received by the caller. Connection is established upon the called subscriber lifting the handset.

Incoming Junction Call

Operation is similar for an incoming junction call. A free link is seized via the junction relay set and the linefinder hunts for the calling junction line. When it is located, dial tone is returned and the connection completed as above.

Outgoing Junction Call

On the dialling of the appropriate single digit, the junction selector relay JS is operated and the connector hunts for a free junction. Immediately this is seized, relay H operates to battery potential on the junction P-wire and disconnects the drive circuit. Relay HA operates at this stage to extend the calling line to the parent exchange and also reduce current drain by releasing all other relays in the seized link.

In the event of all junctions being engaged when a junction call is originated, busy tone is returned to the caller.

Other Facilities

Metering

Metering, when required, takes place immediately a called subscriber answers. Local call metering is untimed. Provision is also made for unit-fee or fixed multi-fee metering of junction calls. When fixed multi-fee metering is used, the calling subscriber's meter is operated a determined number of times according to the fee charged for a call to a particular area. To meet an Administration's requirements, a simple relay device can be included to enable the fixed number of meter operations to be repeated at specified periods during a call.

A traffic overflow meter can also be provided to record occasions on which all junctions are found to be busy.

Coin-Box (Paystation) Lines

Any subscriber's line circuit can be arranged for coin-box working by appropriate terminal strapping. When a call is made to the parent manual exchange, a short burst of tone is received by the operator to enable her to discriminate between the coin-box call and a call originated by an ordinary subscriber.

If the parent exchange is auto-manual, a coin-box subscriber can be barred from dialling all junction calls other than '90' for the operator or '999' emergency.

Forced Release

An essential feature of the unattended exchange is the forced release facility. It ensures that should a subscriber fail to dial within a specified period or fail to replace the handset on completion of a call, the common switching equipment is released for use by other subscribers. Forced release is also applied to prevent a connecting link being held for an unnecessarily long period by an earth or permanent loop fault on the line.

Local Line Limits and Short Line Facility

Satisfactory operation is possible over a subscriber's loop of 500 ohms, inclusive of telephone resistance. To avoid unnecessary drain of the exchange battery by subscriber's short lines, facilities are provided to enable suitable resistors to be inserted in each leg of the line.

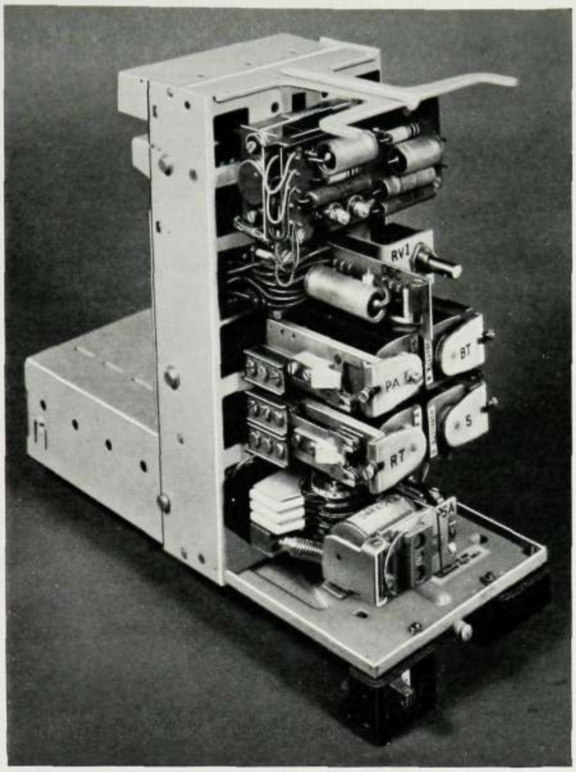


Fig. 3—General View of Ring and Tone Relay Set, showing top to bottom, transistor generators, control relays and miniature uniselector

ALARMS AND TESTING

The exchange will normally be unattended but it may be considered advisable to provide fault indication in an adjacent room or building. An alarm cabinet, containing three lamps, two keys and a buzzer, has been designed to meet such a requirement and can be provided as an optional extra.

The exchange can be tested for satisfactory working by the staff at the parent exchange on the dialling of a chosen number ('7'), known as the test number. Distinctive tones are returned to the caller to indicate either normal working or the nature of an existing urgent fault (i.e., ring fail, fuse alarm, P.G. or low volts).

EQUIPMENT

The automatic apparatus is housed in a floor-standing, pressed steel cabinet designed for attachment to a wall for stability (Fig. 4). Access is gained from the front by means of two dustproof doors fixed with quick-release fasteners.

The Minirax is wired for its total capacity to enable certain facilities not required initially to be easily added as required.

RINGING AND TONES SUPPLIES

Ringing and tones are derived from two transistor generators (Fig. 3) brought into use when a connecting link or junction relay set is seized. Both ringing and tones are interrupted by relays controlled by a miniature uniselector and pulsing circuit. The periodicity of the ringing generator is 25 c/s, and sufficient power is produced by the generator to satisfactorily operate up to six telephones arranged in parallel. The frequency of the tone generator is 400 c/s and both busy tone and N.U. tone are derived from this source; ringing tone is obtained by a combination of both generated frequencies.

Because of the proved reliability of transistors and the absence of any moving parts in either of the generator units, risk of failure is small and, hence, no standby or changeover arrangements are provided.

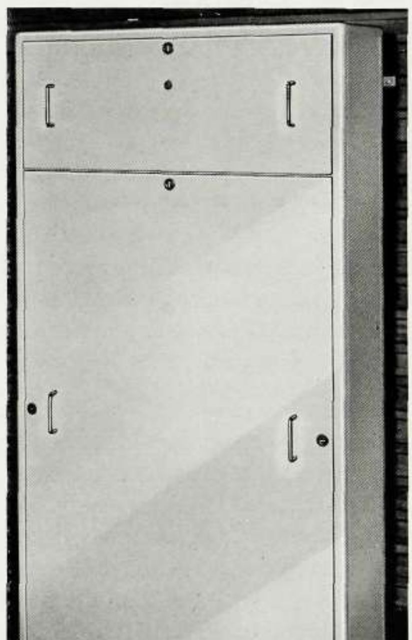


Fig. 4—General view of Minirax Unit

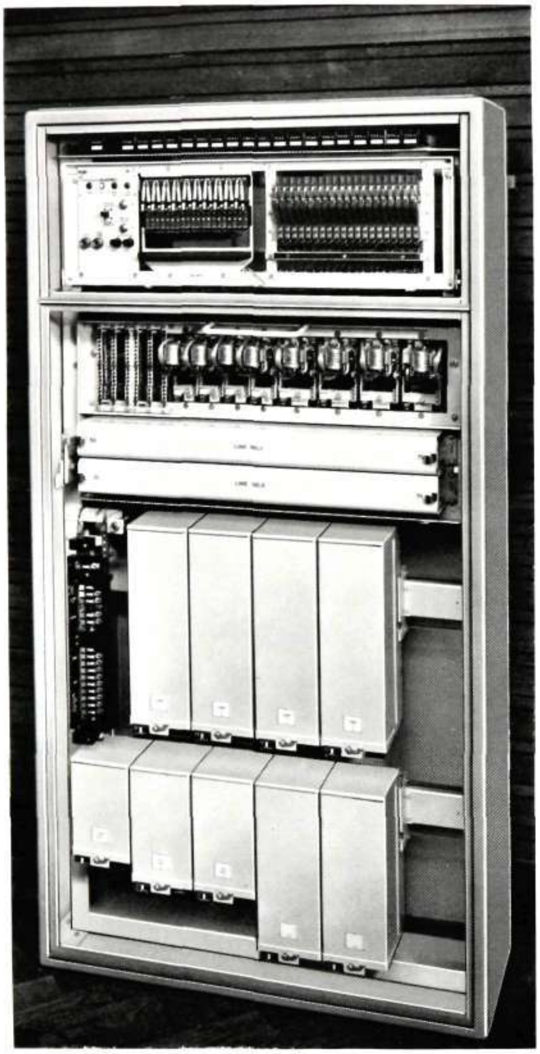


Fig. 5—Front view of unit with both doors removed

Apparatus of orthodox type and proved reliability is used throughout and includes heavy-duty B.P.O.-type uniselectors, relay sets and two types of relays: 3000 type and high-speed.

As may be seen from Figs. 5 and 6 the arrangement of the apparatus is compact and accessible. The upper compartment contains the alarm display panel (including low-voltage alarm regulator), line fuses, heat coils and arrestors, all mounted on a gate-type framework to provide convenient access to the carrier equipment, subscribers' cross-connecting field, and wiring points in the rear. Because all circuits requiring external connection are terminated in this compartment, the connection of incoming lines can be completed without interfering with or exposing the apparatus below.

In the lower compartment, mounted on a similar hinged-gate structure, are uniselectors and strip-mounted line circuits. Arranged on the left-hand side of the uniselectors are termination points to allow the insertion of 'short-line' resistors should subscribers' line conditions demand.

With the gate open, as shown, all associated wiring is revealed together with line-circuit resistors and the miscellaneous connection block.

All relay sets jack-in to the lower shelves, the first shelf accommodating equipment for connecting links and the second, apparatus for ringing and tone supplies, miscellaneous alarms and three junctions (one physical and two carrier).

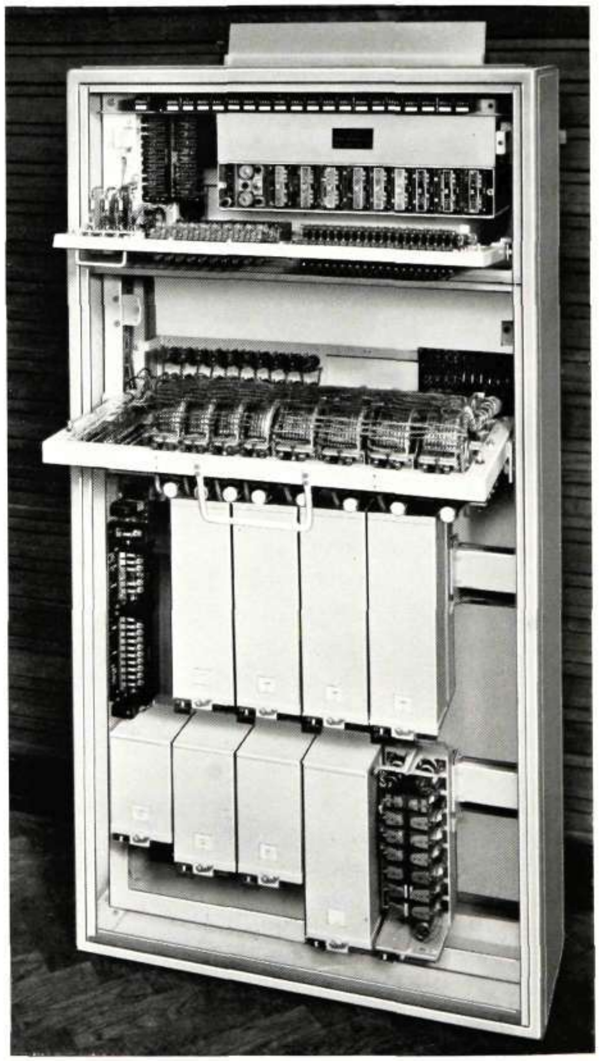
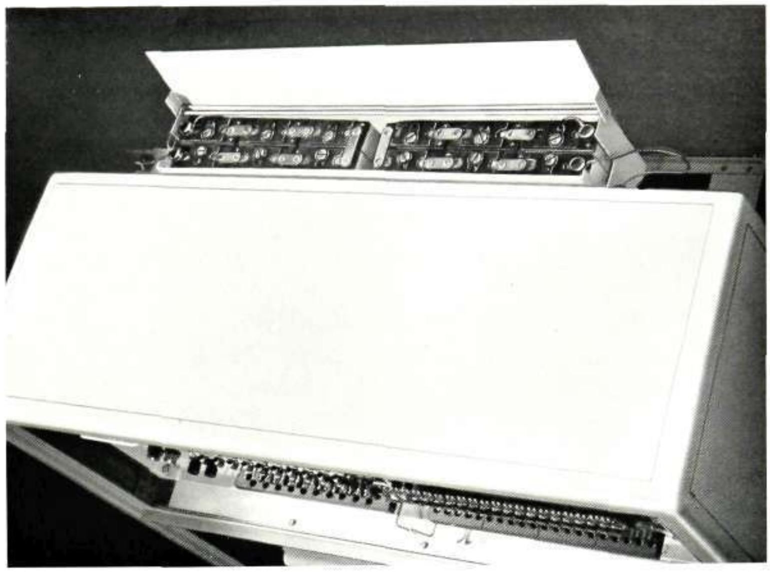


Fig. 6—Front view of Unit with gates open to expose wiring and rear equipment. At the top of the unit the battery box lid is shown raised

Fig. 7—Plan view of Unit showing the 24-volt 8 a.h. Battery in acid-resistant metal box freely positioned on mounting



The arrangement of the junction relay sets shown is typical, one physical junction being essentially provided to permit battery charging. The junction relay set shelf wiring, however, is arranged to permit the use of either physical or carrier circuits in any of the last two positions.

A novel feature of the Minirax is the provision made for battery accommodation (Fig. 7). The battery is enclosed in a sheet metal box, the dimensions of which are $4\frac{1}{2}$ in. (11.4 cm) high, 2 ft. 0 in. (61 cm) wide, and $4\frac{1}{2}$ in. (11.4 cm) deep from front to rear. The box has a special acid-resistant finish and is freely positioned in metal channelling supported by the exchange wall-fixing bracket. The hinged lid opens to the rear and, when closed, lies in the same plane as the top of the exchange cabinet. This method of battery mounting makes the Minirax completely self-contained, eliminates the need for cable leads to remote battery positions and allows the entire installation to be inspected from one point.

The unit occupies small space, its overall dimensions being 5 ft. 1 in. (155 cm) high, 2 ft. 9 in. (84 cm) wide, and 1 ft. $4\frac{1}{2}$ in. (42 cm) deep including depth of battery box.

The whole equipment has a high quality finish and is designed to withstand tropical conditions. The cabinet is enamelled externally opaline green, and inner surfaces are finished cream to provide maximum reflection of light.

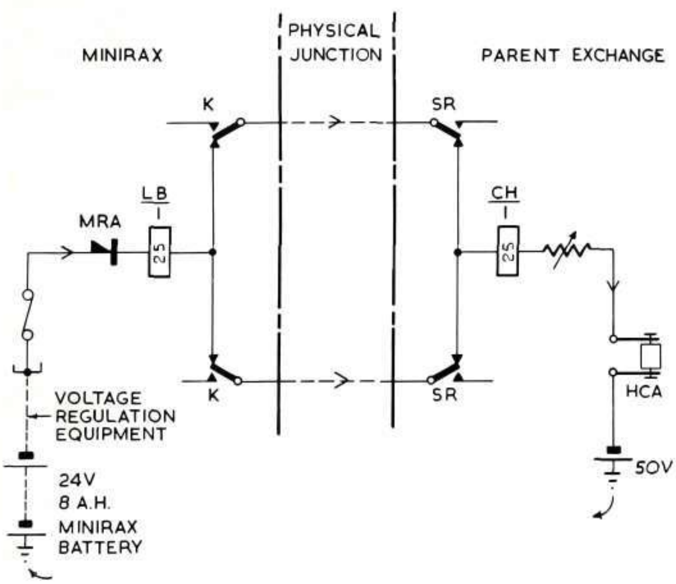


Fig. 8—Charging arrangements on physical junction

Battery Charging over Junctions

When three junctions consisting of one physical and two carrier circuits are used in the system, the physical junction is tested last in sequence by the connector switch to allow the maximum time to be given to battery charging. Under average traffic conditions, this period approximates $22\frac{1}{2}$ hours per day.

The basic charging arrangement is shown in Fig. 8. Charging is effected over both wires of a 2-wire junction arranged in parallel with the positive terminal of each battery connected to a satisfactory exchange earth to avoid unwanted resistance. Direction of charging current flow is indicated by arrows. Rectifier MRA safeguards against battery drainage occurring owing to the presence of an earth fault on the junction, and the heat coil serves to disconnect the circuit in the event of a low resistance earth fault.

Relays LB and CH function as signalling relays and remain operated while the junction is traffic free and charging is in progress. A junction call made from either exchange causes both relays to release and initiate circuit conditions to seize the junction for conversation.

Charging Rates and Junction Limits

The resistance of a physical junction for use in battery charging is primarily governed by the need to maintain a charging rate of approximately 148 mA. Assuming the battery is charged over a 2-wire line from a 50-volt d.c. supply at the parent exchange, the total permissible resistance of the line is 100 ohms. This is equivalent, for example, to a distance of approximately 46.5 miles should 200 lb/mile copper wire be used.

If more than one physical junction is used with the system these may be paralleled to decrease the overall charging path resistance, allowing greater line lengths to be obtained.

When a charging potential exceeding 50 volts is permitted by an Administration, this may be used to advantage to provide the required charging current over even greater distances. When this procedure is adopted a relatively inexpensive rectifier is provided at the charging source.

Battery Voltage Regulation

To prevent excessive charging of the Minirax battery during long periods when junction traffic is absent or slight, equipment is included in the first junction relay set to limit the terminal voltage to a safe level of 27 volts.

In the circuit arrangement shown in Fig. 9, the transistor is used as a sensitive switching device. Its base voltage varies with the potential of the local battery and is derived from the potential drop across resistor R4 and part of variable resistor RV1. The emitter voltage, however, does not change, but remains constant under all conditions of the battery potential owing to the nature of diode Z1.

Within normal battery voltage limits (22V to 27V) the base voltage is positive to the emitter and is therefore cut off, allowing no current flow in relay VR. When the battery voltage exceeds the upper limit of the battery, the transistor base potential becomes negative with respect to the emitter and the transistor switches to 'on'. Collector current then flows to operate the relay. Contact VR1 in operating, short circuits resistor R2 to prolong the 'on' condition and prevent 'hunting' of the relay; additionally, resistor R5 is introduced into the charging path, thus materially reducing the charging current.

Conclusion

The Minirax is a significant contribution to rural telephone communications because it has the desirable qualities of small size, economy of working, adequate facilities, ease of installation, and reliable performance over a wide range of temperatures and humidities. By its use, the particular telephone requirements of small groups of rural subscribers with common interests and activities are efficiently served. In addition to this special application, the characteristics of this small exchange make it suitable for use in other situations. For example, it may be employed to meet unexpected development in defence services or to provide temporary service during delays in the scheduled erection of an exchange building or in the acquisition of a suitable exchange site.

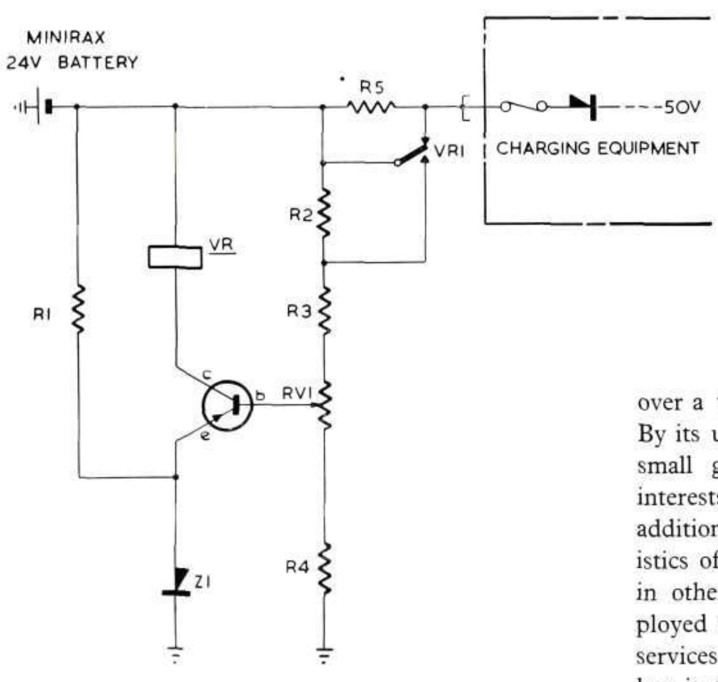


Fig. 9—Voltage Regulation Circuit

U.D.C.621.395.44

THE RURAL CARRIER 101 SYSTEM FOR OPEN-WIRE LINES

E. H. NORMAN, Grad.I.E.E. — Carrier and H.F. Development Department

The RC.101 rural carrier system has been designed to increase the efficient usage of open-wire lines in rural areas. It provides up to 10 independent speech circuits on one open-wire line pair, each circuit having all facilities necessary for a subscriber connected to a C.B., auto. or magneto exchange. The design of the system is such that any circuit may be conveniently 'dropped' along the route by means of simple filtering arrangements.

Full use has been made of transistors and modern types of components to obtain a compact equipment unit requiring the minimum of mounting space and suitable for installation at subscribers' premises. The equipment may be operated from a primary battery.

OWING to the high cost of line plant it has been the practice for many years to provide a telephone service on a party-line basis to a number of subscribers in rural areas. This method of operation imposes a number of limitations on the service so provided, in particular, the loss of secrecy on exchange calls, and many methods have been devised to overcome this drawback.

The introduction of transistors has enabled this problem to be reconsidered from the point of view of multi-channel carrier operation, with the allocation of a different carrier-frequency circuit for each subscriber, thereby obtaining complete secrecy and full exchange facilities for each individual subscriber.

Such a scheme necessitates the installation of equipment of a more complex nature than is normal at the subscriber's premises and demands careful consideration of such matters as maintenance, power supply and size. Other important considerations are, convenience in extracting channels for various subscribers along the route and ease in extending the number of subscriber circuits to the maximum by simple addition of appropriate channelling equipment.

As the only revenue from a system of this nature will be that obtained from a normal subscriber's service it is essential that capital and maintenance costs be kept as low as possible to ensure economic installation of the equipment on relatively short routes. Every effort has therefore been made to keep the amount of equipment required to the minimum without sacrificing performance. Plug-in units are used to facilitate maintenance and allow changes in service to be readily effected at the subscriber's premises.

DESIGN CONSIDERATIONS AND FEATURES

Electrical

In conventional carrier systems, operation is on a group basis, signals in one direction being accommodated in one frequency band and those in the opposite direction in another. With such systems, multiple—modulation techniques are often employed to obtain the necessary close channel spacing with economically acceptable filters. A difficulty arises when 'dropping' circuits, since the carriers are suppressed at the sending end and must be regenerated accurately in synchronism at the receiving terminal. This requires equipment normally common to all channels and the extraction of channels is therefore expensive since various demodulating supplies and quite costly filters are required at these points.

The Rural 101 system employs stacked channels, using adjacent frequency bands for each transmit and receive channel. The carrier wave is not suppressed as in an orthodox system, but is transmitted to line with both sidebands. This simplifies the demodulation equipment, and a simple detector arrangement suffices as no demodulating supply is required.

When the carrier is transmitted a much lower order of carrier frequency stability is acceptable compared with suppressed carrier systems. In addition, the carrier is used to convey signalling information (ringing, dialling, etc.) and for automatic gain control.

The price paid for this simplification and consequent lower cost per carrier circuit is the need for a wider band of frequencies. The overall frequency allocation is 160 kc/s compared with 102 kc/s for a standard 2-wire 12-channel system. Carrier spacing is 8 kc/s to allow both sidebands to be transmitted whereas 4 kc/s spacing is used on orthodox systems.

To reduce filter requirements to the minimum the frequency allocation is as shown in Table 1. When channels are to be extracted *en route* it is normal to drop the higher frequency channels first. Table 2 indicates the approximate maximum length of line over which a given channel will operate.

Carrier Circuit	*A-B Carrier kc/s*	*B-A Carrier kc/s*
1	16	24
2	40	32
3	48	56
4	72	64
5	80	88
6	104	96
7	112	120
8	136	128
9	144	152
10	168	160

Table 1—Allocation of Carrier Frequencies

Carrier Circuit	40 *lb/ml*	70 *lb/ml*	150 *lb/ml*	*Approx. Line Loss (Wet Weather)*
1	90	135	220	40 db
2	80	107	185	40 db
3	72	95	165	40 db
4	65	85	140	40 db
5	60	75	125	40 db
6	55	67	110	40 db
7	50	60	100	40 db
8	34	40	70	30 db
9	30	37	65	30 db
10	27	34	61	30 db

Table 2—Approximate maximum line length of operation (in miles) using various gauges of Cadmium-Copper Wire

The spacing between the pairs of carrier frequencies allows the use of simple filter sets for the 'dropping' of individual circuits without the introduction of appreciable attenuation of the signals in the adjacent circuits.

Since rural carrier equipment is likely to be called upon to operate in regions where no electrical supply is available it should be capable of operating from dry batteries for a considerable period. The advantage of using transistors is obvious, the chief design problem being to obtain satisfactory performance, particularly at the higher frequencies, from types which are reasonably priced and easily obtainable in quantity. The RC.101 equipment was therefore designed to use the currently available high frequency junction transistors such as the OC.45. Precautions have been taken to ensure satisfactory performance at ambient temperatures from —20°C to +50°C, and for a range of supply voltage from 9 to 14 volts.

Mechanical

Unit-type construction has been adopted to facilitate maintenance and to permit the many combinations of signalling, channel frequency, power requirements, etc., of particular systems to be readily provided from stock units. The complete channel terminal panel, measuring $20\frac{1}{2}$ in. x 7 in. x $3\frac{3}{8}$ in. (52 x 17.8 x 8 cm), contains the following plug-in units:—

1. Power Unit or Regulator Unit (optional).
2. Signalling Unit (3 basic types available).
3. Hybrid Unit.
4. Compressor Unit (or bridging unit in lieu).
5. Transmit Unit (fitted with crystal appropriate to channel frequency).
6. Transmit Filter Unit (pass band appropriate to channel frequency).
7. Line Transformer Unit (only one per o/w line connection).
8. Receive Filter Unit (pass band appropriate to channel frequency).
9. Receive Unit.
10. Expander Unit (or bridging unit in lieu).

A photograph of typical units is shown in Fig. 1 and of the complete channel panel in Fig. 2. The units plug into sockets inter-connected by a main printed wiring card, which is connected via a short cable form to a tag panel to facilitate external connections.

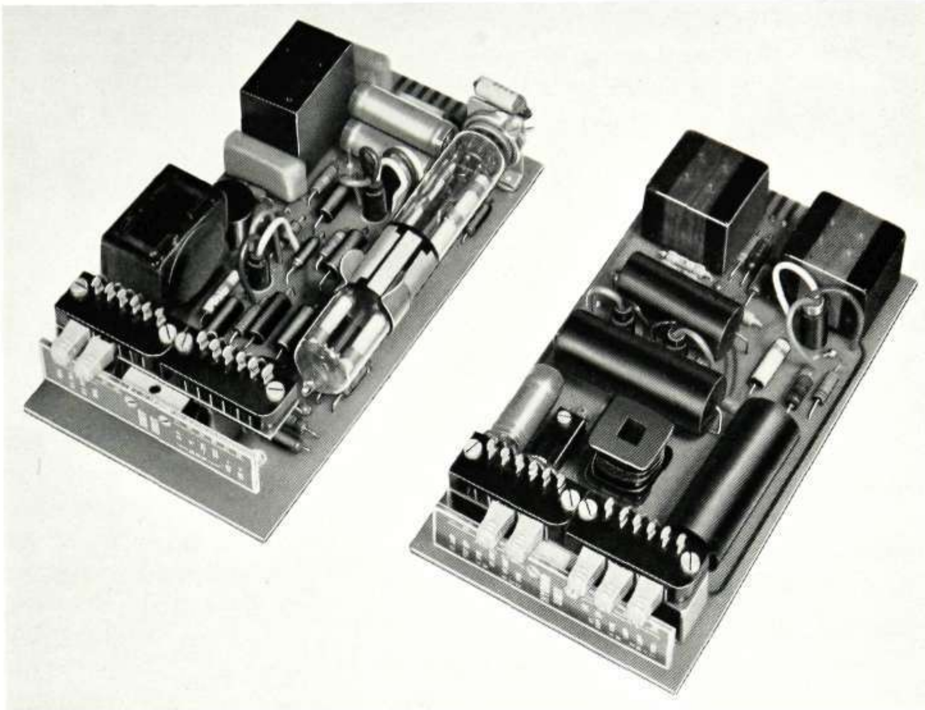


Fig. 1—Typical Plug-in Units

Positive location of the units is ensured by the use of guides on the channel panel, which is suitably drilled for screwing to a standard (O.E.P.) transmission equipment rack. Fittings can also be supplied for wall mounting.

Applications

Subscriber Working

Fig. 3 illustrates the simplest application of the RC.101 system to provide service to ten subscribers, leaving the physical circuit still available for its

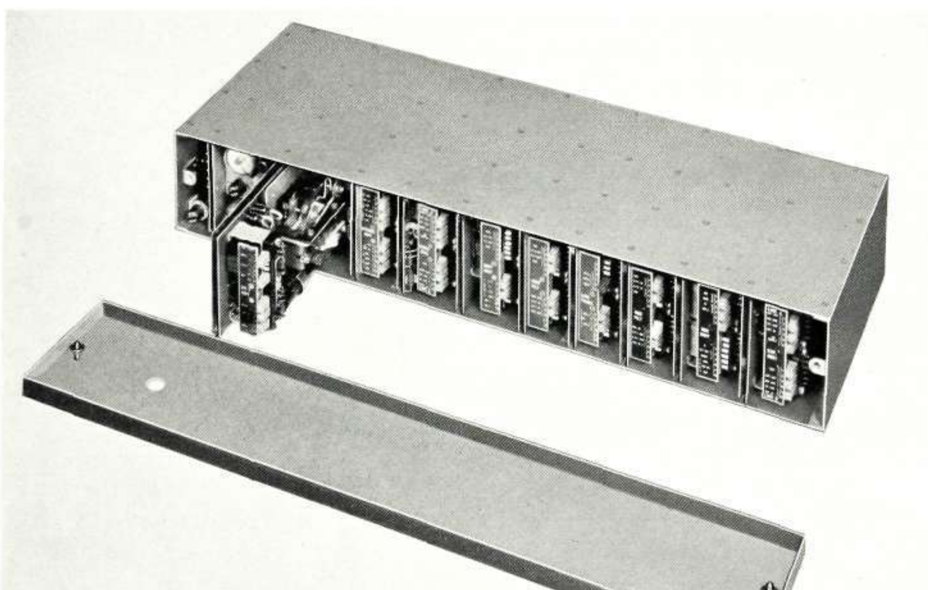
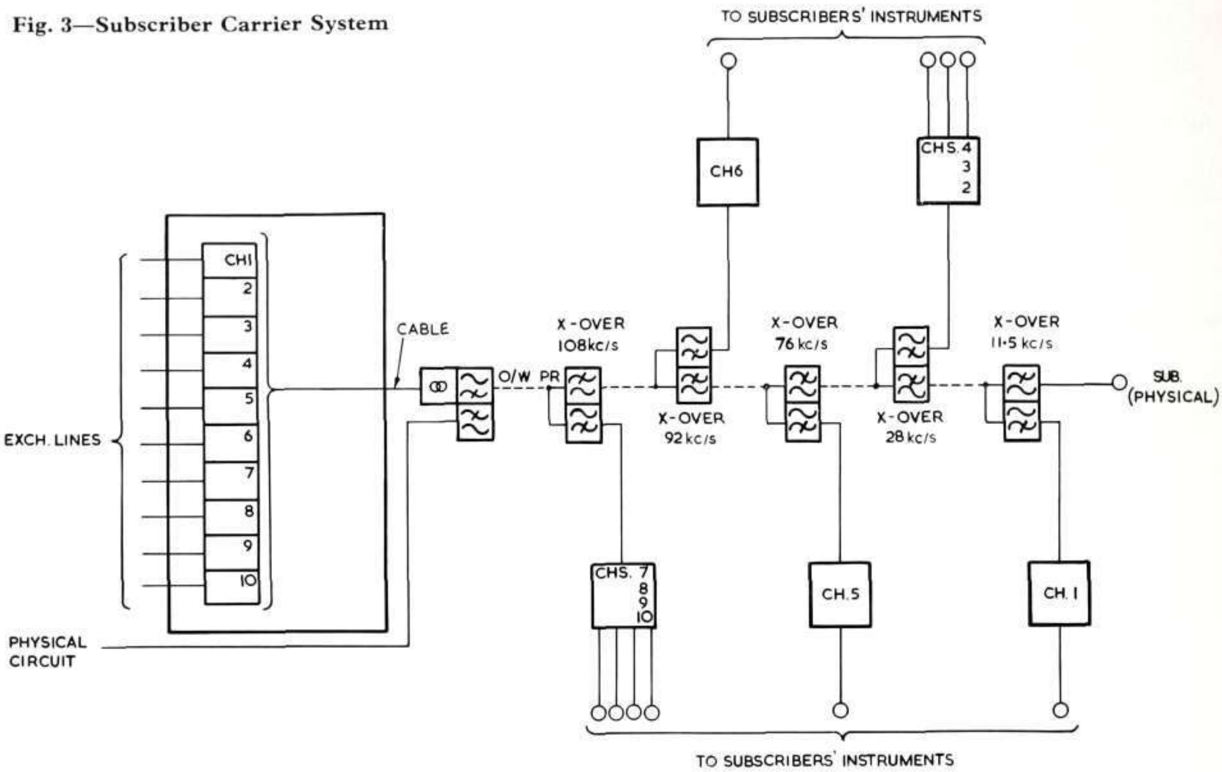


Fig. 2–Channel Panel with cover removed

Fig. 3—Subscriber Carrier System



normal use. Many variants of this arrangement are possible but are too numerous to illustrate.[1] As it is possible to operate a number of subscribers in parallel (i.e., party line) on each carrier circuit, one interesting application is shown in Fig. 4. The physical circuit is divided into sections by the introduction of stop filters; channel 4 is dropped and its 2-wire audio output fed back via low pass filters to the physical circuit of that particular isolated section. Party line subscribers may then be connected at different points of the section via low pass filters.

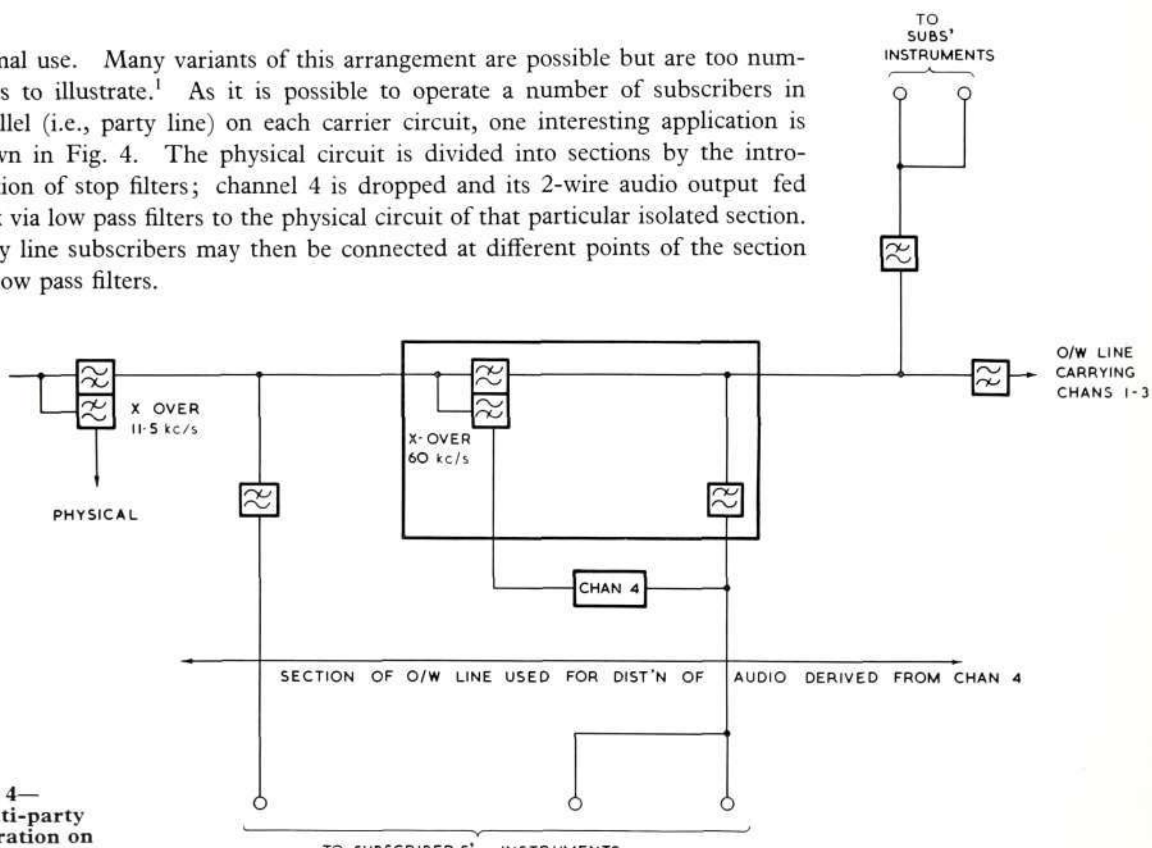


Fig. 4—Multi-party operation on one channel

[1] A simple junction application may be seen by reference to the Minirax equipment described elsewhere in this issue.

Junction Working

Although the system is primarily designed for subscriber working with a limited speech band of 300 to 2700 c/s it may be used for the provision of junction circuits where conditions permit the use of narrow band equipment and Fig. 5 illustrates such an application where three exchanges are interconnected.

Pole Mounted Filter Units

In a rural area it is quite possible that a subscriber's premises will be some considerable distance away from the pole route and be served by a single pair spur. When 'dropping' a rural carrier circuit to serve such a subscriber, a simple line filter set is fitted in a weatherproof case for mounting on the pole.

Suitable lightning surge arrestors can also be mounted in the case, as well as impedance matching transformers for use when cable is employed for lines on the spur route instead of open wire.

Circuit and Unit Descriptions (Fig. 6)

Since the RC.101 is intended for use on magneto, C.B. and auto. telephone systems, it must be capable of converting the various signals used for initiation and termination of a call to a form suitable for transmission over the carrier circuit. These different system applications require terminals with similar transmission circuits but completely different signalling circuits.

Signalling Unit Type 1

This unit is used at both the exchange and subscriber's terminal when magneto signalling ('ring down') is employed. With this type of signalling the carrier terminals are permanently energized, transmitting carrier continuously to line. This arrangement is necessary because in the magneto system there may be no significant change in the subscriber's d.c. loop resistance to give indication whether the handset is on its rest or otherwise.

On the application of a ringing signal to the audio 2-wire input, the carrier is interrupted at ringing frequency for signalling over the carrier channel. Received ringing signals control a transistor generator to provide ringing current to the subscriber's telephone.

Signalling Unit Type 2

For use at a subscriber's terminal with C.B. and auto. telephone systems, this unit provides microphone current in addition to means for switching on the quiescent parts of the carrier equipment when a

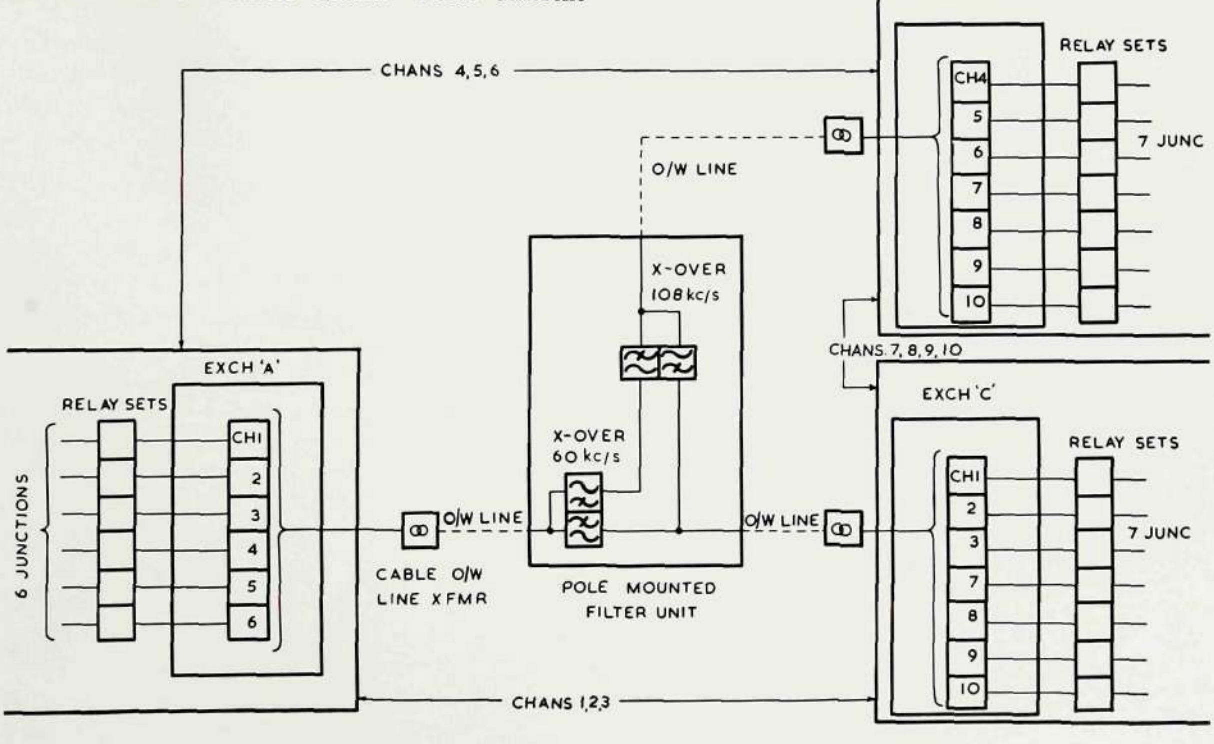


Fig. 5—Junction Carrier System

call is originated. On the lifting of the handset, the 'loop' current causes a diode in the transmit unit to conduct, allowing carrier-frequency driving power to be applied to the input of the carrier amplifier. Carrier current is then fed to line via the transmit filter and is interrupted each time the loop current is disconnected during dialling.

Incoming calling signals in the form of interrupted carrier are detected in the receive unit and converted to a.c. ringing signals by the signalling unit for extension to the subscriber's line. Removal of the handset trips the ringing and the return carrier is switched on.

Signalling Unit Type 3

This is the exchange terminal signalling unit for use on C.B. and auto. systems and is used when a subscriber's terminal equipment includes a Signalling Unit (S.U.) Type 2 above to provide exchange/subscriber service. The S.U. Type 3 is employed in the terminal equipment at each end of a junction circuit. When used for junction working, a relay-set is required at each end between the carrier and exchange equipments.

Provision is made for 'loop' or 'E and M' signalling to suit each application and either method may be selected by the simple adjustment of terminal strapping. When the unit is arranged for 'loop' working, a loop is applied to the exchange line whenever a loop is presented to the audio input of the remote carrier terminal. With the 'E and M' method, an earth is extended to the 'M' lead at one terminal and reproduced via the carrier channel at the 'E' lead of the other terminal.

Hybrid Unit

As shown in the block schematic (Fig. 6) this unit contains the resistance hybrid, transmit limiter and receive voice-frequency amplifier. When a call has been set up, outgoing speech signals are directed to the transmit path, and incoming carrier-derived signals are amplified and passed to the audio line via the signalling unit.

The limiter serves to prevent extra loud speech from modulating the outgoing carrier more than about seventy per cent, thereby avoiding false operation of the remote signalling circuits.

Incoming signals from the expander unit (when fitted) are amplified by the voice-frequency amplifier and applied to the receive side of the hybrid. To compensate for filter 'turn-up', a small amount of equalization is incorporated in the v.f. amplifier.

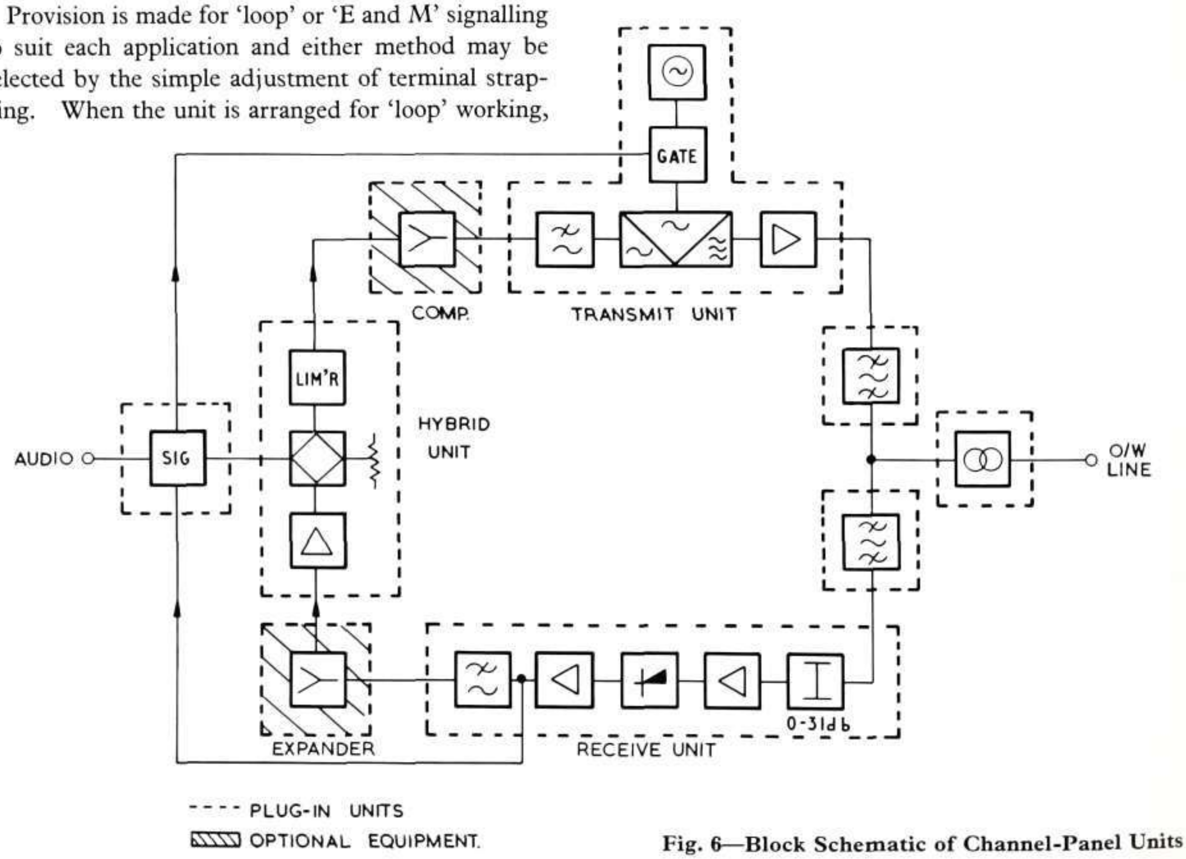


Fig. 6—Block Schematic of Channel-Panel Units

Compressor and Expander Units

To permit the use of lines which might otherwise be too noisy, these units (forming a compandor) may be included in the transmit and receive paths respectively. Briefly, the compressor increases the side-band power present on the line to improve the signal/noise ratio, while the expander restores the received audio signals to their proper relative values. Weak speech is thus boosted to a level where it can over-ride cross-talk and noise. The use of the compandor can result in cross-talk and noise being effectively reduced by as much as 20 db.

When the compressor and expander are not required, suitable bridging units are substituted.

Transmit Unit

This comprises the carrier oscillator, carrier amplifier, transmit v.f. filter and means for adjusting the carrier level and depth of modulation. The oscillator is crystal controlled and operates continuously, the drive to the amplifier passing via a diode gate under control of the signalling unit. The amplitude of the output carrier current is modulated by the speech frequency signals which are also applied to the amplifier input. Modulation products other than the carrier and both sidebands are eliminated in the transmit filter unit which couples the amplifier to the line transformer.

The transmit unit is basically the same for all channels, the appropriate oscillator frequency being obtained by inserting the correct crystal. No tuning adjustments are necessary.

Transmit/Receive Filter Units and Line Transformer

Unwanted modulation products generated in the transmit unit are removed by the transmit filter to obviate inter-channel cross-talk. Both transmit and receive filters of all channels at a terminal are connected in parallel on the line side and coupled to the line (or lead-in cable) by the line transformer unit. The filters have an impedance of 75 ohms unbalanced on the line side, and the line transformer is designed to match a 150-ohm entrance cable or 600-ohm open-wire line. Carrier output level to line is +3 dbm. The receive filter unit discriminates against signals of all frequencies except the band allocated for the channel concerned.

Receive Unit

At the input of this unit, an attenuator enables adjustment to be made to reduce the level received from a particular line so that the receive amplifier operates within the range of its automatic gain control (A.G.C.). This ensures that for a change of 10 db line attenuation, caused by weather conditions, the audio-frequency output remains within 1 db of its median value. Temperature compensation is applied by means of germanium diodes to ensure satisfactory operation of the A.G.C. circuit up to 50°C.

In the receive unit, a v.f. output is produced via a low-pass filter and passed through an expander (if fitted) to the hybrid unit. Here, the level is increased to a value suitable for application to the subscriber's line.

POWER CONSUMPTION AND SUPPLIES

The nominal current consumption is 40 mA per channel panel during a call. When Signalling Units Types 2 and 3 are used the load varies from a quiescent current of 10 mA between calls to 100 mA during the ringing interval. With Signalling Unit Type 1, because carrier current is applied continuously to line, no reduction in current is possible.

When an a.c. power supply of 90—120 or 200—250 volts (40—60 c/s) is available, one of two forms of

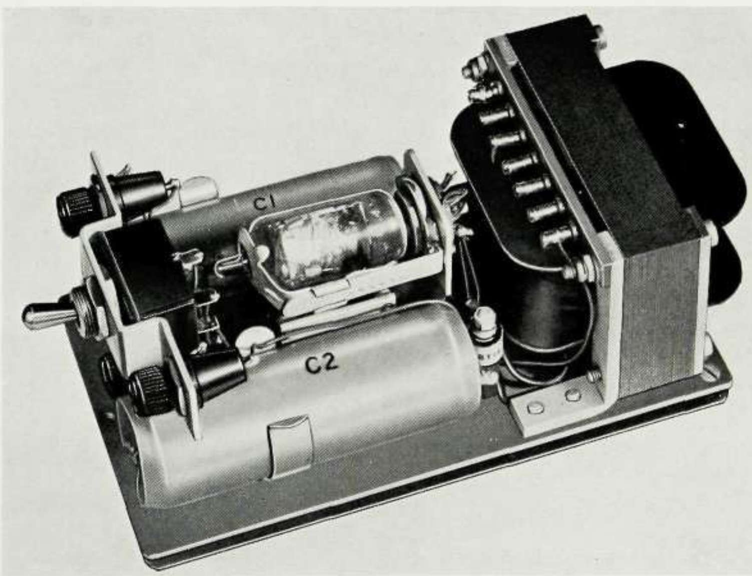


Fig. 7—Plug-in Power Unit

power unit may be used. The plug-in power unit, of the type shown in Fig. 7, is used to operate individual channel panels at terminals with up to three carrier circuits. At terminals of greater capacity, a common power panel, incorporating a transistor regulator, is employed.

In situations where the a.c. supply is liable to interruption, a nickel-cadmium battery of suitable capacity may be 'floated' across the output of the plug-in or panel power unit. Alternatively, the equipment may be switched to a standby battery by means of a sealed plug-in relay.

To allow operation from an existing 20—60 volt d.c. supply, regulator units are provided, designed to give a smoothed 12-volt supply independent of load conditions. As in the case of the mains unit, two versions of regulator units are available; plug-in and panel mounted.

Because of the very low power requirements of the system, operation is possible from a primary battery supply. The battery consists of primary cells specially designed to operate in extreme temperatures and is of sufficient capacity to operate one carrier circuit, on any of the three telephone systems mentioned, for a period of at least six months.

Future Developments

The standard system described has sufficient flexibility to fulfil most requirements, but the adaptation of the RC.101 for special purposes is receiving attention. One such application is the provision of links for a Line Concentrator via a single pair and this arrangement will be the subject of a future article. A further application, now being studied in collaboration with the Central Electricity Generating Board, is the provision of a communication circuit via high-voltage power lines.

Abridged Specification

Operating Levels

Carrier level to line		+3 dbm
Normal modulation depth		50%
Normal audio input		0 dbm
Normal audio output		—3 dbm
Minimum receive carrier level from line under worst weather conditions	Chans. 1—7	—40 dbm
	Chans. 8—10	—30 dbm
Approximate change in audio level for 10 db decrease in line loss		1 db

Frequency Allocation and Response

Carrier frequency spacing	8 kc/s
Lowest carrier frequency	16 kc/s
Highest carrier frequency	168 kc/s
Overall frequency allocation for RC.101	12—172 kc/s

Audio frequency response within ± 3 db of level at 800 c/s from 300 to 2700 c/s.

Power Supplies

Consumption of 1 channel terminal during calls	40 mA at 12V.
Consumption between calls (C.B. and auto. working)	10 mA
Consumption during ringing interval	100 mA

Integral power unit or regulator unit will operate one channel panel.

Common power panel or regulator panel will operate up to 10 channel panels.

Operation of one or two channels from dry batteries is feasible. Approx. running cost per channel end (at 40 mA) = ½d. per hour.

United Kingdom Patent Application No. 44181/59