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Modems for the Datel 200 Service—Datel Modems No. 2A and 2B

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The Datel 200 Service provides facilities for the duplex transmission of serial binary data signals over the public telephone-switching network, at rates up to 200 bits/second. The largest field of application for this service is with time-sharing-computer bureaux, enabling powerful computers to be made available, economically, to a wide range of users, who can be located anywhere served by the public telephone-switching network, and who need only have relatively-simple data terminal equipment such as a suitable teleprinter. The modems used for this service are described, and the interface arrangements between the modems and the data terminal equipment are explained.

INTRODUCTION

The Datel 200 Service enables the data-terminal equipments in a system such as that shown in Fig. 1, to exchange duplex serial binary data signals at transmission rates up to 200 bits/second. An example of such a system which requires the facilities provided by the Datel 200 Service, is the time-sharing-computer bureaux complex in which a number of teleprinter data terminals can operate simultaneously to a remote computer, using the public telephone-switching network. In this system, having established a connexion with the computer, a dialogue takes place between the computer and the teleprinter operator. It is in this field of direct man-to-machine communication[1] that the Datel 200 Service has its largest application, enabling the power of the computer to be available, on demand, to a wide range of users, who can be located anywhere that permits access to the computer over the telephone network.

The demarcation between the customer's equipment and those items which are the responsibility of the Post Office, is the point at which the data-terminal equipment is connected to the modem. This point is called the modem/data-terminal-equipment interface. Fig. 1 shows the areas of Post Office responsibility in a typical system using Datel 200 facilities, the functions of the items shown being briefly as follows:

(*a*) *Telephone Instrument.* A Telephone No. 710 is usually associated with a Datel Modem No. 2 at a customer's installation, except at computer centres, where special alternative arrangements are made. The telephone is used to establish a connexion with the distant terminal over the public telephone-switching network. Various push-button key facilities are provided by the telephone; these are used to effect switching functions in the modem, e.g. manual connexion of the modem to the telephone line, channel switching and other functions. These keys are arranged to give the facilities necessary at a particular installation, and are largely determined by the type of telephone exchange to which the modem is required to operate, i.e. automatic, manual, p.a.b.x. or p.m.b.x. These features will be discussed further in the section dealing with channel switching and the connexion of the modem to line.

(*b*) *Communication Channel.* The Datel 200 Service is almost entirely based upon use of the public telephone-switching network, although private circuits can be used if required. Previous articles in this Journal have discussed the characteristics of the telephone network in relation to data-transmission,[2,3,4] and it will be sufficient here to briefly restate the problems involved in transmitting data signals over circuits designed to transmit speech signals. Firstly, the bandwidth available to data transmission in the telephone circuit is restricted by the presence of 1 v.f. and 2 v.f. signalling receivers, and, in order to prevent the false operation of these equipments to data signals, the Datel 200 Service is restricted to the band 900–2,000 Hz. Secondly, the telephone-network characteristics, namely loss/frequency, phase/frequency, echo and noise, all contribute to degrade the system performance, which is defined in terms of the bit error-rate. The bit error-rate is a measure of the number of bit (binary-digit) errors which occur in a given number of bits transmitted over the system. The errors occurring in the received data stream are caused by the effects of the network characteristics upon the signals passing over the telephone circuit. Impulsive noise is particularly troublesome to data systems when the noise level approaches or exceeds that of the data signals, whose element time can be short in comparison with the duration of the noise burst. The level of the data signals at any point on the line will depend both upon the signal level transmitted to line and the loss/frequency characteristic of the circuit. The phase/frequency characteristic, which is non-linear, introduces phase distortion, i.e. the phase relationships of the frequency components in the received waveform are different from the original phase relationships in the transmitted waveform, thus resulting in distortion of the received-signal waveform. This effect is not serious in speech communication, since the ear is insensitive to phase distortion, but it is a limiting impairment to data transmission, particularly over the telephone-switching network.

(*c*) *Modem.* The modem is a modulating and demodulating device which translates the serial binary data signals fed from the data-terminal equipment transmitter (data source) into voice-frequency (v.f.) signals and, simultaneously, converts v.f. data signals received from line into serial binary signals which are passed to the data-terminal equipment receiver (data sink). This duplex mode of operation requires two separate channels to be allocated within the available 900–2,000 Hz bandwidth, one channel being used to transmit v.f. data signals and the other channel being used to receive v.f. data signals.

The modem is connected to the data-terminal equipment by means of an interface cable. This cable enables a number of d.c. (nominally ±6-volt) signals, including data, to be

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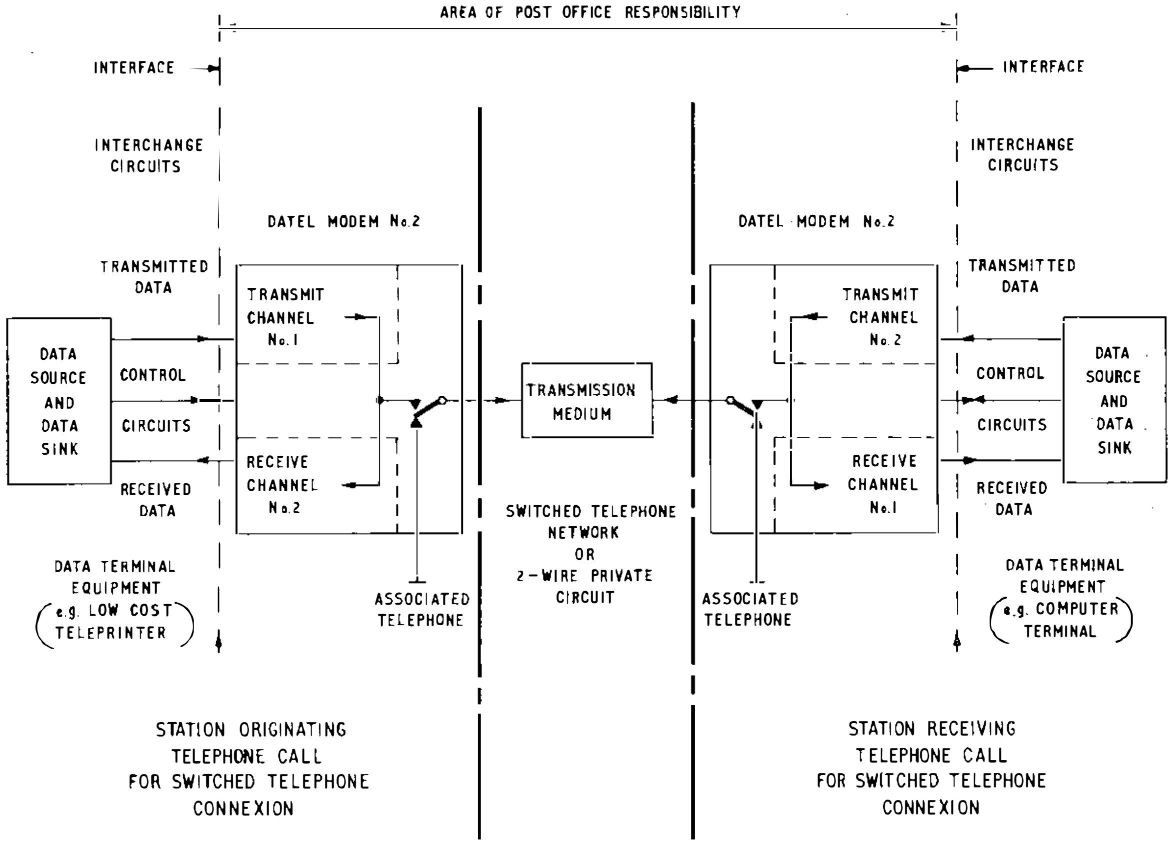


FIG. 1—Essential features of a Datel 200 data-transmission system

exchanged between the equipments. The various circuits within the interface are called interchange circuits, whose functions include the interchange of data, control and supervisory signals between the modem and the terminal equipment.

The above outline of some of the aspects of the Datel 200 Service is necessarily brief, and a fuller discussion of some of the points touched upon can be found in earlier issues of this Journal.[2,3,4,5,6]

DESIGN CONSIDERATIONS FOR THE DATEL MODEM NO. 2

The specification and design of a datel modem is based upon a consideration of the following factors: the maximum transmission rate required; the characteristics of the worst (nominally extreme) connexion over which data will be transmitted; the error-rate performance; and the interface requirements. From the above information the modulation and demodulation techniques are selected and the choice between synchronous or asynchronous operation is made. These aspects of a modem design are the subject of C.C.I.T.T.* Recommendations for international data transmission, and the modem design should, therefore, comply with any relevant C.C.I.T.T. Recommendations.

Datel Modem No. 2 complies with C.C.I.T.T. Recommendation V21, which sets out the standards of a modem operating at 200 bits/s over telephone circuits. These recommendations are briefly as follows:

(*a*) The system should allow duplex data transmission over telephone circuits at any rate up to 200 bits/s.

(*b*) Frequency modulation should be employed. The characteristic frequencies recommended are listed in Table 1.

(*c*) The transmission may be either asynchronous or synchronous.

(*d*) Channel 1 should be used for the transmission of caller's data, while channel 2 should be used for transmission in the other direction.

The recommendation also covers power levels and operational procedures.

TABLE 1

Characteristic Frequencies for Modem Operating at 200 bits/s over Public Telephone-Switching-Network Circuits

Channel No.	Nominal Mean Frequency F_0 (Hz)	Binary Symbol 1 Frequency F_Z (Hz)	Binary Symbol 0 Frequency F_A (Hz)
1	1,080	980	1,180
2	1,750	1,650	1,850

Frequency modulation has been chosen because it gives a good performance, is reasonably simple to implement, provides stable operation over a wide variety of channels, and permits asynchronous operation. In addition, this modulation technique enables the modem performance to be unaffected by the data code used, i.e. by any sequence of binary 1s or binary 0s.

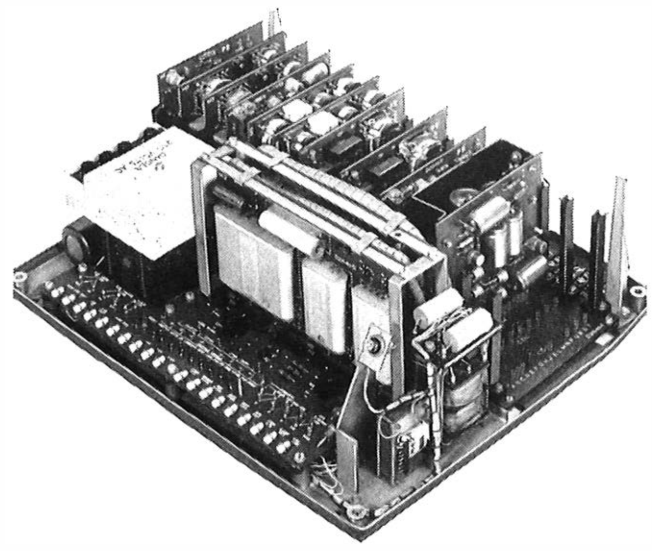
TYPES OF DATEL MODEM NO. 2

The Datel 200 Service was inaugurated in 1967 with the Datel Modem No. 2A. Improved versions of the original design, coded Datel Modems No. 2B, based on 62-type equipment practice, will be put into service in 1969. Two versions, Mark 1 and Mark 2, are being manufactured. Both these modems will comply with Recommendation V21, as amended at the 1968 C.C.I.T.T. Plenary Assembly at Mar del Plata.

Datel Modem No. 2A

Fig. 2 shows the Datel Modem No. 2A. The assembly consists of a printed-circuit mother board, into which 10 printed-circuit boards are plugged. At the rear of the modem are situated terminal blocks for telephone and power cords,

* C.C.I.T.T.—International Telegraph and Telephone Consultative Committee.



(*a*) Modem with Cover Removed

(*b*) Modem with Cover On

FIG. 2—Datel Modem No. 2A

and a non-locking press-button for remote-testing purposes. Test switches, test sockets and strapping pins are located at the front of the modem. The weight of the modem, including the cover, is 20 lb and the dimensions are 16 in wide × $15\frac{1}{2}$ in deep × $6\frac{1}{4}$ in high. The cover is made from fibre-glass and is coloured in 2-tone grey to match the standard grey of the Telephone No. 706. The majority of the semiconductor devices used in the modem are of germanium. Reed relays are used for circuit switching.

Datel Modem No. 2B

Both the Mark 1 and Mark 2 versions of the Modem No. 2B are based upon the circuit principles of the Modem No. 2A; the Mark 1 model uses silicon semiconductor devices, and the Mark 2 model germanium devices.

Fig. 3 shows the construction of the Datel Modem No. 2B Mark 1, the front cover being raised to show the units housed within the case assembly. The two versions of the modem are of similar appearance and use identical case assemblies to house the 62-type units. The units in the two versions of the modem differ, however, both electrically and physically, and are not interchangeable items. Test points and U-link plugs and sockets for testing purposes are located on the front of each unit. The interface plug and socket, together with the terminal blocks for the telephone and power cables and the non-locking press-button to facilitate remote testing of the modem, are situated at the rear of the modem. Reed relays are used for circuit switching.

The outer case assembly was designed with the assistance of an industrial design consultant and has a textured vinyl-paint finish in 2-tone grey to match the 700-type telephone instrument. The styling of the case has now been adopted as a standard house style for all datel modems.

The weight and dimensions of both modems are 20 lb and $14\frac{1}{4}$ in wide × $16\frac{1}{2}$ in deep × 6·8 in high.

THE INTERFACE BETWEEN MODEM AND DATA TERMINAL EQUIPMENT

The modems comply with C.C.I.T.T. Recommendation V24, which defines the purpose and electrical characteristics of the interchange circuits, and with C.C.I.T.T. Recommendation V21, which additionally specifies a list of interchange circuits selected from Recommendation V24 for use with the modem, together with operational requirements and response times.

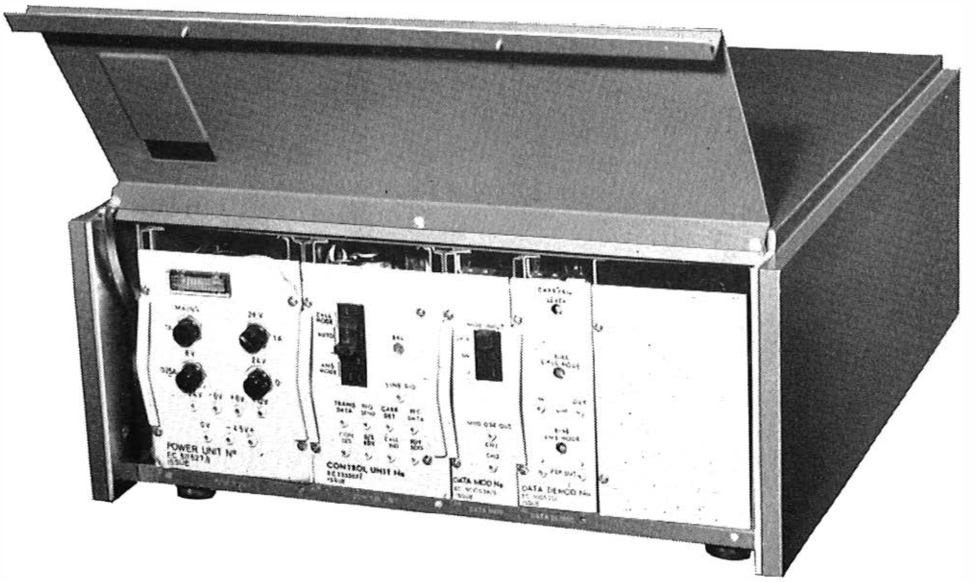
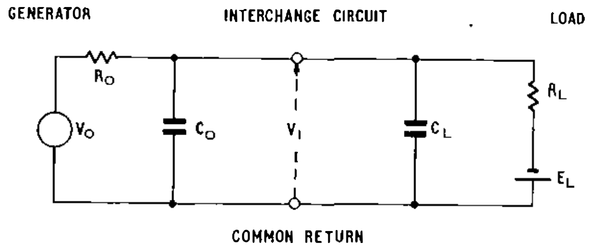


FIG. 3—Construction of Datel Modem No. 2B Mark 1

The interchange circuits defined by C.C.I.T.T. Recommendation V24 are operated by nominally ±6-volt signals: a +6-volt signal represents a binary 0 or ON condition and a −6-volt signal represents a binary 1 or OFF condition. Input circuits in the modem are, however, designed to operate satisfactorily to applied voltages over the range +3 to +25 volts and −3 to −25 volts. Output circuits in the modem are designed to generate a nominal ±6 volts into a load impedance which is the total resistance and capacitance of the interface cable and the input circuit. The load impedance is defined as a d.c. resistance between 3,000 and 7,000 ohms and a shunt capacitance not exceeding 2,500 picofarads.



V_0 — Open-circuit generator voltage not greater than ± 25 volts
V_I — Interface voltage: −3 volts to −25 volts or +3 volts to +25 volts
R_0 — Generator internal impedance, value not stated
R_L — Load impedance, 3,000–7,000 ohms
E_L — Load open-circuit voltage (bias), not greater than ± 2 volts
C_L — Total effective load capacitance measured at an interchange point and including any cable
C_o — Capacitance associated with generator, including any cable to interchange point. C_o plus C_L must not exceed 2,500 pF

FIG. 4—Equivalent interchange circuit

The modem and the data-terminal equipment are connected by an interface cable which is plugged into a 25-way socket located on the modem. Fig. 4 shows the equivalent interchange circuit as defined by the Recommendation.

Table 2 lists the interchange circuits used by Datel Modems No. 2 and also shows a typical operational sequence.

The changes to Recommendation V21 re-define the use and timings of some of the interchange circuits, and Table 3 sets out the differences between the old[7] and new[8] Recommendations as implemented by the Modems No. 2A and 2B.

CHANNEL SWITCHING AND THE CONNEXION OF THE MODEM TO LINE

Before data transmission can take place between two Datel 200 terminals, it is necessary to switch the channels to conform with the convention that the calling station transmits data on channel 1 and receives data on channel 2, whilst the called station operates in the opposite mode. The switching is done by a channel-switching relay. When the relay is unoperated, the modem is conditioned to transmit data on channel 1 and to receive data on channel 2, the modem then being said to be in the CALL mode. When the channel-switching relay is operated the channel function is reversed and the modem is said to be in the ANSWER mode. The modem can be connected to the public telephone network or to a 2-wire private circuit when the appropriate mode of operation has been selected.

Both channel switching and the modem-to-line connexion can be controlled either manually or automatically. Channel switching can be automatically effected by the incoming

TABLE 2

List of Interchange Circuits Used by Datel Modems No. 2A and 2B with a Typical Operational Sequence

Data Terminal Equipment (D.T.E.) Condition	Interchange Circuit (arrows show direction of transmission)	Datel Modem (D.M.) Condition
	C.C.I.T.T. Circuit 125: CALLING INDICATOR to D.T.E. ←	Ringing current from line. ON ringing current. OFF no ringing current.
D.T.E. Responds with ON	C.C.I.T.T. Circuit 108: CONNECT DATA SET TO LINE or, optionally, on D.M. 2B, DATA TERMINAL READY, to D.M. →	ON condition connects D.M. to line or ON condition indicates that D.M. is prepared to connect the line on the receipt of ringing current.
D.T.E. applies ON if channel selection from interface option required (D.M. 2B only)	C.C.I.T.T. Circuit 126: FREQUENCY SELECTOR (D.M. 2B) to D.M. →	ON condition switches modem to ANSWER mode.
	C.C.I.T.T. Circuit 107: DATA SET READY to D.T.E. ←	ON condition; acknowledgment that D.M. is connected to line.
D.T.E. Responds with ON	C.C.I.T.T. Circuit 105 : REQUEST TO SEND to D.M.: (use optional, see Table 3) →	ON condition turns modulator oscillator ON. Carrier tone sent to line.
	C.C.I.T.T. Circuit 106: READY FOR SENDING to D.T.E. ←	ON (after delay time), indicates data can be sent.
	C.C.I.T.T. Circuit 109: CARRIER DETECTOR to D.T.E. ←	ON condition. Carrier tone received from distant terminal.
When Circuits 106 and 109 are ON, D.T.E. transmits ±6-volt data signals	C.C.I.T.T. Circuit 103: TRANSMIT DATA to D.M. →	Binary data signals translated into v.f. signals and transmitted to line.
D.T.E. receives ±6-volt data signals	C.C.I.T.T. Circuit 104: RECEIVED DATA to D.T.E. ←	Received v.f. signals translated into binary data signals.
	C.C.I.T.T. Circuit 102: COMMON RETURN (0 volts). Establishes the common reference potential for all interchange circuits ↔	

TABLE 3

Interchange-Circuit Differences Between Datel Modem No. 2A and No. 2B

Interchange Circuit	Old C.C.I.T.T. V21 Recommendation (Modem 2A)	New C.C.I.T.T. V21 Recommendation (Modem 2B)
REQUEST-TO-SEND (use optional) in Modem 2A but use defined for Modem 2B	No statement on use, apart from requirement to switch modulator ON. Strap option in modem can apply +6 volts to modulator when CONNECT DATA SET TO LINE ON	Strap provided in modems as in Modem 2A. REQUEST-TO-SEND circuit to be used when modem connected to private-circuits. Internal strap to be used when modem connected to telephone network. In either case, ON condition is applied to modulator only when CONNECT-DATA-SET TO LINE is ON.
READY-FOR-SENDING (Response times with respect to REQUEST TO SEND or CONNECT DATA SET TO LINE if strap option used. Response time (*b*) in Modem 2B with respect to the carrier-detector circuit)	OFF-ON can be selected to be either 15–25 ms or 180–220 ms. ON-OFF not specified	Two cases are specified: (*a*) Modem connected to private circuits. ON-OFF ≯2 ms. OFF-ON 20–50 ms. (*b*) Modem connected to the switched telephone network. Response time with respect to the carrier-detector circuit: ON-OFF ≯2 ms. OFF-ON 400–1000 ms.
CARRIER DETECTOR. (Circuit response times with respect to the incoming carrier level. Option selected by straps in modem)	Circuit turned OFF if incoming channel carrier level falls below −55 dBm at the line terminals. Circuit turned ON if incoming channel carrier level between −53 dBm and −51 dBm or higher at line terminals. ON-OFF can be selected to be either 40–60 ms or 90–110 ms. OFF-ON 2–10 ms	Circuit turned OFF if incoming channel carrier level falls below −48 dBm at line terminals. Circuit turned ON if incoming carrier level is between −46 and −43 dBm or higher at the line terminals. Timings specified for (*a*) modem connected to private circuits: ON-OFF 20–80 ms. OFF-ON ≯20 ms. (*b*) modem connected to the switched telephone network: ON-OFF 20–80 ms. OFF-ON 300–700 ms.
DATA TERMINAL READY	Not defined	Option to CONNECT DATA SET TO LINE: ON condition prepares for connexion of modem to line when either incoming ringing current is received or d.c. loop applied from a key on the associated telephone.
FREQUENCY SELECTOR	Not defined	OFF. Modem transmits on channel 1 and receives on channel 2. ON. Modem transmits on channel 2 and receives on channel 1.

TABLE 4

Functions of Push-Button Keys on Telephone No. 710

Key	Locking or Non-locking	Function
DATA	Locking	Operates DS relay which connects the modem to the line terminals (see Fig. 5). Cannot be used when relay DS is operated from data-terminal equipment.
TELE	Non-locking	Releases the operated DATA key, which restores the telephone-to-line connexion. (Handset left off rest during data transmission.)
BKD CALL (Booked call)	Non-locking	Modem connected to automatic exchange or p.a.b.x. Modem wired for automatic channel selection. Used at calling terminal when a call has been booked via an operator. The operator rings back when the connexion has been established. The channel-switching relay, relay FSA, operates to the ringing current. Operation of the BKD CALL key puts the calling terminal into the CALL (channel 1) mode by releasing relay FSA.
RECD CALL (Received call)	Non-locking	Modem connected to manual exchange or p.m.b.x. lines. Modem not wired for automatic channel-selection. Used at called station to operate FSA relay to put modem into the ANSWER (channel 2) mode.
AUTO ANS	Locking	Used when automatic answering is controlled from telephone. For modem connected to automatic-exchange line, the key (operated) provides an operate circuit for relay U the calling indicator-relay. For modem connected to manual line, the key provides an operate circuit for relay A. (See Fig. 5). Ringing current initiates ON-OFF conditions on calling-indicator circuit. (Telephone handset on rest during data transmission.)
NORM	Non-locking	Releases AUTO ANS key.
(To be allocated)	Non-locking	Used with Modems 2B. To connect modem to line in conjunction with DATA TERMINAL READY facility.

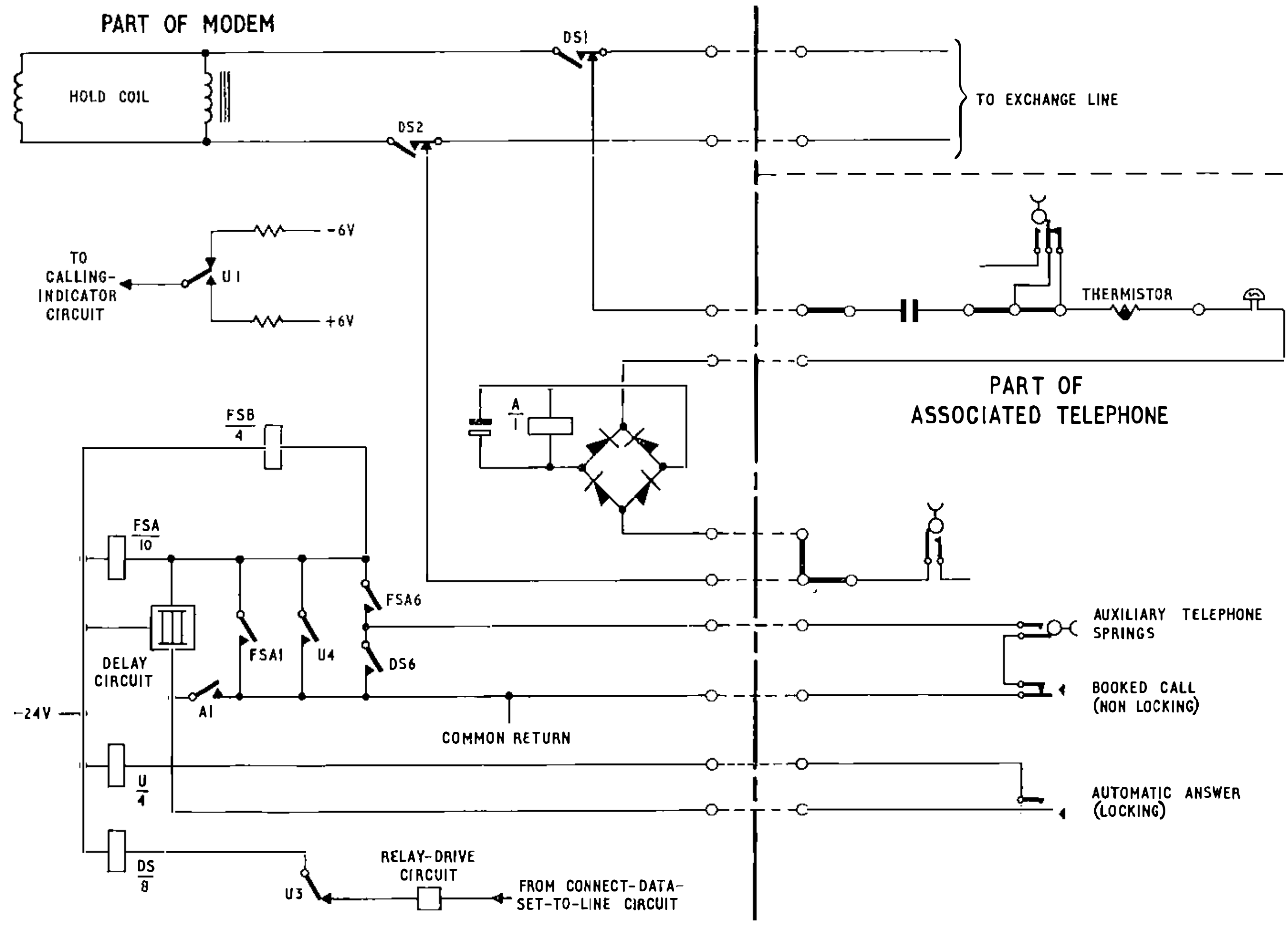


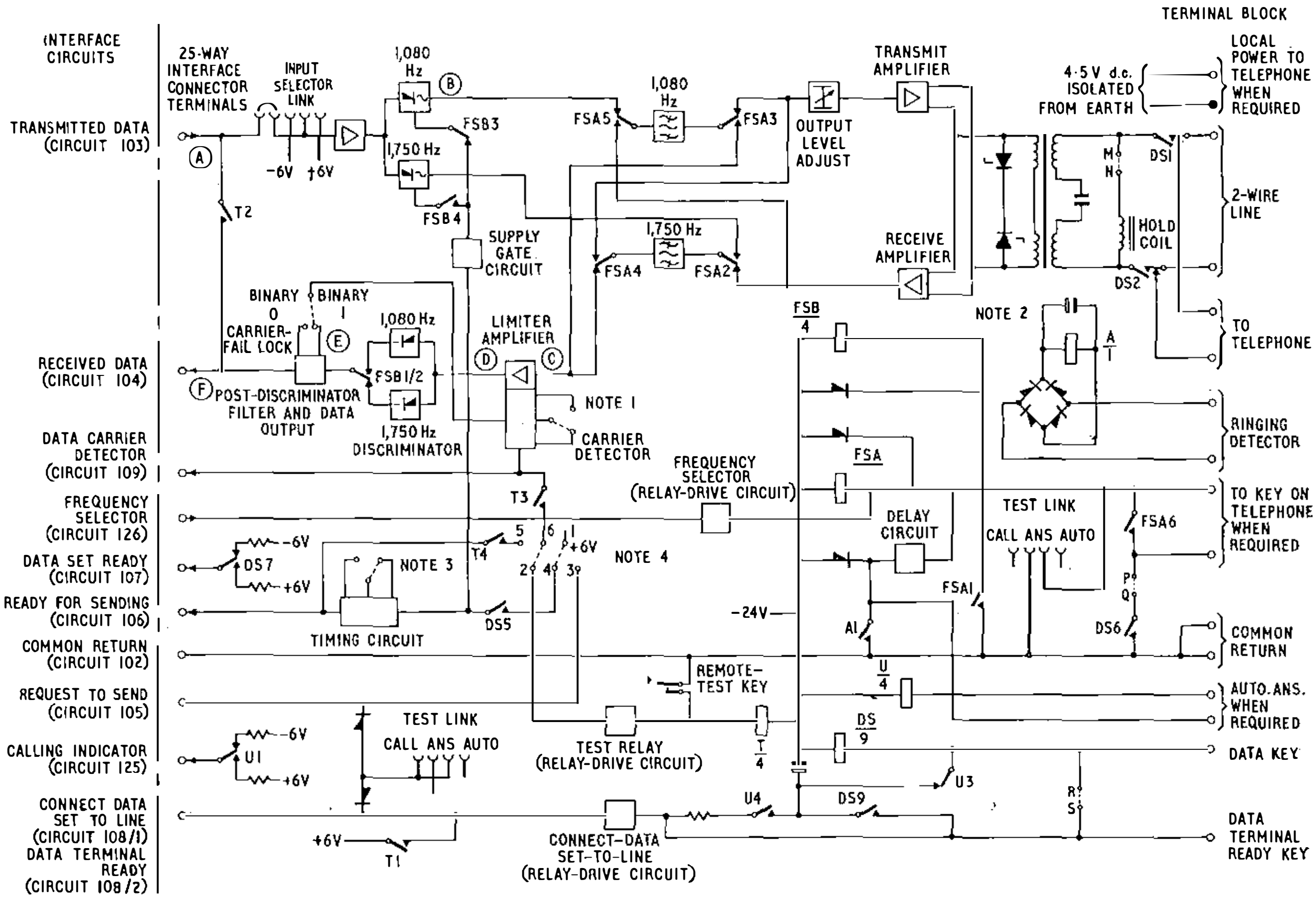
FIG. 5—Typical connexion between Datel Modem No. 2A, Telephone No. 710 and automatic exchange line: automatic answering is provided

ringing current, which is arranged to operate the channel-switching relay in the modem. In the Datel Modem No. 2B switching can, alternatively, be controlled from the interface. In certain situations it is necessary to be able to override the operation of the channel-switching relay, and press-button keys provided on the associated telephone enable the customer to revert the mode of operation. The connexion of the modem to line can be controlled, by means of a line-switching relay in the modem, either from a press-button key on the telephone or from an ON (+6-volt) condition applied to the CONNECT DATA SET TO LINE interchange circuit. Table 4 is a list of the various push-buttons of which up to four can be provided on the Telephone No. 710 associated with the modem to enable the modem to operate in a variety of line and system configurations.

A most important facility of the modem is its ability to automatically switch to the ANSWER mode and to extend conditions to the data-terminal equipment, enabling the subsequent automatic connexion of the modem to line. Both these operations are initiated by incoming ringing current and Fig. 5 shows the connexions necessary for automatic operation of a Datel Modem No. 2A. The on periods of incoming ringing current operate the ringing-detector A relay, which in turn causes the channel-switching relay, FSA, to operate. The operation of relay FSA switches the modem channels into the ANSWER mode and also operates relay FSB, which also performs channel-switching functions. (Relay FSA is slow to release, in order to hold over the 2-second off period in the ringing current.) The calling-indicator relay, U, is also operated by the operation of relay A via the AUTO-ANS key, operated on the associated telephone. Relays A and U both follow the on–off cycle of the ringing current. Relay U accordingly applies ON (+6 volts) and OFF (−6 volts) potentials to the CALLING-INDICATOR interchange circuit, to the data terminal equipment. The terminal equipment is designed to respond to the ON condition on this interchange circuit, by returning an ON condition to the modem, on the CONNECT DATA SET TO LINE circuit. Relay DS, the line-switching relay thence operates via a drive circuit, connecting the modem to line, tripping the ringing current and providing a holding circuit for relay FSA.

The cleardown of a telephone connexion set up for data transmission is initiated when either modem in the system is disconnected from the line, thus removing the carrier signal to the other modem. The carrier-detector circuit in the modem still connected to line, goes to OFF on the loss of an incoming signal and the data terminal equipment is then arranged to set the CONNECT DATA SET TO LINE interchange circuit to OFF, releasing relay DS and so disconnecting the modem from line. The above sequence of operations would also occur under certain fault conditions, e.g. the loss of the line circuit. To prevent the system clearing down in response to line breaks of short duration, the carrier-detector circuit has built-in on–off delay times, as indicated in Table 3.

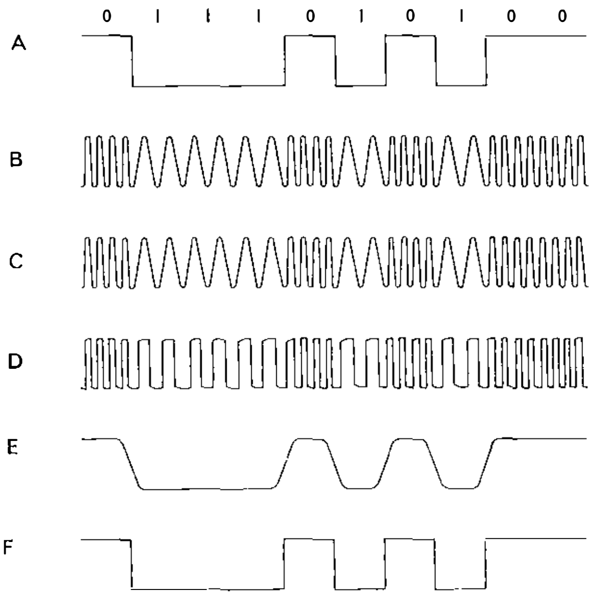
In addition to the above facilities Datel Modems No. 2B will include two extra functions listed in the revised C.C.I.T.T. Recommendation V21, namely DATEL TERMINAL READY and FREQUENCY SELECTOR. DATA TERMINAL READY is an optional use of the CONNECT DATA SET TO LINE interchange circuit and FREQUENCY SELECTOR enables the channel switching to be controlled from the customer's interface. Fig. 6(*a*), which is a simplified block diagram of the Datel Modem No. 2B, Mark 1,



Notes:

1. Carrier detector timing: on to off—50 ms; off to on—20 ms for private circuits and 500 ms for exchange lines
2. Operate delay >5 ms
3. Ready-for-sending time: off to on —35 ms or 700 ms; on to off—2 ms
4. Strapping for exchange line: 1–4, 2–6; strapping for private circuit: 2–5, 3–4, 4–6

(*a*) Simplified Block Schematic Diagram of Modem



A—Transmitted data signal
B—Output signal from oscillator
C—Input signal to limiter amplifier
D—Output signal from limiter amplifier
E—Output signal from post-discriminator filter
F—Received data signal

(*b*) Waveforms at Points A–F on Diagram (*a*)

FIG. 6—Explanatory diagram of Datel modem No. 2B Mark 1 showing waveforms at key points

shows the elements of both facilities. The DATA TERMINAL READY option is provided by removing the strap between points R and S in Fig. 6(*a*). An ON condition applied to the CONNECT DATA SET TO LINE interchange circuit, causes 0 volts to appear on the output of the DS relay drive circuit, thus preparing the operate circuit of relay DS, which can now be operated on the receipt of incoming ringing current or to a loop condition extended from a key on the associated telephone. It is arranged that incoming ringing current causes relay U to operate with the operation of relay A. The capacitor across relay DS is then charged towards −24 volts via a U relay contact. In the off period of ringing current, relay DS operates to the voltage across the charged capacitor through the contact of U relay, now released. The operation of relay DS trips the ringing current and connects the modem to line, relay DS then being held operated via its own and U relay contacts. This facility provides the customer with an alternative method of automatic answering which is useful in some system applications. A new interchange circuit called FREQUENCY SELECTOR, enables the channel-switching function to be controlled exclusively from the interface, an ON condition operating relay FSA to switch the modem into the ANSWER mode, and an OFF condition releasing the relay, so that the modem is conditioned to operate in the CALL mode. This facility is selected by disconnecting straps between points P and Q in Fig. 6(*a*).

CIRCUIT DESCRIPTION OF THE DATEL MODEM NO. 2B, MARK 1

The following brief description outlines the main features of the circuits of the transmit and receive data channels of the Datel Modem No. 2B, Mark 1. Fig. 6(*b*) shows the signal waveforms at various parts of the circuit. The circuit principles of the other Datel Modems No. 2 are identical, except for the stated interchange-circuit differences between the Modem No. 2A and Modems No. 2B.

The following description of the modem will assume that the modem is required to transmit data to, and receive data from, a distant terminal, over a telephone-switching network connexion. The modem is strapped therefore to conform with the C.C.I.T.T. recommendations for operation over the telephone network as indicated in Fig. 6(*a*). The modem will also be assumed to be in the CALL mode.

When a telephone connexion has been established to the distant terminal, an ON condition is applied from the data terminal equipment, on the CONNECT DATA SET TO LINE interchange circuit, to the modem. Relay DS operates and performs the following functions.

(*a*) It connects the modem to the telephone line.

(*b*) It connects +6 volts to a gate circuit which applies −20 volts to the collectors of the transistors in the 1,080 Hz modulator oscillator, which is then energized to transmit 1,180 Hz to line within 15 ms, via the 1,080 Hz filter and transmit amplifier,

(*c*) It connects +6 volts to a timing circuit, which responds after 400–1,000 ms, to return an ON condition via the READY FOR SENDING interchange circuit to the data terminal equipment. This delay is required to allow the system to reach a stable operating condition before data is transmitted, enabling the modem oscillators to stabilize and line transients due to the initial tone to decay,

(*d*) It connects an ON condition to the DATA SET READY interchange circuit to the data terminal indicating that the modem is connected to line.

A similar sequence of events at the distant terminal results in the receipt of a 1,850 Hz carrier, which turns the carrier-detector circuit ON within 300–700 ms of the signal appearing at the line terminals.

An ON condition on both the READY FOR SENDING and the CARRIER DETECTOR interchange circuits, indicates to the data terminal equipment that data transmission can start. Binary data signals are applied by the data terminal equipment on the TRANSMIT DATA interchange circuit to the modem. These signals are taken to the data input circuit, which regenerates them so that ±6-volt signals are applied to the modulator input.

The modulator is basically a simple oscillatory circuit in which the values of L and C are changed to generate the required frequencies. The ±6-volt input data signals are arranged to connect appropriate values of parallel reactance, by transformer coupling, into the tuned circuit of an oscillator so that its resonant frequency is changed to either 980 Hz or 1,180 Hz for the binary 1 and binary 0 inputs, respectively. The abrupt switching of the energy-storing elements in the oscillatory circuit leads to phase discontinuities and amplitude changes, but the resulting distortion of the transmitted signal is acceptable. The output from the modulator can be shown to be a frequency-modulated wave[9] with a minimum modulation index of 1,* most of the output-signal energy being concentrated at the carrier and first-order sideband frequencies. A resistive network enables the output level of the modulator to be adjusted in 0·5 dB steps. The buffer stage which follows the modulator prevents any variations in the input impedance of the transmit band-pass filter from loading the oscillator.

The modulated signal is taken to the 1,080 Hz band-pass filter, which is designed to give high out-band cut-off attenuation to minimize interchannel interference and to have acceptable group-delay/frequency distortion of in-band frequencies. The band-limited signal from the 1,080 Hz filter passes via a potential-divider network enabling the output of the signal to line to be adjusted in 2 dB steps between the limits of +1 dBm to −17 dBm. The transmit amplifier consists of two transistors connected as a Darlington pair, having a gain of 14 dB set by emitter feedback. The working point of the amplifier is selected so that the second-harmonic components produced in the amplifier are a minimum.

The output signals from the transmit amplifier are passed to the telephone connexion via a balanced transformer which matches the line impedance to the transmit and receive amplifiers. Provision is made to strap a hold coil (straps M to N in Fig. 6(*a*)) across the telephone line in order to hold the telephone connexion when the modem is switched to line.

The v.f. data signals received on channel 2 from the distant terminal are fed via the line transformer to the receive amplifier, which also consists of two transistors connected as a Darlington pair, emitter feedback setting the gain to 5 dB. Since the output of the transmit amplifier is directly connected to the input of the receive amplifier it is clearly undesirable for channel 1 frequency components to lie within the channel 2 pass band, since interference with the received signals would occur, resulting in high error-rates on this channel. Consideration of the channel frequencies shows that the second-harmonic component of 980 Hz (1,960 Hz) will cause interchannel interference, this frequency being nearly within the pass band of the channel 2 receive filter. To overcome this problem the working point of the receive amplifier can be adjusted by means of a variable potentiometer so that the phase and amplitude of the second-harmonic component of 980 Hz produced in this amplifier is opposite to the second-harmonic component of 980 Hz generated in the transmit amplifier and amplified by the receive amplifier. By this means an 80 dB rejection of the 1,960 Hz channel 1 second-harmonic component is achieved.

The output from the receive amplifier is taken to the 1,750 Hz channel 2 band-pass filter, which is designed to the same objectives as the channel 1 filter. The band-limited signal from the filter passes to the limiter-amplifier and carrier-detector circuits. The limiter-amplifier is a 3-stage

* Minimum modulation index

$$= \frac{\text{frequency shift between binary 0 and binary 1}}{\text{maximum modulation rate in bauds}}$$

d.c.-coupled amplifier, which converts the frequencies at its input into constant-amplitude frequency-modulated square waves at the output. These signals arc then fed to the discriminator stages via an impedance-matching buffer amplifier.

The discriminators are of a conventional design, consisting of two tuned transformers, resonant at 1,950 Hz and 1,550 Hz, for the 1,750 Hz discriminator and at 1,260 Hz and 900 Hz, for the 1,080 Hz discriminator, to give a substantially linear output/frequency characteristic. The signals developed across the tuned transformer secondary windings are rectified so that the voltage produced at the rectifier output is positive relative to a common reference point when a binary 0 frequency is received, and a negative voltage is produced when a binary 1 frequency is received. Voice-frequency components in the discriminator output are removed by the post-discriminator filter. The filter output is taken to a bistable-trigger circuit, which is arranged to switch to the voltage changes across the filter output, caused by the received data signals. An output stage following the trigger applies ±6 volts to the RECEIVE DATA interchange circuit, corresponding to the binary data signals transmitted from the distant terminal.

The input to the CARRIER-DETECTOR interchange circuit is derived from the second stage of the limiter amplifier. The limiter amplifier is designed so that for low-level input signals limiting does not occur at the second stage, the amplitude of the signal output from this stage being proportional to the input signal level. The output from the second stage of the limiter-amplifier is taken via an emitter-follower to a rectifier circuit across which is developed a voltage proportional to the received-signal level. This voltage forms part of the biasing to the input of a monostable trigger. When the received signal level falls to −48 dBm the voltage across the rectifier circuit, as set by a potentiometer in the second stage of the limiter-amplifier, is such that the monostable trigger is set, causing the CARRIER DETECTOR interchange circuit to change from ON to OFF, after a time interval determined by the time-constants of the monostable trigger. The OFF condition of the CARRIER DETECTOR circuit can, if required, be used to clamp the RECEIVED DATA circuit to either an OFF or an ON condition, this being removed when the CARRIER-DETECTOR circuit is next restored to the ON condition. The CARRIER DETECTOR circuit changes its state from OFF to ON when the level of the received signal from line is between −46 and −43 dBm; the monostable trigger is then reset via a different time-constant circuit.

All Modems No. 2 are operated from a.c. mains, the power unit providing −24-volt, +12-volt, +6-volt and −6-volt d.c. outputs, together with a 4·5-volt d.c. supply to act as a local power supply for the associated telephone if necessary.

REMOTE-TEST FACILITY

The remote-test facility is used by the testing officer at a datel test centre to check that a modem at an installation is functioning correctly. This is done by establishing a telephone connexion between the datel test centre and the customer's installation, the customer being requested to co-operate with the testing officer by operating a non-locking test-button and removing the interface plug at the rear of the modem when a 980 Hz tone is heard in the associated telephone receiver. The operation of the remote test-button operates the test relay, T, in the modem. Relay T, in operating, operates relay DS, thus connecting the modem to line. Other contacts of relay T connect the ON condition of the CARRIER-DETECTOR circuit (ON to the received carrier from the test centre) to the modulater oscillator, which is energised, and to the READY-FOR-SENDING timing circuit, the +6-volt output being used to hold relay T operated via a relay-drive circuit; in addition, the RECEIVE DATA circuit is connected to the TRANSMIT DATA circuit, enabling the received-data signals on channel 1 to be returned on channel 2 to the datel test centre for examination. The remote test facility is restored when the line signal from the datel test centre is removed, causing the carrier detector circuit in the modem under test to go to OFF, thus releasing relay T.

CONCLUSIONS

The Datel Modem No. 2A, which has been available to customers since 1967, has given reliable performance at transmission rates up to 200 bits/s. The service has been used primarily over switched public telephone network connexions.

The Datel 200 service has grown rapidly since its inauguration, and it is estimated that, from a present total of about 500 installations, the number of installations in 1973 is likely to be about 17,000. This growth is a reflection of the important role of the modem in the developments occurring in time-sharing computer bureaux systems.

ACKNOWLEDGMENTS

The Datel Modem No. 2A and the Datel Modem No. 2B Mark 1 were designed and developed to a British Post Office specification by the Telephone Manufacturing Company, Ltd.; the Datel Modem No. 2B Mark 2 is manufactured by Standard Telephones and Cables, Ltd., to a modified electrical design of the Datel Modem No. 2A.

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Mechanization of Cable Recovery

M. DOHERTY†

U.D.C. 621.395.7 : 654.15 : 629.114.3

The recovery of old telephone cables absorbs 25 per cent of the total manhours on cabling work. Productivity will be improved by the use of a versatile, trailer-mounted winch towed by a 7-ton stores-carrying vehicle which has successfully completed its field trials. The recovered cable is still cut into pieces manually but the development of automatic methods is proceeding.

INTRODUCTION

The recovery of old telephone cables is a tedious task taking a large number of manhours and represents approximately 25 per cent of the total manhours on cabling work. The amount of main trunk cable programmed for recovery during 1968–69 is 450 sheath miles. To help in this work, and the recovery of many local cables, a machine is being produced which will enable redundant cables to be recovered with minimum expenditure of manpower and physical effort.

To meet the wide range of manhole conditions and cable types encountered in the field, the machine must be extremely versatile. It must, for instance, be capable of dealing with cable from $\frac{1}{2}$ in to 3 in in diameter, with polythene or lead sheathing materials, plain and protected (hessian, pernax, polythene). The lengths of cable to be recovered vary from a few yards to about 180 yards.

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THE WINCH

The winch, which is mounted on a trailer towed by a 7-ton vehicle, shown in Fig. 1, consists of two capstans of 28 in and 9 in diameter mounted on the same shaft and driven by a 6·5 h.p. diesel engine through a 3-speed gearbox and a reduction gear. Table 1 shows the speeds and the tensions which can be achieved by the capstans.

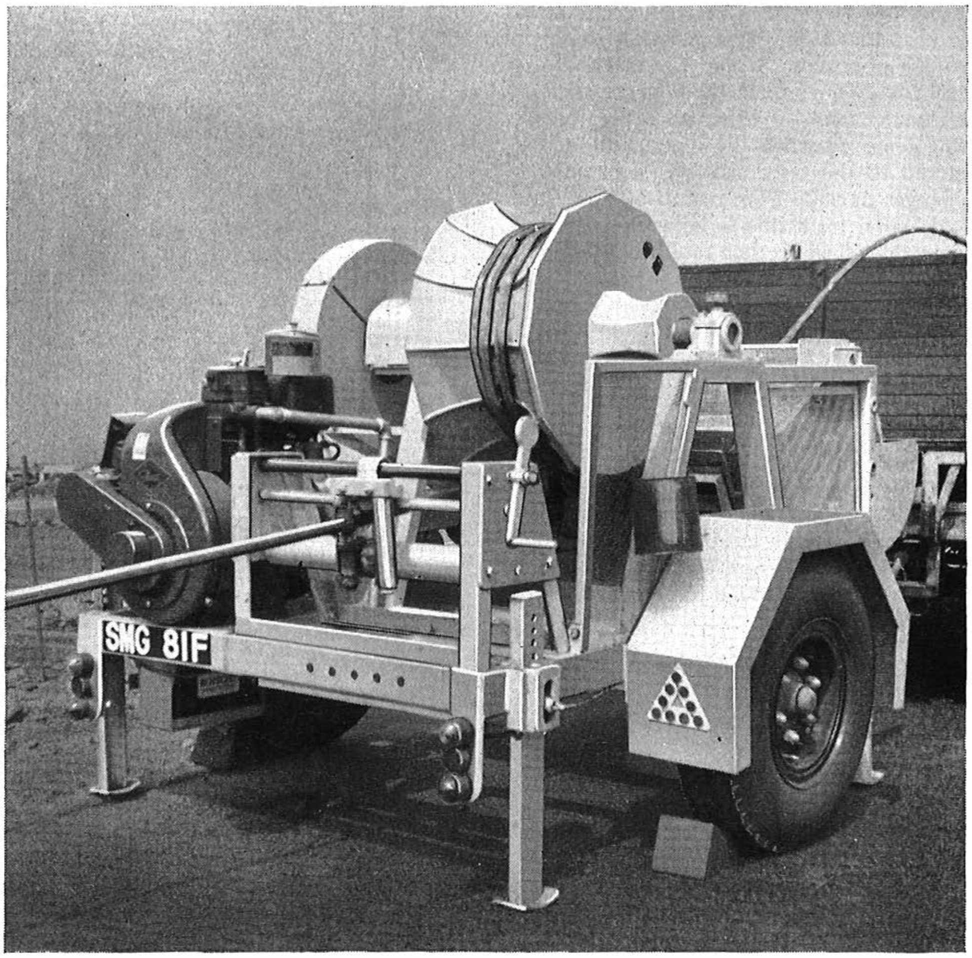

FIG. 1—Cable-recovery winch towed by 7-ton stores-carrying vehicle

TABLE 1
Capstan speeds and tensions

	Large capstan		Small capstan	
	Speed (ft/min)	Tension (tons)	Speed (ft/min)	Tension (tons)
1st gear	19	3·0	5	10·5
2nd gear	40	1·5	10	4·9
3rd gear	80	0·75	20	2·5

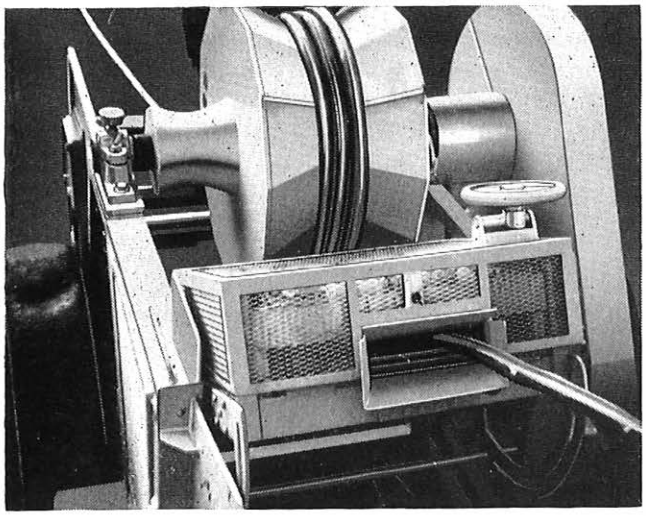

FIG. 2—Power-driven take-up rollers keep the cable tight on the capstan

FIG 3—Cable-guiding equipment for use with the recovery winch

The cable is kept tight on the capstan by two pairs of power-driven take-up rollers, see Fig. 2. To guide the cable from a manhole to the capstan, a pair of roller quadrants and adjustable mountings have been designed, and these are shown in Fig. 3. This equipment is fixed to the rear chassis-member of the trailer and its lower end strutted against the wall of the manhole containing the duct.

To give sufficient pull to free the cable in the duct, a short length of steel rope is attached to the cable end and given three turns round the small capstan with the low gear engaged. When the cable has moved substantially, a higher capstan speed can be used until the cable is clear of the manhole. The steel rope is then transferred to the large capstan and the cable allowed to follow the rope onto the capstan for one or two turns. The cable end is then fed between the tensioning rollers, which are tightened on to the cable. The winch will continue to pull the cable out of the duct with the minimum of supervision, the speed and tension being selected by engaging the appropriate gear.

CUTTING UP

Cable is delivered from the tensioning rollers on to the platform of the 7-ton stores-carrying vehicle, where it can be cut into 4-ft lengths and placed on pallets. Currently, cutting is carried out manually by a pneumatic cutter which will sever a maximum-size cable in $1\frac{1}{2}$ to 2 seconds. This is just fast enough to keep pace with the winch, which can deliver cable for cutting at up to 80 ft/min. Field trials have shown that further advantage might be gained by fully automating the cutting operation so that the machine pulls out the cable, cuts it and delivers it in 4-ft lengths suitable for palletization, or for bundling with steel bands. A machine of this type has just started its trials. A crane mounted on the towing vehicle would ensure that the bundles could be unloaded mechanically, even at depots where a fork-lift truck is not available.

CABLE-RECOVERY METHODS

To achieve maximum performance from the machine, the process of cable recovery must be carefully organized. The first operation is to ensure that the cable scheduled for recovery is free from working circuits and is identified, cut, and marked in the manhole or jointboxes. Manholes need to be pumped out and buried jointboxes and couplings opened so that the machine can proceed with the minimum of interruption. Disposal of the scrap cable needs to be expedited to avoid large amounts occupying valuable storage space for long periods. In ideal conditions it is possible to set up the recovery winch, pull out a typical length of cable, cut it up and move to the next manhole in approximately half an hour. Under good conditions, recovery of full-size cable at the rate of one mile a day is possible. The unit is very suitable for the recovery of old trunk and junction cables and high recovery rates are achievable if it is employed continuously on this work. For recovery of local cables, a suitable program of work must be arranged.

Field trials have proved the usefulness of the cable-recovery winch and development continues, particularly on the automatic cutting of recovered cable.

Electronic Telephone Exchanges: TXE 2—A Small Electronic Exchange System

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The first type of electronic exchange to be used in large numbers by the British Post Office is a small exchange, covering the size range 200–2,000 lines. The space-division system is used, and switching is carried out with reed-relays. This article describes the trunking and operation of the exchange, the physical design and the features, both inherent and in the form of maintenance facilities, which enable a high quality service to be given to subscribers.

INTRODUCTION

The small electronic exchange system, TXE 2, has been designed for use as a local exchange in the approximate size range of 200–2,000 lines, and is now in full-scale production for the Post Office. It was designed under the auspices of the Joint Electronic Research Committee by Ericsson Telephones Ltd. in collaboration with the Post Office.

The system is register controlled, and employs a multi-stage network of co-ordinate reed-relay switches.[1] It gives a full range of subscriber facilities, and has simple growth capabilities within the designed size range. This range can be increased, should it be found to be necessary, after installation. The equipment is compact, has inherent reliability, is simple to install and maintain, and is compatible with the existing telephone network.

SYSTEM OUTLINE

The reed-relay[2] with four dry-reed inserts is used in the switching network for the speech path cross-point and for logic purposes in the control circuits. It has a high reliability as the contacts are sealed against the atmosphere, a high operating speed, requires a small amount of space and lends itself to fully-automatic production techniques. Fig. 1 shows a typical reed-relay with four dry-reed inserts and twenty-five such relays mounted in a 5 × 5 matrix. When used as cross-point relays, two of the inserts are used for switching the speech path, the third for switching the control and testing wire (P-wire), and the fourth switches the operate and hold circuits. A basic switch used in the system consists of 25 reed-relays arranged to form a 5 × 5 cross-point matrix.

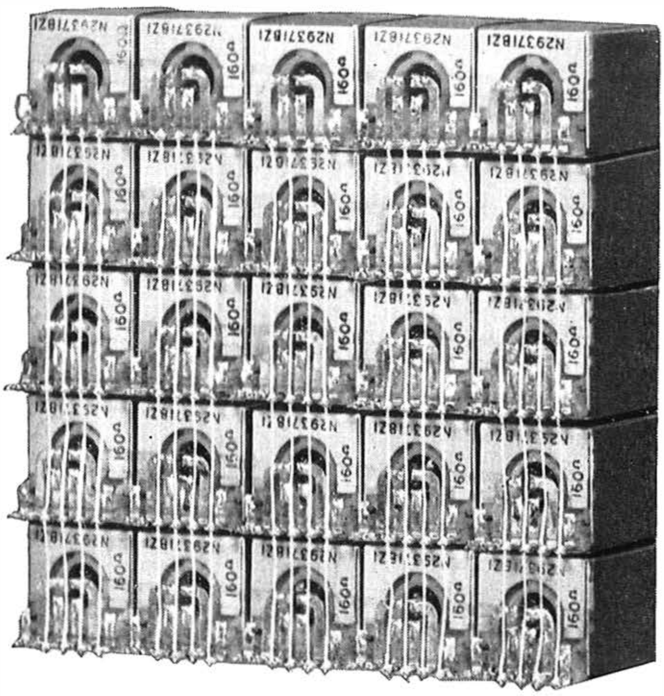
Fig. 2 shows the exchange system in simple schematic form. The exchange can be divided into three main areas.

(*a*) The switching area, with three cross-point-type switching stages, A, B and C, for originating and terminating traffic, and an additional switching stage, D, for terminating traffic.

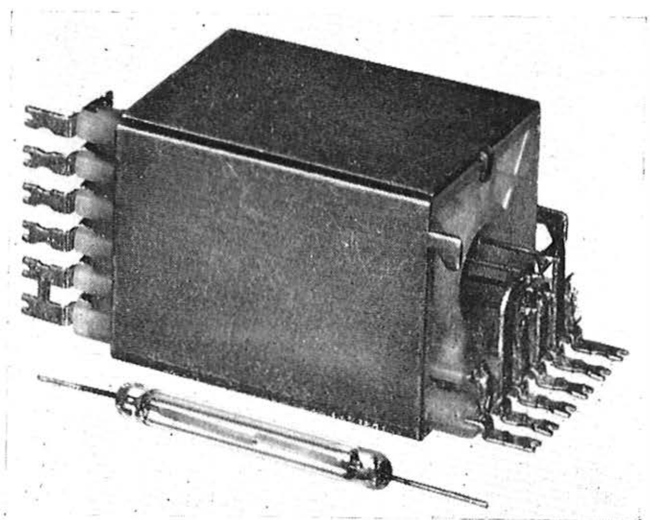
(*b*) The supervisory and register area with outgoing junction, incoming junction and own-exchange supervisory relay-sets, together with a common pool of registers serving all three types.

(*c*) The common control area with calling-line selection, speech-path selection and call-control equipment.

Subscribers' lines are connected via their line circuits to A-switches. Outgoing supervisory relay-sets are connected to C-switches and incoming supervisory relay-sets to D-switches.



(*a*) 5 × 5 matrix



(*b*) Reed-relay and dry-reed insert

FIG. 1—Reed-relay matrix

† Electronic Exchange Development Branch, Telecommunications Development Department, Telecommunications Headquarters.

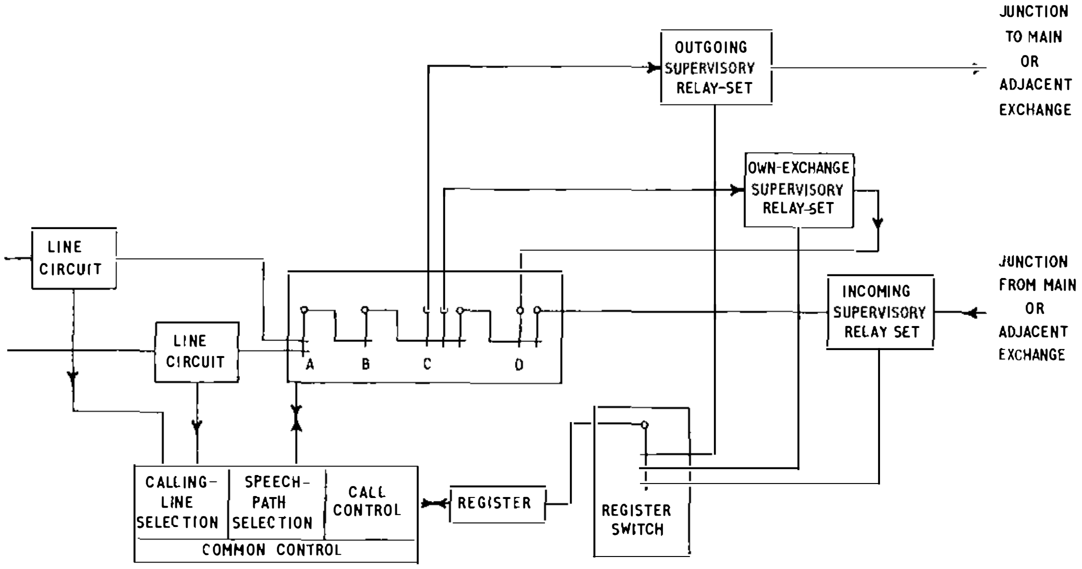


FIG. 2—TXE2 exchange system: simplified schematic

●wn-exchange supervisory relay-sets, which are used on local calls, combine the outgoing and incoming functions, and are connected between C-switches and D-switches. The speech paths between subscribers' lines and supervisory relay-sets are connected by operating the cross-point switches in switching stages A, B, C and, when appropriate, in stage D. The A-switches, B-switchcs and C-switchcs are assembled from basic 5 × 5 cross-point matrices and the D-switches from 4 × 5 matrices.

Calls through the switching network are controlled by one centralized common control which, for security reasons, is duplicated and consists of a combination of reed-relays, semi-conductors, and other solid-state components. Calls are processed on a one-at-a-time basis in a sequential manner. The relatively fast processing time of 50 ms ensures that there is very little delay in setting up calls which arrive almost simultaneously.

When a subscriber calls, a path is set from the subscriber's line to either an own-exchange supervisory relay-set or a primary junction-route supervisory relay-set, from each of which access is given to the registers. The dialled information received by the register will indicate the route required. If this is different from the route initially selected at the time the call originated, the register discriminates during an inter-digital pause, releasing the original connexion and establishing a new path to the required route.

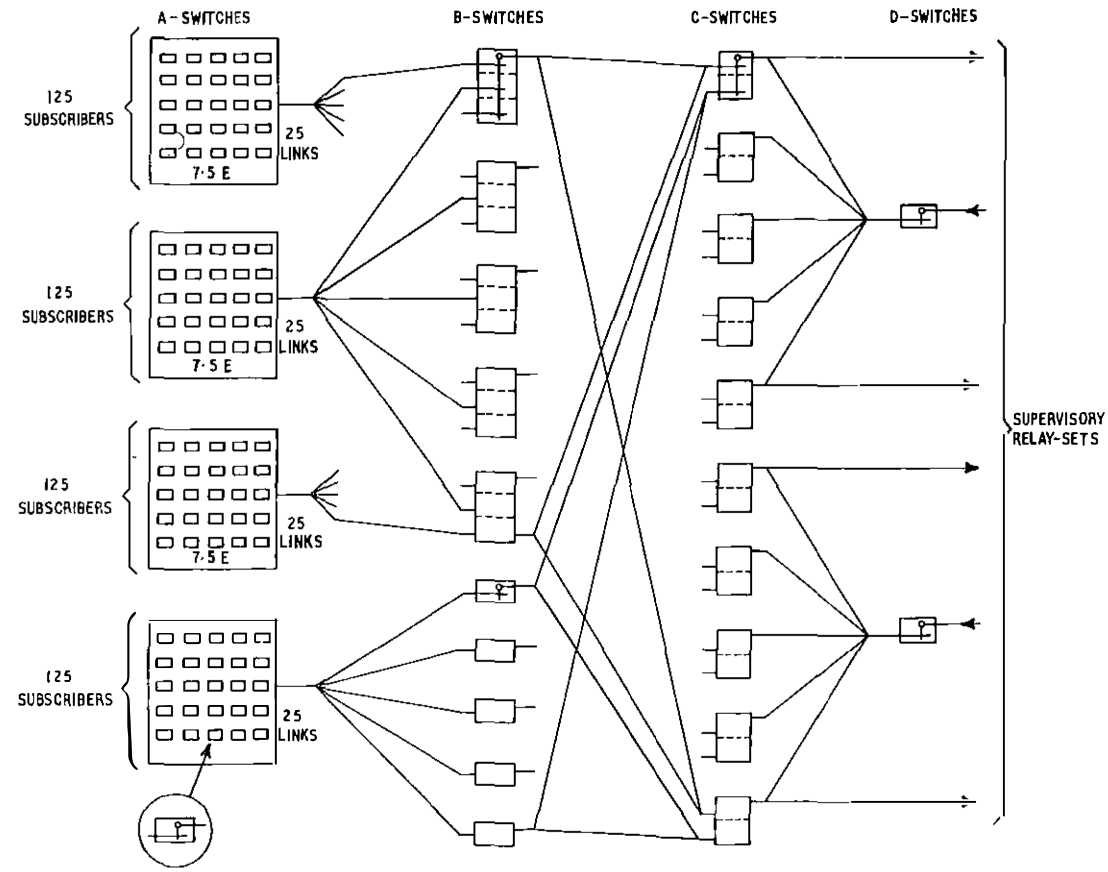


FIG. 3—Basic exchange trunking arrangements

TRUNKING

General

In the A-switching stage, the basic 5 × 5 switch allows five subscribers' lines to be connected to five B-switches in the B-switching stage. Each B-switch has ten outlets giving access to ten C-switches in the C-switching stage. Thus, each subscriber has access to every C-switch and so to every supervisory relay-set. The trunking arrangements are shown in Fig. 3.

A-Switching Stage

The A-switching stage concentrates subscribers' traffic by commoning the A-switch outlets on to the A-switch to B-switch (A–B) links. The outlets of the A-switches are interconnected so that no two switches share more than one link. The interconnecting arrangement results in a good traffic-handling capability and permits a mixture of high and low calling rate subscribers to be allocated at random to a group of A-switches. A typical A-stage group consists of 25 basic 5 × 5 switches connected on to 25 A–B links. The total traffic which can be carried on the 25 links in a group is 7·5 erlangs.

B-Switching Stage

Up to three A-stage groups may be connected to a given set of five B-switches, resulting in 5 × 10, 10 × 10 or 15 × 10 B-switches. The rack wiring is provided to cater for the 15 × 10 B-switch, but the switches are mounted as separate 5 × 10 plug-in units. Thus, increased traffic in 7·5 erlang steps can be catered for by additional plug-in switches.

When the traffic is greater than 22·5 erlangs, the five 15 × 10 B-switches are fully loaded, and more than three A-stage groups are required, hence another set of five B-switches are provided and will grow as described for the first group of B-switches. When the traffic is greater than 45 erlangs, a third group of B-switches is required, and so on, to a total capacity of 240 erlangs.

C-Switching Stage

Each B-switch has 10 outlets serving 10 C-switches. The number of inlets to the 10 C-switches depends on the number of 22·5 erlang B-switch groups. The number of C-switch outlets depends on the number of outgoing junctions, own-exchange supervisory circuits and D-switch inlets required. Provision has therefore been made for the C-stage switches to grow in the two co-ordinate dimensions. This has been made easier by mounting the B-switches and the related co-ordinates of the C-switch on the same rack.

D-Switching Stage

D-switches have been introduced so that a terminating call can be given a choice of C-switches from which to find a path to the wanted subscriber, and thereby reduce traffic blocking. The D-switch gives own-exchange and incoming supervisory relay-sets access to five of the 10 C-switches.

SYSTEM OPERATION: ORIGINATING CALL

The exchange equipment has two main functions: to provide a speech path between a subscriber's line and the supervisory equipment, and to select and set-up this path. The selection and setting-up procedure requires that the identities of both the calling and called subscribers are stored in the register.

The calling condition must be detected and the line identified so that its connexion into the switching network can be controlled.

The Line Circuit

Each exchange line is jumpered to a line circuit designed to operate to a loop calling condition from the subscriber's instrument. The operation of relay LR to this condition starts the calling-line selection and identification process (Fig. 4). The line circuit is identified by an equipment number, and any subscriber's line or directory number may be connected to any equipment number. The line circuit handles both originating and terminating calls. Because the complete

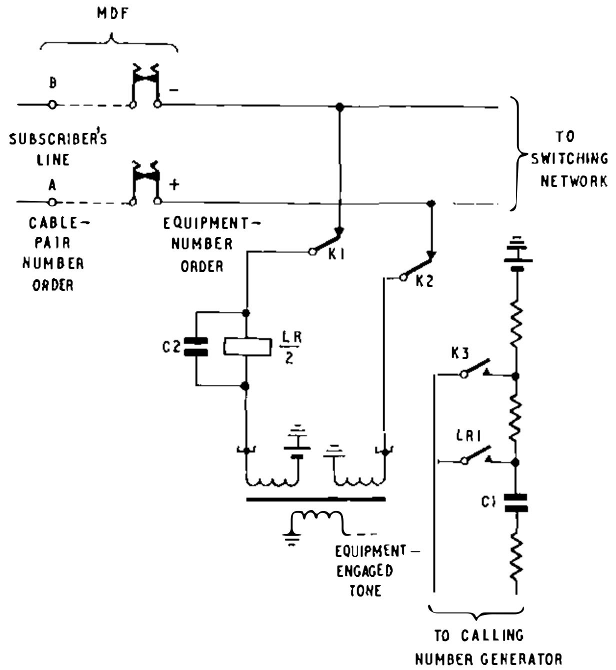


FIG. 4—Subscriber's line circuit

circuit requires change-over contact actions on both the LR and K relays, the present equipment uses Type 12 relays[3] for these functions. Fig. 4 shows how equipment-engaged tone can be inductively coupled into the line feed, to ensure that the subscriber is not left without tone if network blocking prevents a connexion being completed.

The Calling Number Generator

As a result of relay LR operating in the line circuit, the identity of the calling line in directory number form is generated and stored, so that, subsequently, the line circuit can be identified, or marked. On operation of relay LR in the line circuit, a current pulse passes in a jumper wire threading an array of pulse transformers (Fig. 5). This array, known as the calling number generator, consists essentially of four rows of pulse transformers, known as cores, each row representing, respectively, the thousands, hundreds, tens and units parts of the directory number. There are 10 transformers in each row, each of these representing a digit 0–9. The jumper is connected to the equipment number (EN) tag from the line circuit and passes through a start core, the appropriate thousands, hundreds, tens and units cores and is terminated on a similar EN tag at the bottom of the field.

Where the local exchange uses 5-digit or 6-digit directory numbers, the last four digits only are generated, as these are sufficient to identify the calling subscriber.

When the circuit is idle the capacitor C1 is charged to 50 volts (Fig. 4). Operation of relay LR in the line circuit causes the capacitor to discharge around the loop of jumper wire between the EN tags. The jumper forms a single-turn winding on each core through which it passes, and the output signals from the secondary windings of the cores are amplified and stored. To reduce the storage required for the calling-line identity, each decimal digit is coded into a 2-out-of-5 form. The K-relay contact performs two functions; on originating calls it ensures that when the LR relay is disconnected from the line, the capacitor cannot be charged, so that on clear-down any bounce on the switch-hook contacts of the telephone instrument will not cause spurious calling conditions into the exchange. On incoming calls, contact K3 slowly discharges the capacitor so that no pulse is generated. Thus, when the calling party clears, relay K releases and connects relay LR to the called subscriber's loop. Contact LR1 is now ineffective.

It is important for the exchange to be buffered against spurious calling signals, hence two start signals are generated in response to the pulse from the line circuit. These are S and SS as shown in Fig. 6. The start signal, S, is fed to an insensitive amplifier so that, unless a pulse of adequate amplitude is received, the call cannot proceed. The second start signal, SS, is taken to a sensitive amplifier so that, in the event of signal SS being produced in the absence of signal S, a spurious noise condition is assumed with the chance that a partial code may have been generated. The store is then cleared as a precautionary measure.

The outputs from the pulse transformers, through which the calling subscriber's calling number generator jumper

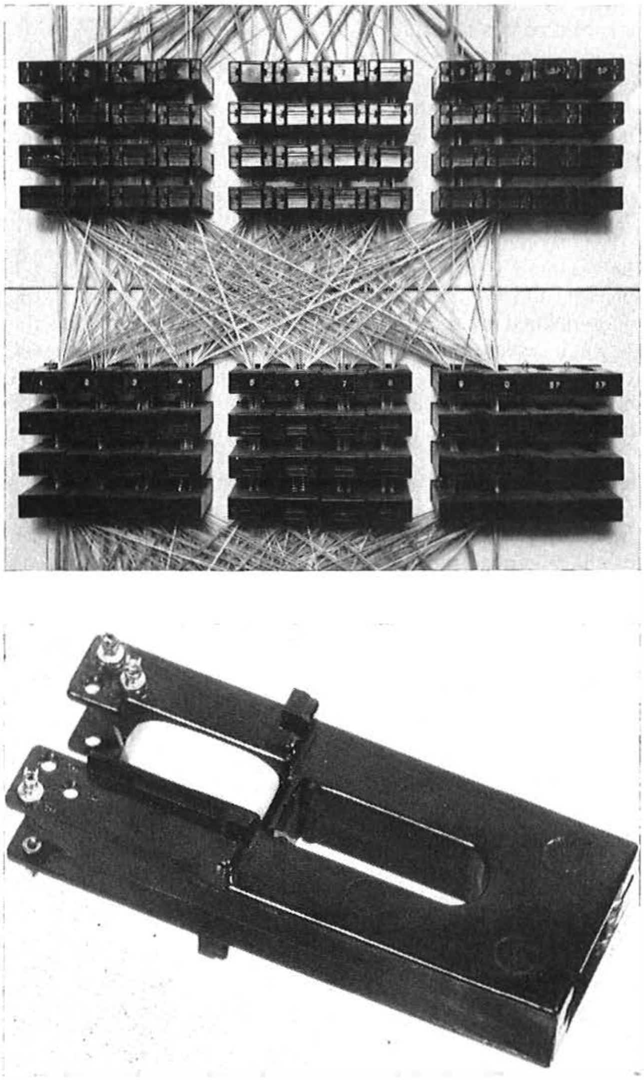


FIG. 5—The calling number generator and an individual core

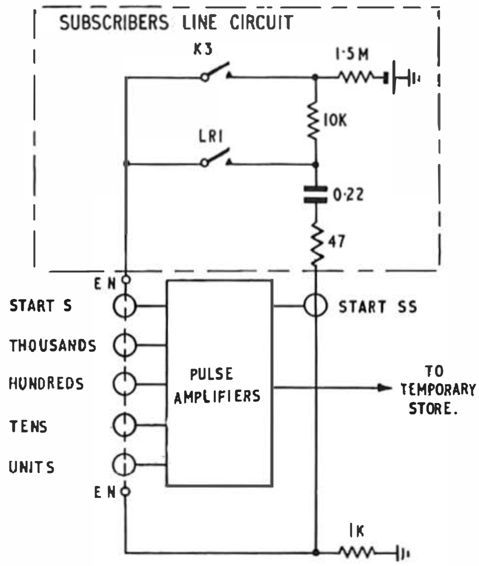


FIG. 6—Simplified circuit of the calling number generator

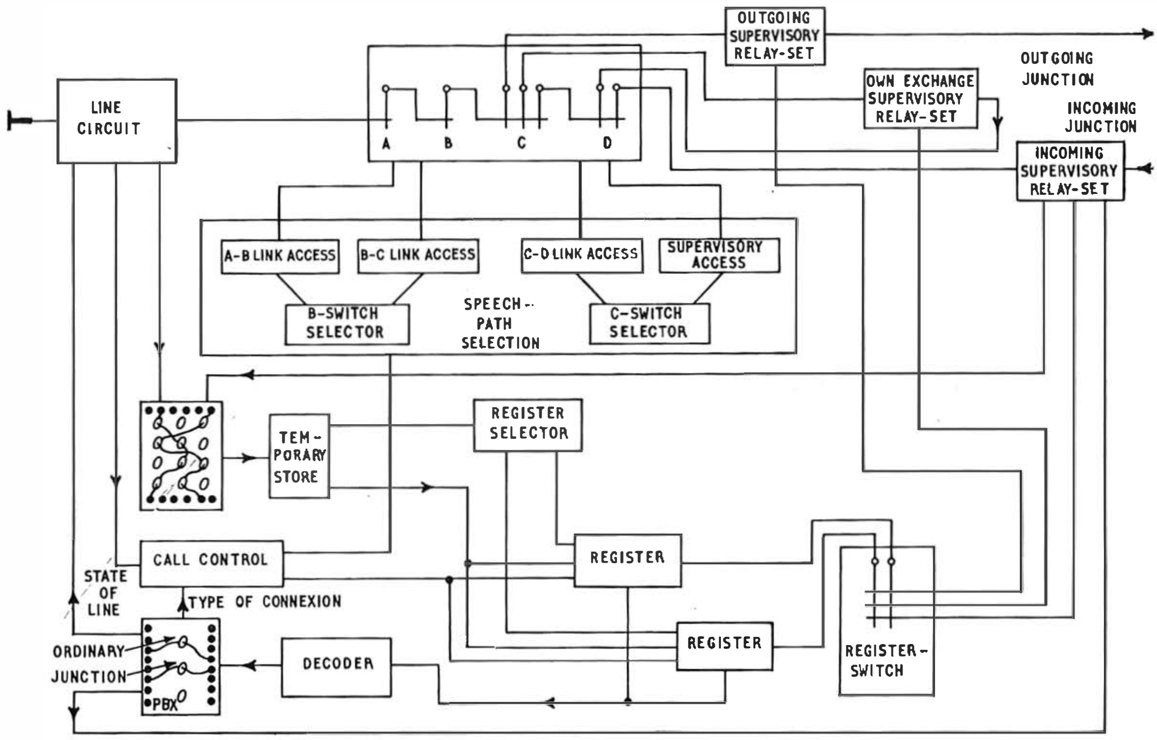


FIG. 7—TXE2 exchange system: detailed schematic

connexion is wired, pass into a temporary high-speed store. From there the signals pass rapidly into a second high-speed store, and the process of selecting a free register is started. When selection is complete the calling line's directory number passes into the register store. The use of two high-speed buffer stores has two advantages; calls originated in quick succession can be distinguished, and time is allowed to select a free register, thus permitting the use of inexpensive reed-relay access and storage in the register (Fig. 7). This arrangement can handle calls arriving at not less than 100 μs apart.

Speech-Path Selection

The subsequent testing, selection, marking and switching processes are performed on a one-at-a-time basis, and hence the register signals a demand to the call control for the exclusive use of the exchange common-control equipment. When the register receives a signal from the call control to proceed, it passes the calling subscriber's directory number to the decoder where it is changed from 2-out-of-5 code to a 1-out-of-N signal, which appears on a specific output lead at the top of a translation field. A jumper wire from this lead to the line-circuit marker relay is threaded through an appropriate pulse-transformer core. The core generates the class of service of the subscriber, e.g. ordinary, shared-service, coin box, and passes this information to the register. The class-of-service signal enables a normal setting-up program to be modified when required.

Operation of the marker relay in the line circuit operates the access relays which extend the busy/free condition of the five A–B links available to the subscriber into the B-switch selector (Fig. 8). The marker relay also defines the section or plane in the C-switches to which the calling line has access.

A C-switch, with at least one free supervisory relay-set of the required type on its output, is chosen by the C-switch selector, and the five B–C links of the chosen C-switch in the plane defined by the calling subscriber are extended into the B-switch selector. The type of supervisory relay-set chosen for the initial connexion will depend upon the program used in the particular exchange. It will generally be a circuit in the major traffic route.

The B-switch selector will now attempt to find a free path between the A-switch and the selected C-switch. If a free path cannot be found, an alternative C-switch is chosen and the above process repeated until all possible paths have been tested. When a free path is found, a selection is made to determine which supervisory relay-set will be used on the chosen C-switch.

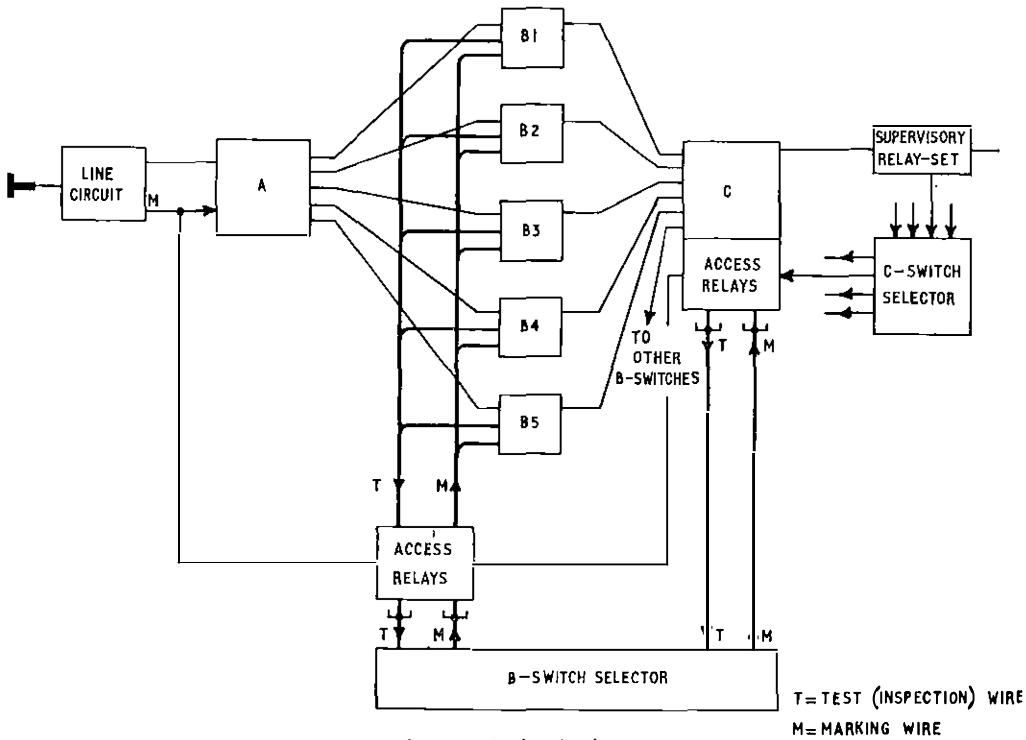


FIG. 8—Path selection

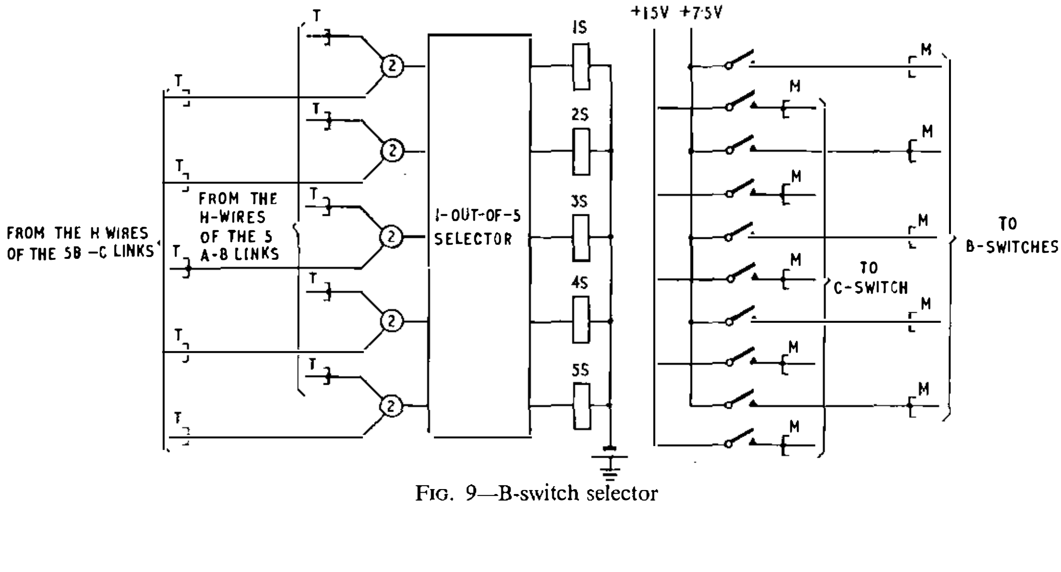


FIG. 9—B-switch selector

The selectors used in choosing a speech path are all similar in principle, having five inputs and five outputs. They operate in a sequential, non-homing manner; the potentials on the inputs are examined and one output, corresponding to a free input condition, is defined. Hence the circuit is referred to as a 1-out-of-5 selector. As a fail-safe feature, battery-testing principles are employed to indicate free or busy conditions. The elements of the B-switch selector are shown in Fig. 9. Since the selector is testing for link pairs, it is preceded by five, 2-input transistor AND gates. The 1-out-of-5 selection is performed by interconnected diode AND gates.

point relay replaces the marking earth with negative potential. The initial end-to-end holding potential is thus 100 volts, but the positive battery is subsequently removed, leaving the cross-point relays holding in series to an earth at the supervisory relay-set.[4]

The supervisory relay-set operates the K relay in the line circuit by applying an earth to the P-wire, thereby disconnecting the LR relay from the line. The line is extended from the supervisory relay-set into the register by means of a fully-available register switch. The register supplies line-feed current, returns dial tone and awaits dial pulses (Fig. 11).

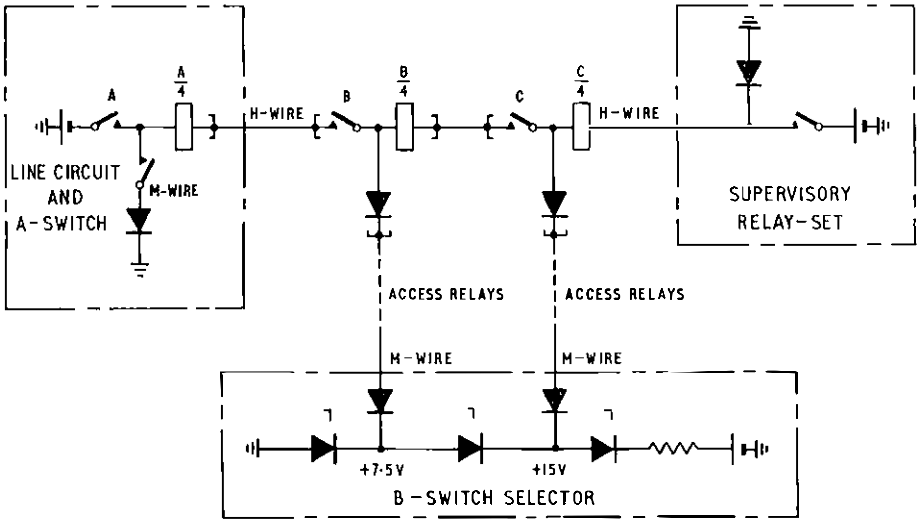


Fig. 10—Marking the selected path

The marking of the path to be switched is shown in Fig. 10. The selected supervisory relay-set is marked by the common-control equipment and as a result, the supervisory relay-set applies positive battery to the H-wire. The line circuit being marked has earth applied to the M-wire of its A-switch cross-point relays. Positive potentials are applied to the M-wires of the B-switch and C-switch by the selector and access circuits. Hence the C-switch cross-point operates in the C-switch, followed by the B-switch cross-point and the A-switch cross-point. The operation of the A-switch cross-

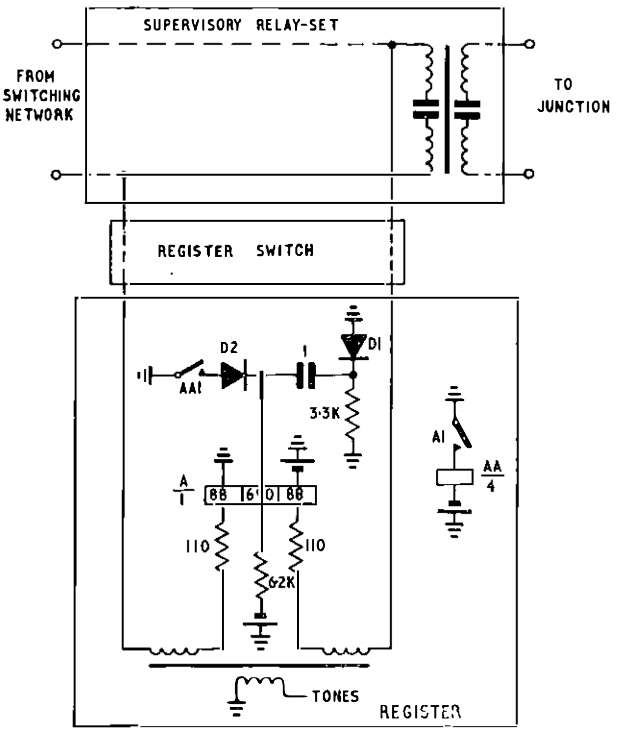


Fig. 11—Register pulsing element

The time taken from the operation of the line relay to the return of dial tone is approximately 50 ms.

Dialling

When relay A operates (Fig. 11), it operates the relief relay AA, a contact of which energizes the 690-ohm bias winding of relay A. The effective ampere-turns in relay A are reduced, since the flux produced by the bias winding is in opposition to the other windings. Hence, when the dial contacts open, relay A will release quickly. This reduces positive-pulse distortion on highly capacitive lines. The capacitor-resistor circuit connected to the bias winding of relay A eliminates contact bounce on relay A, and ensures that relay A does not flick-operate when relay AA releases. Diode D1 ensures a short charge-time for the capacitor, while the 3·3 kohm resistor limits the discharge current, and hence protects contact AA1.

The register pulsing-relay feeds a 10-bit counter. An inter-

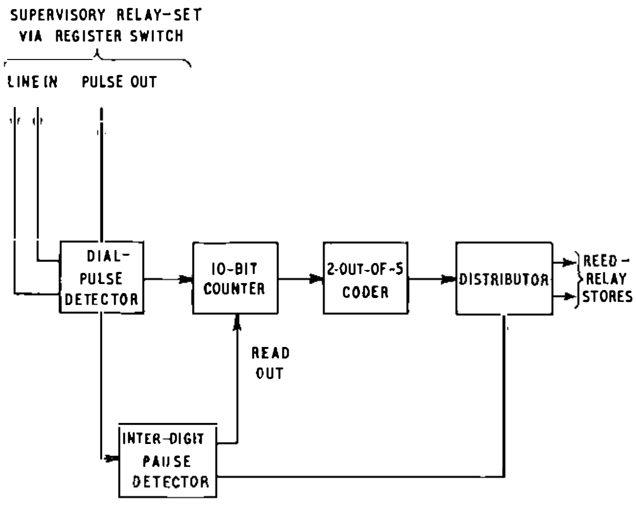


Fig. 12—Block schematic of the register pulse detector and counter circuits

digit-pause detection circuit causes read-out of the counter via a 2-out-of-5 coder and distributor into a reed-relay store. Fig. 12 shows the element in schematic form.

Provision is made for simultaneous pulse-repetition via the supervisory relay-set to a junction when required.

Register Discrimination

The register, in conjunction with other common-control equipment, can determine the route required from the dialled digits. If this is different from the route chosen when the register connexion was made, the supervisory relay-set releases the connexion during an inter-digital pause and the selection process is repeated. This time a path to a supervisory relay-set of the required type is established. The register can be reconnected before the arrival of the next digit. If the register finds that the outgoing route required was chosen on the original connexion, then it can transfer control to the supervisory relay-set and the register releases; any further digits are repeated directly by the supervisory relay-sets.

The principle functions of the supervisory relay-set are to provide a transmission bridge, control the call, and, when appropriate, provide junction signalling.

SYSTEM OPERATION: TERMINATING CALLS

Own-Exchange Call

The system organization for connecting a calling subscriber to an own-exchange supervisory relay-set has been described above. When the complete number of the wanted line has been dialled and stored in the register, a new demand for call control is made and the sequence used for the initial connexion is repeated. The directory number of the wanted subscriber is passed to the decoder and translated to mark the line circuit of the wanted line. The class of service of the wanted line is determined, and also the state of the line circuit, i.e. free, busy, or parked. A line circuit is parked as the result of a permanent calling condition.

If the wanted line is engaged or parked, the appropriate tone is sent to the calling line from the register. If free, the own-exchange supervisory relay-set handling the call is marked so that access relays in the associated D-switch operate and extend the five C-switch to D-switch links into the C-switch selector. The path-selection process proceeds as for the originating call, the wanted line being switched to the calling side of the supervisory relay-set. The register and common-control equipment are then released for further calls.

Incoming-Junction Call

Seizure of an incoming supervisory relay-set causes an identity number to be generated in the calling-number generator in the same way in which, on an originating call, the calling subscriber's directory number is generated when a line circuit is operated. The subsequent program is very similar to that for an originating call in that the identity of the calling junction is transferred into a register. A priority signal is generated so that a register handling an incoming call will have preference in obtaining the use of the common-control equipment.

The identifying number is passed via the decoder to mark the incoming supervisory relay-set, and the register switch operates to extend the junction into the register. The number of the wanted line now passes into the register, and the procedure is then identical to that for an own-exchange call.

Standardization of the switching sequences for originating, incoming and own-exchange calls has enabled the common-control logic to be kept to a minimum, which is an essential requirement in an exchange system designed to be economic with only 200 lines.

SECURITY AND MAINTENANCE

Despite the need for economy, especially at the smaller sizes, exchange service has to be safeguarded under fault conditions. Security and maintenance features include the use of inherently reliable components with adequate working tolerances in the circuit design.[5]

In the setting-up and control of each call, use is made of equipment common to the whole exchange, so for security this equipment is duplicated. Under normal conditions the two sets of common equipment are brought into service alternately every eight minutes. If a fault occurs in one set of common equipment, then this set is locked out and the other maintains service continuously. An alarm is given to the Maintenance Control Centre requesting the attendance of a maintenance engineer. To eliminate any possibility of a fault remaining undetected for long periods, as could occur during a low calling-rate period, test calls simulating originating calls are automatically passed through the exchange after each periodic change-over.

A feature of the system, which allows a repeat attempt to be made at setting up a path through the switching network if a fault is detected on the initial attempt, has a profound effect on the quality of service given to the subscriber. The primary object is to give service whenever possible, regardless of faults. Therefore, when a faulty speech path cross-point is detected, or a call fails to mature owing to a transient fault, the common equipment makes a second attempt to establish the call using a different network path wherever possible.

The system incorporates many automatic fault-detection circuits. When a fault is detected, the particular equipment section affected is usually indicated. Accessible test points are provided to check the circuit condition before removal of the equipment unit. Faults that are detected in the system are automatically printed on a 5-inch wide paper tape. Ninety bits of information can be recorded on the tape to describe the state of the equipment when a fault is detected. The information includes the directory number of the calling and called subscribers, the speech path chosen, and the nature of the fault. Other maintenance aids designed into the system include the provision for setting up calls to any particular supervisory relay-set, displaying the directory number of the calling and called lines at the register, and call and path tracing.

FACILITIES

The facilities provided by a TXE2 exchange include all the facilities offered by the equivalent Strowger exchange, and in addition a number of new features.

(*a*) A radical improvement in p.b.x. working has been achieved. Because any equipment number may be associated with any directory number, thecustomarypractice of reserving groups of numbers for p.b.x. lines is not required. Any size of p.b.x. group may be formed without the need for consecutive directory or equipment numbering.

(*b*) Barring of outgoing or incoming calls is easily achieved. A particular exchange line may be barred by threading the jumper wire on the translation field to include the outgoing-call-barred core or the incoming-call-barred core.

(*c*) Complete flexibility is provided between subscribers' equipment positions and the directory numbers of the subscribers. Therefore, if due to changing traffic conditions it is required to reconnect subscribers to a different section of the exchange, there is no necessity to change their numbers.

(*d*) Subscriber-controlled transfer. When connected for this service a subscriber can, by dialling an appropriate code, arrange for his incoming calls to be transferred to any of a group of specified subscribers' lines. The controlling subscriber's telephone line is allocated an ex-directory number as well as the directory number. Close associates of the subscriber can thus communicate with the subscriber's line even when the directory number is on transfer, as in the case of an off-duty doctor.

In addition, anticipatory provision has been made for the following further features:

(*a*) Keyphones. The calling number generator and register association arrangements have been organized so that keyphone registers may be readily added.

(*b*) Freefone service. The arrangements for giving freefone service, which enables the called subscriber to pay for incoming calls, are being developed.

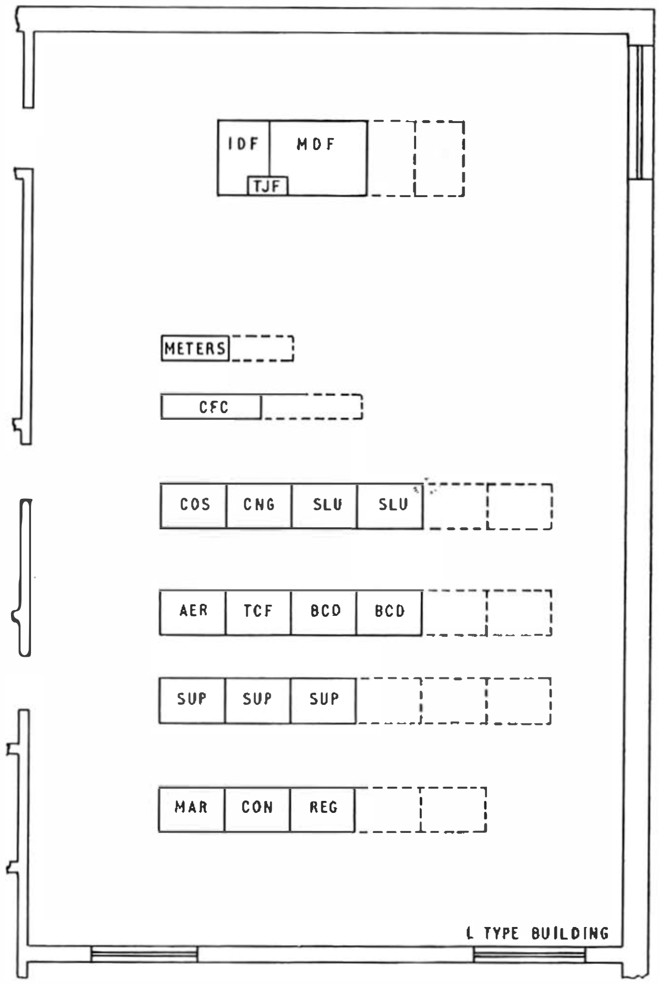
(*c*) Calling-line identification. The availability of the subscriber's directory number in the register will assist in the later provision of calling-line identification to a centralized point, if required in the future.

(*d*) Short-code dialling. Short-code-dialling equipment could be made available to the registers, which would then pass to the equipments the identity of the calling line to enable the appropriate routing translation to be given when a preallocated abbreviated code is dialled into the register.

PHYSICAL REALIZATION AND EQUIPMENT LAYOUT

The electronic equipment is contained in either 8 ft 6 in or 10 ft 6 in high racks. Each rack is 3 ft wide and 1 ft 10 in deep, and is composed of shelves containing a number of plug-in units, generally of the type shown in Fig. 13.

A typical exchange layout for a 1,000-line exchange is shown in Fig. 14. Each subscriber's line unit rack caters for 500 exchange lines. A number of B-switches, C-switches and D-switches are grouped on a rack, and each rack can cater for 45 erlangs of traffic, but the later versions can cater for 67 erlangs of traffic. The exchange requires no special ventilation facilities and is powered from conventional battery power supplies of +50 and −50 volts. The power consumption is comparable with that of an equivalent size Strowger exchange. The exchange equipment occupies about half the volume of a Strowger exchange having the same number of lines. This space economy has been achieved by the use of small components and compact layout, consistent with the requirements of accessibility.



AER — Alarm equipment rack
BCD — B-switch, C-switch, D-switch rack
CFC — Coin and Fee Check equipment rack
CNG — Calling number generator rack
CON — Control equipment rack
COS — Class of service rack
IDF — Intermediate distribution frame
MAR — Miscellaneous apparatus rack
MDF — Main distribution frame
REG — Register rack
SLU — Subscriber's line unit rack
SUP — Supervisory equipment rack
TCF — Trunk connecting frame
TJF — Test jack frame

Note: Racks shown by dotted lines are for exchange growth

FIG. 14—Typical TXE2 exchange layout

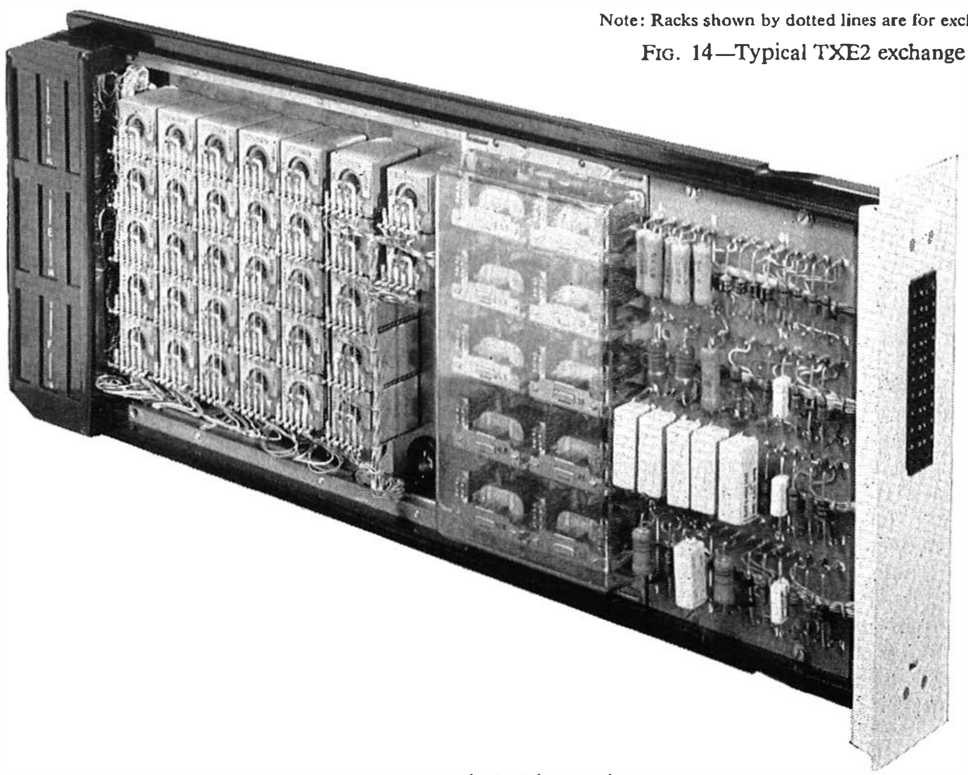


FIG. 13—Typical slide-in unit

SIZE RANGE

The system has been designed for use as a local exchange in the size range of 200–2,000 lines, or 240 erlangs of traffic. Development work has now been completed on increasing the capacity of the exchange, to approximately 4,000 directory numbers, by physical redesign of the calling-number generator and class of service fields. However, the total traffic must not exceed the 240 erlangs limit.

A method of connecting two exchange units to effectively double the capacity of the electronic exchange up to 8,000 directory numbers, or 480 erlangs of traffic, has been developed. The principles adopted employ close interworking between the two exchange units so that the subscriber services are identical to those provided by a single exchange. Terminating supervisory relay-sets are given access to both exchange units, the unit required on terminating calls being determined by the initial digit(s) received.

Further development is planned to increase the capacity still further, and hence the field of application of the system is continually expanding.

CONCLUSIONS

TXE 2 exchanges are now in quantity production, and the exchanges that are in public service are justifying the claims advanced for electronic systems. The maintenance commitment is much less than that required for a Strowger exchange of equivalent size. The service given to the subscriber is much improved due to the comprehensive fault-checking arrangements and repeat-attempt facility. The flexibility inherent in the system organization gives the ability for future subscriber and service facilities to be provided when required.

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Containers for Transporting Mail

U.D.C. 656.86.2 : 621.798.15

For transporting parcels and letters in bags between offices and within sorting offices a new wheeled container is to be introduced experimentally until a comprehensive design study can be completed. This short article describes the new interim standard container which is suitable for use in either normal rail and road vehicles or freightliners.

Parcels and letters have been carried in bags for many years but with the advent of mechanization a larger container is required. The postal business has launched a complete study of mail handling to try to optimize the design of a range of containers from letter trays to freightliners. While this study is being carried out, experience is to be gained using an interim design of container for parcels.

This interim standard container, designated Post Office Trailer, Universal Mark III (POTU Mk.111), can be towed or manhandled, put into road vehicles, ordinary parcel trains or freightliners. The container superstructure has smooth walls to permit automatic loading and emptying, and can be either 5 ft 6 in high, with a closed lid, for normal rail use, or extended to 6 ft 9 in high, with an open top, to go into a freightliner. Under the latter condition it is not necessary to have a closed lid, as Post Office staff will close the freightliner container. The container has one side that can be dropped down to ease the loading and unloading when this is done by hand. Fig. 1 shows the container with the side lowered, and Fig. 2 with the container in its extended-height position.

At the extended height the container will hold about 100 parcels. The unladen weight is about 300 lbs and is easily manoeuverable by one man. When fully loaded the total weight could be over a ton, although usually it will be nearer to 1,000 lb, and two men are needed to move it. Alternatively it can be towed by a tractor. Tractors will be able to tow up to a maximum of 15 containers in line with safety. An overrun brake is provided as well as a parking brake and the parking brake is automatically applied when the brake handle is released. The base is 4 ft × 3 ft and has two fixed wheels and two castors. The castors are similar to those used on BRUTEs (British Railways Universal Trailing Equipment) in that the axis of the castor is not on the centre line of the castor wheel. This reduces the snaking action of the trailers when they are towed in a train.

The interim containers fail to meet the operational requirements in two major aspects. One obvious one is that the cost is higher than that desirable. It would also have been better for the container to be collapsible. The parcel-post flow between two centres is rarely balanced, and empty containers

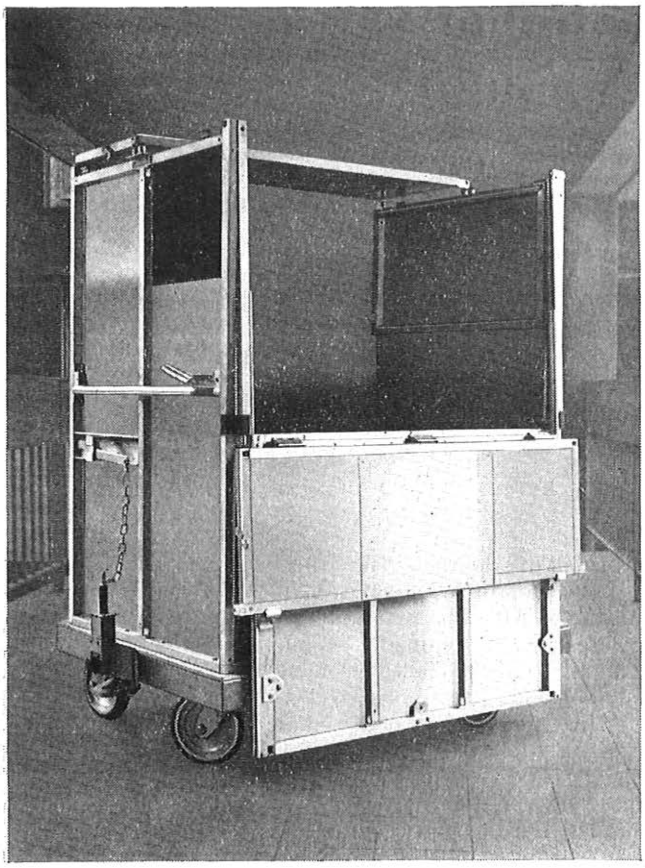

FIG. 1—Wheeled container with side lowered for loading

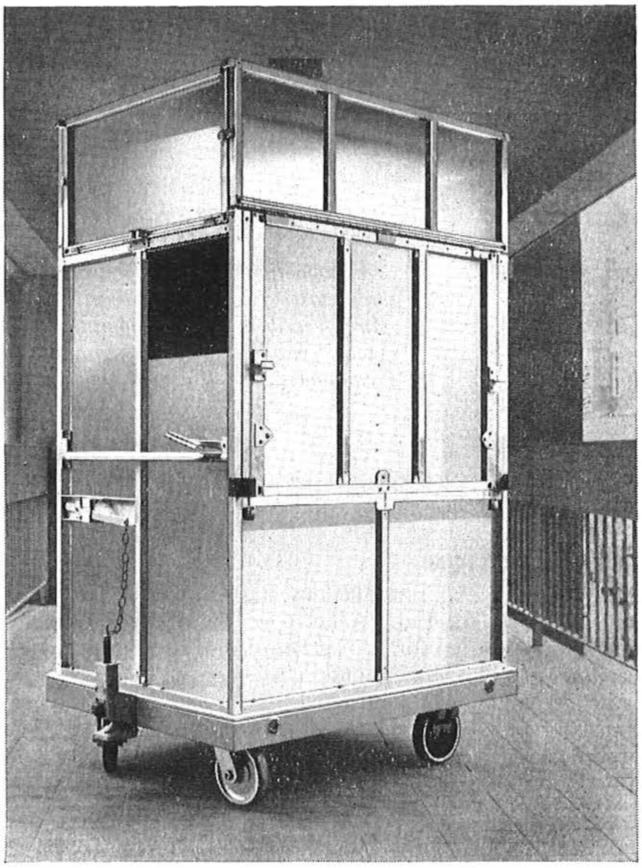

FIG. 2 — Wheeled container extended to 6 ft 9 in height for use in freightliners

have to be transported. There is an economic advantage to be gained if the containers can be collapsed and returned empty at a low cost. In addition, to cater for peaks of demand, empty containers must be stored at sorting offices and the cost of the storage can be reduced if they can be stored in a minimum of floor space.

In spite of the limitations of the interim container it will prove very useful to gain experience in operating with containers and for experiments with mechanical emptying and loading machinery.

C. E. E. C.

Book Review

"Network Analysis and Transmission Lines." G. J. Konully, M.A.(Physics), M.S. Asia Publishing House. 339 pp. 445 ill. 30s.

This volume, which could be considered as a collection of four related books on current circuits, networks, transmission lines, and modern circuit analysis, has the merits and demerits of its origins.

In the main, it is based on lectures given to telecommunication students, and is therefore particularly suited to such a readership, who will welcome the many worked examples which have been included.

Diagrams are based on what appear to be the author's quite neatly executed, freehand sketches. In itself, this can be a good idea, in making the author-reader relationship approach that of lecturer-student in intimacy. However, it is spoiled in many instances by uneven and blurred reproduction, which goes ill with the smallness essential to packing so much information into one book, albeit still of some 380 pages. It is not immediately obvious, for instance, that Fig. 27 is upside down. Furthermore, the standard of printing and quality of paper are such that the reverse side of the page tends to become obtrusive.

It would be a pity if these drawbacks, not helped by a certain awkwardness of style, are found to detract too much from the merit of the contents. This volume can in fact be recommended not only to students but to engineers requiring a reference book more informative than the normal pocket variety. It would be useful, for instance, to refresh the memory on the application of Laplace Transforms or Smith Charts, or to extract a particular formula. Nevertheless, a certain degree of caution should be exercised. As a case in point, the cut-off of a loaded cable is expressed in terms of C and L where these are section values, but not expressly stated as such. In fact, the formula is set in a text environment where the symbols are used freely in their quite usual role as primary constants. The reader is presumably expected to have the chapter on filters fully in mind.

All in all, this is a worthwhile book in spite of its presentation.

P.R.B.

A Register-Translator for Control of a Large P.A.B.X.

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U.D.C. 621.395.25

A magnetic-drum register-translator is being used to control originating calls on a 6,500-line privately-purchased p.a.b.x., and to give facilities additional to those normally provided. The equipment principles are described, and the operation of the system in providing typical facilities is outlined. The problems of security of service, taking into account the estimated component-failure rate of the common-control equipment, are discussed, and the maintenance aids and documentation are also described.

INTRODUCTION

A 6,500-line p.a.b.x., installed by the Automatic Telephone and Electric Co., Ltd. (A.T.E.), of the Plessey Telecommunications Group for British Petroleum, Ltd., in their new headquarters building in London, uses conventional Strowger switching equipment controlled by an electronic register-translator based on magnetic-drum storage techniques. The procedure used to control the planning, development and installation of this p.a.b.x. was the subject of an earlier article in this Journal.[1] The switching equipment is basically a pre-standard A.T.E. P.A.B.X. No. 4[2] and will not be described here. The register-translator provides a common control for the setting-up of all calls within the p.a.b.x., except for directly-dialled incoming traffic, and enables many additional facilities to be provided.

While the general organization of the magnetic-drum equipment follows principles established for subscriber-trunk-dialling (s.t.d.) register-translators and is described elsewhere,[3] the equipment uses transistors, a different equipment practice and later-type magnetic drums.[4,5]

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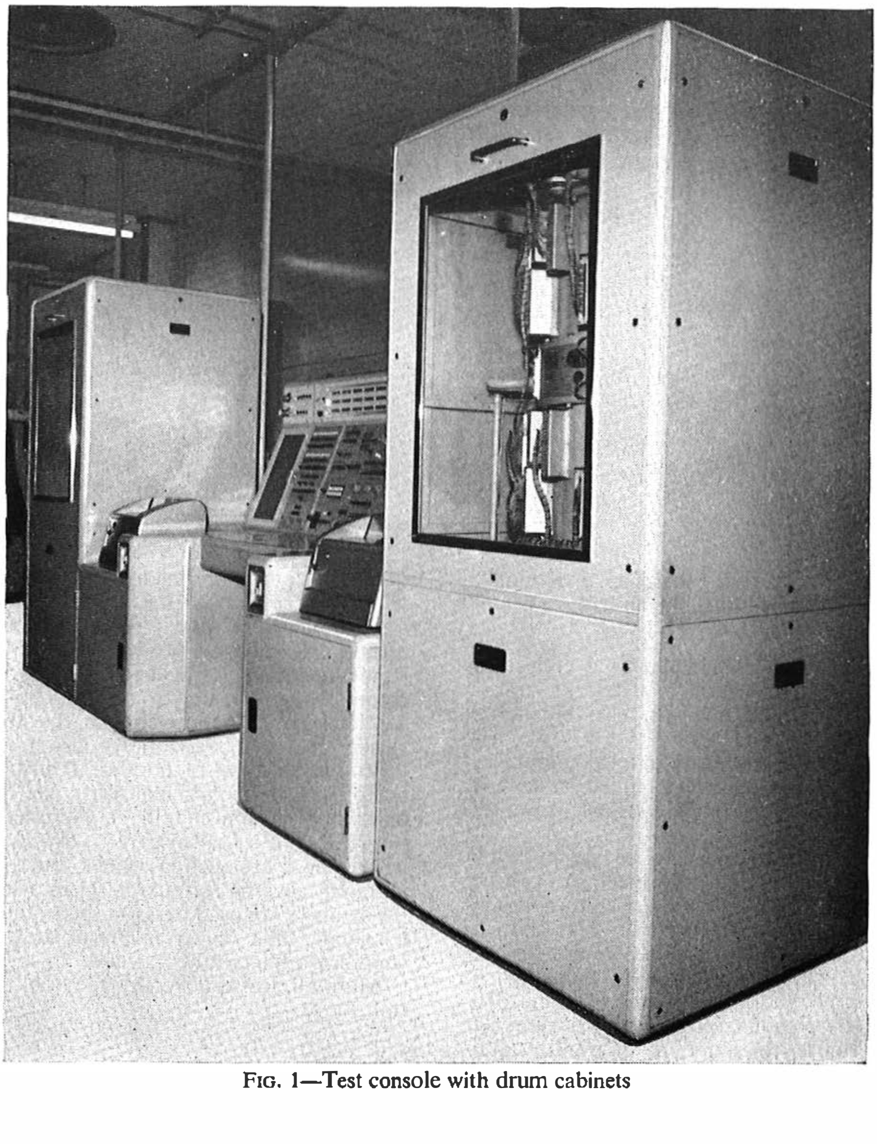


FIG. 1—Test console with drum cabinets

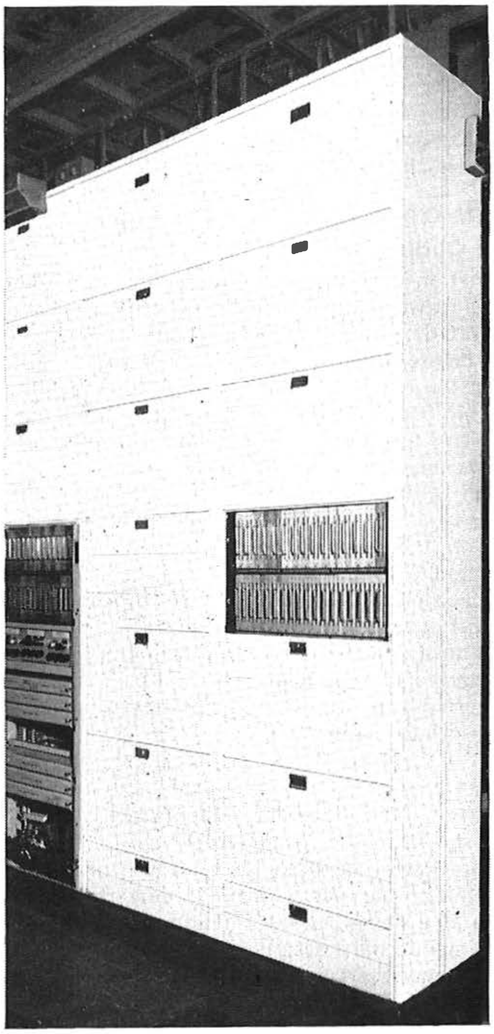


FIG. 2—Electronic-equipment racks

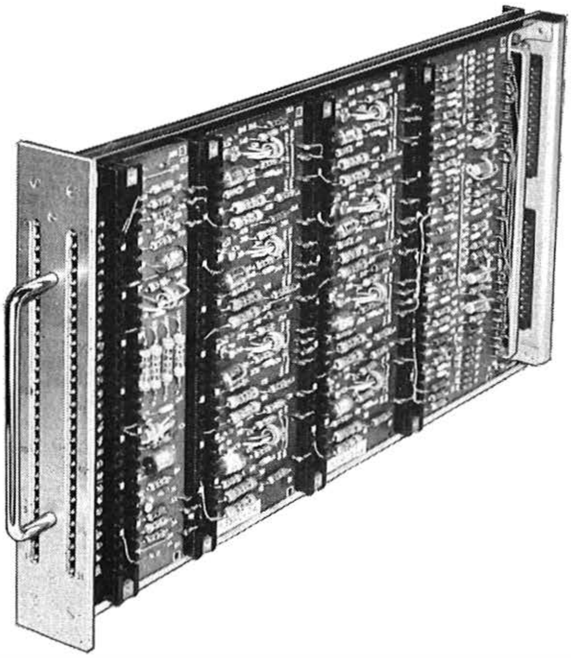


FIG. 3—Typical slide-in unit

EQUIPMENT PRINCIPLES

Two magnetic drums, each with its own electronic equipment, are provided to give adequate system security, and, under normal working conditions, both equipments are operational and share the exchange traffic on a random basis. Fig. 1 shows the duplicate drum cabinets with the control and test console between them. This console houses the keys, switches and lamps required for the control and alarm features of the system, and gives access facilities to all drum tracks for program writing, as well as providing printing-out facilities for test routines. Fig. 2 shows two of the five 10 ft 6 in equipment racks. Each rack shelf accommodates up to 18 slide-in units similar to that shown in Fig. 3, on which four printed-wiring boards are mounted on each side of the unit.

Magnetic Drums

The drums used were manufactured by the Sperry Gyroscope Co. Ltd., and are equipped with recording heads designed and manufactured by A.T.E. Each drum unit consists of two 12 in diameter iron-oxide-coated cylinders mounted coaxially on a vertical shaft, with a common induction-motor drive mounted between them. The assembly is completely enclosed in a mantle with precisely-located apertures for mounting recording heads in groups of 25, as shown in Fig. 4, which indicates the division of the assembly

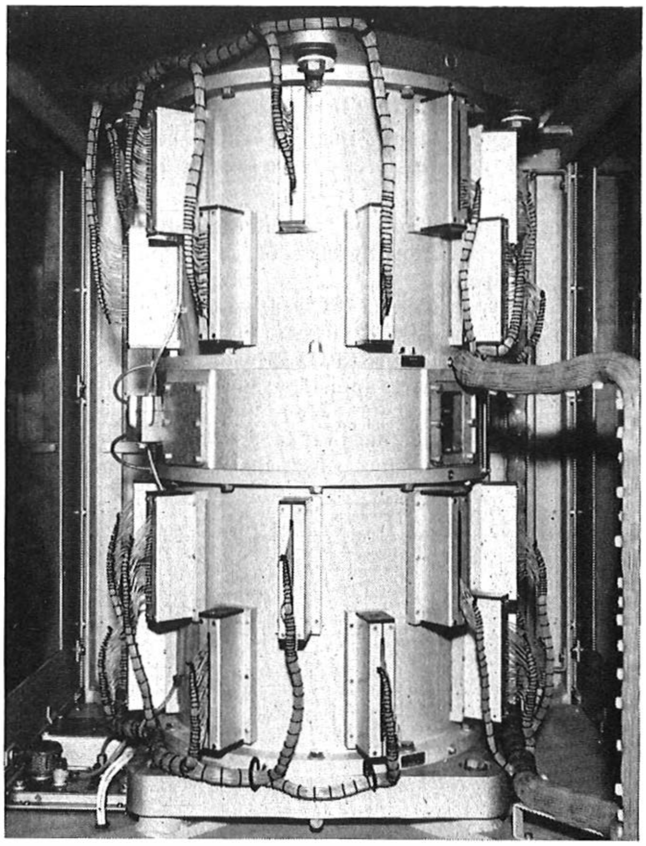


FIG. 4—Drum assembly

into upper and lower drum areas with a central drive section.

No speed control is used, the drum operating close to 1,500 revolutions/minute, the synchronous speed of the 3-phase induction motor at the standard mains frequency, 50 Hz. Four hundred tracks are available, and binary information is stored at 3,960 bits per track. The packing density is thus approximately 100 bits per inch, the total storage capacity about 1·6 million bits and the bit rate, or system frequency, nominally 100 kHz. Synchronization of the drum with its associated electronic equipment is achieved by means of a recorded clock track on the drum. The output pulses from this track drive a series of ring counters, which ensure the correct timing of all operations and make the system independent of small variations in drum speed. No attempt is made to synchronize the two drums; each equipment operates independently for most processes. When it is necessary to transfer information between the two equipments, signals read out from one equipment are staticized on transistor 2-state memory circuits, and then written into the other equipment.

Information is stored on the drum in binary/decimal code, and a basic word-length of six bits is used. This provides four bits to represent the decimal number, and two bits are available for control purposes. The storage capacity of 1·6 million bits is thus equivalent to 270,000 decimal digits.

In addition to the use of the drum as a large-capacity memory, regenerative techniques on drum tracks assist in data-manipulation processes. These tracks on the drum are referred to as temporary stores, and register tracks and transfer tracks are typical examples. However, most of the drum storage is used for reference or library information that is recorded on permanent-store tracks which, although equipped with both read heads and write heads, have only the read heads connected to the electronic equipment. The write heads are only connected when it is necessary to change the contents of the stores. This operation is controlled from the test console, where the required store can be selected on a series of rotary switches, the appropriate write head connected by a coaxial link and the information in the store changed by a simple keying-in operation. A visual display allows the information to be checked on a transfer track before being written into the permanent store.

ADDITIONAL FACILITIES

The additional facilities that can readily be provided as a consequence of using an electronic register-translator are as follows.

(*i*) Push-button signalling from all extensions.

(*ii*) Route restriction by class of service on calls to the public exchange.

(*iii*) Short-code dialling (SCD 4) with 4-digit access to a common library of 3,000 addresses.

(*iv*) Short-code dialling (SCD 2) with 2-digit access from nominated extensions to individual libraries of 40 addresses each.

(*v*) Calling-line identification (c.l.i.) and class of service (c.o.s.) display on assistance calls to the p.a.b.x. manual board.

(*vi*) Automatic re-routing via the public network of inter-switchboard calls encountering route-busy conditions.

(*vii*) Automatic re-routing of extension-extension calls.

(*viii*) Automatic message accounting (a.m.a.).

(*ix*) Watchman's patrol recording.

(*x*) Direct-access key-calling without multiple cabling.

(*xi*) Teledictation recorder access.

SYSTEM OPERATION

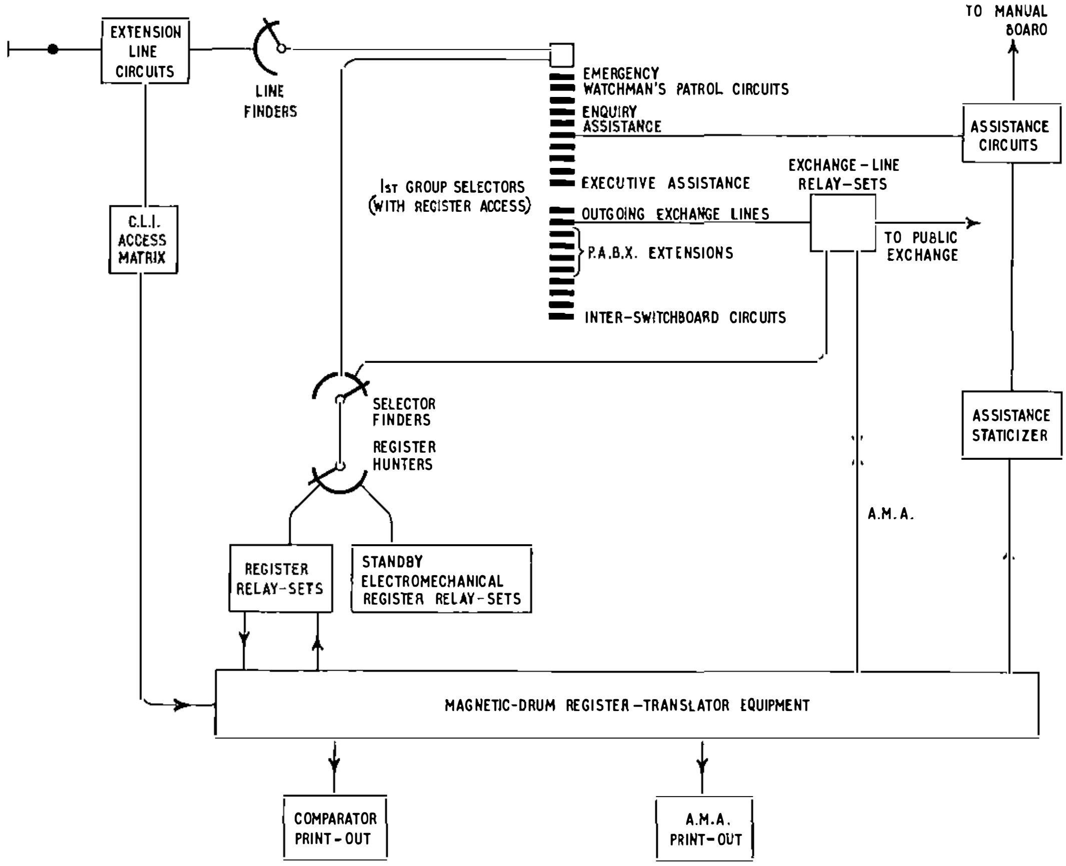
General Outline

Information originating from a calling line-circuit is collected in a register store, where it may be altered in accordance with a pre-determined program, built into the electronic control, before instructions are released to the switch train to set up the required connexion. Fig. 5 shows the general relationship between electronic and electromechanical equipment. Access to the registers is obtained from register relay-sets via scanning circuits so that each register relay-set is associated with a particular register store on the drum. The c.l.i. matrix associates each line circuit with its individual address on the drum library tracks, where its directory number and c.o.s. information are stored. For automatic message accounting (a.m.a.), scanners provide a connexion directly between the outgoing exchange line relay-set and the a.m.a. control circuits on the drum equipment.

Assistance staticizers allow c.l.i. and c.o.s. information to be transferred from drum registers to the particular assistance circuit associated with a call.

Registers

The layout of the 40 registers on four tracks of the magnetic drum is shown in Fig. 6, and each register appears under a reading (or writing) head twice in each drum revolution. This reduces the register-access time by half, giving access in 20 ms to write information into a register, while, for reading-out purposes, the four tracks plus a dummy track are scanned serially every 100 ms. The layout of register



A.M.A.—Automatic message accounting C.L.I.—Calling-line indentification

FIG. 5—Trunking diagram showing relationship of electronic and electromechanical equipment

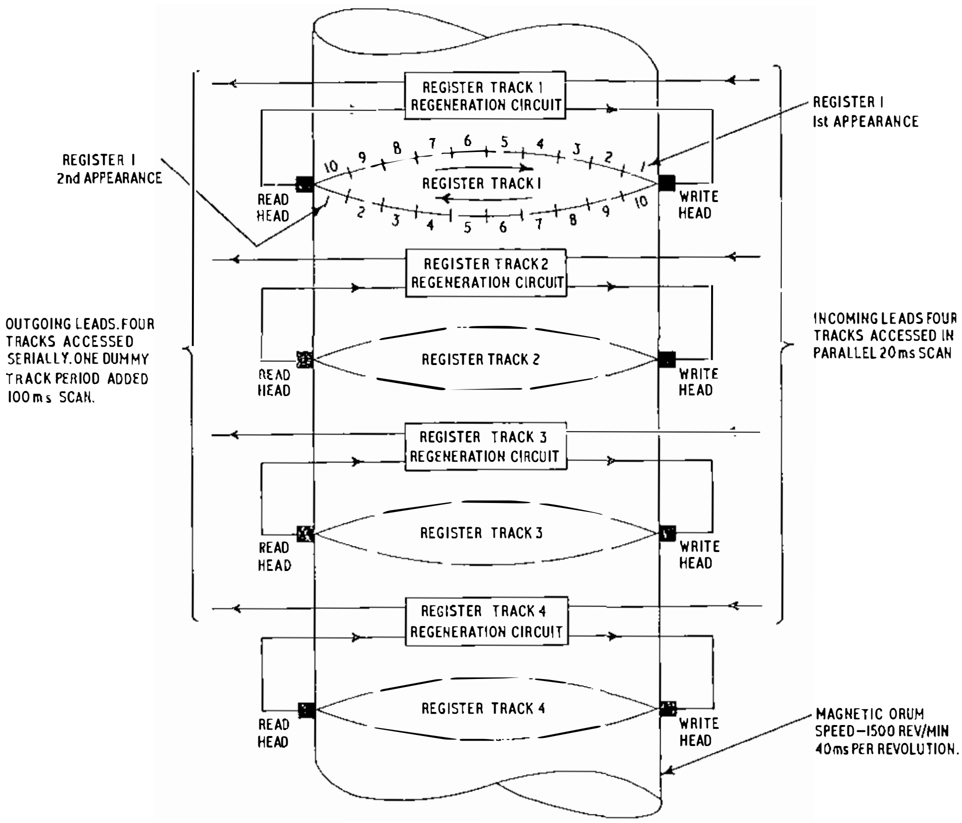


FIG. 6—Layout of register tracks on magnetic drum

tracks is shown in Fig. 7. There are 10 register periods on each track, each register having three groups of 11 words each of six bits. In order to provide adequate storage, each register relay-set has access to two tracks in parallel; these are referred to, respectively, as the regular register track and the shadow register track. The regular register stores the main control signals (dots), keyed or translated digits and controls the pulsing-out process. The shadow register is used to store c.l.i. and c.o.s. information, check-cycle control and timing counts.

Basic Processing of an Extension-to-Extension Call

On the user lifting the handset the extension line circuit is associated with a free 1st group selector by line-finder action, and the group selector is then associated with a free register relay-set via the selector-finder and register-hunter links (Fig. 8). The drum equipment is continuously scanning the leads from all register relay-sets, and when seizure is recognized a LINE CONDITION dot is written into the control section of the regular register. This starts a 25-second time-out count in the third 11-word section of the shadow register; forced release follows if no keyed-in information is received.

The next process is to determine the identity and c.o.s. of the calling extension and to record this in the register. The c.l.i. process is available to all registers on a one-at-a-time basis, and detection of the LINE CONDITION dot leads to seizure of the c.l.i. transfer track if no other register is using the facility. On seizure, the transfer track is busied, and, to mark the register that is allocated the use of the c.l.i. logic, a C.L.I. NOW dot is written into the regular register. At the same time the register sends a REQUEST-C.L.I. (RC) signal back to the register relay-set via the outgoing RC scanner; this signal is relayed to the group selector and causes negative potential to be applied to the L-wire of the calling-extension line circuit. This operates the appropriate selection relays in the c.l.i. matrix, identifying the track and store number in which the extension's identity and c.o.s. are written.

The outputs from the c.l.i. matrix switch a reading circuit to the required track, and the contents of the required store are read out and written into the c.l.i. transfer track. Here, the information is available at every register period, but only when the scanning cycle reaches the register marked with C.L.I. NOW is the c.l.i. and c.o.s. information transferred to the shadow register and the c.l.i. transfer track cleared and released for use by another register. On receipt of the c.l.i. information the register sends a signal via the outgoing

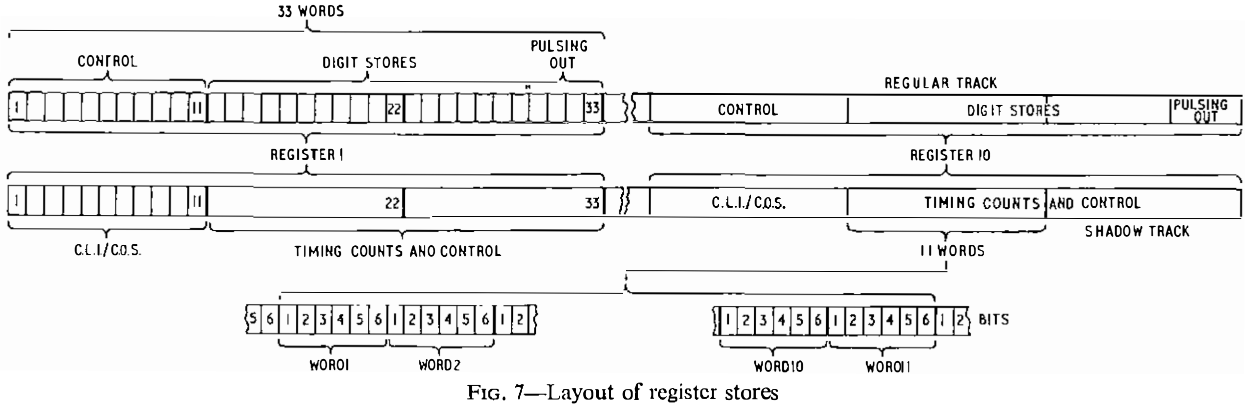
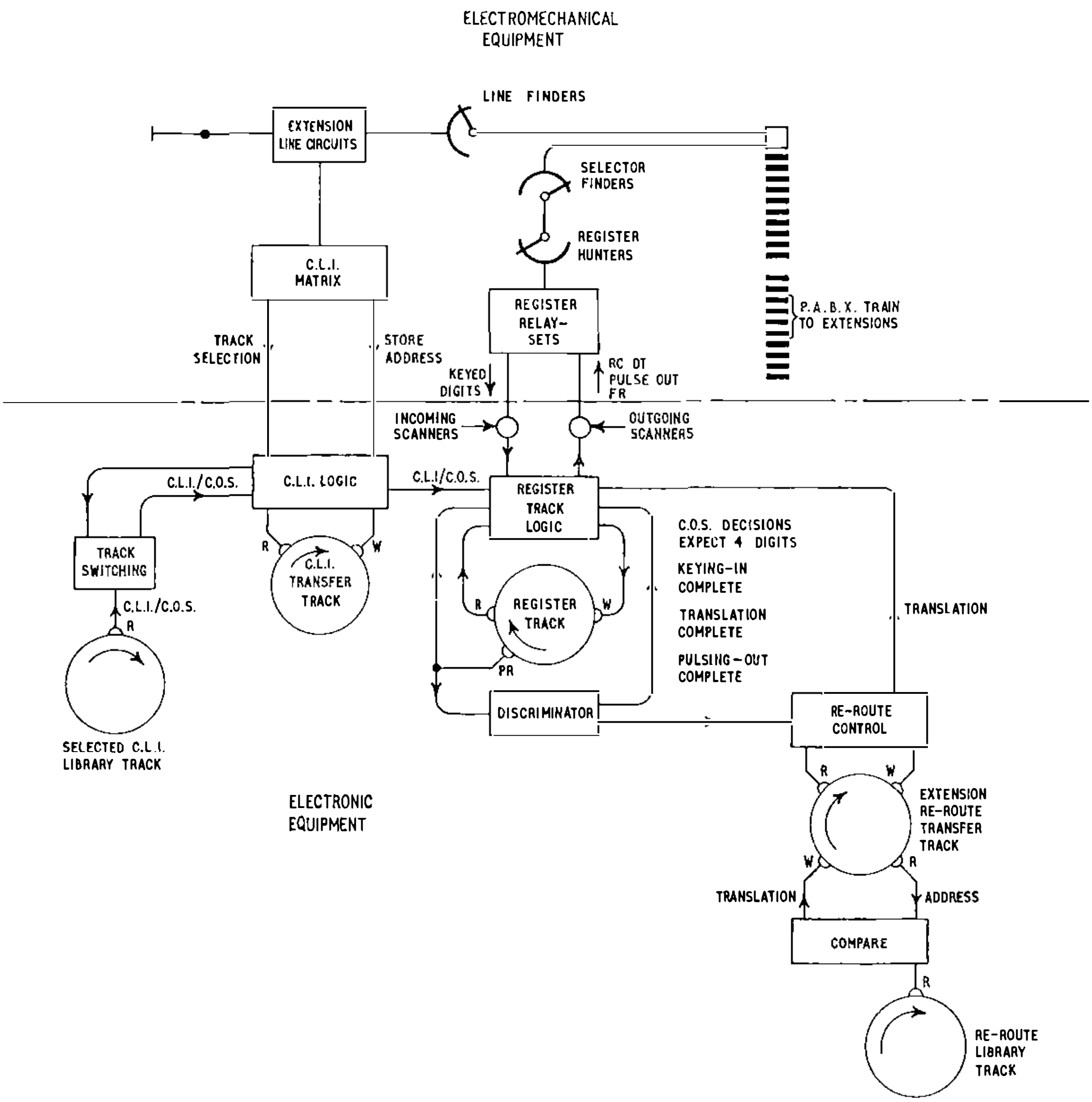


FIG. 7—Layout of register stores



RC—Request c.l.i. signal
DT—Initiate return of dial tone
FR—Forced release signal

FIG. 8—Association of equipment for extension-to-extension call

scanner to return dial tone from the register relay-set to the caller. On receipt of dial tone the caller starts to key the digits of the required number. This information is transmitted from the push-button telephone instrument in d.c. form. The keyed signals are detected in the register relay-set and signalled via the incoming scanners to be stored in binary decimal code in the second section of the regular register. Receipt of a digit starts a 12-second timing count to replace the previous 25-second time-out.

The contents of all registers are continuously monitored in a scanning cycle which reads all registers every 100 ms. Thus, the discriminator is able to check the progress of a call at all stages, and determines every 100 ms what action is required to be taken. The input to the discriminator is taken from a pre-read head, i.e. a reading head which the register store reaches before it comes under the normal reading and writing heads, so that logic decisions by the discriminator can be effective during register time and do not have to wait for the next scan 100 ms later. For example, if the c.o.s. written in the shadow register shows that outgoing exchange-line calls are barred, and if the first keyed-in digit is 9 (giving access to outgoing exchange lines), then, immediately the discriminator detects the digit 9 in the first position, it is able to write an instruction into the register to initiate return of number-unobtainable tone from the group selector and to release the register relay-set.

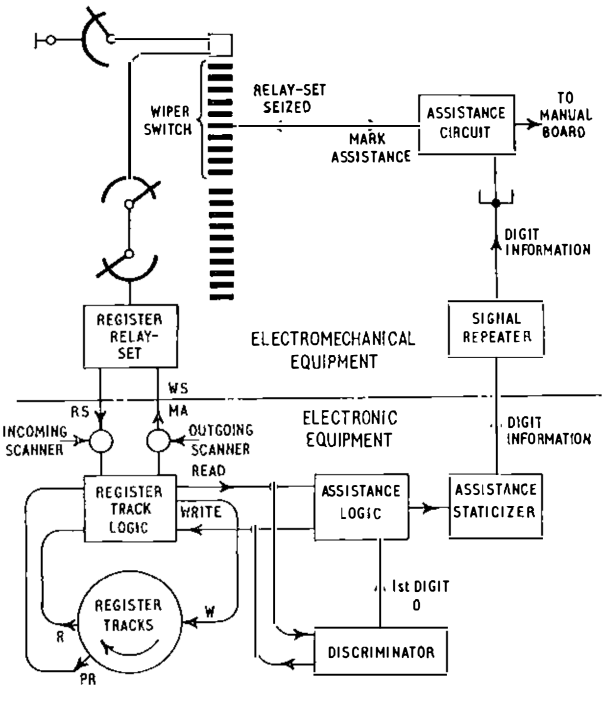
The discriminator determines whether translations are required and instructs the various translation processes to act when a register has sufficient information stored. If the first digit stored is 5, 6 7 or 8, i.e. within the extension numbering range, the discriminator logic will respond by recording (for the register period being monitored) EXPECT 4 DIGITS and subsequently, on detection of the fourth keyed-in digit, will write into the shadow register a KEYING-IN COMPLETE dot, and will stop the 12-second time-out.

All digits are now stored in the register, but pulsing-out cannot start until it is verified that the called extension is not using the extension re-route facility. An extension user may arrange for incoming calls, originating within the p.a.b.x., to be transferred to another specified extension. The enquiry operator, on being advised of details of the required transfer, including the times and dates for which it is to be effective, will program the re-route library, and all subsequent calls to that extension will be transferred until the library entry is deleted. The presence of re-route instructions is checked by seizing the extension re-route transfer track as soon as it is free. The seizing register is marked by writing a RE-ROUTE NOW dot, and the four digits of the called number are written into the transfer track. They are then compared with all addresses written in the re-route library. If no correspondence is found, the called extension is not having its calls re-routed to another extension, and the keyed-in digits may be pulsed-out unchanged. If correspondence is found, the translation is written into the transfer track and at the end of the 40 ms scan is written into the register marked by the RE-ROUTE NOW dot. In either case TRANSLATION COMPLETE is written into the regular register and the information in the transfer track is erased. The transfer track is released for use by another register, and pulsing-out can now commence.

Detection of TRANSLATION COMPLETE by the discriminator causes a PULSING-OUT ALLOWED dot to be written in the last section of the regular register in word 32, and the digits stored in words 12–15 are transferred one at a time to word 32, to be available for pulsing-out. This word is scanned every 100 ms, a break pulse of nominal 66 ms (but varied to give ratio-correction if required) is sent to line under the control of the register relay-set, and the digit stored is reduced by one. This continues until the digit stored is reduced to unity; the logic then inserts an interdigital pause of 700 ms. The second stored digit is then transferred to word 32, using the pre-read circuit and staticizer toggles, and the process is repeated until all four stored digits have been pulsed out. As the discriminator had written in KEYING-IN COMPLETE after four digits had been stored, this dot, together with completion of the pulsing-out of the fourth digit, allows PULSING-OUT COMPLETE to be written in word 33, and a forced-release signal is sent to the register relay-set. Both regular and shadow register tracks now return to their normal conditions where all information is erased at every scan, and the register is available for a further call.

Assistance Calls

Fig. 9 shows the trunking arrangements for an assistance call.



RS—Relay-set seized signal
WS—Wiper-switch signal
MA—Mark-assistance

FIG. 9—Association of equipment for assistance call

An extension requiring the assistance of the p.a.b.x. operator keys the assistance codes 05, 06 or 00. Receipt of the digit 0 in the first keyed-in digit position of the register indicates that an assistance call is being made. The stored digit is busied by the discriminator to prevent its being pulsed out, and a wiper-switch (WS) signal is sent to the 1st selector to bring the second hundred outlets of the 200-outlet selector into use. The second digit received is either pulsed-out as received or modified for executive calls, and the 1st selector seizes the first free assistance circuit on the appropriate level.

C.L.I. and C.O.S. information for the calling extension is displayed to the operator as follows. Seizure of an assistance circuit causes a relay-set seized (RS) signal to be returned to the register. The assistance logic detects the first keyed-in digit 0 and the RELAY-SET SEIZED dot, and applies for the use of the assistance staticizer, one of which is provided on each drum equipment and which feeds its own signal-repeater relay-set. If free, the staticizer is seized and the c.l.i. and c.o.s. information read out from the shadow register is stored on the staticizer toggles. These toggles extend signals via an output amplifier to operate relays in the signal-repeater relay-set. At the same time a mark-assistance (MA) signal is sent via the output scanner and the 1st selector to mark the particular assistance circuit being used. The c.l.i. and c.o.s. information is transferred from the staticizor signal-repeater to the storage relays in the individual assistance circuit.

The staticizor is released and ASSISTANCE RECEIVED is written into the register to initiate a forced-release action.

When the operator answers the assistance call on the manual position the stored c.l.i. and c.o.s. information is transferred from the assistance-circuit relays to the position display circuit, where it is converted to give a numerical display on a series of in-line indicators.

Short-Code Dialling

Repertory-dialling facilities are provided, with access by keying four digits (SCD 4) or two digits (SCD 2). The SCD 4 facility is available to all extensions with exchange-access instruments even if their c.o.s. normally bars outgoing calls. The SCD 2 facility is available to executives. Fig. 10 shows the control-circuit arrangements.

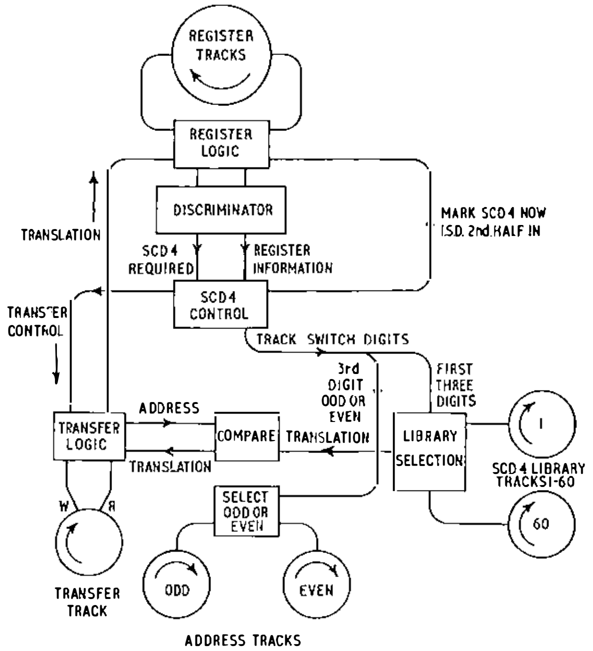


FIG. 10—Control-circuit arrangements for 4-digit short-code dialling

The SCD 4 facility provides for the 4-digit address to be translated to a full local, national or international number, or to an access code for an inter-switchboard route followed by the required extension number at the remote p.a.b.x. The translations are stored in 60 library tracks, each with 50 translations, of which a maximum of 10 may be international numbers.

Detection of digit 1, 2 or 3 in the first keyed-in digit position and the presence of a total of four digits, causes the facility-transfer track to be seized, busied against use by other registers, and the originating register to be marked by a SCD 4 NOW dot.

The digits keyed by the extension are now used to find the required translation. The first and second digits are staticized and decoded. The third digit is inspected to give an odd or even indication. This gives a selection of $3 \times 10 \times 2 = 60$, which identifies the required library track. The third and fourth digits (XY) are copied from the register on to the transfer track and are used to locate the particular translation on the selected library track. Comparison is made between the address in the library track and the transfer track. When coincidence occurs the associated translation is read out of the selected library track and written on to the transfer track. It is held in the transfer track until the SCD 4 NOW marked in the originating register is detected, and is inspected for the presence of a SECOND-HALF I.S.D. TRANSLATION dot. This control dot is included in the translation to indicate that an additional application to the library is required, since the transfer process deals with 11 digits at a time, which is insufficient for i.s.d. translations. If this dot is not marked, then, on detection of SCD 4 NOW marking the originating register, SCD 4 NOW is cancelled and a TRANSLATION COMPLETE dot written into the register to prevent attempts to reseize the facility by the same register. The translation is read from the transfer track and written into digit stores 1–11 in the regular register, overwriting the four digits keyed by the extension. The transfer track is cancelled allowing the facility to be released and the track-selection logic reset. The PULSING-OUT ALLOWED dot is marked when the discriminator detects TRANSLATION COMPLETE, and the translated digits are pulsed out to set up the call over the p.a.b.x. and the national network.

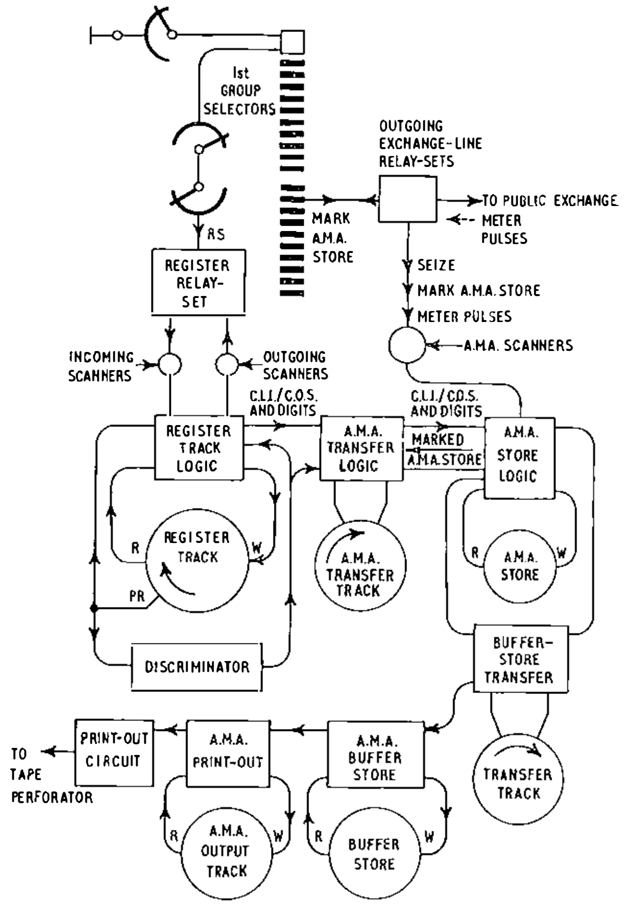
If the i.s.d. control dot is marked, the translation on the transfer track is the second part of an i.s.d. translation. When the originating register is detected by the presence of the SCD 4 NOW dot, this translation is written into the register stores for digits 12–18, thus keeping the keyed-in address digits intact in positions 1–4. The control dot SECOND-HALF I.S.D. TRANSLATION IN is written in the register, and when this is read on the next appearance of the register, the transfer track is erased but remains seized. The keyed-in digits (XY) are again copied into the transfer track and a further digit 1 is added. The comparison process is carried out as before and the translation read out when coincidence is found. The first 11 digits of the i.s.d. translation are stored under this special address XY1 (X, Y are the third and fourth keyed-in digits). On detecting the marked originating register this second section of the information is written into digit positions 1–11 and the transfer track erased to release the facility. Pulsing-out then takes place to set up the connexion over the p.a.b.x., national or international network.

The address and library tracks are capable of storing 60 11-word blocks. Forty of these blocks are available for s.t.d. translations and 20 for i.s.d. translations. Because the i.s.d. translations require two blocks per translation, the total storage capacity of each library track is 50 translations.

The SCD 2 facility is similar to SCD 4 but is made available to executives only. Track switching is controlled by an executive-group code stored in the extensions c.l.i. and c.o.s. store. There are 50 group numbers, each relating to a particular library track. The numbering scheme of the system allows an executive with this facility access to 40 translations of which 20 may be i.s.d. numbers.

Automatic Message Accounting

Each outgoing exchange line is associated via the automatic message accounting (a.m.a.) scanner with its own a.m.a. store of 33 words. There are 18 a.m.a. store tracks with 10 stores to each track. The register is associated with the call only during the setting-up process, so that it is necessary to transfer from the register to the a.m.a. store of the seized exchange line the information on calling extension and pulsed-out digits when the register clears down after setting-up is completed. To this stored information is added a record of meter pulses as they are received throughout the duration of the call. After the access-digit 9 has been pulsed-out on an extension-originated call and a free outgoing-exchange-line relay-set has been seized, a RELAY-SET-SEIZED (RS) signal is returned via the 1st selector to the register relay-set and a corresponding mark written into the register store. At the same time a SEIZED mark is written into the a.m.a. store. The trunking arrangements are shown in Fig. 11.



PR—Pre-read head
R—Read head
W—Write head
A.M.A.—Automatic message accounting

FIG. 11—Association of equipment for automatic message accounting

Application for the use of the a.m.a. transfer facility is made when the following conditions are stored in the register:

(*a*) the first keyed-in or translated digit is 9,
(*b*) a RELAY-SET-SEIZED mark is present, and
(*c*) KEYING-IN COMPLETED has been marked by the discriminator.

If free, the transfer equipment is seized, the originating register is marked A.M.A. TRANSFER NOW and a signal is sent via the register outgoing scanner to the register relay-set. This causes a MARK A.M.A. STORE signal to be extended for 80 ms via the exchange-line relay-set to mark the corresponding a.m.a. store on both drum equipments. C.L.I. and c.o.s. information and digits stored ready for pulsing-out are copied from the register into the transfer track and, when the marked a.m.a. store is detected, are transferred to that store.

A mark is also written in the store to indicate that information is present. The only mark in the corresponding a.m.a. store on the other drum equipment is the seize condition After completion of pulsing-out, the register is released and its stores erased. Meter pulses received over the exchange line are recorded in the a.m.a. store until the call is cleared. The seize mark is removed by the exchange line relay-set and this initiates the transfer of the stored information to the buffer store.

On detecting that the SEIZE A.M.A. STORE mark has been erased and that information is present in the store, application is made to seize the buffer-store-transfer track. The a.m.a. store is marked TRANSFER TO BUFFER STORE NOW, and the transfer track seized when a free buffer store is found. The a.m.a. store information is written into the transfer track and the NOW dot erased. The free buffer store is searched for, and when found the information is copied into it from the transfer track and the transfer track erased. The a.m.a. store is erased and a release signal sent back to release the cxchange-line relay-set.

Ten buffer stores are provided on the buffer-store track, and the information is held there before transfer to the output track for printing out. Discrimination may be exercised at this stage, and any store containing information not required for printing-out is erased. The following types of call may be excluded, under key control.

(*i*) translated calls, i.e. short-code dialling,
(*ii*) test calls,
(*iii*) s.t.d. and i.s.d. calls, and
(*iv*) local-fcc-area calls.

Printing-out may also be inhibited for all calls.

SECURITY OF THE INSTALLATION

Joint discussions between customer, manufacturer and the Post Office were held to consider the fault liability of the electronic equipment and the effect of equipment failure on service. The manufacturer proposed to install two similar equipments, each capable of meeting the full busy-hour demand; normally, the traffic would be shared between the two equipments. Each equipment would contain an estimated 105,000 components, including plug-and-socket connexions, and, of this total, 43,000 components were in circuits where failure would lead to the equipment being completely out of servicc. Assuming a component failure rate per annum of one in 2,000, a fault due to component failure could occur every 7 days, and an equipment failure every 17 days. Assuming an average repair time of 4 hours, the mean time between coincident failurcs (m.t.b.f.) of two similar equipments would be 4 years. Since incoming traffic to the p.a.b.x. does not make use of the registers, the Post Office was satisfied that electronic-equipment failure would not affect the service given to other customers, i.c. incoming traffic would be routed either directly to the called extension or to the manual switchboard where the operator could extend the call by using an emergency dial with direct-pulsing access to the switching train.

The customer was, however, advised of the estimated m.t.b.f. and asked to consider whether the loss of all internal connexions as well as traffic outgoing to the public network could be tolerated if it occurred every 4 years and lasted for 4 hours. The customer decided to purchase standby electromechanical register equipment with limited facilities in order to maintain originating traffic with a reduced grade of service during periods when both electronic equipments were out of service. Experience of component failures during commissioning of the equipment suggests that the component-reliability estimate used was in fact pessimistic, and component failures on both equipments averaged two per month for the first 3 months of full service.

Since it is necessary for the customer to provide a standby mains supply to maintain other services within the building, the power supplies for the p.a.b.x. are secured by providing for change-over within 10 seconds of failure of the normal supply to a reserve supply from a motor-alternator set provided and maintained by the customer. The regulated 3-phase supply to the magnetic-drum motors is thus directly secured, since the reduction of speed due to a break of 10 seconds is acceptable. The 50-volt positive and negative supplies to the electromechanical equipment and the 24-volt positive and negative supplies to the electronic equipment arc additionally secured by being derived from single-battery-float rectifier plants which differ little from the standard −50-volt equipment supplied for public exchanges.

MAINTENANCE AIDS AND DOCUMENTATION

To keep repair time short, it is necessary for faults to be indicated as soon as they occur. All cyclic processes in the logic are provided with in-built check circuits so that failure to reset at the end of a cycle leads to an alarm. The alarms are displayed on the test console as individual facility failures, with separate displays for first and second failures of a facility within a pre-determined interval. Provision is made to test the check circuits from the console. These check circuits cannot cover all components and, in particular, will not indicate faults on access circuits, including scanners. To include all the electronic equipment in an automatic fault-indicating system, a comparison is made between working and check registers, using signals from sampled live traffic monitored at the interface between electromagnetic and electronic equipment, so as to include all acccss leads and scanning circuits. Signals incoming to the register-translator from the register relay-set are monitored and extended to a comparator register, which will be on the drum equipment not allocated with the working register, if both equipments are in service. These signals are processed by the comparator register at the same time as they are being processed by the working register, and the output is stored for comparison with the output monitored on the output leads from the register-translator to the access relay-set being observed. If parity exists, the successful-calls total is advanced by one and the comparator equipment is disconnected from the access relay-set. If disagreement is found between the two outputs the information from both registers is available in the comparator stores. It can be arranged for this information to be printed-out and the comparator released, or the comparator can be held until reset. In either case the incorrect-calls total is advanced by one.

The comparator equipment is normally allowed random access to offered traffic so that it is seized, when free, by the first access relay-set to be seized by a 1st selector, or it may be arranged to be associated with a selected access relay-set to monitor all calls set up via that relay-set, i.e. to give a CAMP-ON facility. With either arrangement the identity of the observed register is part of the information stored in the comparator and available for print-out.

One register on each equipment is specially allocated as a facility-check register to continuously check the track selection and transfer operations of the SCD2, SCD4 and interswitchboard circuit (PW) re-route facilities. The process is started by the insertion of an SCD4 address in the keyed-in digit positions of the check register. Application to this address on the first SCD4 library track leads to a translation which is an SCD4 address on the second library track. This over-writes the original address stored in the keyed-in digits position, and is not pulsed-out but used to apply for a second translation. This process is repeated through a series of addresses, one on each library track to be checked. The address on the last track returns as its translation the original first track address to restart the process. Each translation includes the serial number of the step in the checking program, and this is compared with a counter in the register; failure to compare leading to the initiation of a first-failure and second-failure alarm process. Another register acts as a discriminator-check register by presenting to the discriminator a program of combinations of register conditions (keyed-in digits, c.l.i., c.o.s. and control dots), and comparing the instructions received from the discriminator with those expected for each combination.

Signals at the input and output of all active devices, such as buffer amplifiers and inverters, are available at test points on the front panel of each slide-in unit. The signals may be observed by using a portable oscilloscope or may be extended to the test console, which is provided with digit-display equipment capable of displaying or staticizing up to 11 6-bit words, or by time-sharing capable of displaying 33 6-bit words.

Documentation

The equipment documentation is based on the use of Boolean logic script organized into two series of documents covering functional and operational logic, respectively. The functional or theoretical logic is written in 2-line form, the lines following a functional sequence independent of equipment location, with the first line of each pair giving the combination of signals required to produce a given output, and the second line giving the test points where the signals may be observed. The operational or practical logic is written in 3-line form and is grouped to correspond with each slide-in unit. The first line indicates a practical gate, which may differ from the corresponding gate shown in the theoretical logic because of the need to amplify or buffer signals, these details being omitted from the theoretical logic. For the same reason, one line of theoretical logic may require several practical logic gates. The second line records the test points at which the signals may be observed, and the third line gives the location of printed-board terminals to which device inputs and outputs are connected.

ACKNOWLEDGEMENTS

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A New Multi-Pair Coaxial Cable

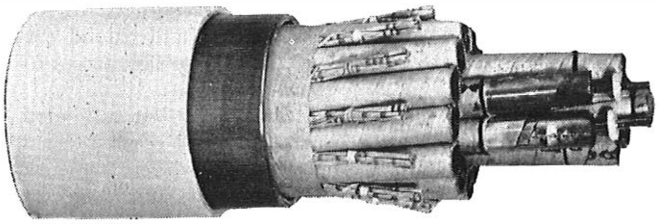
U.D.C. 621.315.68

The planned development of the United Kingdom trunk network on the basis of the 0·375 inch coaxial pair has shown the need for a cable having a larger number of pairs than have yet been used in this country.

The cable illustrated has been developed for the Post Office by Messrs. Telephone Cables Ltd. to make the best use of the standard 3 in diameter duct. It has an outside diameter of 2·7 in and contains 18 0·375 in coaxial pairs within a lead sheath with polythene protection overall. The coaxial pairs are arranged in two layers—the inner with 6 pairs and the outer with 12 pairs. A 10 lb/mile quad is laid in each of the outer interstices.

Experimental lengths have been made for evaluation.

J.P.



A Wire-Jointing Machine for Subscribers' Cables

J. P. HARDING, B.SC.(ENG)., M.I.E.E., M.I.C.E.†

U.D.C. 621.315.68:621.9

Manual methods of wire-jointing are time-consuming, fatiguing and liable to produce joints of variable quality. This hydraulically-operated machine has been designed to reduce the operation time to a minimum and, by use of a crimped-connector, to improve the electrical permanence and consistency of the joint. Tests in the field have shown the machine to be practicable and plans are going ahead for its introduction in the Areas.

INTRODUCTION

There have been notable advances in external construction over the years which have resulted in improved efficiency and reduced costs. However, until now, an improved method of jointing wires in multi-pair cables has not been introduced although several mechanical jointing-devices have been tested.

Cable jointing, using the standard twisted and sleeved joint, has been practised in substantially the same form for some 50 years. In the past, labour rates, output per man and the electrical standard required have combined to give an acceptable joint at reasonable cost. Present labour rates with attendant high overhead charges and the need for a better electrical standard for some applications have changed the emphasis and justified the search for a more economic, mechanized process. A machine can only be justified if it confers a real overall advantage and, although most of the factors can be assessed in terms of cost, others which cannot such as reduction in fatigue or boredom must be taken into account. Much jointing work is carried out in unfavourable or arduous conditions and anything which facilitates such tasks is to be welcomed.

THE EXISTING MANUAL METHOD

The present manual method involves stripping the insulation, twisting the bare ends and finally enclosing the joint in a paper sleeve. It is necessary in the design of a jointing machine to assess carefully the possible saving in time from its use and allowance must be made for the cost of machine provision, maintenance and materials. A low output from manual jointing clearly leads to a high cost per wire jointed and there is considerable economic scope for a machine to improve on this. However, better working conditions, the application of time and motion studies and quicker sleeve removal and replacement methods should result in a higher output from the jointer in the future. Attention to these and other factors, some of which are already in hand, could well lead to twice the present output and a proportional reduction in the cost of a manual wire-joint. This means that a jointing machine should give an overall saving when compared with, say, one half of the present manual costs. The choice of method of machine jointing is therefore critically dependent on the cost per joint made and it would be advantageous also if it could be capable of further development and economy to meet any unforeseen requirements.

Observation in the field has shown that a skilled jointer can maintain a jointing rate of about 25 seconds per wire and it is only this time which can be reduced by use of a machine. A machine for selecting the wires has been found to be impracticable and the scope for the use of a machine is therefore limited to this 25 second period. Since reduction of this time of 25 seconds is the main source of economy, it is clear that really high speed is necessary to justify the cost of a machine.

There are, however, other advantages to be gained from mechanization as follows:

(*a*) Fatigue is reduced leaving the jointer able to work better in wire selection and other respects.

(*b*) There is the prospect of an improved electrical connexion which is more consistent and reliable than that obtained by hand jointing, particularly for thinner conductors (4 lb/mile, $2\frac{1}{2}$ lb/mile, or less). A better mechanical strength is also obtained for the smaller conductors.

(*c*) A more compact joint can be obtained, permitting a smaller sleeve and less bulk in the jointing chamber.

(*d*) The method is suitable for paper and polythene insulation.

(*e*) The jointing of wires of different gauges and material is possible.

(*f*) A method suitable for aluminium conductors, which may be necessary in the future, is feasible.

POSSIBLE METHODS OF MACHINE JOINTING

Alternative methods by which machine jointing is possible are as follows:

(*i*) Conductors can be stripped and twisted by machine, so simulating the present manual method.

(*ii*) A mechanical sleeve, single or double ended, which may be whole or split longitudinally, can be fitted directly over the insulated conductors.

(*iii*) Conductors can be stripped and brazed.

(*iv*) Conductors can be stripped, cleaned and welded hot or cold.

(*v*) Conductors can be stripped and soldered.

The various methods must be examined firstly for speed and cost and unless the method, when these two aspects are taken together, shows a marked saving its adoption will not be justified. Equally, a method using a more bulky joint, and therefore a larger sleeve than at present, will occupy more space in the jointing chamber where accommodation is already at a premium and likely to increase in cost in the future. Correspondingly, a decrease in sleeve size, which continues to give reasonable access to the pairs, would show a commensurate saving.

ADOPTED METHOD

A machine using a split mechanical sleeve or connector, (a crimped joint) was developed mainly because this method gave the best prospect of reaching the highest speed and exploiting the advantages listed above. To be

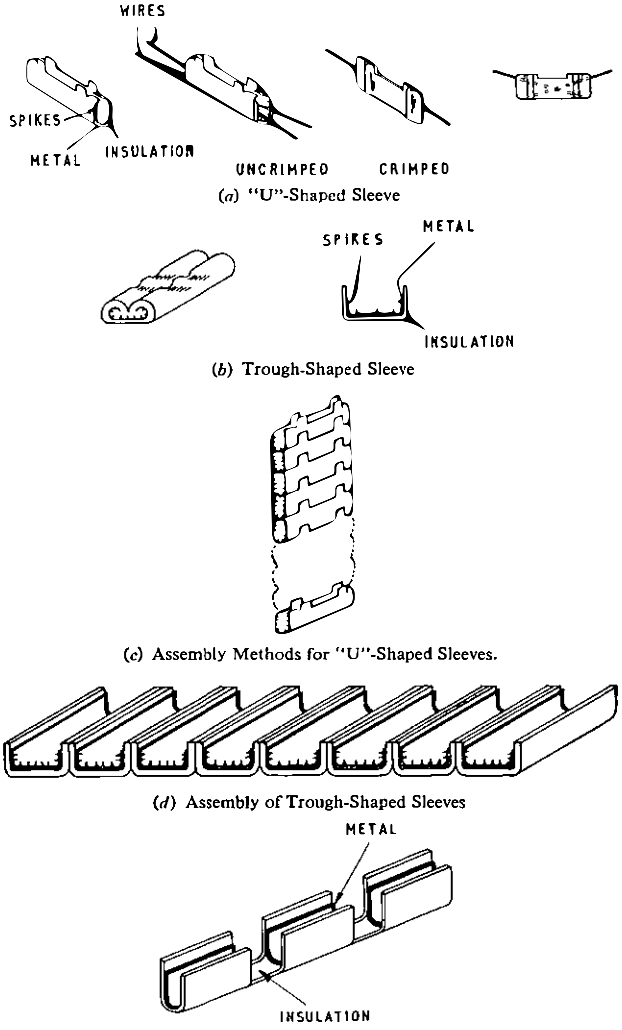
† Post Office Research Station

economic the machine should joint the wires, cut off the unwanted ends and eject the complete insulated joint in, say, 3 seconds from the moment wires are in the hands.

The Form of the Crimping Sleeve or Connector

The form chosen for the connector governs the design of machine and, bearing in mind a possible annual consumption of 40–50 millions per year, it is most important to minimize the cost whilst obtaining the highest efficiency and reliability. The connector can take a number of forms but there are two distinct types worthy of examination. One, the simplest, is a "U"-shaped metal section backed with insulation of the dimensions shown in Fig. 1(*a*). The wires are preferably, although not necessarily, crossed within the sleeve as shown; the insulation is pierced and contact made by the crimping action, which is a direct closing up of the legs of the "U."

A second approach is to use an insulated trough-shaped section which is tightly formed over each wire as shown in Fig. 1(*b*). A corrugation, or other deformity along the line of the connector, may be used to give a lock and to limit relaxation.



(*a*) "U"-Shaped Sleeve

(*b*) Trough-Shaped Sleeve

(*c*) Assembly Methods for "U"-Shaped Sleeves.

(*d*) Assembly of Trough-Shaped Sleeves

(*e*) In-Line Assembly of "U"-Shaped Sleeves

FIG. 1—Types of connector

Connectors of both forms can be assembled together by a light adhesive for use in a machine (see Fig. 1(*c*) and (*d*).)

Machines operated by a footpedal were constructed to test the suitability of these connectors and the feeding arrangements and it was found that the required speed and presentation to a cable were satisfactory. The cost of the machines and connectors could also be expected to show the necessary economy in operation. From this data, a hydraulically-powered machine using connectors fed end-on, as in Fig. 1(*e*), was chosen for an initial detailed development and trial. There were a number of reasons for this:

(*a*) A powered machine can give a consistent crimping force which allows easy reproduction of crimps and enables the optimum force to be chosen and sustained.

(*b*) The end-on connector-feed permits the support and feed of connectors in a continuously-extruded, insulated section which may be conveniently coiled. This was also the most reliable method of feed.

(*c*) The "U"-shaped connector is smaller than the other alternatives and is capable of the most economic design. It is also expected to be better electrically than other forms.

The Design of the Connector

The joint needs to give the required quality of electrical contact in reliability and permanency at the lowest cost, but the actual ohmic value is relatively unimportant so long as constancy is ensured (values of a few milliohms are usual).

Any crimped joint is essentially a device in which a contact (or more usually a number of contacts) is made using a relatively large force initially. On completion, a certain minimum force must then be sustained at the contact points notwithstanding small dimensional changes in the wire, its insulation, or in the connector itself. These dimensional changes can arise from thermal changes, changes in humidity, or from creep in any element in the structural chain. The maintenance of a minimum force at each contact point requires a spring restraint to exist at each point. Only by this means can the contact pressure, which is essential for permanence of the electrical connexion, be sustained over long periods. To be able to define the minimum force needed at each contact, and the elastic movement over which this force must be substantially sustained, is clearly a necessary preliminary to a design. Knowing this, the connector as an entity can be designed structurally to meet these requirements at minimum cost with an appropriate margin of safety.

A simple connector, as shown in Fig. 2, will, when folded

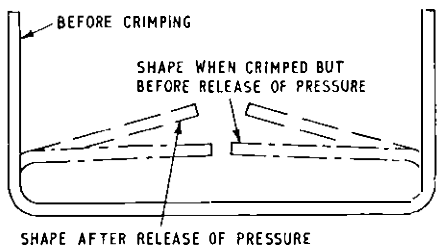
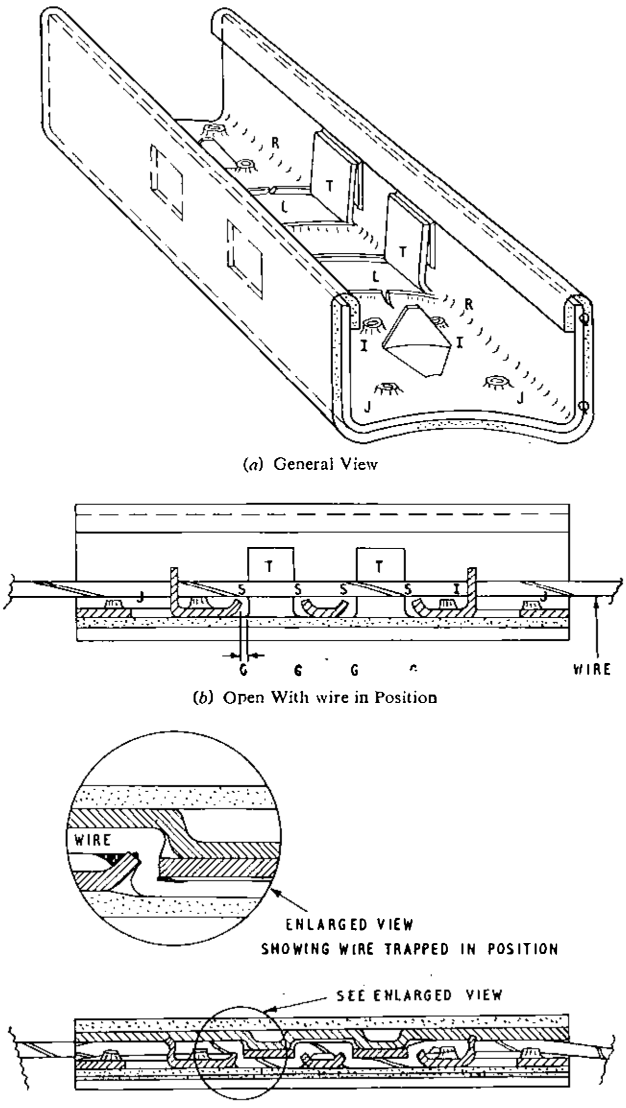


FIG. 2—Simple connector showing the effect of crimping

over, relax on release of pressure and slightly further with the passage of time. Unless some locking arrangement, or other device to avoid relaxation is incorporated, the electrical connexion will generally be impermanent. It may be prudent to incorporate several devices by which relaxation can be avoided or minimized so that an infavourable manufacturing tolerance, or other imperfection in the act of crimping, will still leave a safety margin in performance.

The crimp can be formed by compression instead of by ordinary bending by taking the whole of the material into compression beyond the elastic limit. An inherently better arrangement is for relaxation to act so that there is no component in a direction reducing the contact pressure, i.e. the line of relaxation is perpendicular to the direction of contact pressure. This is possible in the connector in Fig. 3 in which the tongues TT are positioned to trap the wires in the manner shown. On closing, each wire is trapped at 4 points as shown in section in Fig. 3(*c*) and is self locking.

A number of important advantages can be incorporated in a connector of this form:



(a) General View

(b) Open With wire in Position

c) Closed

FIG. 3—The adopted connector

(a) When the tongue T closes and begins to trap the wire, there is a relatively long contact movement allowing a good tearing action to strip the insulation and scrape and clean the wire for final contact.

(b) The wire is shorn of insulation and trapped on opposite sides avoiding the presence of insulation in the structural path. This would otherwise conduce creep and relaxation which must be prevented as far as possible.

(c) The turn-ups at S (Fig. 3(b)) are designed to give the required contact pressure notwithstanding the effects of creep and relaxation.

(d) The turn-ups are designed to yield as a cantilever at a horizontal force on each wire of about 2 lb. They will, therefore, bend downwards closing the gaps G and adjust themselves to trap effectively wires of varying diameter. Wires of gauge of $6\frac{1}{2}$ lb/mile (20 mils), 4 lb/mile (16 mils) and $2\frac{1}{2}$ lb/mile (12 mils) can be accommodated efficiently by this device and may be jointed in any combination by a symmetrical connector. The slit formed at LL in Fig. 3(a) allows independence of action in trapping wires of differing diameter.

(e) The four contact points of each wire are mechanically in series and the total force is only that of one contact which is about 5 lb. This load is taken for both wires by the two top folds in balance and in simple tension, which is the most efficient structural means possible.

(f) In the available remaining space each side of the double tongues TT, shown in Fig. 3(a), piercing tangs and a triangular erection are formed. The latter serves two purposes. It ensures that wires are delivered into the connector in the correct position for the best crimping, i.e. near the crutch at each side and, in conjunction with the tangs, assists in the penetration of the wire. It is also necessary for selectively cutting the right wire. The inner tangs at I hold the wire in tension in conjunction with the turn-ups, S, preventing the latter from folding over. The combination of the action at I and S, in stretching the wire and scraping it, is also advantageous. The tangs at JJ (Fig. 3(b)) are about half the height of the tangs at I and give a small grip to the wire near this point of emergence, thus holding it without appreciably weakening the wire itself.

MECHANICAL DETAILS AND OPERATION OF THE MACHINE

The essential features of the machine are that it should be capable of compressing the connector between a punch and die, cutting off the unwanted ends of wire, and detaching the connector from its neighbour.

Formation of the Crimp

Fig. 4 gives internal and Fig. 5 external views of the machine. A small hydraulic ram, M, is coupled mechanically to the main vertical member V containing cam profiles at CC and, at its upper extremity, the platform on which the connector rests forming the punch. The die is formed from the two beaks BB, which are brought together under the action of the cams, CC, and followers, FF, on the initial movement of the ram. The final movement of the vertical member compresses the connector, N, between the platform (the punch) and the underside of the closed beaks (the die). The knives, KK, cut the wires which are laid in the slots SS. On completion of the crimp the ram retracts, opening the beaks and allowing the crimped connector to be withdrawn. The distance through which the crimped connector has to be lifted to withdraw it from the machine is kept as small as possible since this will control the amount of slack remaining in the jointed wire. The amount is comparable to an average manual joint. The joint is therefore made as high as possible on the machine and the tips of the beaks are no taller in dimensions than suffices for structural strength.

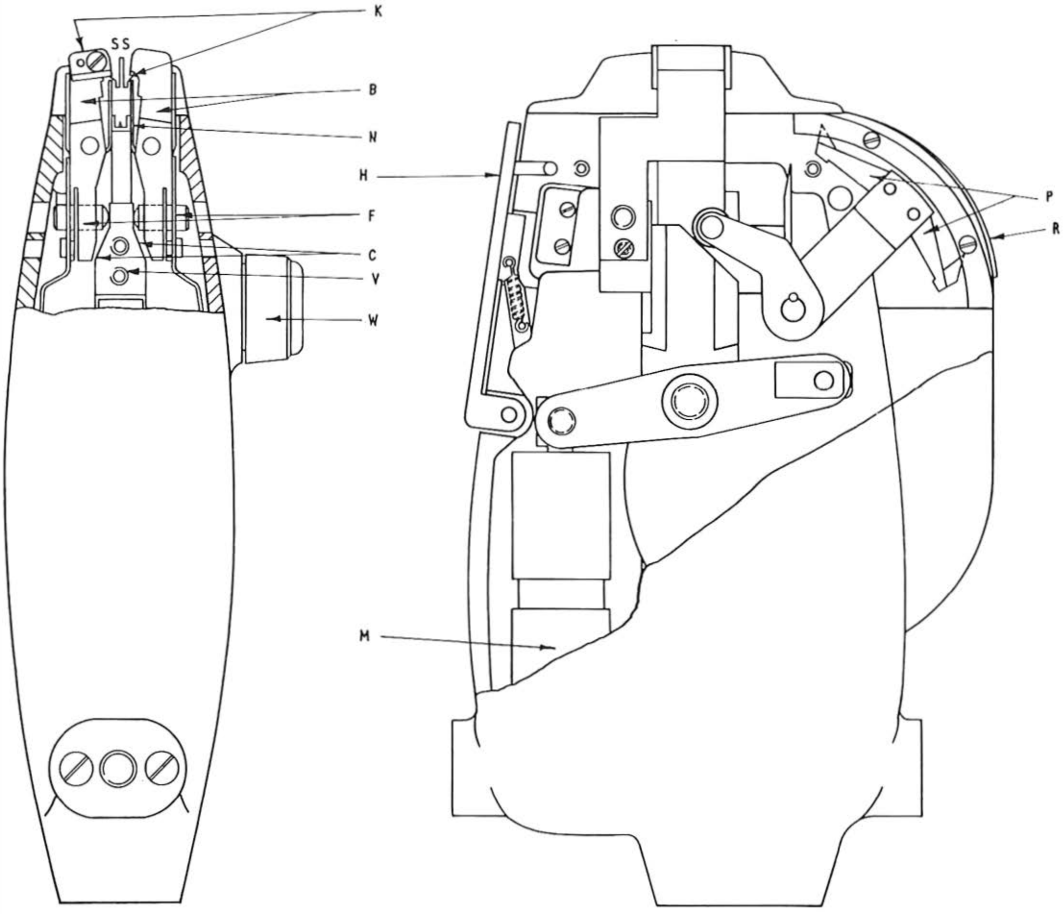
Arrangement of Feed of Connectors

Connectors are formed in lengths of about 55 and fixed in an extruded P.V.C. "U"-shaped section. This section is partially cut at each connector, which allows easy coiling whilst preserving good mechanical continuity.

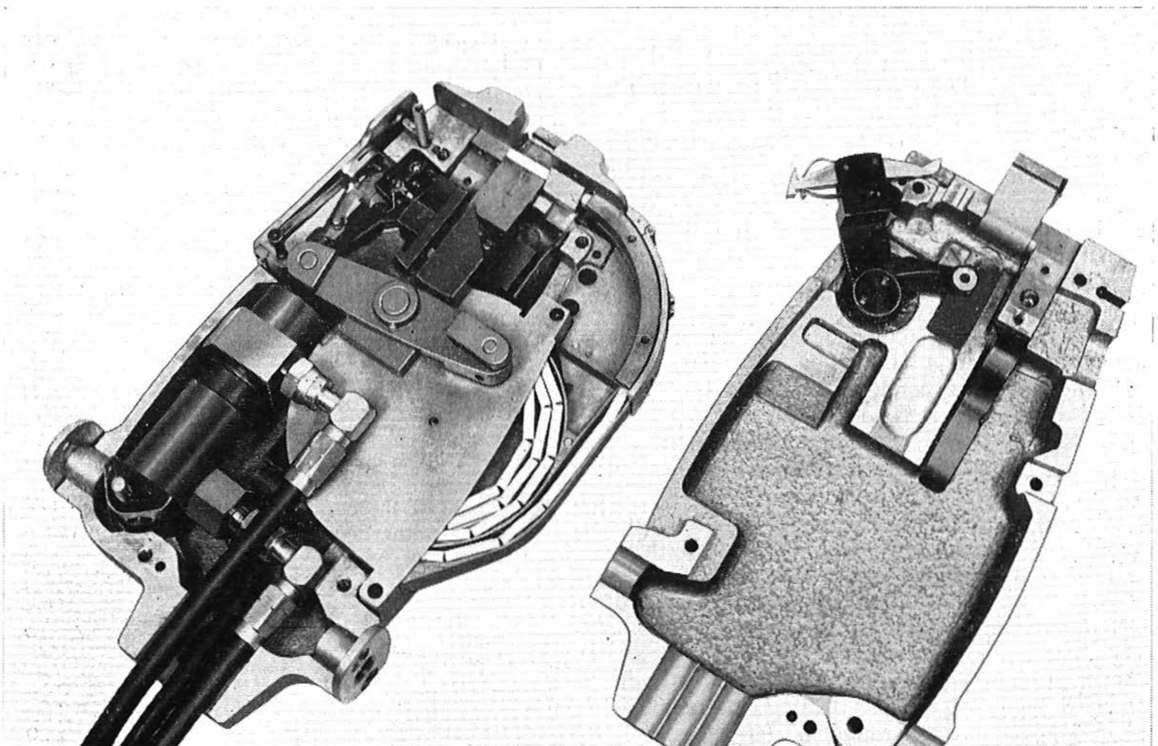
The detachable plastic cassette shown in Fig. 6 contains 55 connectors in a coil, and can be loaded into the machine in 2–3 seconds. Connectors are advanced automatically at each crimping action. The upward movement of the ram crimps the connector, which is ready on the platform and, on the downward stroke, the fingers, PP, engage in holes in the underside of the connectors which are then driven forward causing another connector to move into position on the platform. The spring, R, acts as a ratchet preventing the backward movement of the connectors on the up-stroke. The hand-wheel, W, enables connectors to be advanced manually if required and is useful in bringing the first connector to the platform when initially feeding in a cassette.

The Hydraulic Drive

The hydraulic ram requires to be energized to compress the connector and then reversed to its original position. This is done by a separate unit incorporating an electric motor driving an impeller pump. The operation is carried out automatically after closure of the operating switch H located on the side of the machine. The control circuit is given in Fig. 7.



(*a*) Mechanism of the Machine



(*b*) Internal Views of Machine

FIG. 4

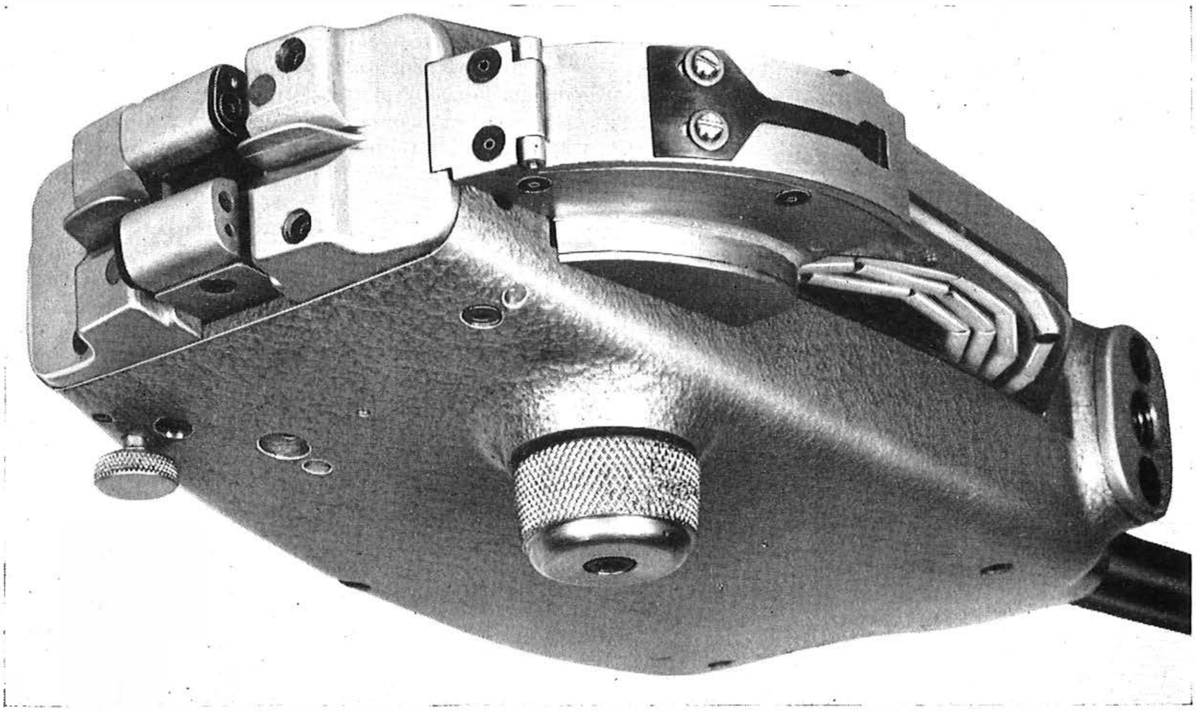


FIG. 5—External view of machine

Operating the mains switch lights the pilot lamp and the capacitor is charged via the contacts on the operating switch. Relay A is normally in the operated condition held by the mechanical latch and relay B is not operated. Closing the operating switch discharges the capacitor across the coil of relay B via contacts A2 and B2. Relay B operates and relay A is released. The circuit to relay B is now broken by contact A2 but held in the operated position by the mechanical latch of relay A. The motor now starts and the jaws close. The limiting switch closes immediately the forward stroke commences and the hydraulic pressure switch is closed when the required crimping pressure is obtained and the forward stroke approaches the end of its travel. Relay A is energized and operates whilst relay B releases, but the motor circuit is retained via the limiting switch and contact B1. The motor reversing-solenoid is energized via contact A1, the limiting switch and contact B1, which now reverses the stroke. The hydraulic pressure switch opens, relay A is retained by the mechanical latch, the jaws open and a counter registers. At the completion of the return stroke the limiting switch opens, the motor stops and the cycle is complete.

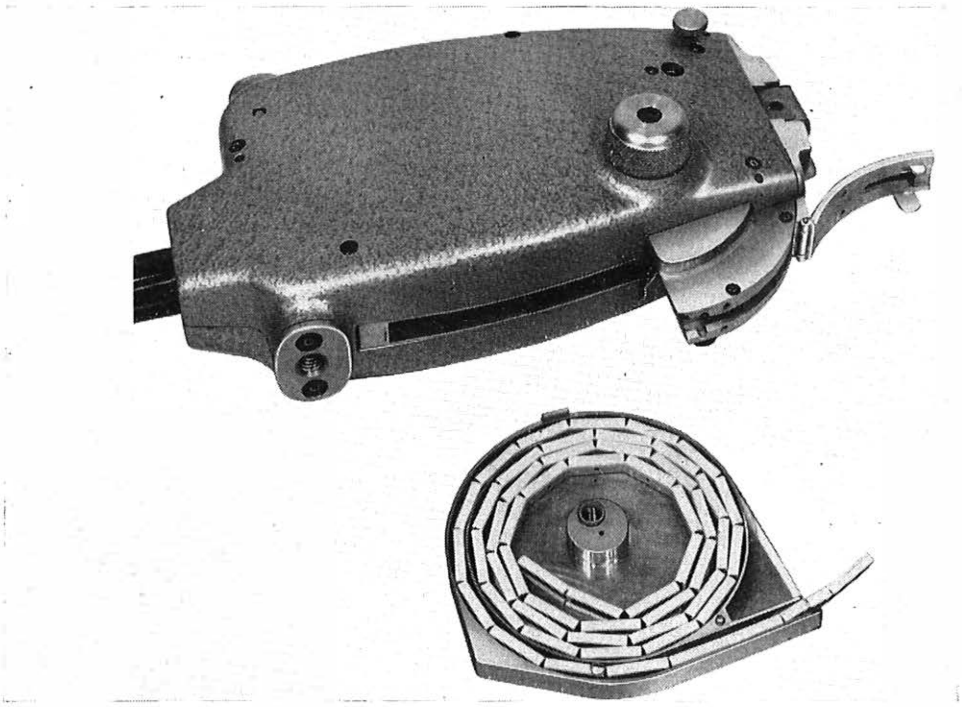
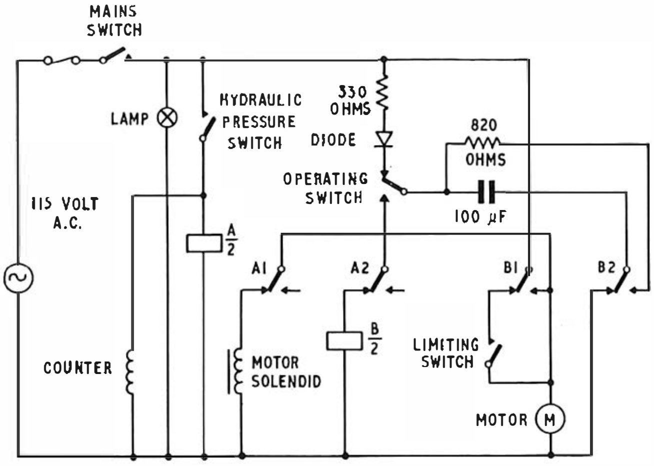


FIG. 6—Plastic cassette

An important advantage accrues from hydraulic operation which would be difficult to incorporate in a mechanical drive. This is that the release valve in the hydraulic system enables a predetermined pressure of about 2,400 lb/in^2, and therefore a force of about 1,200 lb at the crimp, to be sustained consistently within very small limits. Notwithstanding any dimensional changes due to manufacture or adjustment, the connector can be closed with a consistant force which is, therefore, independant of the size of wire jointed. This is a most important advantage because a crimping action which is controlled by distance is critically dependent within one or



RELAYS A AND B ARE MECHANICALLY LINKED AND LATCHED

FIG. 7—Control circuit

two mils for success. Inevitable wear in the tool or other sources of lost motion could be expected to lead to inaccuracies of this order, resulting in a crimped joint which was apparently acceptable but imperfectly closed and perhaps impermanent. The plastic insulation backing to the connector and the separate action of the beaks in resisting the tensile load imposed on them during crimping, allow a degree of independence in the closing of each half of the connector. This permits a nearly equal crimping force on each half of the connector and, therefore, an efficient joint with wires of different gauge.

PRESENTATION OF THE MACHINE TO THE CABLE

A horizontal rod is fixed directly to cable bearers or extensions if necessary. Alternatively small tripods may be used, particularly in joint boxes. A typical arrangement is shown in Fig. 8.

So, that joints can be evenly distributed over the available length of the conductors, which may be 2 ft, it is important that a convenient and rapid means of horizontally advancing the machine by a predetermined amount is available. The machine head can be loaded with wires at any angle required by local circumstances and the carriage must allow for this.

The carriage shown in Fig. 9 is mounted on ball bearings

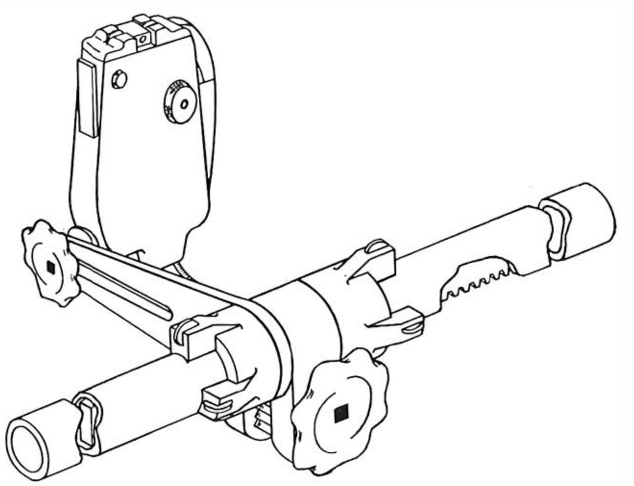


FIG. 9—Carriage and rack drive

and engages in a rack fixed on the underside of the tube. Rotation of the hand wheel by a quarter turn enables the carriage to be moved horizontally one inch at a time, the distance being defined by a simple spring restraint at each inch of movement. Typically, four or eight joints may be made at one position, and the machine head then moved 1 in to make the next group. The movement can be made in about one second.

There is clearly much scope in the field for showing ingenuity in the successful presentation of the machine to cable joints difficult of access.

TESTS ON COMPLETED WIRE JOINTS

The appraisal of a joint for reliability and permanence is always a difficult matter and the risks can never be entirely

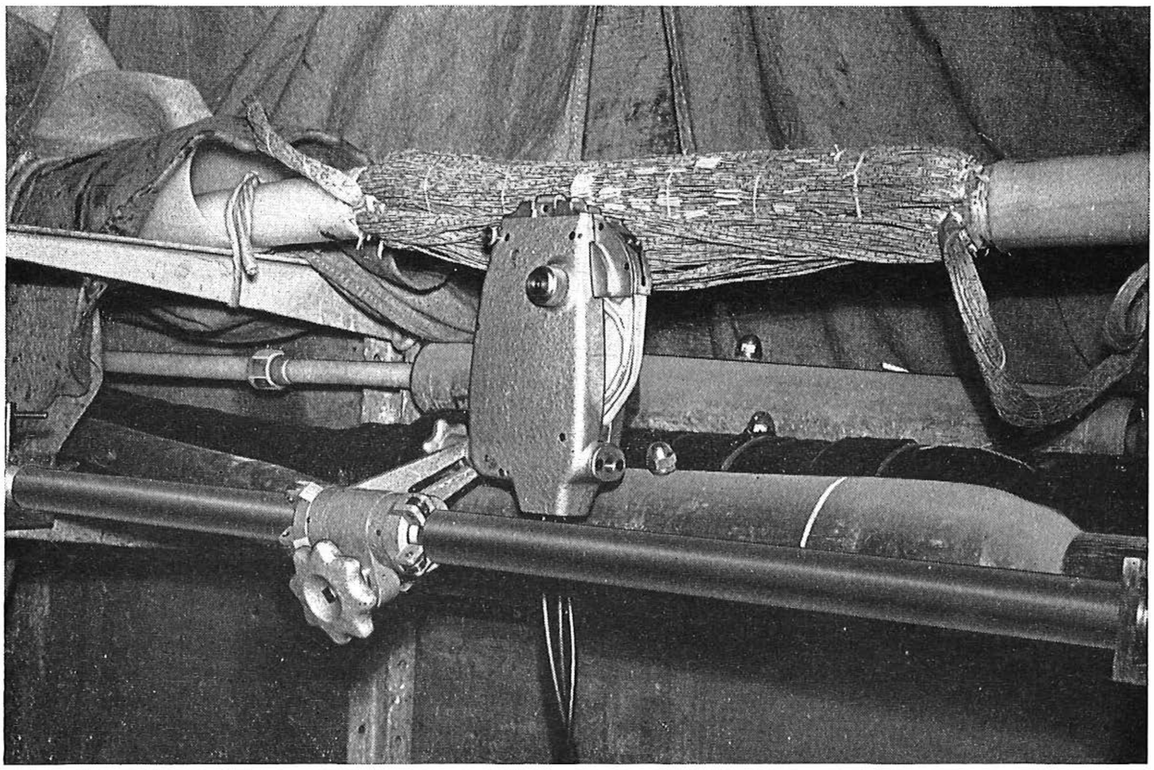
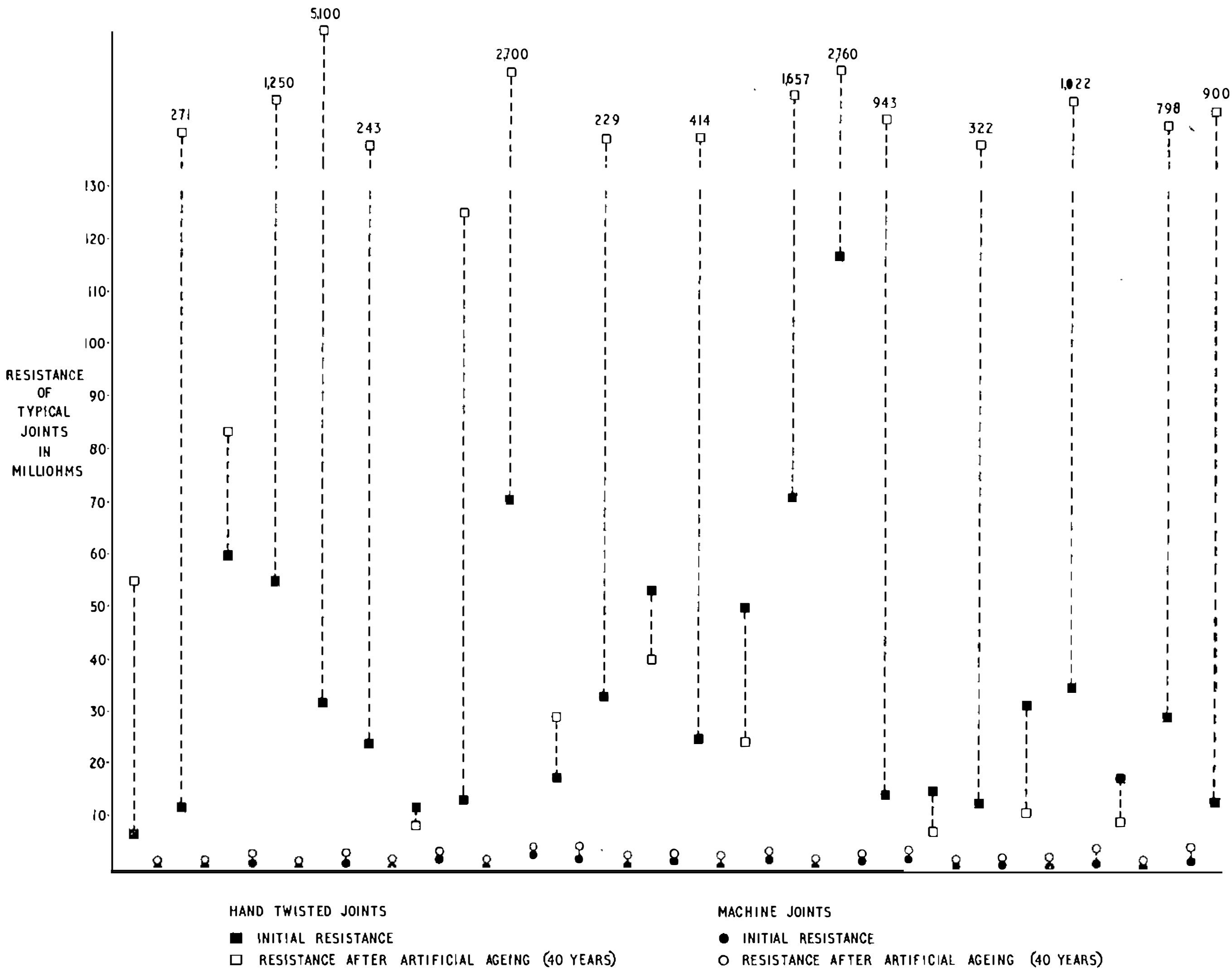


FIG. 8—Machine in jointing position



Notes: 1. Artificial ageing simulated by exposure to 175° C for 4 hours.
2. Testing voltage, 2 volts.
3. All joints 6½ lb copper—paper insulated.

FIG. 10—Resistance of hand-twisted joints compared with machine-made joints.

eliminated. Nevertheless, a careful study of the contact requirements which are largely mechanical, and the assessment of reliability and ageing factors coupled with knowledge of the performance of similar devices, enables a confident prediction to be made.

There is abundant evidence to show that if the necessary contact pressures and stored energy exist to combat the known dimensional changes liable to occur, the connector will have a satisfactory electrical permanence. Having established that electrical consistency is attainable, it is then necessary to maintain, in practice, the mechanical quality of the connector and the crimp itself to ensure uniform results. It is clear that requirements in reliability are very high since, for example, a local call may involve several hundred wire joints the failure by excessive noise or disconnection of any one of which could interrupt the call.

Comparison tests of the resistance of manual and machine joints before and after an accelerated ageing test simulating life of 40 years are shown in Fig. 10.

50-volts potential supplied by the exchange battery on a local circuit is sufficient to break down the oxide film or other insulating coating thus causing the joints to improve. It is largely for this reason that the manually-twisted joint has endured in service for so long.

Machine joints show negligible variation when tested with high and low applied voltages, and are much more consistent in themselves. The reason for this is the far higher initial forces and pressures applied in a crimped joint, compared with a manually-twisted joint. In the former, the piercing tangs and edges of the tongues of the connector each deliver a force sufficient to penetrate the conductor to some 30 per cent of its diameter reaching bare clean metal and puncturing the insulation or oxide or any other surface film in the process. In the twisted joint the forces are low and the intensity of pressure actually falls with increasing twist as the wires flatten and offer a greater surface.

Temperature cycling tests (20°–50°C) are withstood satisfactorily with resistance increases of only a few per cent for 1,500 cycles.

CONCLUSIONS

Tests have proved the speed and effectiveness of the wire-jointing machine and plans are going ahead for its introduction in the field. A preliminary order has been placed for 60 machines, 20 of which have been received and are undergoing extensive testing.

ACKNOWLEDGEMENT

Development has been carried out jointly by the Plessey Company and the Post Office Research Department.

The help of Messrs. Lee, Burgess and Morgan of the Research Dept. in the design and evaluation of the machine and connector is gratefully acknowledged. Thanks are also due to Mr. A. F. Faulkner of the Plessey Company.

Planning Problems Associated with a Developing Trunk Switching System

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A national telephone system tends to develop from one utilizing manual exchanges to a fully automatic network with international subscriber dialling facilities. Special reference is made to the development of the British Post Office network and some of the difficulties that can arise when the trunk traffic growth rate remains at a high level are discussed.

INTRODUCTION

Telephone exchange equipment and line plant is costly to provide but once installed can be expected to remain in position for several decades. Provision plans, therefore, take into account the difficulties inherent in the forecasting of telephone traffic and are made sufficiently flexible to accommodate reasonable variations. Account is also taken of possible future changes in plant costs resulting from technical developments, since a change in the relationship between equipment and line costs can have widespread repercussions on the overall economics of a trunk switching network.

The task of fitting current plans to longer term requirements is more straightforward where the evolutionary steps in development are small and can be taken in the correct sequence. In a system which is developing rapidly, not only in size, but also in terms of equipment techniques and service facilities, the practical problems are more complex. The most important of the factors affecting the planning of a telephony service are described in this article.

GENERAL STAGES OF TELEPHONE SYSTEM DEVELOPMENT

From the point of view of operational progress, several development phases may be identified in the growth of switching systems:

(*a*) manual local exchanges with manually-controlled trunk interconnexions,

(*b*) local automatic-networks with manual trunk-interconnexion, either on a delay or demand basis,

(*c*) local automatic-networks with single operator-control of the trunk traffic,

(*d*) fully automatic network with subscriber trunk dialling (s.t.d.) and international subscriber dialling (i.s.d.).

In the development of any particular system there is no strict reason why all these phases should be followed through, but it is usual first to introduce automatic working at local exchanges and then gradually to extend subscriber-dialling access to all other exchanges. Moreover, as in the Post Office, it is not unusual to find within one national network, more than one of these phases in existence at the same time.

INTRODUCTION OF TRUNK MECHANIZATION

Although automatic working had been introduced much earlier, the first major change to the Post Office system started in 1927 when consideration was given to the conversion of the London system. This was not a difficult planning operation with most problems of a local nature. Viewed in retrospect, perhaps the most important task which followed in the 1934–36 era was the selection and standardization of the type of switching equipment.

The introduction of trunk "on demand" working in 1932 aimed at improving the service given to subscribers by eliminating the delays in call completion and by increasing overall efficiency. The major work associated with the change stemmed from the need to provide more trunk circuits from the manual boards and associated exchange equipment.

Dialling over trunk circuits was first introduced in 1938 when operators were given facilities to dial into distant director areas using S.S.A.C. No. 1 (old style 2 v.f.) signalling equipment. It was not until 1954 that the first steps were taken towards the provision of a fully-mechanized trunk-switching system by the opening of Faraday and Kingsway trunk exchanges in London and the introduction of single-operator control of trunk traffic. Under this scheme the operators at originating control centres were able to complete calls through to their ultimate destination without the assistance of any intermediate operator. Fig. 1 shows how a typical call was connected.

From the planning viewpoint, the introduction of trunk mechanization required major building extensions and the installation of non-director type trunk-switching equipment at all zone centres. It was also necessary to provide automatic switching facilities through the terminating group-centres to local exchanges. Bringing these new trunk switching-units into service required careful co-ordination of the plans for utilizing the new units and all the outstations to which they were connected, together with the publication of the new access codes for all the operators required to use the new routings.

In 1946 subscriber-dialling access was also extended by the introduction of multi-metering. This resulted in changes of trunking and the introduction of new-type metering equipment at group centre and local exchanges.

NETWORK PLANNING FOR S.T.D.

The program for the completion of single operator control of trunk traffic has been rapidly overtaken by the need to introduce s.t.d.

Fig. 2 shows the trunking of the originating group switching centre (G.S.C.) and how register-control equipment has taken over the function of the controlling operator. It shows the extent to which trunk mechanization was an essential prelude to the introduction of s.t.d.

The strowger step-by-step method of routing and switching is retained and the comparatively expensive register control has been introduced only to deal with those calls to be routed via the trunk network.

The introduction of full subscriber trunk dialling into any

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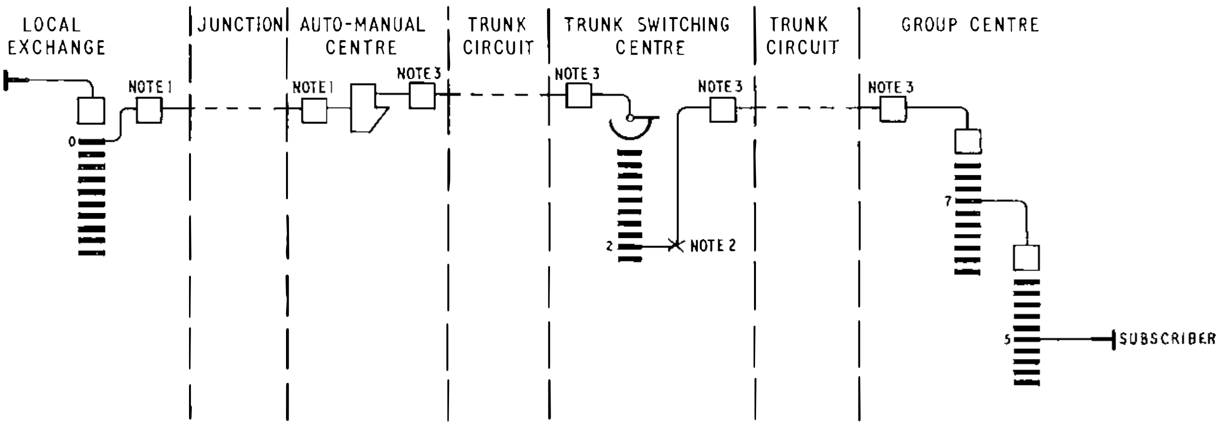


Notes. 1. Assistance level relay-sets.
2. Via extra switching stages.
3. S.S.A.C.1 trunk signalling relay-sets.

FIG. 1—Routing of a call with trunk mechanization

national switching system must have widespread implications, and it is usually only provided after a thorough study of a wide variety of inter-related factors. Not only is it necessary to ensure that the engineering problems are solved, but also that full account is taken of any possible social and economic consequences.

In the first place, it is necessary to determine the form of the national numbering scheme, taking care not to prejudice the world numbering scheme. The division of the country into appropriate charging and numbering groups and the location of G.S.C.s to serve them needs also to be examined. The transmission standards for the national network require study as do the transmission losses allocated between the different sections of the trunk and local network. Due weight needs to be given to:

(*a*) the C.C.I.T.T.* recommendations concerning the overall reference equivalent[1] values for any connexion which is likely to form part of an international connexion,

(*b*) the choice of telephone instrument, in particular its transmission and reception characteristics,

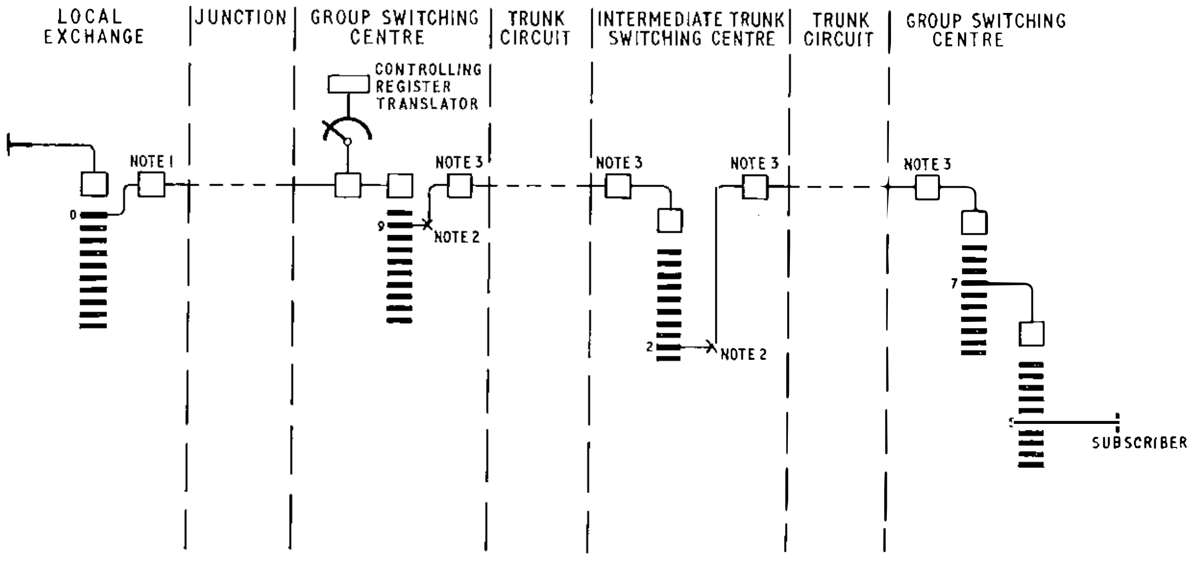
(*c*) the advantages which may be achieved by allocating as large a proportion of the reference equivalent values as possible to the local network,

(*d*) the reference equivalent values to be allocated to the trunk section where minimum values are influenced by echo and stability considerations. It is also necessary to decide how the reference equivalent values within the trunk section are to be allocated, as these may be a deciding factor in the choice between 2-wire or 4-wire switching within trunk exchanges.

Once the foregoing have been settled it is possible to decide the routing principles to be adopted and the layout of the routes to form the basic, or mandatory, network. In a hierarchical scheme, further calculations are necessary to decide the basis of provision for high usage and fully-provided direct auxiliary-routes.

The type of signalling to be adopted is governed by both the type of line plant provided and the type of exchange-switching-control (e.g. register, stored program or digital processor), coupled with such factors as the need to transmit metering signals during a conversation. Due weight must be given to the cost penalties, as well as the service advantages of higher signalling speeds, and reliability offered by register-controlled transmission of information, as distinct from line supervisory signals. Fig. 2 shows S.S.A.C. No. 9 (inband/v.f.)

* C.C.I.T.T.—International Telegraph and Telephone Consultative Committee.



Notes 1. Auto-auto relay-set with metering over junctions.
2. Via extra switching stages.
3. S.S.A.C.9 trunk signalling relay-sets.

FIG. 2—Routing of a typical s.t.d. call

signalling equipment, the current P.O. standard system for trunk circuits routed over h.f. line plant.

To simplify dialling procedures and to maintain effective use of the trunk network, some form of register control for setting up s.t.d. calls is essential. Register equipment may be designed to handle calls either on an "own exchange" basis or on the basis of "right-through" routing and the method employed at originating exchanges is influenced by the techniques used to control the switching of local exchange traffic. In the Post Office system, the former method of control has been used for the transit network, although to exploit more economic routings fully, and to extend automatic access in advance of the availability of the transit network, the controlling register translators at G.S.C.s are being used to control the routing of calls over one or two strowger links.

Because an established network represents a large investment, it is important, during the intial equipment-circuit-design stages, to ensure that the plant to be added is fully compatible with the equipment already existing in the system. It is undesirable to enforce the premature replacement of plant on a national basis solely to introduce s.t.d., although exceptions may be acceptable, e.g. at some of the oldest types of exchanges. Where new facilities can only be introduced by the premature replacement of useful equipment, then the cost of replacement needs to be balanced against operational savings and the improved quality of service. Finally, care must be taken to ensure that it will be possible to introduce s.t.d. at an individual exchange without requiring consequential changes at a large number of other exchanges to which it requires access.

There is also a need to anticipate the stimulation of all trunk traffic which normally follows the introduction of s.t.d. Augmentation of plant on a fairly extensive scale is frequently required as it is not unusual for trunk traffic to increase by 30 per cent to 40 per cent over the level which would otherwise have been achieved during the 3 to 4 years following the introduction of s.t.d.

To benefit the largest number of subscribers, and to ensure an adequate return from invested capital, s.t.d. is usually first introduced into the larger exchanges and those known to originate the maximum amount of trunk traffic.

THE TRUNK TRANSIT NETWORK

The s.t.d. equipment provided at G.S.C.s in the Post Office system has been designed with sufficient translating capacity to route calls over one or two G.S.C.–G.S.C. trunk links, as this is the limit which is permitted by the present national transmission plan. The trunk transit network, operating on a 4-wire switched basis, which is now being introduced,[2] will ultimately extend access to all exchanges in the network. It will provide high-speed switching and signalling facilities and improve the transmission performance of some calls.

This new transit network will provide a basic network throughout the country of 37 transit exchanges, 9 of which will be fully interconnected and known as main switching centres (M.S.C.s). The remainder will be known as district switching centres (D.S.C.s). Each G.S.C. in the country will eventually be connected to its home transit switching centre (T.S.C.) at least.

Register-controlled m.f. signalling (2 out of 6 frequencies in the forward direction, and 2 out of 5 in the return direction) will be used to transfer digital information (within the speech band) between the originating G.S.C.s, the transit exchanges and the terminal G.S.Cs. The majority of the interconnecting trunks will be routed via h.f. plant and the line supervisory signals are 2,280Hz.

The first T.S.C. will be brought into service early in 1969 and the majority of G.S.C.s will be connected to the network by 1973.

From the planning viewpoint, the actual location and provision of the 4-wire transit switching units does not constitute a serious problem, except for the need to make available adequate accommodation. Functionally the units may be located quite separately from any other switching unit, although slight economies may be achieved if they are located in the same building as a controlling register-translator unit.

To provide access to and from the transit network at G.S.C.s is rather more difficult. In the first place, the existing installations need to be augmented by the provision of m.f. sender and receiver equipment for both incoming and outgoing circuits, together with associated power plant.[3, 4] Appropriate selector-level access must be provided to the basic transit route and to any fully provided or high-usage auxiliary route. A typical G.S.C. installation is shown in Fig. 3. Suitable grading and interconnexion arrangements must also be completed to permit automatic alternative routing.

When plant has been provided, there is a need to make the additional access available as soon as possible and also to encourage the subscribers to use the facility instead of continuing to route calls via an operator.

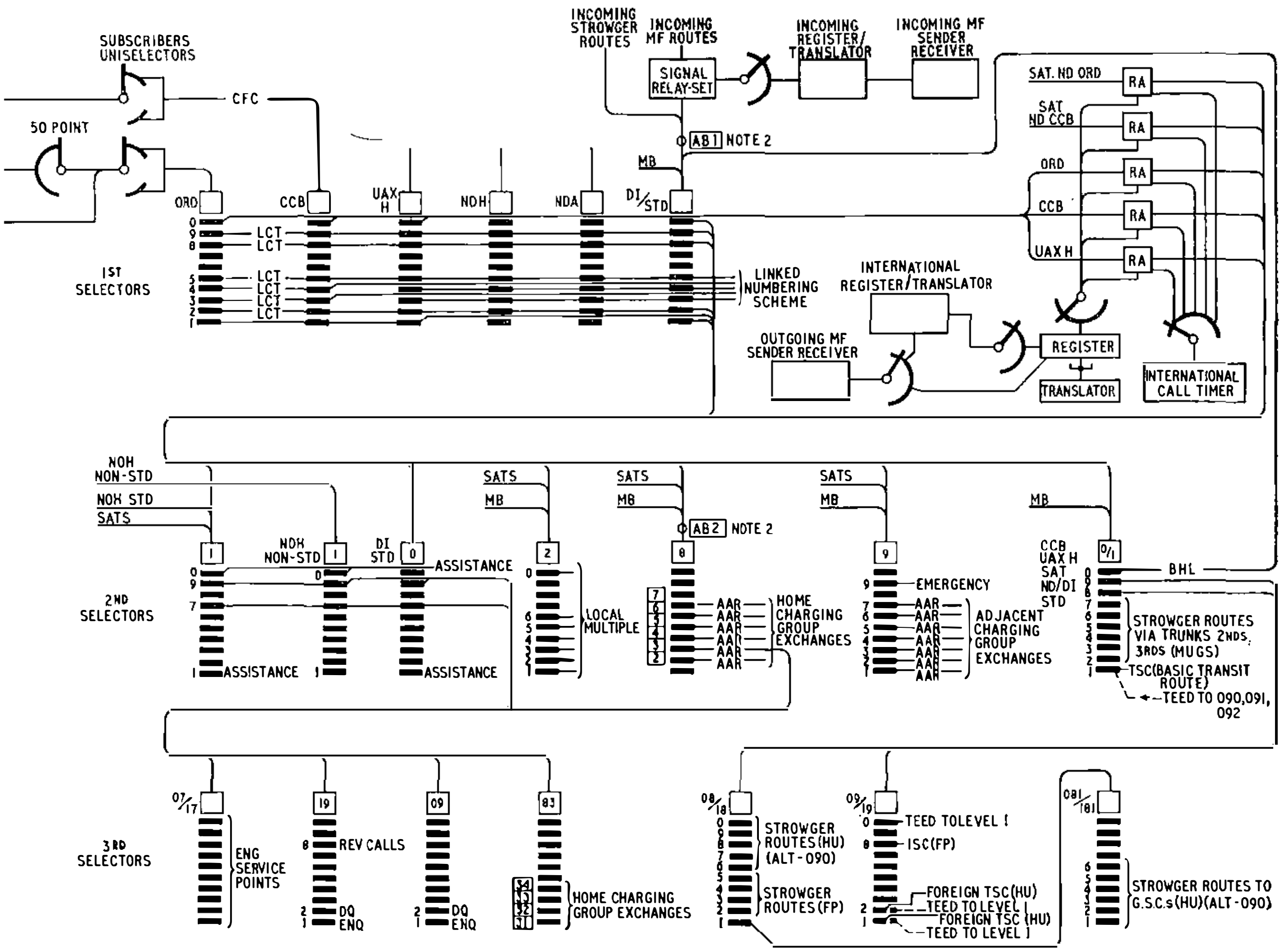
The introduction of full s.t.d. facilities, coupled with the growth in trunk traffic, has led to the need for re-assessment of the number of switching nodes required to serve the network. Originally, when trunk traffic was operator controlled, it was planned to establish some 250 group centres working in conjunction with 24 fully-interconnected zone and sub-zone centres. It is now anticipated that some 360 G.S.C.s will be required, together with the 28 D.S.C.s and 9 M.S.C.s.

The introduction of G.S.C.s where group centres did not exist previously, has raised numerous planning problems and each new centre needs to be justified by comparing the cost of handling the traffic at an existing centre, usually in an adjacent charging group. In practice, this question arises first when the longer term studies of traffic patterns reveal that one or more exchanges in particular numbering groups are forecast to generate sufficient traffic to justify direct auxiliary routes to a number of other G.S.C.s.

The new G.S.C. site has to be chosen to minimize both trunk and junction line-plant costs. Care needs to be taken to ensure that existing s.t.d. access, which might have been given via another centre, is not withdrawn between the time when the new G.S.C. opens and when transit access is fully introduced. This could happen if the new G.S.C. justified fewer trunk routes than those which were obtained via the first centre.

The justification of a new G.S.C. in an established system is one of engineering economics applied to a small portion of the network, but the provision of a new switching network, such as the transit network, is a proposition of quite a different magnitude and requires study of the whole national network. The s.t.d. traffic from existing G.S.C.s is either routed over direct routes or on a G.S.C.–G.S.C.–G.S.C. basis; so long as certain engineering conditions are satisfied, it is the remaining trunk traffic which is to be routed via the trunk transit network.

The initial problem of determining call-routing principles, the number, status and the location of transit centres to deal economically with the traffic from existing G.S.C.s, and that which will arise in the future, can be best solved with the aid of a computer. Conventional cost and engineering study methods were used in the planning work leading up to the decision by the Post Office to provide 37 transit switching centres. Future changes in the ratio of the cost of line plant to the cost of exchange equipment, or considerable increases in the growth of trunk traffic in certain parts of the country, would justify changes to the number of centres and to the pattern of the network. Cheaper line plant, coupled with higher traffic quantities, could lead to the justification of more direct routes with less traffic routed via the transit network, whereas the possible introduction of integrated p.c.m. switching and transmission may lead to an increase in the percentage of traffic routed via tandem switching points.



NOTES 1. Levels not numbered are spare.
2. Points reached by translation of number group code.
3. [5] Indicates levels dealing with the untranslated portion of the national number.
4. Legend. L.C.T.—Local-call-timing relay-set.
C.F.C.—Coin-and-fee-checking relay-set.
R.A.—Register access relay-set.
M.U.G.S.—Motor uniselector group selector.
A.A.R.—Auto-to-Autorelay-set with regenerator.

FIG. 3—Typical group-switching-centre trunking

INTRODUCTION OF INTERNATIONAL SUBSCRIBER DIALLING (I.S.D.)

At present only subscribers connected to the larger towns served by magnetic-drum-type originating s.t.d. control equipment have been given i.s.d. access to the continent of Europe; subscribers with access to the London magnetic-drum equipment will, in due course, be able to dial the North American continent. Plans are being made to extend similar facilities to subscribers in about 30 other cities and large towns in this country, during the early 1970s.

The technical development plans envisage the addition of control, storage and timing equipment to the plant already provided at G.S.C.s to give control of i.s.d. traffic and to provide transit access. The main planning considerations arise from the need to closely associate the new plant with existing plant, and take the form of limitations in the maximum permissible resistance of the cabling involved. The need for sufficient and suitable accommodation to meet the provision program may also be a problem.

GROWTH OF EXISTING TRUNK SWITCHING UNITS

Apart from the factors associated with the introduction of new facilities into an existing trunk switching network; there are those which can arise solely from the rapid growth of the trunk traffic.

At existing G.S.C.s there is the continuing problem of planning to cope with the normal growth of the traffic within the network but relief measures can be properly planned and implemented so long as time is available. However, any rapid and sustained changes in demand are likely to cause some difficulties. Of late the U.K. trunk network has been growing rapidly, as shown in Fig. 4.

It may take from 2 to 8 years to plan and provide a new trunk switching unit from the time the need is foreseen, a suitable site purchased, a building erected and equipment manufactured and installed. Consequently, any rapid and unforeseen increase in traffic could lead to the exhaustion of equipment or accommodation capacity.

The early exhaustion of a building does not normally jeopardize the growth of the system, so long as adequate time is available to permit an extension. The premature exhaustion of a complete site can be much more serious and can lead to expedients and expensive relief measures, especially where an alternative site cannot be found in time.

It is always economical to remain on an established site as long as sufficient capacity is available to meet future needs —this means that any opportunity to purchase an additional site adjacent to an existing site must be carefully studied. Circumstances inevitably arise where an adjacent site is not available and another site must be sought elsewhere. This problem may occur at existing non-director G.S.C.s; it may also occur in director areas and, although solutions are similar in principle, they differ in detail. However, before a move is made to divide the function of a trunk switching-centre over two sites, there is a need to establish the development plan for the long term as well as accounting for any

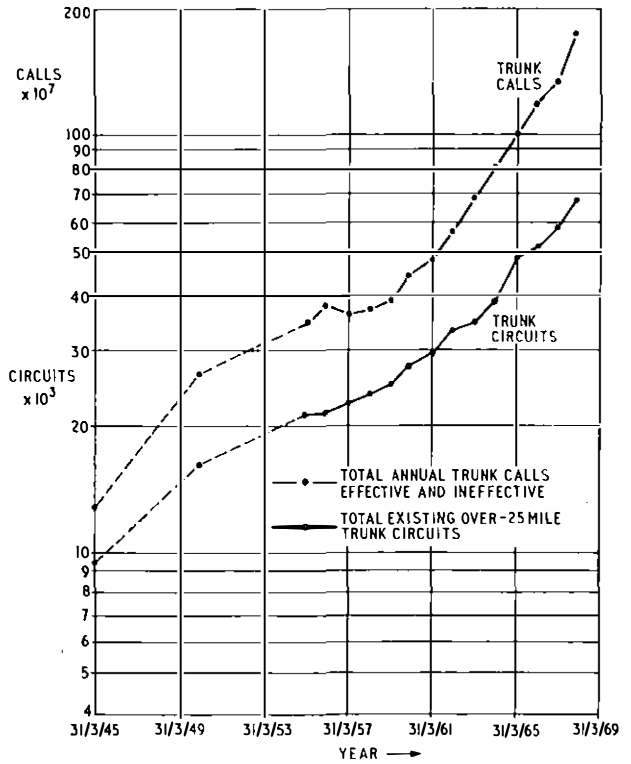


FIG. 4—United Kingdom trunk system growth

short-term wastage of existing plant. Any additional maintenance effort and constructional work which might be incurred in establishing new units must also be taken into account.

If, in a non-director G.S.C. area, the purchase of a site separated from the existing site is necessary, then the new site should be as close to the existing centre as possible. Moreover, there are advantages from the trunk switching and auto-manual centre points of view, if certain cabling distances are not exceeded. For example, it could well be possible to integrate the switching function of the new unit with that of the old without sacrificing transmission standards. Nevertheless, exceptions will arise in major re-development areas where a substantial growth of originating trunk traffic takes place within a locality some distance away from the existing G.S.C. Under these circumstances there is no alternative but to exceed the limits concerned. Consideration must then be given to the cost of establishing two separate G.S.C.s and to the cost of duplicate line networks within the same area, as opposed to the cost of the complete replacement of the existing G.S.C. and the provision of a new G.S.C. on a different site.

G.S.C.s are normally planned on the basis that the main switching-unit performs the following functions:

(*a*) control of s.t.d. traffic originating in home and dependent charging groups,

(*b*) switching trunk traffic (*i*) outgoing, incoming and through, via strowger routings and (*ii*) outgoing and incoming via m.f. routings,

(*c*) switching incoming trunk-traffic to local exchanges in home and dependent charging groups,

(*d*) switching local code-dialled traffic to and from exchanges within the local-fee area, including traffic between satellite exchanges,

(*e*) switching traffic to and from the various service points.

The G.S.C. building may also house transmission equipment, an auto-manual centre (A.M.C.) and a local automatic exchange.

Because of the integrated nature of the switching unit design, it is not always possible to relate functional units to practical divisions. Consequently, when an existing G.S.C. becomes exhausted, consideration is given first to the separation of the local exchange and the G.S.C./A.M.C. elements; it is assumed that the G.S.C. includes the line transmission equipment. As an example, the capacity of the existing building and site might be adequate to accommodate either the local multiple or the G.S.C./A.M.C., but not both. A detailed study, taking into account the respective development rates, traffic levels, traffic distribution, location of trunk and junction line plant and the age of the existing plant is necessary to determine whether to re-locate the local exchange or the G.S.C./A.M.C. Alternatively, it may be found that the re-location of the A.M.C. only will give the necessary relief. A cordless-type switchboard would permit office-type accommodation to be used to house remote switchboards, although the need to provide associated switching equipment in the G.S.C. might detract from this solution. Sometimes it is clearly desirable to install a G.S.C. in a new building and recover the equipment from the existing G.S.C. for immediate re-use elsewhere, thereby freeing space for the growth of the local exchange. Elsewhere, the G.S.C. element may be significant and only partial recovery of equipment will be necessary to allow for the growth of the existing unit. In some instances, however, considerable rearrangement of racks might be involved and full rearrangement costs must be allowed for.

One possible method of inter-working strowger plant between an existing unit and a second G.S.C. unit on a new site is shown in Fig. 5. It is assumed that the recovery of the A.M.C., and part of the G.S.C. equipment, is sufficient to allow for the growth of the local unit. Three-wire circuits and P-wire link-circuits will be required between the units. Ultimately, the existing G.S.C. will be recovered to permit the growth of the local exchange.

Where it is not possible to comply with the limitation on cabling distances between the existing and relief G.S.C.s, then any circuits between the two units must be 2-wire, constituting an extra transmission link in any through-routed calls.

Some G.S.C.s have been installed in association with tandem trunk units and at these centres the component of through trunk-traffic is much greater than at those G.S.C.s already described. Similar problems arise at these exchanges, and the choice of relief site is governed by the same constraints, but, because of the very considerable investment in plant which exists at these larger centres, the need to avoid premature plant replacement becomes of paramount importance.

SECTORIZATION IN DIRECTOR AREAS

The problems of meeting growth in traffic to be handled at trunk exchanges in director areas are broadly similar to those already described. In the provincial director areas the main trunk-unit normally provides facilities for controlling outgoing, incoming and through traffic. In general, there is merit in fully exploiting all available centrally-located site-capacity before a deliberate policy of de-centralization is adopted.

To afford relief to trunk units which become exhausted, other incoming units can be located separately from the main incoming unit, and incoming trunk routes requiring access to director exchanges only, can terminate on these new units. Relief outgoing-trunk units may also be located separately from the main unit and, depending upon the quantities of traffic originated from the director exchanges in the area they serve, may justify their own direct trunk routes. However, unless these units are sufficiently close to the main unit for the link connecting them to be ignored from the transmission viewpoint,

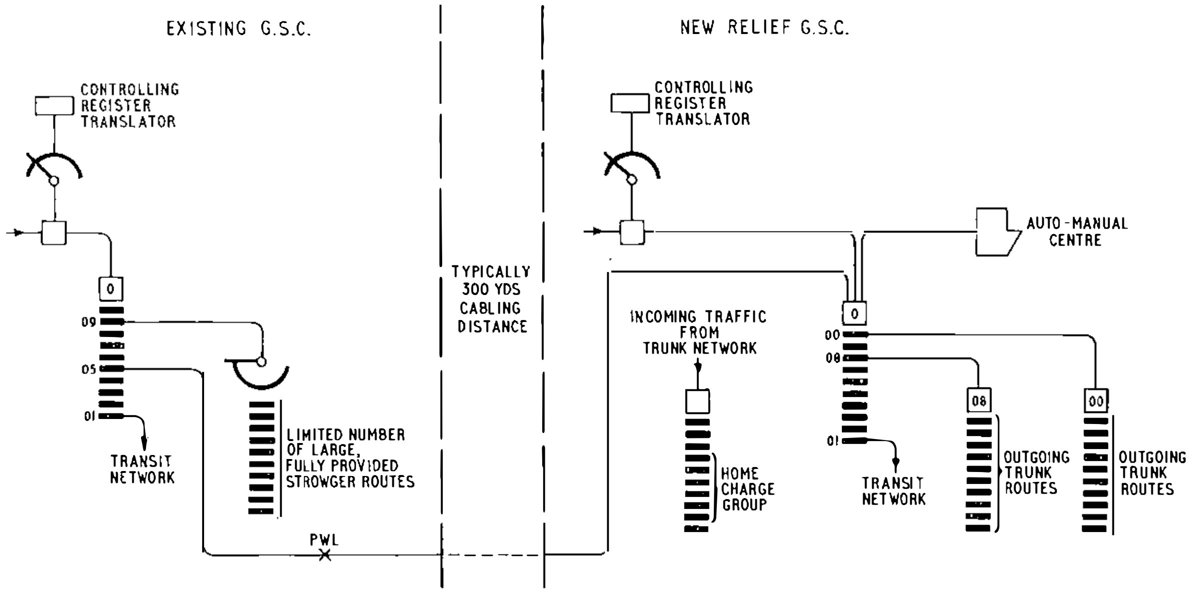


FIG. 5—Trunking between existing and relief group switching centres

then tandem access via the main unit is limited to a single link beyond the latter.

For many reasons, particularly in the larger director areas, the provision of a multiplicity of trunk units is not an entirely satisfactory solution. For example, each new incoming trunk unit requires its own network of junctions to all director exchanges. To take advantage of the opportunity offered by the introduction of all-figure numbering (AFN), all director areas have been divided into a number of sectors for exchange identification purposes. Director exchanges identified by the same first, or by the same first and second digits, in the exchange codes are chosen to be located in the same sector. Thus it becomes possible to identify groups of exchanges within their sectors, and to provide trunk units, both incoming and outgoing, to serve one or more sectors. This process of sectorization is already being implemented in London.[5]

UTILIZATION OF TRUNK SWITCHING AND TERMINATING EQUIPMENT

Where the growth of trunk traffic rises rapidly throughout a major portion of a national network, at a rate which does not allow sufficient time to plan, manufacture, and bring into service, all the extra switching, signalling and line plant needed, it becomes more than ever necessary to ensure that all available plant is fully and efficiently exploited.

This also means that as soon as new plant becomes available it must be brought into service. However, a trunk network cannot function efficiently without both exchange equipment and interconnecting trunk circuits. Trunk network co-ordination arrangements must be strengthened to ensure that both of these essential components are available for utilization at the same time and where the service need is greatest.

The urgent need to bring equipment into service at the earliest date raises the question whether exchange design techniques for extension of major switching centres should be changed to enable blocks of switching capacity to be brought into service at stages during the overall installation period. This could avoid major regrading schemes, but at the cost of a marginal reduction in the efficiency of plant provision.

CONCLUSIONS

It has been possible to review only briefly some of the major factors which can influence planning in a developing trunk switching system and these have been considered in general terms rather than on the basis of their precise effect on the design of individual switching centres. Even so, some equally important problems, which must also be allowed for in current plans, have not been included. As an example, no mention has been made of the widespread repercussions which are certain to arise as the traditional electromechanical systems gradually give way to their electronic successors. Apart from the need to meet the comparatively well-established and understood demands of a trunk telephone service, an even greater and quite different requirement will arise from within the rapidly-developing data-communication field. The provision of a separate line and switching network designed essentially to handle high-speed data calls operating on an integrated transmission and switching basis is a possibility.

To remain efficient, and to give the subscriber the service demanded at an economic price, the whole trunk network must always be able to change its shape and to grow. To be of real value, forward planning of line and switching elements of the trunk network must, at the very least, take this into account.

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A New Message-Relay System for the Overseas Telegraph Service

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U.D.C. 621.39.4:621.394.65

An electromechanical message-relay system with magnetic message-storage devices has been installed in Cardinal House, London, for the overseas telegraph service; it replaces a tape-relay unit installed at Electra House, London. The system uses the space-division principle for message switching, motor-driven uniselectors being positioned by a common-control unit, which sets up message paths one at a time. Messages with a prescribed format are routed automatically, but semi-automatic routing under operator control is available for other messages.

INTRODUCTION

The new message-switching system in Cardinal House, London was installed to switch overseas public telegrams to and from telegraph offices in the United Kingdom dealing with overseas traffic, and to switch telegrams in transit between overseas countries. The system replaces the tape-relay unit in Electra House, London[1] to reduce the amount of manual processing, to eliminate perforated-paper tape as a message-storage medium and to speed up the disposal of traffic.

The system is based on a series of telegraph message-switching systems developed by N.V. Philips Telecommunicatie Industrie of Holland, but adapted to suit the British Post Office requirements for handling telegram traffic of the overseas telegraph service.

The system uses the space-division principle for switching messages. The switches are 100-outlet motor-driven uniselectors, positioned by marking conditions from a single control unit, which sets up switched paths for messages, one at a time. Ferrite-core and magnetic-tape devices are used instead of perforated-paper tape both for the temporary and the overflow storage of messages. The remainder of the equipment consists largely of relays and motor-driven uniselectors, but use is made of electronic equipment where its characteristics can be exploited to advantage.

Messages prepared in accordance with a prescribed format are routed automatically by the system, but messages that do not comply with the prescribed format, or for various other reasons are not required to be routed fully automatically, can be accepted for semi-automatic routing under operator control.

By eliminating the handling of paper tapes, and presenting the message heading to the semi-automatic routing position as soon as possible after it begins to enter the system, retransmission can be effected, under normal conditions, within 18 seconds. For messages routed fully automatically the period is reduced to 11 seconds.

The system is expected to handle some 35,000-45,000 messages per day, when fully loaded, and has a designed busy-hour load of 3,000 messages—of average duration 54 seconds—from 50 overseas and 59 inland channels. The system switches messages to 50 overseas and 54 inland channels.

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MESSAGE FORMAT

The efficient operation of a message-relay system, especially one designed to route messages fully automatically, relies upon the characters that indicate the start of the message, its sequence number, destination and priority, as well as an indication of the end of the message, being arranged to consistently conform to the rules agreed between the various operating administrations. The Cardinal House system is designed to accept messages conforming to C.C.I.T.T.* Recommendation F31. This recommendation was drawn up for fully-automatic message-switching systems, and the essential parts of the recommended message format, from a switching viewpoint, are the numbering line containing the start-of-message indicator (SOM), channel indicator and channel-sequence number, the pilot line containing the destination and priority indicators, and the end-of-message (EOM) indicator, as shown in Fig. 1.

The system will, however, accept messages for fully-automatic routing whose format differs in minor respects from that shown in Fig. 1. For example, the functional pairs of LETTER SHIFT-SPACE or SPACE-FIGURE SHIFT may be transposed without any adverse effects on the system or the routing of such messages.

OUTLINE OF OPERATION

Fig. 2 shows a simplified block diagram of the system. Each message received by the system must be stored, at least temporarily, while the destination indicator is examined and the path through the system is determined and established. To economize on the provision of relatively-expensive storage devices, this system is equipped with a group of 74 incoming stores serving 109 incoming channels, with a grade of service of one message in 10,000 failing to be immediately connected to a store in the busy hour.

An incoming store, embodying a 2,000-character ferrite-core matrix, and associated incoming connecting circuit is connected to an incoming channel at the commencement of a message by an incoming line-finder arrangement employing motor-driven uniselectors controlled by a relay-type allotter. To ensure that the incoming store will receive all the characters that follow a SOM sequence, fast line-finding is necessary. This is achieved by arranging for five non-homing line finders to simultaneously hunt for the channel when the second code-element in the first character Z in the SOM signal is detected. This is detected by a relay-type halving-

* C.C.I.T.T.—International Telegraph and Telephone Consultative Committee.

Item	Start of Message (SOM) Signal (Note 1)	Channel Sequence Numbers (Note 3): Channel Indicator	Sequence Number	Channel Indicator	Sequence Number	Telegram Identification Group (Note 4)	End of Line
Number Line (Note 2)	Z C Z C →	G E B ↑	0 9 9 ↓ →	A F A ↑	1 3 5 ↓ →	L X ↑ 7 4	< ≡
Item		**Destination Indicator** Country | Office	**Priority and Tariff (Note 5)**	**Origin Indicator** Country | Office	**Number of Chargeable Words**	**End of Line**	
Pilot Line (Note 2)	↓	G B L O →	H L →	U R W A → ↑	0 1 3	< ≡	
Preamble Line	↓ W A S H I N G T O N → ↑ 1 3 / 1 2 → 1 3 → 1 2 0 5 < ≡ ≡ ≡						
Paid Service Indications	↓ L T < ≡						
Address Line (Note 6)	↓ – ↓ M I D B A N K → L O N D O N ↑ – < ≡ ≡ ≡						
Text	↓ F O R W A R D → S O O N E S T → P R E S E N T → A C C O U N T < ≡						
	↓ B A L A N C E → J O N E S → N U M B E R → ↑ 7 8 ↓ A ↑ 7 6 5 < ≡						
Signature	↓ → → → → → J O H N S O N < ≡						
Collation	↓ C O L → L T → ↑ 7 8 ↓ A ↑ 7 6 5 < ≡						
End of Message (EOM) Signal (Note 1)	↓ N N N N						

Key to symbols representing functional combinations:

→ = Space
↑ = Figure Shift
↓ = Letter Shift
< = Carriage Return
≡ = Line Feed

Notes:

1. The SOM and EOM signals are the same for every message; the SOM signal may be preceded by the page-alignment function < ≡ ↓ and the EOM signal may be followed by a message-separation signal of 10 × ↓
2. Items in the number and pilot lines are identified because they constitute the message heading presented to the automatic routing equipment.
3. Channel sequence numbers are included for every channel over which the message has already been transmitted.
4. The telegram identification group may contain up to 12 printed characters plus shift combinations.
5. The priority indicator may be A, B, C or H: the tariff indicator may be N, O, P, L, M, U, D, I or Q.
6. The hyphen signs in the address line are provisional and may be omitted.

FIG. 1—Example of message format to C.C.I.T.T. Recommendation F31

circuit, in each incoming line circuit, which counts polarity reversals on the channel and activates the line finders if the second and third reversals are separated by one element of stop polarity. There is a risk that the line finders can be activated by spurious characters between EOM and SOM sequences and so cause an incoming store to be connected to line prematurely. The risk is, however, small and is acceptable.

The messages in the incoming stores need to be handled in different ways, depending on whether the incoming channel is a cable circuit or a radio channel with error-correcting facilities, and whether the originating country prepares the message format so that it is suitable for automatic routing or only for semi-automatic routing. Details of these requirements are programmed by strapping in each line circuit, and the information is passed over a common multiple, under the control of a further allotter, to the connecting circuits, associated with each incoming store, for the appropriate action to be taken. By effecting discrimination via the allotter instead of via the line finder, the number of wipers required on each selector has been reduced.

The channel remains connected to the incoming store until the EOM sequence; this is recognized by a character-detector that detects four Ns in the receive side of the store and causes the channel to be disconnected.

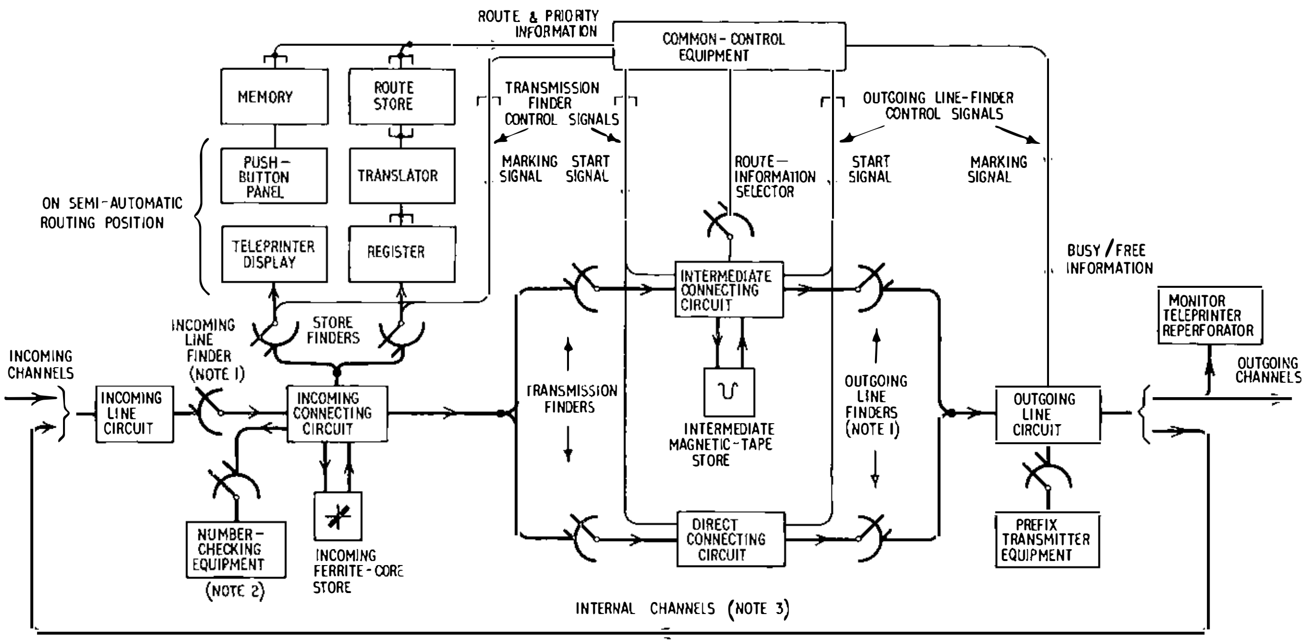
Determining the Route Automatically

Twelve registers and a single translator are provided for decoding the routing and priority information contained in the message format into instructions for the common-control equipment.

When 41 characters from line have been received by an incoming store, a register is connected to the store via the store finders.

The incoming store transmits the information at 75 bauds to the register (the contents of the store being preserved) until the second carriage-return and line-feed combinations have been detected. The register, whilst this message heading is being received, carries out checks on the format of the heading and, if the format is correct, stores the 4-character destination indicator and single-character priority indicator in 5-unit code form on an array of capacitors. Associated with each register is a teleprinter which monitors the message headings presented to the register. The register is connected to the translator, when the latter is free, for the route and priority information held in the capacitor store to be transferred to one of three route-stores.

Routing may be effected on either the first two characters, or on all four characters, of the destination indicator, as predetermined by strapping within the translator. The destination indicator is translated into a 2 × 2-out-of-5 code on relays in the route store appropriate to one of 100 routes. The route store also receives the priority information on one of four relays. Once the information has been passed to the route store the translator is released to deal with calls from other registers. The register is partially released, enabling it to receive information from another incoming store; how-



Notes:

1. As there are more than 100 incoming and outgoing channels, two groups of incoming and outgoing line finders are provided but are not shown in the diagram. The correct group is selected by relay switching in the appropriate connecting circuit.
2. Sixteen number-checking circuits are provided and, normally, free circuits are associated with an incoming connecting circuit before it accepts an incoming message.
3. Internal channels are provided when it is necessary to recirculate traffic to the system input, e.g. when the register finds that it cannot handle the message (due to format error), or traffic for a particular route is being manually diverted. In these circumstances the traffic is recirculated for semi-automatic handling.
4. The thicker lines indicate transmission and control paths; the thinner lines indicate control paths only.

FIG. 2—Simplified block schematic diagram of message relay system

ever, a connexion is maintained from the route store to the incoming store ready to set up the outgoing connexion for the incoming store. The information remains in the route store until the common-control equipment (c.c.e.) is ready to route the message.

The c.c.e. with its message-handling capacity of 6,600 messages per hour deals with all calls—whether routed fully automatically or semi-automatically—on a one-at-a-time basis.

Routing—Outgoing Channel Free

For a message destined for a route which has one or more channels free, the incoming store is connected to an outgoing channel via a direct connecting circuit. Each connecting circuit has two motor-driven uniselectors: a transmission finder for connexion to the output of the incoming store, and an outgoing line finder for connexion to the outgoing channel.

The c.c.e., upon accepting the routing information from the route store, tests the channels of the outgoing route, marks the appropriate bank contact of the outgoing line-finder multiple associated with the free channel, marks the bank contact of the transmission-finder multiple associated with the store, allocates a direct connecting circuit and finally causes the two selectors to hunt for the marked contacts. Once the connexion has been established, the c.c.e. and the route store are disconnected ready to route another message.

Before the transmission path from the incoming store is extended to the outgoing channel, a prefix-signal transmitter is connected via the outgoing line circuit to transmit a new SOM signal, followed by the outgoing-channel identity and the next sequence number for the message to be transmitted. The read-out of the store is commenced in two stages. The first stage is the read-out of the original SOM up to and including the first stored space; as these characters are not required they are suppressed, and to save time they are read out at 75 bauds whilst the prefix-signal transmitter is transmitting to the outgoing channel. The second stage, which commences after the prefix transmitter has finished, is the read-out of store at 50 bauds to the outgoing channel, commencing at the first character of the incoming channel identity.

The connexion is cleared down, after the fourth N of the EOM signal (Fig. 1) has been transmitted, by an EOM detector, which monitors the signals transmitted from the incoming store.

Routing—Outgoing Route Busy or Out of Service, or via Radio Route

A common group of intermediate stores is provided to store messages from the incoming stores whenever the message cannot be transmitted over the appropriate outgoing route because the channels are all busy or out of service, or if the channels are error-correcting radio links.[2] For such radio channels, the intermediate store, when transmitting, is controlled by the ARQ pulses, thus replacing the buffer store normally associated with each radio channel. This arrangement effects some economies, and increases the flexibility in the use of intermediate stores. One hundred and twenty five intermediate stores are provided, each arranged to store 80 messages.

The intermediate stores are allocated by the c.c.e. The allocation is made on the basis that each store should only contain messages for one outgoing route, all with the same priority classification. The number of stores allocated per priority classification is predetermined by strapping, and is in general equal to the number of outgoing channels in the route. The c.c.e. directs subsequent messages into the allocated stores in cyclic order. To enable the c.c.e. to do this, the c.c.e., whilst making the allocation with the first messages, marks the store with the appropriate priority by operating one of four relays in the intermediate connecting circuit associated with each store, and marks the store with the route allocated, by positioning the route-information selector.

If a route is out of service for long periods the allocated stores for one or more priority classifications can become full. In these circumstances the c.c.e. can allocate further stores, one at a time, as the need arises.

Each intermediate store embodies an intermediate connecting circuit, which has two motor-driven uniselectors associated with it: a transmission-store finder and an outgoing line finder via which messages are received and transmitted, respectively.

When the c.c.e. accepts routing information from the register-translator group and determines that the message should go into an intermediate store, it allocates a store on the principle described above, marks the appropriate bank-contact multiple of the transmission finder and controls the finder in hunting for the marked contact. The c.c.e. is then disconnected ready to handle further calls. The message, with the original SOM suppressed, is then read out from the incoming store to the intermediate store at a speed of 75 bauds. The connexion between the stores is cleared down upon detection of the EOM code by the NNNN detectors on the incoming-store output and intermediate-store input.

Transmission of Messages from Intermediate Stores

When a channel of a route becomes free and there are messages waiting for that route in intermediate storage, the c.c.e. is signalled over the busy/free information path. The c.c.e. then selects the store or stores with messages for that route by examining the route-information selector. The intermediate store containing the highest priority message is then selected by the c.c.e. by examining the priority-marking relays in the intermediate connecting circuits. The c.c.e. marks the bank-contact multiple of the outgoing channel finder and starts the finder. Once the finder has found the marked outlet, the c.c.e. disconnects itself to route another message.

Before the transmission path is extended to the outgoing channel and the message read out of the intermediate store, a prefix transmitter is connected via the outgoing line circuit to transmit a new SOM signal, followed by the outgoing-channel identity and the next sequence number. The connexion is cleared down when the EOM signal has been detected by a NNNN detector in the store-output circuit.

Other messages held in store when a route becomes free are read out in the manner described above, the group of stores with the highest priority classification being read out before a group with lower priority. Stores within a group are read out one message at a time in cyclic order, starting with the longest-waiting message.

Determining the Route Semi-Automatically

Some overseas administrations cannot assemble the message format in the prescribed manner for the message to be routed fully automatically. The incoming line circuits connected to channels operated by such administrations are strapped to instruct the incoming connecting circuit to direct the message to a semi-automatic routing position (s.a.r.p.).

Fourteen s.a.r.p.s (Fig. 3) are provided, each one embodying two teleprinter displays, operating at 75 bauds, and a push-button panel containing 100 buttons for routing, plus two small groups of control buttons associated with each display.

After 41 characters of a message that requires semi-automatic routing have been received by an incoming store, the message is copied out at 75 bauds to a teleprinter on a s.a.r.p. allocated by the store finders. The characters of the message will continue to be copied out as and when they are stored from the incoming channel, until the operator completes the routing operation. The operator, having observed sufficient characters to determine the route and the message priority, presses the appropriate routing button and one of four priority buttons. Lamps in the buttons light to enable the operator to check his action; if satisfied, the operator presses a start button, which stops the recording of the message on the s.a.r.p. teleprinter, and the route and priority information is transferred to a memory associated with each push-button panel. If the wrong route or priority button is pressed, the selection may be cancelled by pressing a cancel button, but this cannot be done after the start button has been pressed. Two teleprinter displays are provided on each s.a.r.p., so that while the routing is being determined for one message, the other may be recording a further message. This, together with 75-baud operation, provides both an efficient presentation of messages from incoming stores and a suitable load for the operator.

FIG. 3—Semi-automatic routing positions

The memory associated with each push-button panel has a function equivalent to that of the route store described under fully-automatic routing, in that it retains the route and priority information until the common-control equipment is ready to handle the call. The message is then routed by the common-control equipment, as previously described, direct from the incoming store to the outgoing channel or to intermediate storage. When the appropriate connexion has been established, the push-button memory is cancelled, the teleprinter display is freed ready for a subsequent message, and the push-button panel lamps are extinguished, enabling the operator to handle further messages on either display.

CHECKS AND SAFEGUARDS TO PREVENT LOSS OF MESSAGES

The system has three features to protect messages from irretrievable loss. The first is the use of incoming channel-sequence number-checking equipment to indicate whenever the number of a message received by the system from any incoming channel is not one integer more than the last number received. This enables messages not received by the system to be identified at the sending end, and a request to be made for a re-run. The second feature safeguards messages in transit through the system by measuring their delay time in storage, and by periodically checking transmission paths. If either is found unsatisfactory an alarm indicates the equipment involved. When a store is so indicated the message contained in it may then be read out on a teleprinter in the traffic-control area. The third protective feature is the connexion of a monitoring teleprinter to each outgoing channel, to record every message transmitted. If a message fails to be received at the distant terminal, a repeat transmission can be made from the record.

Channel-Sequence Number-Checking Equipment

Channel-sequence number-checking equipment is connected in parallel with the input of each incoming store, so that whenever a store is recording the numbering line of a message, the same sequence number is also stored in the checking equipment. The equipment identifies the channel from the position of the incoming line finder connected to the channel, and stores the 3-digit sequence-number when it detects the figure-shift signal preceding the number. To guard against a message being correctly checked by the channel-sequence-number equipment but failing to be stored in an incoming store, due to a fault, the incoming store is designed to operate an alarm to draw attention to such a condition.

The number-checking equipment compares the currently-stored number with the previous one, and, if the comparison indicates the number is out of sequence or incorrect, the numbers involved in the comparison, together with the channel indicator, are printed out on a teleprinter in the traffic-control area. Periodic inspection of this teleprinter record allows print-outs caused by messages which are simply received out of sequence to be ignored and those which are indicated as missing to be picked out.

The causes of messages indicated as missing can be:

(*i*) the message not being transmitted from the distant station,

(*ii*) failure of the incoming channel,

(*iii*) format errors, including the end-of-message signal omitted from a previous message,

(*iv*) number-comparison equipments not being available at the time the previous message was being received, or

(*v*) a fault on the incoming side of the system up to and including the checking facility of the number comparator.

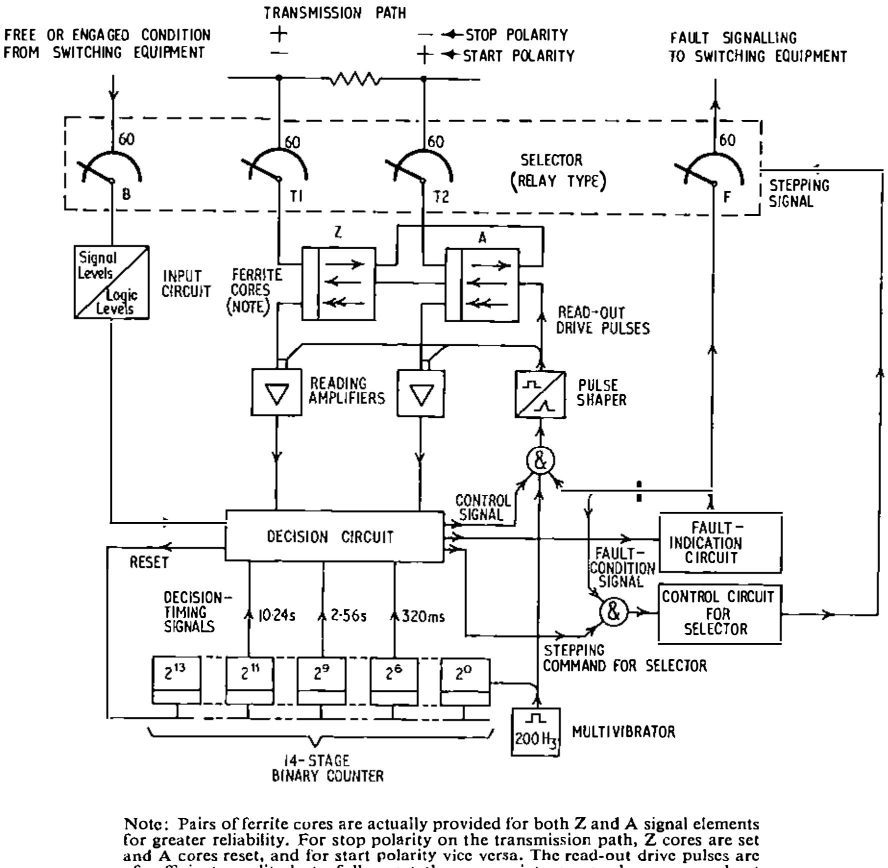
Transmission-Path Checking

The transmission-path checking equipment tests the incoming and outgoing channels and certain internal paths, e.g. the input paths to each intermediate store, approximately every 12 seconds.

The nature of the test applied depends on whether the path is indicated as free or engaged by the switching equipment. Detection of a transmission-path fault causes an alarm to indicate the switching equipment involved and, if necessary, permits a message to be recovered from a store.

Whether the transmission paths are free or engaged, an alarm is given when the test indicates a high-resistance or low-resistance path for more than 320 ms and continuous start polarity for more than 2·56 seconds. On engaged circuits an alarm is also given for continuous stop polarity for more than 10·24 seconds, except that on incoming channels this time is doubled to allow for pauses in transmission at the distant transmitting station. On radio channels transmission is suspended in the absence of ARQ pulses and, to prevent the testing equipment giving an unnecessary alarm, it is arranged for the test to be inhibited by the absence of these pulses.

A simplified block diagram of a transmission-path checking equipment, which has a capacity for checking 60 circuits, is shown in Fig. 4. Seven such equipments are provided, and each equipment is made up of a number of electronic units and a ferrite-core unit for determining the state of the transmission paths, a relay-type selector for scanning the four input leads and a 200 Hz multivibrator and binary



Note: Pairs of ferrite cores are actually provided for both Z and A signal elements for greater reliability. For stop polarity on the transmission path, Z cores are set and A cores reset, and for start polarity vice versa. The read-out drive pulses are of sufficient amplitude to fully reset the appropriate cores when a normal set current is derived from the transmission path.

FIG. 4—Simplified block schematic diagram of a transmission path checking equipment

counter to provide timing pulses for the scanning and testing periods.

The transmission-path testing circuit functions are controlled according to the nature of the test (free or busy test), by a signal from the switching equipment via selector contacts B and the input circuit. A resistor, connected in series with each transmission path, causes a potential difference, the magnitude and polarity of which depends upon the magnitude and direction of the transmission-path current. The potential across each resistor is in turn connected to two pairs of ferrite cores in the transmission-path testing circuit via selector contacts T1 and T2. The state of these cores is read out at the appropriate intervals by read-out command pulses obtained from the multivibrator via the pulse-shaper. The timing information for the logic elements in the decision circuit is obtained by connexions to the appropriate outputs of the binary counter, and, if the transmission path is found to be satisfactory, the relay counter is stepped to the next position. If unsatisfactory, a condition is applied via the fault-indication circuit and selector contacts F to the switching equipment so that an alarm is given before the scanning process continues.

Recording of Messages on Outgoing Channels

Some of the outgoing monitor positions are shown in Fig. 5.

To ensure that every message transmitted on an outgoing channel is recorded, safeguards are incorporated in the recording teleprinter circuit to operate alarms and suspend transmission if the transmission path to the teleprinter is faulty (see Transmission Path Checking) or if the motor circuit is faulty. The store holding the message is indicated by an alarm so that the message may be recovered by manual read-out of the store.

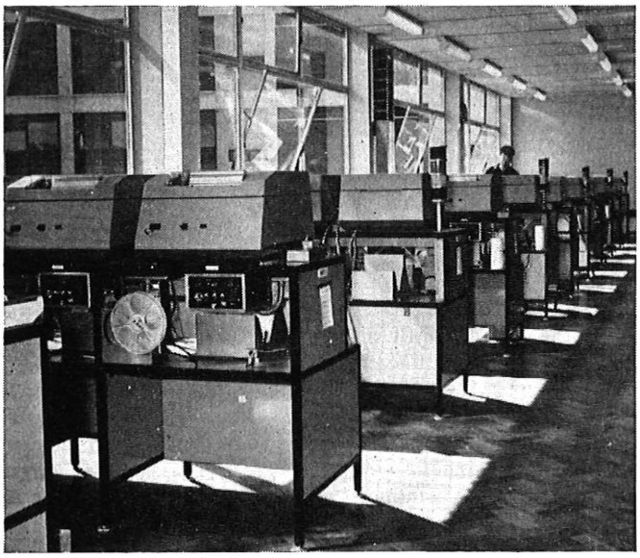


FIG. 5—Outgoing monitor positions

A faulty teleprinter-motor-circuit alarm is given if a centrifugal switch fitted to a motor shaft fails to operate prior to the start of a message or if it releases due to a reduction in speed during a message. The channel associated with a faulty teleprinter may be busied from the machine position to prevent the system routing further messages to that channel.

The recording teleprinters have tape-perforating attachments; the page copy is used to prepare international accounts and to provide long-term storage of every message to meet operational requirements, whilst the tape copy is used when a repeat transmission is required. An automatic transmitter, which may be connected to the outgoing channel via a jack on the machine position, is then used.

INCOMING STORAGE

With the introduction of automatic telegraph message-switching, storage devices are required that can be used repeatedly without the disadvantage of requiring the frequent attention necessary for reperforators and automatic transmitters. Ferrite-core stores, which do not have this disadvantage and are economic when used for small-capacity storage, are utilized in the incoming stores of this system.

Outline Description of an Incoming Store

An interesting feature of the incoming store, a block schematic diagram of which is shown in Fig. 6, is the utilization of a combination of electronic and electromechanical techniques for storage and access circuits, respectively.

The storage medium is a ferrite-core matrix with a capacity for storing 2,000 5-element telegraph characters, each element requiring one core. The matrix, of 3-dimensional form, is constructed of $50 \times 25 \times 8$ cores. However, for explanatory purposes, it is convenient to consider the matrix as consisting of $100 \times 20 \times 5$ cores in the x, y and z planes (Fig. 6), respectively.

The 2,000 vertical columns of the matrix, each comprising five cores, are used to store the five elements of a character. The relay selector steps once every character interval, and the uniselector steps once every time the relay selector completes a 20-step cycle. By applying coincident half currents through the relay selector and the uniselector arc, each column of cores may be selected in turn.

When writing a character into the store, the writing-relay selector and uniselector firstly apply coincident half-reset currents to reset the selected column of cores. The five elements of the incoming character are then stored in the selected column by the receiving distributor converting into parallel form the start-polarity elements of the character into half-set currents on the appropriate wire(s) of the 5-wire output, coincident with the application of half-set currents from the writing, relay selector and uniselector. Thus, only cores corresponding to stop-polarity elements will be set.

Stored characters are read out by the reading-relay selector and uniselector applying coincident half-reset currents to the appropriate column. Those cores in the column which had previously been set due to the storage of stop-polarity elements will be reset, causing read-out pulses on the respective wires in the z plane to operate the reading toggles; the sending distributor converts the character into a sequential output with start and stop elements added. As the stored information has now been destroyed, the same character is immediately re-written into the same column in the matrix.

Each write or read cycle takes approximately 400 μs. Simultaneous write and read cycles are prevented by controlling pulses from the timing and pulse-control circuits, which only permit alternate write and read cycles.

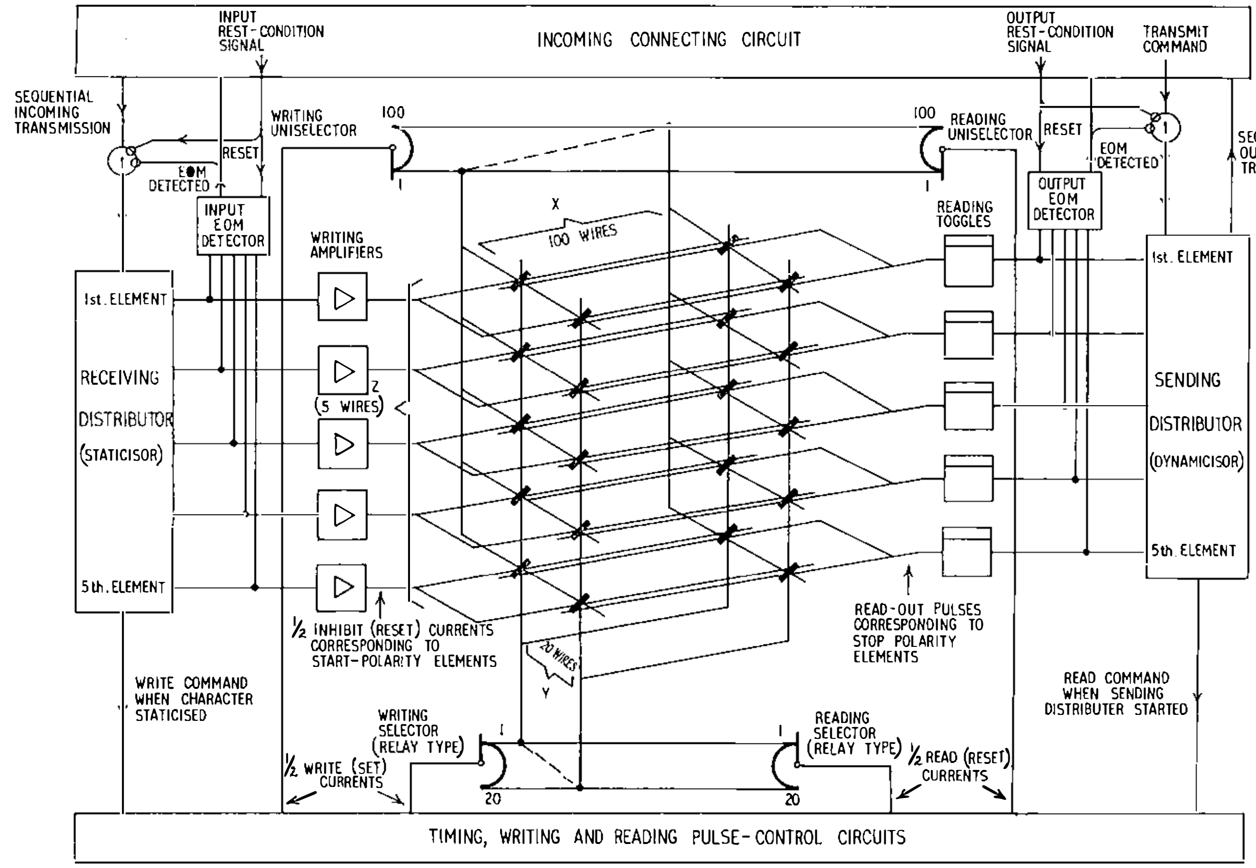
INTERMEDIATE STORAGE

As mentioned earlier, the intermediate storage group is required to have a much larger capacity than the incoming storage group. Ferrite-core stores for large capacities are less attractive economically, and their control arrangements become cumbersome; the physical size also becomes significant. The Philips-type magnetic-tape store used in this system has a capacity of 40,000 characters on a closed loop of tape, providing an attractive compact alternative for intermediate storage.

Outline Description

A simplified block diagram of an intermediate store is shown in Fig. 7.

Each intermediate store contains a mechanical and an electronic section, each section consisting of independent receiving (writing) and transmitting (reading) parts.



Note: The receiving and transmitting functions are unblocked via the gates shown when the input and output sides of the incoming connecting circuit are connected to handle a message, and blocked when the appropriate EOM signal has been detected and whilst the incoming connecting circuit is in the rest condition.

FIG. 6—Simplified block schematic diagram of an incoming store

The mechanical section is a panel, mounted vertically on runners so that it can be slid out during operation for ease of maintenance (Fig. 8). The panel contains a cassette holding the tape, and above the cassette are the write heads, read heads and stepping motors. The tape—20 metres long and 1·25 centimetres wide—contains six tracks, five for the telegraph combination elements and the sixth a synchronizing track which is used to determine the position of the combination elements on the tape. The tape is advanced by friction drive from the stepping motors, which are pulse-controlled from the electronic section. The number of moving parts in the tape-transport mechanism has been kept down to a minimum.

In the electronic section the receiving and sending distributors perform similar functions to those in the incoming store. Six write and six read heads are aligned across the width of the tape in positions corresponding to the six tracks.

When a character is fed to the receiving distributor, the polarity of its elements determines the direction of current, via writing circuits, in five of the writing heads. The direction of current through the sixth head is reversed for each character recorded. The writing motor is stepped simultaneously with the application of these currents, which are of sufficient amplitude to magnetically saturate, in the appropriate direction, a portion (0·5 mm) of the tape track.

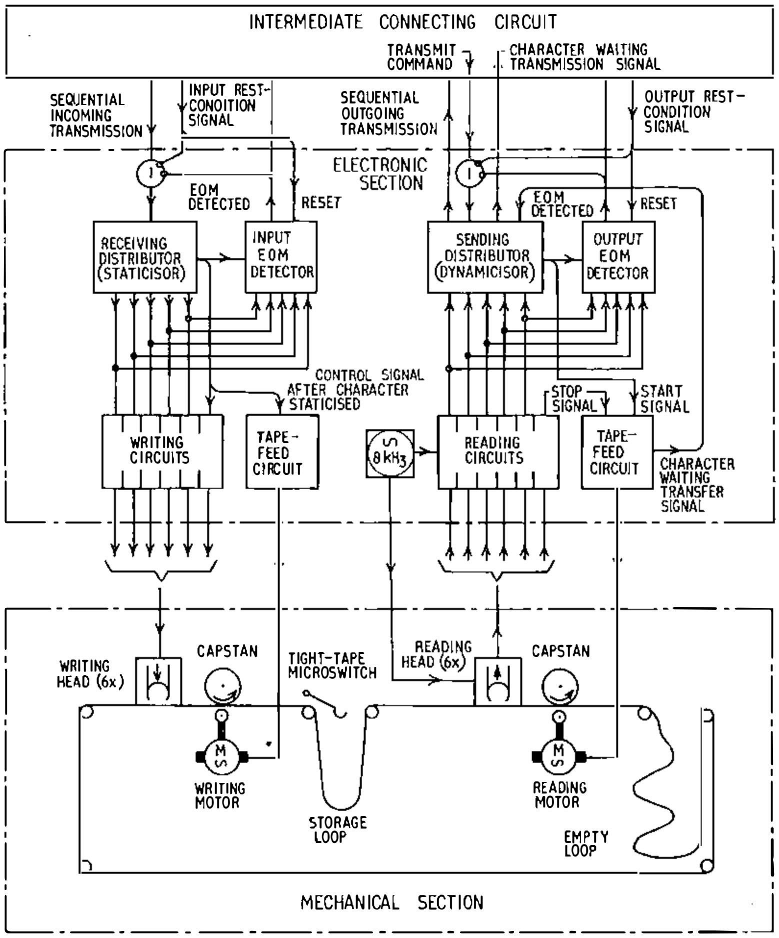
As characters are received they are stored in the portion of the tape loop between the write and read heads until the EOM signal has been detected. The receiving distributor is then blocked until a command signal is given from the switching equipment to store further messages. The slackening of the tape between the write heads and read heads causes the tight-tape microswitch to release, enabling the reading motor to step. As soon as the first character appears under the reading head where it is detected by a reversal of polarity on the synchronizing track, the read motor is stopped. The transmit side of the store then waits until a command is received from the connected outgoing line circuit to transmit the message.

Detection of the polarity present on any of the tape tracks is achieved in the reading amplifier circuit by feeding to each of the read heads an 8 kHz signal of sufficient amplitude to saturate the magnetic core. Each core carries a secondary winding, and the windings and shapes of the cores are so arranged that for every cycle of the 8 kHz input the flux cutting the secondary winding reaches a maximum value twice per cycle. A 16 kHz signal is induced in the secondary winding, its phase with respect to the 8 kHz input being determined by the direction of magnetization of the tape. This signal is compared with the second harmonic of the original signal in a phase-comparator embodied in each reading circuit. The outputs of the five phase-comparators appropriate to the code elements, determine the parallel setting of toggles in the transmitting distributor.

On receipt of a command signal from the outgoing line circuit, the character is transmitted in serial form, with the start and stop elements added. The transmitting distributor may be operated under pulse control, e.g. when transmitting to radio channels.

When the EOM signal has been detected the transmitting distributor is blocked until a command is received to transmit the next message, if any, in the store.

If the last message is being transmitted, a point will be reached where the tight-tape condition occurs and stops the reading motor, but the last part of the message will still be stored between the reading and writing heads. To enable it



Note: Control of the receiving and sending distributor functions is similar to that for the incoming store except that (*i*), the intermediate store may contain more than one message and (*ii*), it is operated under pulse control when transmitting to radio chennels. For (*i*) a signal is fed to the intermediate connecting circuit to indicate that a further message is waiting transmission. For (*ii*) the transmit command is derived from the radio channel's control pulses.

FIG. 7—Simplified block schematic diagram of an intermediate store

to be transmitted, the writing motor will be started (it will have stopped because the EOM signal has been detected on the receive side) to allow sufficient slack in the tape for the remainder of the message to be transmitted. Because no polarity reversals are written on the synchronizing track during this tape-feeding process, then, with detection of the EOM signal on the transmit side, the reading motor will continue to step until the tight-tape microswitch again operates.

TRAFFIC-CONTROL FACILITIES

In a public message-switching system it is essential to provide the operating staff with comprehensive facilities for knowing readily the current message and system status. This is necessary because, in message-switching systems, it is the responsibility of the receiving centre to check the receipt of messages and retransmit them on the correct outgoing channels. Difficulties arising in the system due to faults or exceptional traffic conditions can be minimized if the staff exercise control quickly and this is facilitated by the elaborate facilities available on the traffic-control console. A brief description is given below of some of the more important features.

Checking the Receipt of Messages

The incoming-channel sequence-number-checking equipment has been described already; however, it is possible for a faulty incoming channel to present continuous stop polarity to the system, thus preventing messages reaching the system. As this condition simulates an idle channel it would not be found by the transmission-path checking equipment. To prevent the fault going undetected, a lamp associated with each channel indicates when no traffic has been received for 15–30 minutes.

Indications of Delays in the Retransmission of Messages

Alarms are provided to indicate when more than a preset number of messages are waiting in the incoming storage group for access to a s.a.r.p., or if the s.a.r.p. operator takes too long to route a message from an incoming store. If messages wait too long in incoming stores because the inputs to the intermediate stores allocated to a route are busy, a further alarm is given.

For messages in the intermediate storage group, indications are given for messages waiting longer than a preset period (depending on priority) or when more than a preset number of message are waiting for a route to become free (depending on the number of channels in the route).

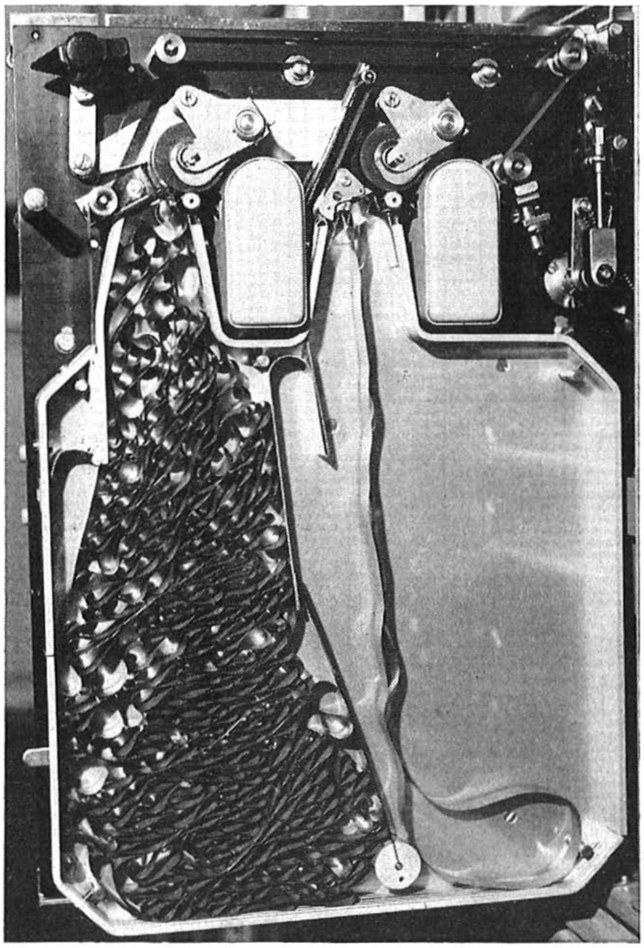
Push-buttons are provided to obtain a print-out of information on the quantity and priority of messages waiting in the intermediate stores for any or all routes.

Indications of Storage Availability

Meters are provided for each storage group (incoming and intermediate) to give a continuous indication of the traffic level in the storage groups. Alarms also operate when 20, five or no stores remain free, visual and audible alarms being given for each condition.

Relieving Storage Congestion

The load on the incoming storage group can be regulated by the operation of push-buttons to stop the automatic transmitters at inland stations—either separately or all at once. These transmitters are stopped automatically at all inland stations when five or fewer incoming stores remain free.



Note: The mechanical section is shown withdrawn for inspection. The six write and read heads are each combined in one unit to the right of the capstan rollers, The writing parts and storage loop are on the right of the mechanical section, the respective motors being mounted on the rear.

FIG. 8—Mechanical section of an intermediate store

Regarding the intermediate storage group, when the queue of messages for a route becomes excessive, or if the route is out of service, traffic may be diverted either automatically or manually to alternative routes. Automatic diversion is available for up to 20 routes, operation of the appropriate push-button allows traffic to overflow from one route to a predetermined alternative route. Manual diversion is provided for all routes, operation of the appropriate push-button causes overflow traffic to be routed via internal channels so that the traffic enters the system a second time, to be directed to the alternative route by operators on the s.a.r.p.s. Either or both high-priority and low-priority traffic may be manually diverted.

COMPONENTS

Uniselectors

The 100-outlet uniselectors used throughout the system have four, five or eight arcs. A common drive source for a suite of racks is provided by a 50-volt d.c. motor mounted in the base of a rack and coupled to shafts running along the base of the suite. This drive is transmitted to shafts along a uniselector shelf through a sprocket-and-chain drive and a torque-limiting clutch.

Each uniselector is controlled by a coupling electromagnet and a detent electromagnet, the connexions of which depend on whether step-by-step or free-running operation is being applied. In step-by-step operations the electromagnets are separately controlled, whereas in free-running operation they are connected in series.

Operation of the coupling electromagnet connects the wiper assembly, via a gear train and friction clutch, to the shelf drive-shaft. Operation of the detent electromagnet disengages the wiper detent-lever.

Testing to a marked outlet and stopping the uniselector is carried out within 2 ms; the wipers may thus be rotated at very high speed. In free-running operation the speed is 300 outlets per second and, for step-by-step operation, 60 outlets per second.

Relays

To reduce maintenance costs, electronic relays are used in the input and output repeaters to convert the 80-volt double-current line signals to 16-volt double-current signals used within the system, and vice-versa. These relays, developed by the M.E.L. Equipment Co., Ltd., have inputs and outputs isolated by transformers and are designed to replace Carpenter-type polarized relays used in the same circumstances.

The input relay contains two sinuosidal oscillators—the oscillation of which depend on the input polarity—to switch a trigger circuit to give a $\pm$16-volt output at 50 mA.

The output relay contains two blocking-oscillators that oscillate according to the input polarity. Each switches one of two silicon controlled rectifiers to give a $\pm$80-volt output at 40 mA.

The electromechanical units in the system use the following three basic types of relay.

(*i*) A general-purpose non-polarized relay having up to three coil-windings and nine contact-units. The springs, embodying twinned dome-shaped contacts, usually of silver, are arranged in three equal sets with up to six springs per set. The armature, held in place by a slot cut in a flat spring clamped to the yoke, operates the moving springs via lifting pins. No buffer block is used; instead, sufficient contact pressure is obtained by making the non-moving contact springs of thick semi-rigid material and by adjustment allowing the moving spring to very slightly flex the thick spring.

(*ii*) A high-speed relay mounted on an 8-pole plug and protected by a transparent cover, having one or two coil windings and one changeover contact. Single domed-contacts, made of gold-nickel alloy, are fitted on two relatively-thick fixed springs and on the moving spring, which forms an extension of the armature and utilizes an anti-chatter spring arrangement.

The operate and release times of the relay are within 2 ms, the main use for the relay being to control the stopping of uniselector wiper motion when searching for a marked outlet.

(*iii*) A polarized relay mounted on a 16-pole plug and protected by a transparent cover, having up to seven coil-windings and one change-over contact embodying dome-shaped platinum contacts. The moving contact, employing anti-chatter springs, forms an extension of the armature and moves between the fixed contacts. These are fitted on capstan-headed adjusting screws which are clamped in a block mounted either side of the armature.

The main use of this relay is in the incoming line circuit, where it operates to code elements of teleprinter signals to control the counting circuit when detecting a SOM signal.

CONSTRUCTION

The equipment occupies 102 racks, some of which are shown in Fig. 9. Each rack is 8 ft 6 in high, 2 ft 4 in wide and 1 ft 1 in deep, and is totally enclosed for dust protection, with glass-panelled doors on the front and metal doors on the rear. Strip fluorescent lighting is provided in angled reflectors at the top front and rear of every rack.

Most relay-sets are of the plug-in type to facilitate maintenance, and range in size from 10 relays and one plug to 60 relays and six plugs. Where necessary, as in the common-control equipment, relay-sets are duplicated, with automatic change-over in the event of failure. Duplicate control paths are also provided between and through the more important relay-sets.

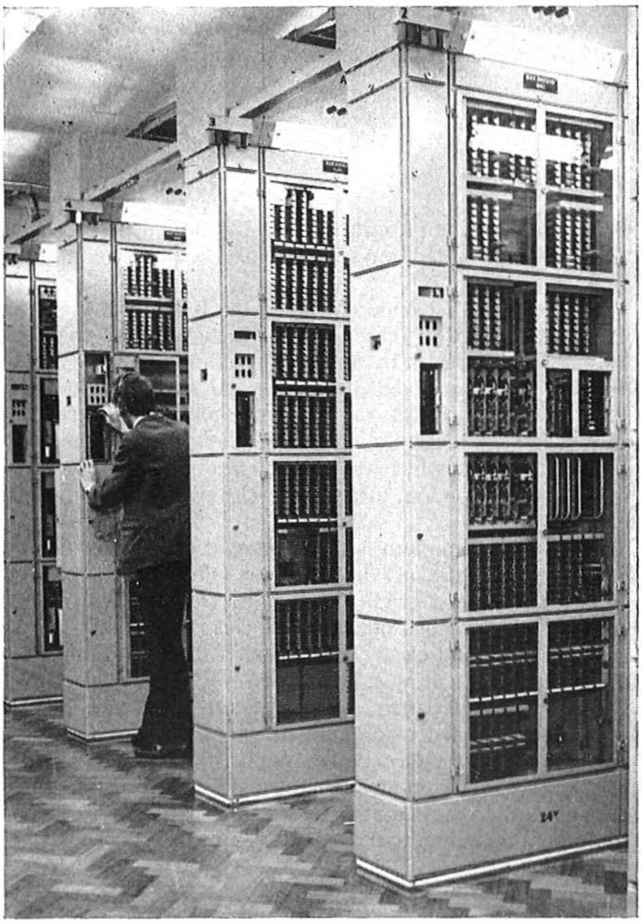


FIG. 9—Part of the equipment room

Electronic circuits are mounted on printed-wiring boards, several boards being embodied on narrow plug-in drawers, which can be pulled forward for inspection.

Connexions to the sockets of plug-in units and to distribution strips—used for strapping to select various facilities—are made at the rear of each rack. Only soldered connexions are employed.

POWER SUPPLIES AND AIR-CONDITIONING PLANT

Standard Post Office power-supply equipment incorporating rectifiers and batteries, is provided for the 50-volt d.c. system and 80 + 80-volt d.c. telegraph supplies, with two standby diesel-alternator sets to cover mains failure. The 50-volt feeders from the equipment-room distribution boards are split over different suites of racks, with at least two feeders per suite to reduce the effect of a blown distribution fuse.

The within-system transmission-path and electronic-circuit voltages are obtained from the 50-volt d.c. supply by d.c.-to-d.c. converters.

To ensure that the system performance is not degraded by environmental conditions, the manufacturer's recommendations were followed for the provision of air-conditioning plant. This plant maintains the equipment room at computer-room standards of cleanliness, at a temperature of 20 $\pm$ 5° C and at a relative humidity of 55 $\pm$ 5 per cent, thus minimizing contact contamination and corrosion and the adverse effect of excessive temperature on semiconductor devices. Magnetic tapes require dust-free conditions, to prevent errors or possible damage to the tape, and controlled relative humidity, to prevent dimensional changes, and to avoid the tape sticking due to static electricity.

FAULT LOCATION

An automatic routiner is provided to test the transmission standards of the incoming and intermediate stores. It continually circulates a test message, switching it alternately via the incoming and intermediate storage group. In time all stores are checked; if a faulty store is detected the test message is stopped and an alarm indicates the store and the connecting circuits being used at that time. Continual circulation of the test message is, in addition, a check that the registers, translator, common control and prefix transmitters are functioning correctly. In the light of experience in maintaining the system, modifications have been devised to extend the scope of the tests so that faulty equipment can be located by tracing the path of the test message.

For the location of faulty connexions, time-out and sequence-checking alarms are built into most units. Alarm lamps are provided on a common panel on every rack, but setting up a call utilizes a number of units scattered throughout the system, and failure in one unit may result in a number of alarms. Thus, fault-location technique is largely a question of noting alarm conditions and the units concerned. From a number of such indications a pattern emerges pointing to the faulty unit.

A test trolley is provided for checking individual stores. The input and output of a store may be looped, permitting a message to be continuously circulated and monitored. A method has been devised for associating two particular equipments for test purposes, i.e. a particular incoming channel with the same incoming store, and this has proved to be a valuable feature in locating obscure faults.

A test box is provided which can be programmed to check the facilities of the various plug-in electronic units used throughout the system.

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A New Telephone Kiosk—Kiosk No. 8

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Existing kiosks which were designed over 30 years ago do not always match their contemporary surroundings and a new design was commissioned, which would not only be unobtrusive in both modern cities and rural surroundings, but would also take advantage of new materials and manufacturing techniques.

INTRODUCTION

The first telephone kiosk used by the Post Office was the Kiosk No. 1, which was introduced in 1922. This kiosk (Fig. 1(*a*)) was made of unreinforced concrete and had an all wood door. Four years later the Kiosk No. 2, (Fig. 1(*b*)), was brought into service. This kiosk was designed by Sir Giles Gilbert Scott and made of cast iron with a wood-framed door.

In 1928, two more of Sir Giles's designs were introduced—the Kiosk No. 3 (Fig. (1*c*)), which was made of concrete with a wood-framed door, and the Kiosk No. 4 (Fig. 1(*d*)). The Kiosk No. 4 was similar to the Kiosk No. 2, but had a letter box and two stamp-selling machines in addition to telephone facilities. Only 50 of this type were made, and most of these have by now been withdrawn from service. All the first four designs of kiosk are now obsolete.

In 1936 the Post Office celebrated the Silver Jubilee of the reign of the late King George V by introducing the Kiosk No. 6 (Fig. 2). This was made of cast iron with a wood-framed door and was also designed by Sir Giles Gilbert Scott.

The Kiosk No. 6 has been the standard kiosk for Post Office use since its introduction, and although it has served well, it does not always harmonize with contemporary architecture.

In 1960 Neville Conder designed the Kiosk No. 7, shown in Fig. 3. Twelve of these were made and put on trial—six were made in cast-iron and six in aluminium alloy. The design was not proceeded with beyond these 12. A useful by-product of this trial was experience with the effect of the atmosphere and weathering on untreated aluminium. The surface of a kiosk, which was installed near the Royal Exchange in the City of London, turned a streaky grey-black with white blisters.

Untreated aluminium is now regarded as quite unsuitable for street furniture use by the Post Office, since the only way to maintain a bright finish is by frequent and regular washing with copious quantities of clean water. This would be too costly, and clean water even in modest quantities is difficult to obtain at most kiosk sites.

In 1965 two designers, Douglas Scott and Bruce Martin, were commissioned to produce designs for a new telephone kiosk. The Post Office design requirements called for the new kiosk to incorporate the best features of previous kiosk designs and to be suitable for both urban and rural surroundings. Glazing and fitments were to be robust and

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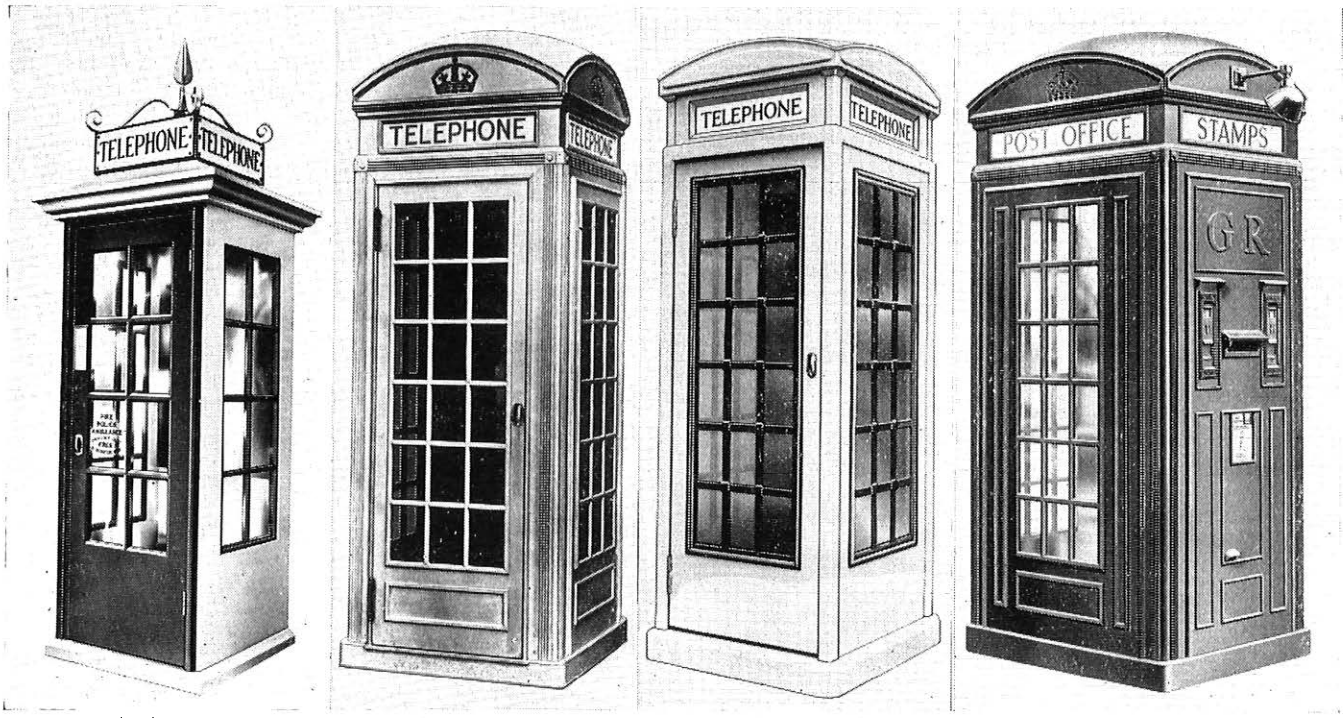

(*a*) Kiosk No. 1 (*b*) Kiosk No. 2 (*c*) Kiosk No. 3 (*d*) Kiosk No. 4

FIG. 1—Early designs of Kiosks

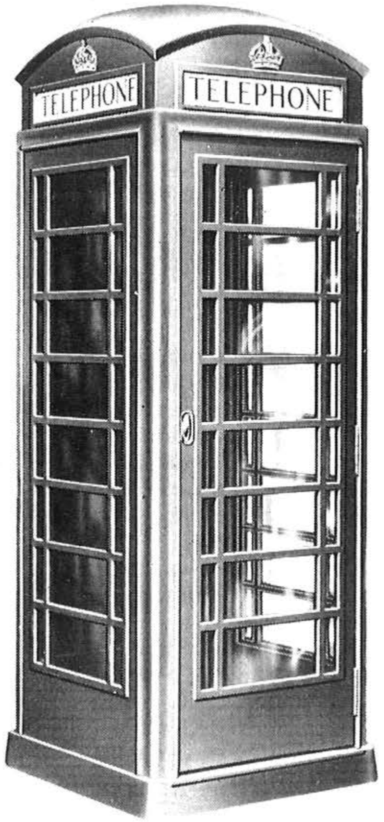

FIG. 2—Kiosk No. 6

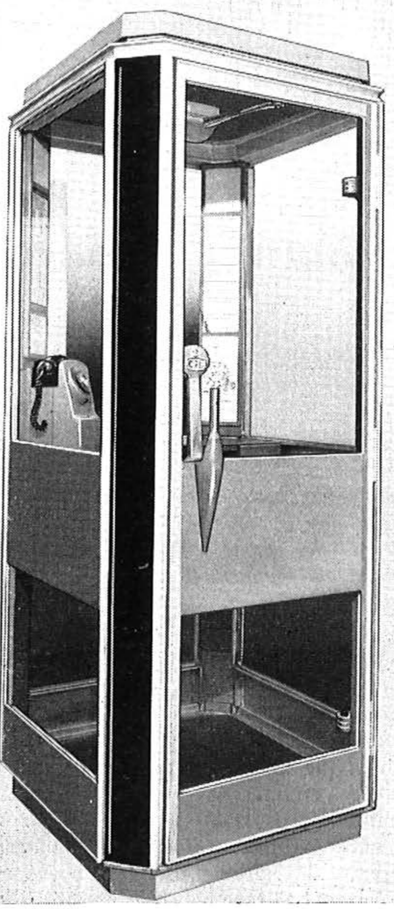

FIG. 3—Kiosk No. 7

crevices, into which levers and jemmies could be inserted, avoided. It was to be possible to see easily into the kiosk from outside as a deterrent for miscreants who might attack and rob the fittings and coin box.

Full-size appearance models of each design were made, and Bruce Martin's was selected for development and eventual quantity production. It is known as the Kiosk No. 8, and will now succeed the Kiosk No. 6 for all replacements and new installations.

DESIGN DETAILS

The new kiosk (Fig. 4) is of sectional construction and consists essentially of seven principal components designed to assemble in a number of alternative ways to give a left-hand or right-hand opening door on any of the three sides not filled by the back panel. The structure, fittings, fixings

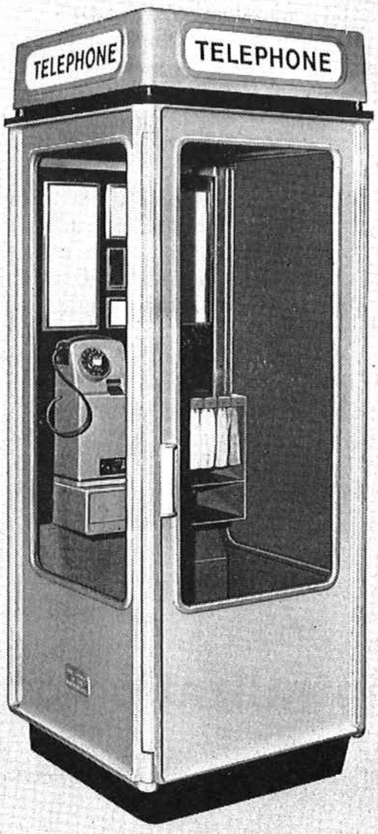

FIG. 4—Kiosk No. 8

and glazing of the kiosk have been designed to be as robust as possible, with full regard to the threat of vandalism and theft.

Basic Components

The sill ring is situated at floor level in the kiosk and acts as a location jig. It is of a strong structural form and provides junctions between itself and the side and back panels as well as positions for the fixings. The fixings are hidden to resist vandals and to give a clean appearance. The sill ring also acts as permanent shuttering for the concrete floor, which is trowelled to an 0·5 in fall towards the door, so that the floor will drain. A ventilation gap is provided under the door for air intake and to prevent jamming of the door by pebbles.

The back panel provides secure fixing for electrical and telephone equipment into bosses, with hidden fixings, for security. The side panels each have a toughened glass pane and are simply fixed through four bosses to the head and sill rings, and are removable for replacement if required.

The head ring is of a strong structural form to act as a location jig, and to provide junctions between itself and the side and back panels with provision of bosses for the fixings of the panels and roof. It provides strong fixing positions for the door closer and electric-light fitting, which is placed to illuminate the white ceiling, notices and telephone equipment and to give general illumination. It incorporates a gutter to collect water from the roof, to prevent dripping over the door, and to prevent weathering of the panels. The gutter is accessible and easy to clean.

The roof is designed to resist weather and has illuminated lettering to assist recognition. The fixings are concealed for a clean appearance and resistance to vandals, and the roof laps over the head ring to provide slots for ventilation. Initially, the roof was to have been made of a glass-reinforced plastic; the lightness of this material making it attractive. But when a model was viewed by transmitted light the inherent unevenness of the texture of glass reinforced plastic gave an appearance which was unacceptable. Other plastic materials were considered but rejected on grounds of cost and fire risk, and the final design has reverted to a cast-iron roof.

The wallboards are fixed, together with the telephone and electrical equipment, to bosses cast onto the back panel to resist damage by vandals and theft of the coin box. The wallboards can be changed should new ones be designed, or new telephone or electrical equipment installed. Both pre-pay-on-answer and pay-on-answer coinboxes can be fitted.

The door is easy to open and close being made of aluminium. It is fitted with a toughened glass pane, and a polished aluminium handle is cast integrally with the door to resist vandals and to give easy recognition. The door is closed automatically by a mechanism mounted on the head ring.

Except for the door, all the main parts of the kiosk are of cast iron. The inside of the roof is painted white, to improve the illumination by acting as a reflector. The sill and head rings are painted black and all other surfaces are painted red. All glazing is carried out at the manufacturers works.

Construction

Since the Kiosk No. 8 is a completely new item it is dimensioned in metric units and uses metric screws and bolts. Existing standard equipment, such as wallboards and directory holders, is used. The kiosk back is ready drilled for mounting a steel cash compartment.

Fluorescent lighting is fitted as standard equipment, and is switched on all day. This has been found to be a cheaper arrangement than the time-switch controlled tungsten lamp hitherto used for kiosk lighting. The lighting in Kiosks No. 6 is to be converted during the next five to seven years to this fluorescent system. A moulded cover is provided to protect the electricity supply cable termination and the consumer's fuse.

Each Kiosk No. 6 was assembled at the manufacturers to ensure a good fit of all parts and then dismantled for transportation. These sets of associated parts were sent out to Post Office depots, as required, for reassembly, but, if separated for any reason, kiosks have to be assembled from parts which have not been matched at the manufacturers. This has lead to wasted effort in correcting parts which fit badly.

The Kiosk No. 8 has seven main parts compared with 14 for the Kiosk No. 6. Consequently some of the Kiosk No. 8 parts are very heavy; for example the back panel weighs over 3 cwt. This could lead to the need for as many as five men to erect a Kiosk No. 8. For these reasons, and because painting is more easily and cheaply carried out in a factory than on site, the Kiosk No. 8 will be completely assembled and painted at the manufacturers works, and transported to depots ready for equipping with lighting and telephone apparatus.

ACKNOWLEDGEMENTS

The help and advice given by the London Office and the Kirkintilloch Works of the Lion Foundry Co, Ltd., by the London Telecommunications Region and by our colleagues in other Branches and Departments of Telecommunications Headquarters is acknowledged.

Decentralization of International Manual Boards

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U.D.C. 621.395.33.008.042

The continued expansion of international telephone traffic has made it necessary to establish new control centres to relieve the international switching centre in Faraday Building in London. The first new remote control-centre will deal with assistance traffic to Europe; the second will be an intercontinental control centre. The facilities provided by these centres are reviewed, and the methods of signalling used are described. The future utilization of these centres is also discussed.

INTRODUCTION

The continued rapid expansion of international telephone traffic over the past few years has created accommodation difficulties at the international switching centre (i.s.c.) in Faraday Building, London. In consequence, the international switching facilities provided by the manual boards in that building are to be decentralized, and the majority of the outgoing manual-board traffic will be dealt with at remote control-centres.

The first of the remote control-centres has been installed in the Judd St. building in central London; the second will be accommodated at Wren House, not far from Faraday Building. The equipment for these installations, as well as that required at the Faraday i.s.c., has been designed to take account of the requirements for future remote control-centres situated outside London and for international sub-

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scriber dialling (i.s.d.) services routed via the national trunk transit network.[1,2] The equipment at the remote control-centres will also be suitable for working to the new i.s.c. to be installed at Wood St., in the City of London.

These new remote control-centres will give much greater flexibility of operation than has been obtained from the schemes that have had to be adopted to provide temporary relief. In addition, the provision of a common outgoing register for both manual board and i.s.d. traffic should not only provide greater efficiency but also reduce maintenance problems.

Operators at the remote control-centres will be able to key all international telephone numbers. The keyed information will be transmitted to the i.s.c., where the call will be automatically switched if a suitable route is available, or diverted to the appropriate manual board if the call requires to be completed manually.

Facilities are also provided for the international operators of foreign administrations to call particular operating positions at the remote control-centres in this country when required, e.g. for the completion of booked calls.

LINE SIGNALLING

Two systems will be used for line signalling, a d.c. system, designated Signalling System, D.C., No. 4, for use on audio pairs not exceeding 4,000 ohms loop resistance, and an a.c. system based on Signalling System, A.C., No. 11 (the standard a.c. line-signalling system to be used for the national trunk transit network), for use on audio pairs exceeding the resistance limit for the d.c. system and also for circuits routed via high-frequency line equipment.

The d.c. system employs phantom signals between the outgoing manual-board relay-set and the register-access relay-set as shown in Tables 1 and 2.

TABLE 1

S.S.D.C. No. 4—Signals in Forward Direction

Signal	Condition
Seizure	−50 volts via 470-ohm resistor
Forward clear	Disconnexion
Forward transfer (operator recall)	+50 volts via 470-ohm resistor

TABLE 2

S.S.D.C. No. 4—Signals in Backward Direction

Signal	Condition
Proceed to send	Earth
Answer	Earth
Backward clear	Disconnexion

The proceed-to-send signal is disconnected on release of the outgoing international register, and when the signal is re-applied it is recognized as the answer signal.

The a.c. system uses the same signals as Signalling System, A.C., No. 11, but in addition provides for proceed-to-send and forward-transfer signals. The a.c. signalling relay-sets for this system are fitted on the line sides of the manual-board and register-access relay-sets, both of which are identical to those used for the d.c. signalling system. All the signals on this a.c. signalling system consist of pulses of 2,280 Hz. The signals sent in the forward direction are as indicated in Table 3; those for the backward direction are as shown in Table 4.

The proceed-to-send, answer and backward-clear signals are identical and are identified by the sequence in which they are received.

TABLE 3

A.C. System—Signals in Forward Direction

Signal	Condition
Seizure	50–80 ms tone
Forward clear	650 ms tone (minimum duration)
Forward transfer (operator recall)	100–150 ms tone 80–120 ms tone off 100–150 ms tone

TABLE 4

A.C. System—Signals in Backward Direction

Signal	Condition
Proceed to send	200–300 ms tone
Answer	200–300 ms tone
Backward clear	200–300 ms tone
Release guard	650 ms tone (minimum duration)

The Judd Street and Wren House installations both use the d.c. signalling system. The a.c. system will be used for remote control-centres now being planned for installation at Leicester and Glasgow.

DIGITAL SIGNALLING

To permit the rapid transfer of the digital information from the remote control-centres to the register equipment at the i.s.c., a new signalling system, designated Signalling System, Multi-Frequency, (S.S.M.F.) No. 3, has been developed. This system has been designed to be compatible with S.S.M.F. No. 2, which is the inter-register signalling system to be used for the national trunk transit network. Accordingly, its use will enable the same registers and associated equipment to be employed, at the Faraday i.s.c., for circuits from remote control-centres in London as well as in the provinces, and for the future provision of i.s.d. service from United Kingdom subscribers to all parts of the world. The signalling code for S.S.M.F. No. 3, which uses a 2-out-of-6 multi-frequency code, is given in Table 5. The frequencies used for the digits 1–0 and the prefix signal are the same as for S.S.M.F. No. 2, but, as S.S.M.F. No. 3 is to be used for operator-initiated traffic, additional signals are included. These are an operator assistance code (code 11), a code for access to particular operators' positions where booked calls are handled (code 12) and a keying-finished signal. With this system there are no signals in the backward direction.

TABLE 5

Signalling Code for S.S.M.F. No. 3

Digit or Signal	Frequency Combination (Hz)
1	1,380 + 1,500
2	1,380 + 1,620
3	1,500 + 1,620
4	1,380 + 1,740
5	1,500 + 1,740
6	1,620 + 1,740
7	1,380 + 1,860
8	1,500 + 1,860
9	1,620 + 1,860
0	1,740 + 1,860
Code 11	1,380 + 1,980
Code 12	1,500 + 1,980
Prefix (guard)	1,740 + 1,980
Keying finished	1,860 + 1,980

JUDD STREET INSTALLATION

The Judd Street installation is intended for use as a continental assistance centre, i.e. assistance on calls to the continent of Europe, for traffic originating from London subscribers. Traffic will be routed from subscribers via 2-wire circuits to the control centre, where it will be switched on a 2-wire basis and then routed by direct 4-wire junctions to the appropriate i.s.c. At present, this is the Faraday Building i.s.c., but, later, traffic will be switched to the Wood Street i.s.c. as well. A simplified trunking diagram of the equipment is shown in Fig. 1.

The operator receives a demand via an assistance relay-set. This is a standard sleeve-control assistance circuit that has been modified to control the connexion of a compromise balance to the associated international circuit when the calling party replaces the receiver. To complete the call the operator selects a free outgoing common-access manual-board relay-set. Seizure of this relay-set causes it to search for a free S.S.M.F. No. 3 sender and associated d.c. keying receiver. When this equipment has been seized, the operator's cord-circuit supervisory lamp darkens to indicate that keying may commence. The operator now keys the required information in the following sequence:

(*i*) terminal or transit start signal,
(*ii*) the required international number, and a
(*iii*) keying-finished signal.

The keysending from the position circuit is based on five d.c. potentials applied to the tip and ring wires of the cord circuit, as indicated in Table 6. These potentials are detected by the d.c. keying receiver and converted to a 2-out-of-6 code for storage of the required information in the S.S.M.F. No. 3 sender.

The operation of either start key clears the digit stores in the sender. The digits of the international number are then stored in sequence in the sender, which can store 15 digits. Operation of the keying-finished signal causes a seizure signal to be sent on the outgoing circuit to the i.s.c. On recognition of this signal at the i.s.c., a free international register and multi-frequency receiver are associated with the incoming circuit. Simultaneously with the junction-seizure signal a continuous multi-frequency prefix signal is sent by the sender. When this signal is recognized by the m.f. receiver associated with the international register, the latter returns a d.c. proceed-to-send signal to the remote control-centre. Receipt of this signal causes the sender to replace the prefix signal by an 80 ms pulse representing the first digit. The remaining stored information is transmitted by the sender as a continuous train of tone pulses. Each 80 ms tone pulse represents a subsequent digit and is preceded by an 80 ms pulse of prefix signal. Following the last digit, the keying-finished signal is sent as an 80 ms pulse preceded by 80 ms of prefix signal. The sender then signals the outgoing manual-board relay-set, causing the latter to release the d.c. keying receiver and S.S.M.F. No. 3 sender.

TABLE 6

D.C. Keying Potentials from Position Circuit

Signal	Potential (volts) Applied to	
	Tip Wire	Ring Wire
Terminal start	−50	+50
Transit start	−20	+50
Digit 1	+50	− 6·2
2	+50	−20
3	+10	−20
4	+50	−50
5	+10	−50
6	−50	−50
7	+50	+10
8	+10	+10
9	50	+10
0	20	+10
Code 11	+50	+50
12	+10	+50
Keying finished	− 6·2	+50

The international register-translator equipment now processes the received digits, selects an appropriate outgoing international circuit, sends the required information over that circuit and is then released, at which stage the operator's cord-circuit supervisory lamp re-lights.

When the distant subscriber answers, the supervisory lamp darkens again.

A forward-transfer (or operator recall) signal can be sent, at any time, by the operation of the ring key on the manual board. This causes a distant (foreign) international assistance operator to be called into the circuit.

When either subscriber clears, the appropriate supervisory lamp glows. The call remains held, however, until released by the operator.

Outgoing loop-disconnect dialling relay-sets are provided so that the operator may recall a London subscriber when the required connexion cannot be made on demand.

Incoming code-12 calls to particular operating positions are routed from a code-12 group-selector level in Faraday Building i.s.c. over a group of 4-wire junctions using S.S.D.C. No. 2 principles[3] and terminating on code-12 group selectors

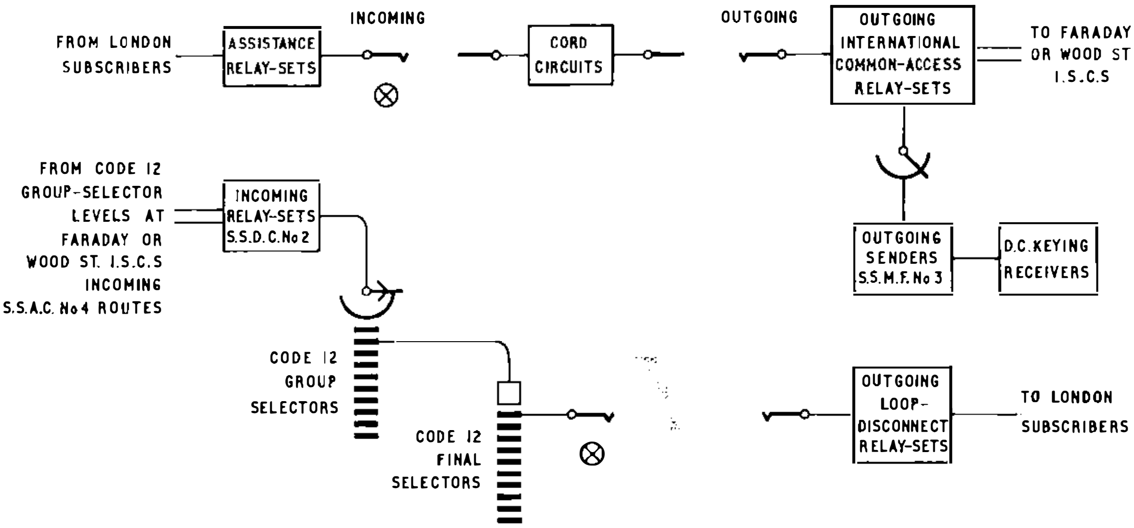


FIG. 1—Simplified trunking diagram of Judd Street remote control-centre

at Judd Street. These selectors give access, via appropriate code-12 final selectors, to the individual operating positions. These arrangements enable an operating position at Judd Street, from which an operator has had to book a call with a distant international operator, to be recalled by the latter as required. Similar facilities will be provided from the Wood Street i.s.c.

WREN HOUSE INSTALLATION

The Wren House installation is intended to be used as an inter-continental control centre, dealing with both outgoing and incoming traffic originating or terminating in the United Kingdom. Outgoing inter-continental traffic will, at present, continue to be operated on a booking and reversion basis. Therefore, in addition to the 2-wire incoming booking circuits, 4-wire outgoing circuits are provided to selected provincial centres, and this traffic is 4-wire switched at Wren House. Traffic originating in London, although similarly booked and reverted, is switched on a 2-wire basis and routed on outgoing circuits to a London tandem exchange.

The equipment is similar to that provided at Judd Street, except that a 4-wire manual-board link circuit of the same design as that installed for the integration of the continental and international manual-board services at Faraday Building[4] is provided. The outgoing common-access manual-board relay-set is therefore a 4-wire version, as also is that for reverting traffic to the provinces. A simplified trunking diagram of the equipment is shown in Fig. 2.

Operation will be generally similar to that described for the Judd Street installation except that, as most inter-continental calls are booked, the connexion to the subscriber will usually be reverted from the switchboard.

For provincial traffic both outgoing and reverting relay-sets are provided, permitting the fullest flexibility of operating procedure whilst ensuring that the relay-sets to be connected on any one call are on the opposite sides of the manual-board link circuits. Accordingly, when a call has been set up, and the operator's cord-circuit speak key is restored, the call will be switched via the manual-board link circuit on a 4-wire basis instead of through the cord circuit. This provides the optimum transmission conditions on this class of call.

To avoid the use of junction signalling over the relatively short distance between Faraday i.s.c. and Wren House, incoming code-12 calls are routed over special 7-wire circuits, using loop-disconnecting pulsing, to connect the outlets of the code-12 group-selector levels in Faraday i.s.c. to the code-12 group-selectors in Wren House. From the Wood Street i.s.c., however, this class of traffic will be routed over 4-wire junctions using Signalling System, D.C., No. 2 signalling in the same manner as the code-12 circuits from Faraday i.s.c. to Judd Street.

The Wren House manual board also deals with the incoming inter-continental assistance traffic (code 11) from Faraday i.s.c., and will eventually also receive this class of traffic from the Wood Street i.s.c.

FARADAY I.S.C.

Faraday i.s.c. will switch all the traffic from the remote control-centres until additional international switching centres are provided. Simplified trunking diagrams of the equipment at Faraday building for these services are shown in Figs. 3 and 4.

The seizure and sending sequence on an outgoing call is as described previously for the Judd Street remote control-centre. When all the required digits have been received and stored in the register, which can store a maximum of 15 digits, the keying-finished signal follows. This causes the register to associate a free translator and then extend to it the information in the first six digit stores, together with a routing demand and a signal indicating that the call is operator controlled.

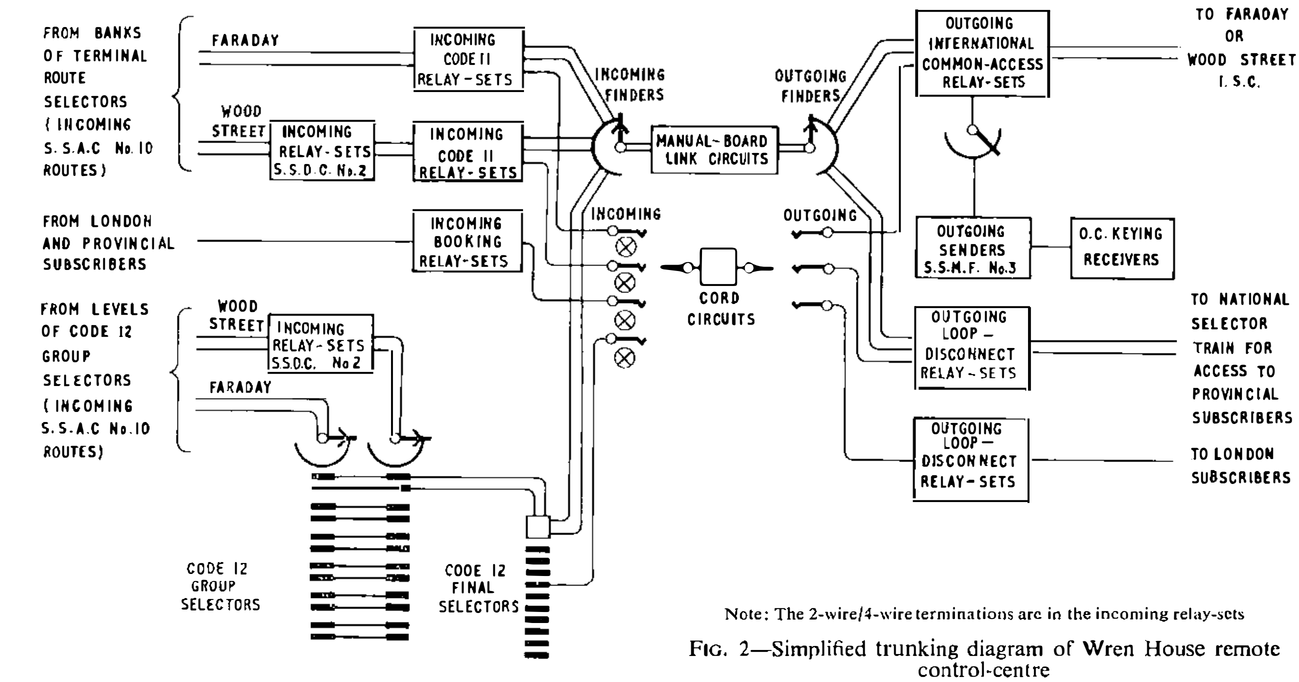
The translator examines the appropriate number of digits, depending upon the numerical information received. For example, on calls to Europe 2-digit or 3-digit examination is normally sufficient, while on calls to North America four digits are examined, to determine whether the call should be routed to the U.S.A. or to Canada. In certain circumstances it may be necessary to examine each of the first six digits. From this examination the translator provides the following routing information to the register:

(*a*) the number of the required outgoing section for access to the route selected (one out of 15),

(*b*) the number indicating the marking group within that outgoing section which corresponds to the route selected (one out of 15),

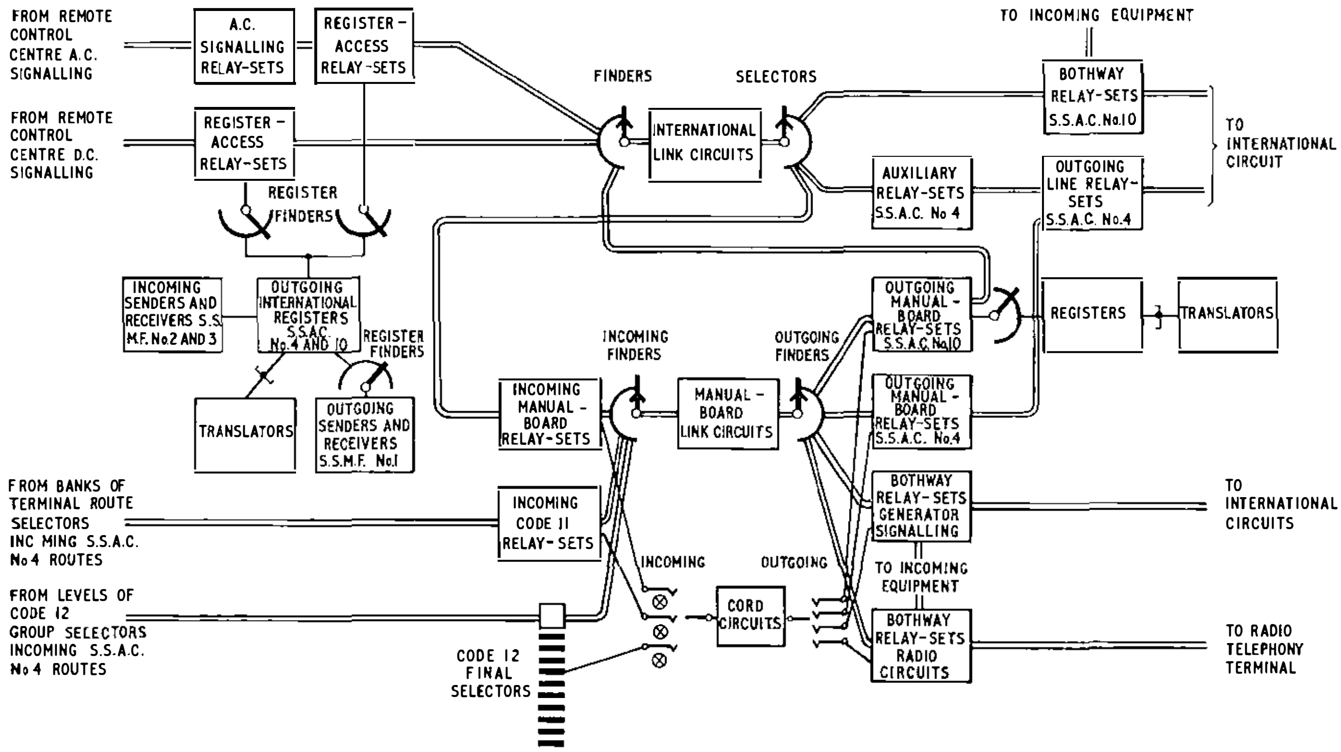
(*c*) whether a terminal or transit seizure signal is required,

(*d*) the number of digits in the country code (one out of three),



Note: The 2-wire/4-wire terminations are in the incoming relay-sets

FIG. 2—Simplified trunking diagram of Wren House remote control-centre



Note: The 2-wire/4-wire terminations are in the incoming relay-sets

FIG. 3—Simplified trunking diagram of equipment at Faraday i.s.c. for calls outgoing from remote control-centres

(*e*) the language digit for the outgoing route (one out of five),

(*f*) the choice of route (one out of five),

(*g*) the charging zone (one out of five), and

(*h*) the signalling system to be used on the outgoing route (S.S.A.C. No. 4 or No. 10).

On receipt of this information the register releases the translator and proceeds to set up a connexion between the register-access relay-set and a free outgoing relay-set on the selected route, via the 4-wire international link-circuit switching equipment.[5] When the appropriate outgoing relay-set has been seized, signalling proceeds normally on the international circuits, an outgoing S.S.M.F. No. 1 sender being called in by the register if the outgoing route uses the intercontinental signalling system, S.S.A.C. No. 10.[6] Supervisory

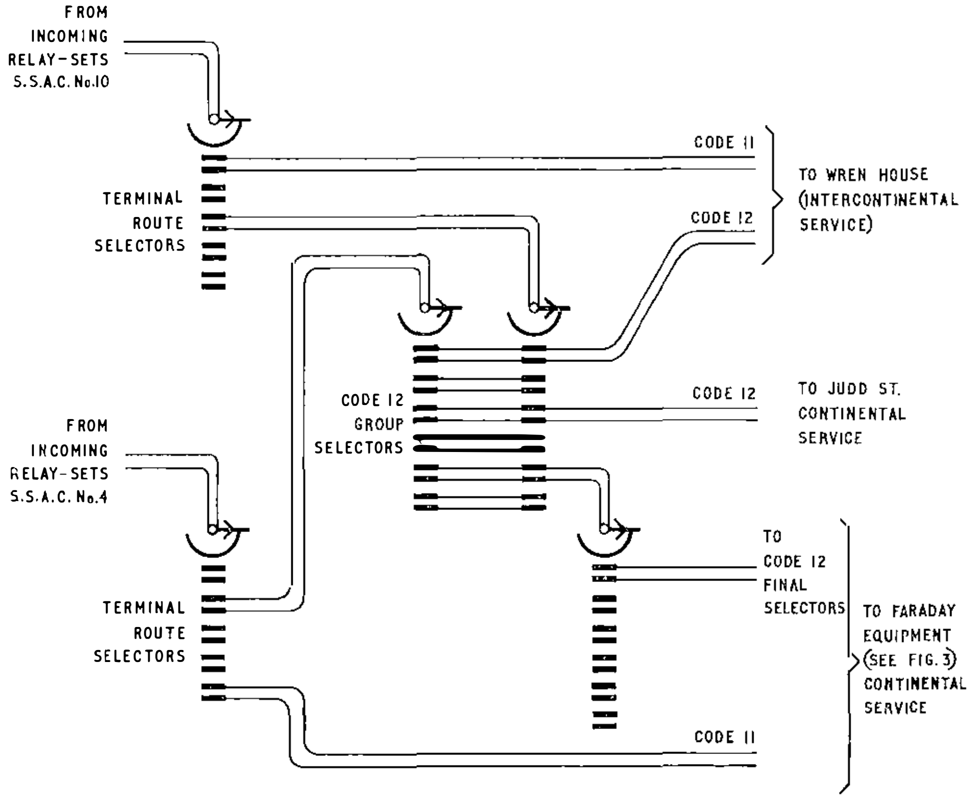


FIG. 4—Simplified trunking diagram of equipment at Faraday i.s.c. for switching incoming code-11 and code-12 calls

signalling between the register and the outgoing S.S.A.C. No. 10 relay-set is on a phantom-signalling basis over the 4-wire international link circuit. The outgoing circuits employing S.S.A.C. No. 4,[7] used for the i.s.d. service from London and provincial director centres to Europe,[8] have a separate wire for these supervisory signals. It has therefore been necessary to introduce an auxiliary relay-set between the link circuit and the outgoing relay-sets, which converts phantom signals to separate-wire signals on calls from the new registers, but is switched out of circuit on i.s.d. calls using existing registers.

When the required information, stored in the register, has been transmitted to the distant country, the register is released and a supervisory signal returned to the remote control-centre to light the operator's supervisory lamp. When the distant subscriber answers, the answering signal from the international circuit is repeated to the remote control-centre to darken the operator's supervisory lamp. Similarly, when the distant subscriber clears, the supervisory signal is repeated by the register-access relay-set causing the operator's cord-circuit supervisory lamp to glow.

The connexion is maintained until the operator at the remote control-centre releases the circuit.

If there is no suitable route for the completion of a call automatically, e.g. those requiring radio links or generator-signalling circuits, the translator provides a routing to the manual board in Faraday Building. Calls routed in this way are switched through on the 4-wire manual-board link-circuit scheme already mentioned. In this instance, however, the incoming manual-board relay-set includes amplifiers, in each direction of transmission, which provide sufficient gain (approximately 1·5 dB) to make up for the losses involved in passing via the two link circuits, their associated cabling and the additional relay-sets.

If all the outgoing routes suitable for the completion of a call are busy, the register is released and busy tone or a congestion announcement is returned to the operator.

Incoming inter-continental assistance traffic (code 11) is routed to the Wren House manual board while continental assistance traffic (code 11) is handled by the Faraday manual board.

The incoming code-12 traffic, for access to particular operating positions handling booked calls, is routed via the code-12 group selectors in Faraday i.s.c. to the group of circuits serving the required building and thence via code-12 group and final selectors to the required position.

The Faraday manual board also deals with all traffic incoming to the United Kingdom routed over generator-signalling circuits or radio links.

FUTURE UTILIZATION

To cater for the continuing growth of traffic from the London area, it is intended to increase the size of the Judd Street remote control-centre to a maximum of approximately 300 positions. In addition, the transmission standards for calls passing through this centre will be improved by compensating for switching losses and by reducing the limits for losses on the circuits by which subscribers gain access to the manual board. Where direct circuits would exceed the revised permitted losses, traffic will be routed via a tandem exchange, and 4-wire amplified junctions will be used from the tandem exchange to the remote control-centre. This arrangement will also permit the catchment area for the control centre to be extended.

It is intended that a demand service will be offered for all international calls, although a small number would still require reverting, e.g. calls to be connected via those radio links which do not provide a continuous service. Suitable equipment is, therefore, being developed for use at remote control-centres with 4-wire switching capability, namely, Wren House and future provincial control centres. This equipment will enable traffic to be routed over 4-wire amplified circuits, either direct or on a multi-link basis (e.g. via the national trunk transit network) to the remote control-centres, where it will be 4-wire switched and routed to the i.s.c. as already described. Normal operating facilities will be provided at the control centres for calls handled in this manner. The resulting reduction in double-handling, necessary with the present method of reverting inter-continental calls from London subscribers and all international calls from provincial subscribers, will considerably reduce the costs of operator assistance.

The incoming register-translator equipment at the Faraday i.s.c. has been designed to meet the requirements of provincial remote control-centres. These installations will be on broadly similar lines to that at Wren House, with a 4-wire manual-board link-circuit system to minimize switching losses. The main differences will be in the method of routing assistance traffic to the remote control-centres and the use of the a.c. line-signalling system already described.

In addition, the design caters for the provision of i.s.d. service from both London and provincial centres. London traffic will be routed from the register-translator centres via direct circuits to the i.s.c. Provincial traffic will be routed from g.s.c.s. either via the national trunk transit network or via direct circuits if justified by the amount of traffic. S.S.A.C. No. 11 or S.S.D.C. No. 3 will be used for line signalling and S.S.M.F. No. 2 for the inter-register signalling. Metering for these calls will be controlled at the g.s.c., special-tariff equipment being provided for the required i.s.d. metering rates. International accounting equipment will, however, be used at Faraday and Wood Street i.s.c.s for recording the appropriate details of all calls using this service. This information is required to settle international accounts between the countries concerned.

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Press Notices

Telecommunications in the 1990's

A symposium on "Telecommunications in the 1990's" was held by the Telecommunications Headquarters of the Post Office at the Civil Defence Staff College, Sunningdale, Berks., on November 29 and 30. The gathering was under the Chairmanship of Mr A. W. C. Ryland, C.B. (Managing Director: Telecommunications) and considered the long-term structure of our society and its possible interactions with Telecommunications.

Subjects discussed included changing patterns of the working population, population migration, future transportation, trends in urban development, education, control and communication in dispersed industry, future patterns of fuel and power, medical services of the future, the uses of leisure, and aid and protection for the citizen.

Attendance at the symposium, which met in private to provide maximum freedom of expression, was drawn from Government Departments, nationalized industries, University life, the I.R.C., Trade Unions, Industry and users as well as, of course, from the P.O. Telecommunications HQ in London.

The discussions will, it is hoped, provide broad signposts pointing to the overall future telecommunication needs of our society.

Telephones: End of an Era

With its swing to the more modern and reliable transistor for use in amplifiers, the Post Office has reached a milestone in its development of the country's telephone network.

The last ever valve-operated coaxial telephone system has just been installed between Manchester and the nearby microwave radio station at Heaton Park, marking the end of an era that began just 30 years ago.

There are now some 150 valve-operated systems in service throughout the country, involving a total distance of about 9,000 miles.

The changeover to transistors began about five years ago, and already there are over 50 of these systems, covering some 2,500 miles, in service. In most cases they use new, small-bore cables and cover shorter distances up to 30 miles. Many more —and longer—systems are on the way.

The number of valve systems will shortly begin to decline as the first of the planned conversions to transistorized working begin to take effect.

Valve systems have given and still give good service, but they suffer from "ageing", which affects their performance.

Transistorized systems are more serviceable—due to improved transistor reliability, and to the fact that the small-bore cables used are more resistant to damage.

Their great advantage is that they are free from ageing effects: they keep up a constant performance for long periods without adjustment or the need to replace parts. Maintenance charges are consequently lower, and as the proportion of transistorized systems increases, overall efficiency should improve.

Transistorized systems capable of carrying up to 2,700 circuits—as big as the largest of the valve systems—are already in use, and even bigger ones are likely in the future.

Ten-Year-Tested S.T.D.

The advent of 1969 finds nearly 80 per cent of the country's telephone subscribers served by subscriber trunk dialling just 10 years after the Post Office launched the service.

More than 65 per cent of trunk telephone calls are now made on s.t.d. Trunk calls for the 12 months ending March 1968 numbered 1,064 million of which 665 million were dialled on s.t.d.

By dialling their trunk calls customers have paid £200 million less than they would have done under the manual system for the same number of calls.

It was on December 5, 1958, that the Queen opened the first s.t.d. installation with a call from Bristol to Edinburgh. The new service was then available to 18,000 telephones connected to the Bristol exchange.

See how the service has grown since then.

By the end of 1962 there were 1½ million exchange connexions—28·2 per cent of the nation's total—with s.t.d.

By December 1963—five years after its introduction—s.t.d. was available to 40·4 per cent of exchange connexions, and subscribers were dialling nearly five million trunk calls a week.

Half the telephone subscribers (about 51 per cent of exchange connexions) in the United Kingdom had s.t.d. by September 1964. This represented nearly five million telephones (52 per cent of all telephones) and more than 2,860,000 exchange connexions. By then people were dialling 41 per cent of the nation's calls.

Exchange connexions with s.t.d. increased to 55·8 per cent by March 1965, to 63·6 per cent a year later, to 69·7 per cent by March 1967, to 78·9 per cent by October 1968.

Before we reach the middle 1970s virtually the whole of the country's telephones will have s.t.d. facilities.

University Appointment for GPO Director

Mr. James Merriman, O.B.E., M.Sc., A.Inst.P., C.Eng., F.I.E.E., Senior Director: Development at Post Office Telecommunications Headquarters, has been appointed by the University of Strathclyde, Glasgow, as Visiting Professor in the Department of Electronic Science and Telecommunications.

The appointment has been made with the object of securing the active interest of a senior practising engineer in the academic life of that department of the university.

Mr. Merriman was born at Pembroke, West Wales (January 1915). He joined the Post Office at the Research Station, Dollis Hill, in 1936 after graduating in Honours Physics and following post-graduate research at the University of London. He went on to serve principally in engineering research, development and management of national and international telecommunieations.

He was seconded to the Treasury from 1955 to 1959 as Deputy Director, Organization Methods.

In 1963 he became Assistant Engineer-in-Chief and in 1965 Deputy Engineer-in-Chief. On retirement of the former Engineer-in-Chief the title of that post was changed to Senior Director of Engineering and to this position Mr. Merriman was promoted in March 1967. In August 1967 he became Senior Director: Development.

He is a member of the Council of, and immediate past Chairman of the Electronics Divisional Board of the Institution of Electrical Engineers and is President of the Institution of Post Office Electrical Engineers.

Mr. Merriman is married, with a daughter and twin sons, and lives at Wimbledon. He is a keen amateur organist and his interests also include painting, rough hill walking and active church work.

Faster Duct Laying

To speed up provision of underground coaxial telephone cables the Post Office has started field trials with a new type of moleplough.

The machine will be used to install about six miles of quadruple p.v.c. ducting on the A34 road north of Stafford for a new cable between Stoke-on-Trent and Wolverhampton.

The moleplough cuts a path for the ducting and draws it into the ground, all in one operation. Later the cable is winched through the ducting.

A similar method has been used before by the Post Office, but only to lay two ducts at the one time.

In the past a trench has had to be dug for multiple ducts and filled in later. This has been a major delaying factor in the installation of new cables.

With the rapid expansion of the trunk telephone system planned—as part of the £2,000 million telecommunications capital expenditure program for the five year period 1968 to 1973—it was necessary to find a quicker way to do the job.

The trial is designed to evaluate the equipment for inter-city cable and duct installation.

Post Office engineers think the moleplough may be able to lay about 1,000 yards of ducting a day—about five times as fast as the old method.

Goonhilly 2 Ushers in Global System of Communication via Satellites

The Post Office has brought a new aerial system into service at its Goonhilly Earth Station to work with the new

INTELSAT III satellite, less than seven years after Goonhilly I's first spectacular experiments with Telstar. The new installation, Goonhilly 2, will maintain for the Post Office a leading role as an earth station owner in the expanding system of global communications via INTELSAT III satellites in synchronous orbits over the Pacific, Atlantic and Indian Oceans. Goonhilly I is being refurbished to communicate with countries to the East and will come back into service as soon as an INTELSAT III satellite is avilable over the Indian Ocean. Meanwhile the new aerial will cater for a further expansion of the transatlantic service. This has become possible because an INTELSAT III satellite has been substituted for Early Bird over the Atlantic Ocean. Whereas Early Bird is capable of linking together only two earth stations and handling no more than 240 telephone conversations or one television programme, the INTELSAT III satellites have facilities which provide flexible interconnexions between a multiplicity of earth stations, as required. Each satellite can carry a total of 1,000 telephony conversations and relay one colour-television programme simultaneously. Initially, Goonhilly will operate telephony circuits to only the USA and Canada but as more earth stations become operational the system will expand until, by 1971, Goonhilly is expected to be working to 20 countries.

The new installation at Goonhilly, which meets the technical requirements of the International Telecommunications Satellite Consortium (Intelsat), has been built to a Post Office specification and installed at a total cost, including roads, buildings, etc. of approximately £2m. The Marconi Company were the main contractors. Threshold extension demodulators and certain other equipment have been supplied and installed by GEC–AEI (Electronics) Ltd. The 90 foot diameter aerial built by Marconi and based upon a design commissioned by the Post Office from their Consulting Engineers, Husband & Co., is the largest and most expensive item. The present aerial follows the pattern established by the first Goonhilly installation of dispensing with a radome. This practice has since been followed by most other earth station designers.

The aerial makes use of a Cassegrain configuration with a spinning horn at the apex of the main reflector. The spinning feed-horn is a feature of Marconi's "mode conversion scanning system" of aerial steering. It introduces a conical scan of the aerial beam only at the frequency of the satellite beacon signal. Thus it avoids unwanted amplitude modulation of the communication carriers or significant degradation of aerial efficiency for either direction of transmission. By this means auto-tracking can be achieved either by servo control of the main reflector mounting or, within a range of about $\pm$ 20 minutes of arc, by deflection of the sub-reflector. Provision has also been made for control of the aerial manually and for the addition of tape control facilities later, if required. Motor-driven bogies running on a circular track rotate the whole aerial about a central pivot and tilting of the reflector about its low level elevation axis is controlled by a single horizontal screw and cross-head linked by a massive connecting rod to the upper part of the strong back of the reflector. Both driving mechanisms are powered by duplicated thyristor-controlled d.c. motors operating via differential gearboxes.

The aerial and telecommunications equipment are controlled and monitored from a suite of consoles in the central building. Each carrier, which may transmit up to 132 telephony channels, is monitored separately and reserve equipment is switched into use automatically if a disabling fault condition arises. Faults which cause degradation of the service but do not interrupt it can be located and eliminated by manual switching of their component sub-systems without interference with traffic. A separate console enables the television service to be monitored and tested.

A microwave radio link from Goonhilly extends the satellite circuits to the International Telephone Services Centre in London. In the central building at Goonhilly, the circuits are re-arranged at baseband frequencies into units of 24, 60 or 132 channels as dictated by traffic requirements. Each baseband unit then modulates an intermediate frequency of 70 MHz in the modulator section of the equipment provided by GEC–AEI (Electronics) Ltd. Also injected into the circuit at this point are a 60 KHz continuity pilot, an energy dispersal signal to restrict the level of intermodulation products during light traffic loading and engineering service channels at sub-baseband frequencies. Intersite coaxial cables transmit the modulated i.f. carriers to the equipment on the aerial where they are converted individually to their assigned frequencies in the GHz band. All carriers are then combined at low power level before amplification in two stages, by common wideband travelling-wave-tube amplifiers. The output stage has a maximum c.w. capability of 8–10 kW but in order to restrict the power of unwanted intermodulation products it will not normally be loaded above 1·5 kW. A second transmitter which serves as a reserve for the telephony system, can be used alternatively for television transmissions.

The very weak signals from the satellite in the 4 GHz band are amplified by a three-stage parametric amplifier, cooled to 16°K in a closed-circuit, gaseous-helium refrigeration system followed by a tunnel-diode amplifier. The four stages have an overall gain of 40 dB over the 500 MHz frequency band assigned for the down path from the satellite. The effective noise temperature of the amplifier, referred to its input is less than 20°K. At the output of the common amplifier the individual carriers are separated by a selective branching network, converted in frequency to 70 MHz and extended individually by co-axial cables to the f.m. feed-back demodulators in the main building. Here, supervision is effected by monitoring the synchronizing pulses.

Extensive provision of switched redundant equipment in the system and the comprehensive control facilities will ensure a high standard of reliability and enable maximum economy of operational manpower to be achieved.

Advisory Group on Telecommunications System Definitions

As part of the change of policy in procurement towards competition the Post Office has set up an Advisory Group on Telecommunications System Definitions to help in the difficult and complicated job of preparing specifications for telecommunications systems of the mid-seventies and eighties.

The Group which will include members from the telecommunications industry will give advice to enable the Post Office to determine system and sub-system definitions. Responsibility for deciding on the definitions and for making them known to all who may be interested will rest with the Post Office but final decisions will not be taken without an opportunity to comment being given to contractors. And, at the same time, through the active participation of its industrial members, it must act whenever possible so that both home and export requirements are recognised.

The Group will be chaired and serviced by the Post Office. It will consist of the Post Office and such established suppliers as there may be from time to time; currently the established suppliers are GEC/AEI, Plessey and STC. However the Post Office will be free to seek or receive advice from, or have discussions with, any supplier or potential supplier outside the Group who may wish to become an established supplier or who may have a contribution to make. The Post Office will also be free to have bilateral discussions with individual established suppliers to supplement Group discussions.

This Group has, in fact, already started work under the leadership of a Post Office Deputy Director of Engineering, Mr. L. R. F. Harris, supported by a team of four experienced Post Office people working in close collaboration with two or three full-time representatives from each of the contractors concerned, supported as needed by other staff for specific tasks.

By this means, the Post Office, with the co-operation of those from Industry who are sharing with it in the work of this Group, hopes to be able to create a series of performance-based specifications for the telecommunications systems of the future that will liberate the innovative powers of Industry. At the same time it will strike a balance between compatibility and competition, and result in the Post Office being able to provide itself with systems—both hardware and software—that will give its customers services to meet the needs of the seventies and eighties.

Notes and Comments

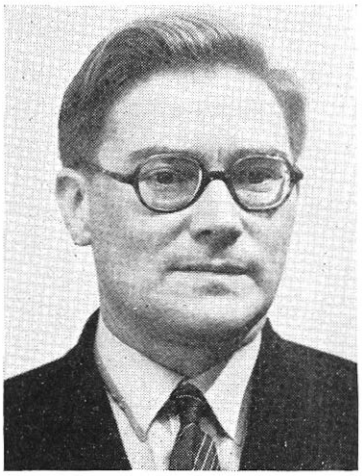
New Year Honours

The Board of Editors offers congratulations to the following engineers honoured by Her Majesty the Queen in the New Year Honours List:

London Telecommunication Region	A. J. Thompson	Chief Regional Engineer	Companion of the Imperial Service Order
Cardiff Telephone Area	C. J. T. Clarke	Assistant Executive Engineer	Member of the Most Excellent Order of the British Empire
Southampton Telephone Area	C. S. Hale	Executive Engineer	Member of the Most Excellent Order of the British Empire
South Eastern Telecommunications	A. H. Ellenden	Senior Executive Engineer	Member of the Most Excellent Order of the British Empire
Canterbury Telephone Area	J. E. Mills	Technician I	British Empire Medal

H. Banham, B.Sc.(Eng.), C.Eng., M.I.E.E.

Harry Banham joined the Post Office in 1937 as a youth-in-training in his native City of Manchester. There, as a U.S.W., S.W.11, and Technician (with an interruption for service in the Royal Signals) he laid the foundations of a noteworthy career.



In 1948 he was successful in the Assistant Engineer competition and moved to London where, in the Telephone Branch of the Engineering Department, he worked on v.f. signalling systems. Following further success in 1951 in the Executive Engineer limited competition he applied his talents to the physical design of telephone equipment, including equipment for s.t.d. Not content with these achievements, Harry studied for his Engineering Degree and was rewarded with success in 1958. Promotion in 1960 to Senior Executive Engineer brought him into the sphere of electronic exchange developments where he dealt with facilities and interworking problems. Promotion to Assistant Staff Engineer followed in 1964 and found him working on maintenance policies for electronic equipment and the trunk network. In 1967 he was transferred to the Long Range Systems Planning Unit, dealing with system evaluation and facilities studies.

His latest promotion to Staff Engineer places him in the P.O.–Industry Advisory Group on Telecommunications System Definitions. Here his wide knowledge and experience, a penetrating mind, and a pleasant personality will be an invaluable combination. Harry also has the best wishes of many friends in his new assignment.

D.L.B.

D. J. Harding, B.Sc.(Eng.), C.Eng., M.I.E.E.

Doug Harding, the new Staff Engineer for Exchange Equipment and Installation Standards Branch, TD2, in ES Division has had a somewhat unusual career in telecommunications. Starting in 1943 as a youth-in-training he was appointed A.E.E. by open competition and was posted to

Dollis Hill after obtaining his degree in Engineering. After spending some time on early work in the electronic switching field, he decided to join the West Australian Telephone Administration and for about three years worked in the Perth area on installation of a variety of telecommunications equipment. By 1954 he had decided to return to England and on being posted to Dollis Hill he began to work actively in the field of electronic switching and signalling. Promoted to Assistant Staff Engineer in 1964, he was posted to the then electronic switching branch, TPE, in 1966. After re-organization and following a short period with the Headquarters Appointments Centre he took up his present appointment as Staff Engineer in November, 1968. Doug. Harding is a well-known figure around Headquarters with a dynamic personality and is much sought after as a lecturer on technical subjects. He has an engaging style, works almost without notes and succeeds in giving his audience an entertaining as well as an informative evening. He is a pioneer in micro-electronics and p.c.m. switching; his friends and colleagues wish him well in his new appointment.

J.A.L.

R. E. G. Back, C.Eng., M.I.E.E.

Ron Back is not a dyed-in-the-wool radio man, for he spent some eight years in the then Construction Branch, on protection and deep-tunnel construction, before moving to Radio Branch to handle the external construction of the large v.l.f. station at Anthorn. Becoming accustomed to towers rather than tunnels he then worked on radio relay before becoming the A.S.E. in charge of construction for the Goonhilly satellite earth station. Here his general engineering experience stood him in good stead, and after beginning the second aerial system he, as the earth station planning engineer, organized the very successful P.O/MINTECH/Industry conference on the "Planning and Operation of Satellite Earth Stations". Now, he has been appointed Head of the Space Communications Systems Branch, a post for which his urbane and debonair qualities of leadership and his down-to-earth engineering judgement fit him well, and his friends wish him every success in his work.

S.G.Y.

Circulation of the Post Office Electrical Engineers' Journal

The Board of Editors is pleased to note the continuing increase in the circulation of the Journal as shown by the following statistics.

Journal Issue	Number of Copies Printed
Vol. 61, Part 1, Apr. 1968	34,330
Vol. 61, Part 2, July 1968	34,700
Vol. 61, Part 3, Oct. 1968	35,000
Vol. 61, Part 4, Jan. 1969	35,400

Approximately 10 per cent of the Journals are sold to overseas readers in more than 50 countries.

Board of Editors

Mr. D. Waldie has resigned from the Editorial staff and the Board are pleased to appoint Mr. C. R. M. Heath as the new Assistant Editor.

Regional Notes

Midland Region

Explosion at Madeley U.A.X. 13

At 0945 hours on 31 December 1968 a message was received at the Telephone Manager's Office that the 350-line U.A.X. 13 at Madeley, Staffs. had been demolished by a gas explosion.

Maintenance staff arrived at Madeley at 1015 hours and found that the U.A.X. building had completely disintegrated. All walls were laid flat and the roof had vanished. The concrete roof trusses were lying on top of the equipment and parts of the roof were found 150–200 yards away. The original U.A.X. building, which housed the power plant and battery, was completely demolished. The accompanying photograph shows the extent of the damage.

The emergency subscribers were restored at approximately 1200 hours. A portable engine-driven 50-volt generator arrived and was connected in order to increase the power supply. The other subscribers were gradually put through and all were working again by 1430 hours.

Fog now began to gather and the racks were covered with tarpaulins to minimize its effect. At approximately 1530 hours Ministry of Public Building and Works builders removed the remaining concrete beams and erected tubular scaffolding around the exchange. This was covered with plywood for the walls and polythene sheeting for the roof. Heaters and temporary lighting were fitted inside. A battery hut had been delivered and this was erected nearby. A larger battery and rectifier were installed and connected to the exchange to replace the engine-driven generator. By 1900 hours the damaged switches had been re-fitted, the exchange seemed to be working satisfactorily and all staff left the site except for one man who stayed over night for security reasons.

A quick inspection was made of the U.A.X. equipment and to everyone's surprise it did not seem badly damaged. It was therefore decided that to restore the existing equipment would be quicker than to install a mobile exchange. A portable telephone was connected to a junction cable pair, requests made for tarpaulins, and arrangements put in hand for the Ministry of Public Building and Works to give advice on a more permanent covering. The delivery of a Type B1 wooden building was organized with T.H.Q. At this time the site had to be evacuated due to danger from overhanging brickwork on the adjacent block of flats. The Fire Authority made this safe and at 1130 hours restoration work was resumed.

The gang removed two dangerous concrete beams, all lines were pegged out on the M.D.F. and a closer inspection was started. Luckily the weather was fine, otherwise the units would have been irreparably damaged. The explosion had lifted all the switches and dropped them back in position again, thus damaging the wipers of any switch in use at the time. There were about twelve examples of this and such wipers were removed for attention later. Meanwhile a portable battery had arrived and this was connected to the exchange and the ringer started. The Electricity Authority's fuse box was standing two feet above the ground on the cable and their workmen checked that the supply was satisfactory. Testing continued and a rectifier was connected to the mains supply.

Explosion at Madeley U.A.X.

The next day further tidying-up operations took place and the wooden building arrived. The builders cleared an area round the U.A.X. in order to erect the new building over the plywood and polythene structure. On 2 January the walls were erected on brick piers and by evening a substantial tarpaulin roof was in position. The following day the permanent roof and a door were fitted and the night attendance discontinued.

The temporary structure has now been removed from inside the wooden building and concrete put down to increase the base to the new size. A power plant is to be installed which can be accommodated in the U.A.X. building. The equipment will be thoroughly cleaned and it is hoped that good service will be provided until the replacement T.X.E.2 exchange is brought into service in 1971.

F.K.

North West Region

Duct Works on a Motorway Services Bridge

One of the most difficult parts of the road construction which involved P.O. cables was an 80-ft services bridge.

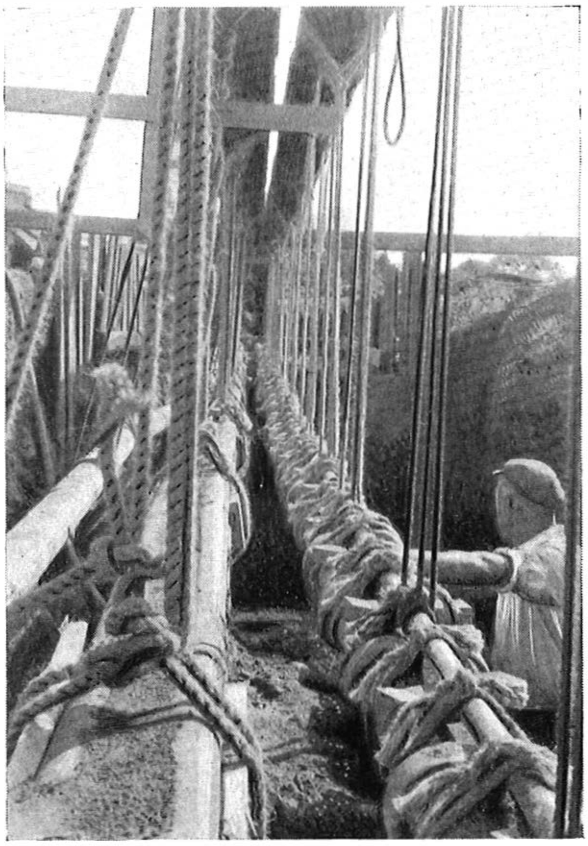
The bridge was built over a stream and was constructed to take both P.O. ducts and a 6-in water main. The existing P.O. ducts consisted of six $3\frac{1}{2}$ in steel pipes and a 2-way multi-way duct.

It was necessary for larger manholes to be constructed at each side of the bridge and this involved demolition work.

The complete system of ducts was to be suspended approximately 16 ft from the ground for a total distance of 90 ft. The total weight of all the plant was approximately 5 tons. From this information the road engineers estimated the strength of support necessary to hold the nest of ducts. There were six longitudinal supports consisting of panels of timber 30 ft × 15 in × 15 in plus four transverse R.S.J.s of 20 ft × 15 in × 6 in.

The bridge engineers, realized the full importance of the cables and requested the P.O. works supervisor to indicate the best method of duct suspension.

The ground was removed from the ducts using hand digging only. The full length of the multiway duct was given a



Suspension of the ducts

strong back of scaffolding poles. Each duct being tied twice to the poles. Wooden wedges were placed between the poles and the ducts to take up the slack. The steel pipes were a different proposition and it was decided to dispense with the strongback and use ties around the nest. To prevent the ducts falling out of formation, rectangular wooden templates were placed around them, this held them in a tight 6-way nest. The ducts were then fastened to the longitudinal panel of timber. Sufficient slack rope was left in the ties to allow for any further housing of the ducts. Due to their additional weight the steel pipes were given ties every 4 ft and over 300 ft of rope was used for the suspension. The site was then ready for bridge construction.

Approximately four months later the bridge was ready to take the ducts. It was partially filled with sand to the inverts of the ducts, a new 4-way multi-way duct was then laid, all the ties and supports were removed and the bridge topped up with sand. Pre-cast lids were then placed over the structure.

During demolition of manholes, supporting of ducts and bridge construction, the sole casualty was one broken multi-way duct.

D. W. S.

Eastern Region

Bungay Exchange Transfer

At 1315 hours on 11 December 1968. Bungay exchange was transferred to automatic working. This marked the end of an era in the Norwich Area and at Bungay. With the transfer the Norwich Area became fully automatic with 107 exchanges. At Bungay the manual exchange had been housed in the same building for over 61 years. In this time it expanded from one position, with 21 subscribers, to six positions with 680 subscribers and three dependent exchanges.

As a result of the researches of Mr. Clayton of the Norwich Area, we have a picture of the service offered to subscribers in 1907. The switchboard was one position c.b.s., and was available for public service between 0800 hours and 2000 hours on weekdays and 0800 hours to 2200 hours on Sunday. In the event of a fault a service telegram was sent to the linemen at Lowestoft, who then cycled the 14 miles to Bungay to deal with it. Subscribers paid £5 per annum (including 500 measured-rate calls) for service and the charges for distance calls were, 3d, up to 25 miles; 6d, 25–50 miles; 9d, 50–75 miles; 1s, 75–100 miles, for 3 minutes.

Calls to subscribers on the local exchange were 1d. The growth of the exchange can be seen from the following:—

The new exchange is a strowger 2000-type R.N.D., G.S.C. with 800 multiple and, as it is situated in a mainly rural area, becomes the main switching and s.t.d. centre for eight dependent exchanges. As it was necessary to relieve the manual exchange as soon as possible, a transfer date was decided upon in advance of a definite contract acceptance date and most of the testing of the equipment was carried out by P.O. staff without a previous contractor's test. This proved successful with very little extra labour expenditure from normal and the transfer took place before the official completion of the exchange. With the completion of this exchange an automatic conversion program spread over 40 years and involving 107 exchanges has been completed in the Norwich Area.

On a more personal level, Mr. T. H. Loome, Executive Engineer, on internal exchange construction, delayed his retirement until after this transfer, so that in his 45 years service with the P.O., he could see the whole area converted to automatic working. He had been involved in some of the earliest U.A.X. 5's installed, and for the last thirty years had been on exchange construction in a supervisory capacity.

T. H. L. and D. J. M.

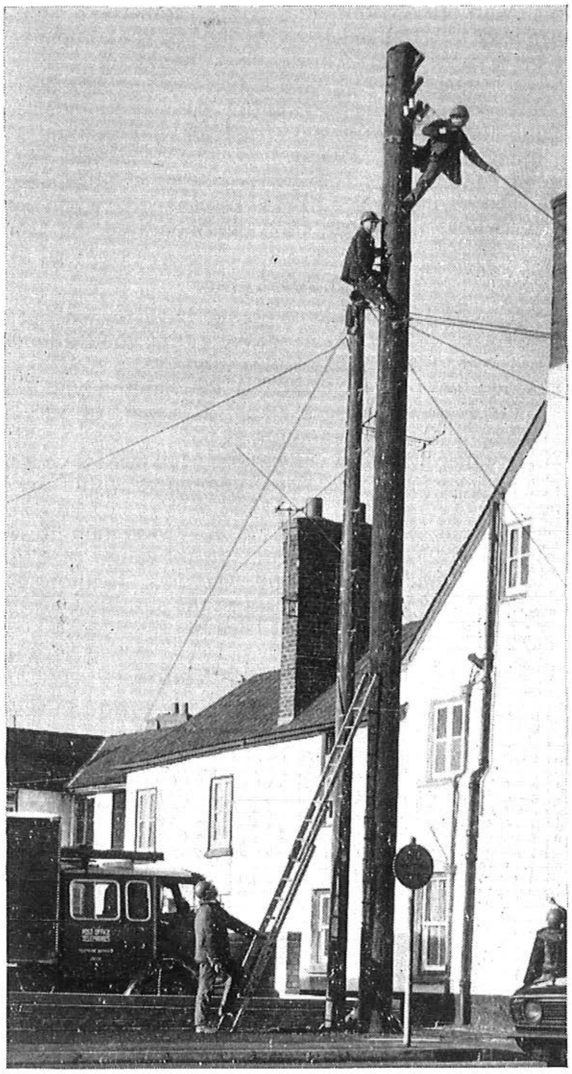
South West Region

Recovery of a "Stout" pole at Cullompton, Devon

So few stout poles are still standing these days that we decided to have a photographic record of this one at Cullompton before it was recovered under a development scheme.

It was originally a 65 ft. stout pole carrying the Exeter-Taunton-Bristol-London overhead trunk circuits of 600 lb heavy-duty copper wire on 16 wood arms.

In the early 1950s, during a time when the K pole recoveries were taking place, a length of 19 ft was cut from the top of this pole, thus leaving it at its present size. This is the reason why the pole roof is seemingly too small for the pole.



Stout pole at Cullompton

It seems a far cry now in these days of trips around the Moon to think that these heavy poles were brought to the site by means of horse and cart.

J. E. M.

Associate Section Notes

London Centre

We are almost at the end of one of the more active seasons in recent times.

There have been numerous changes in personnel both at Centre and at Area level. Brian Shillum, who as Chairman of Test Section gave valiant service both at Studd Street and at Centre meetings, left at the end of 1968. P. G. M. Southgate succeeded the late R. W. Harper as Assistant Secretary to the Centre and the vacant Registrar post was filled by the Librarian, Mr. Randall. The Treasurer, Mr. R. A. Gray, has announced his intention of retiring at the end of the session while both the Chairman and Vice-Chairman have been successful in promotion boards. Thus it is likely that by the beginning of next session in September the Editor and Secretary will be the only Officers left of the 1968/69 committee.

The second half-session's lectures have been given by various members of Post Office Staff including Mr. Harnden and Mr. Merriman whose talks were controversal but stimulating. Other subjects included the "Problems of Maintenance of the S.T.D. Network and External Works Techniques".

London, represented by East area, regretably lost to Brighton in the final of the Inter-Regional Quiz held at a sports pavilion near the Sussex resort. The early rounds of the current L.T.R. quiz have been played off and this year could well see the Tower trophy returning to the metropolis

Visits have been none too successful but nevertheless continue to provide an invaluable part of the annual program and will of course continue into the forthcoming months. The U.S.A. trip was fully reported in the January edition of the 'N.Q.J.' a few copies of which are available on request from the London Centre Editor at the P.O. Tower (Tel.: 580 1316).

Which brings us neatly to the Journal. It continues to flourish and the Editor would like to thank all those who have contributed in one way or another in making it what it is.

Finally the A.G.M. of London Centre will be held as usual in the Council Chamber of the I.E.E., Savoy Place on the 14th of May.

B. E. B.

Aberdeen Centre

On Wednesday, 4 December we welcomed back Dr. Coombes from Dollis Hill Research Station who gave us a talk entitled "Character Recognition for Postal Mechanisation, with Excursions into Hypergeometry." This very entertaining talk was much appreciated by the company, who gave the speaker a very warm vote of thanks.

On 15 January 1969 we held a quiz between Aberdeen and Inverness sections. The two centres were interconnected by an omnibus circuit with spurs to Huntly, Elgin and Wick. The questions were compiled by the Regional Training School in Edinburgh and covered a wide variety of engineering topics. The result of the quiz was Inverness 35, Aberdeen 27. Despite defeat, all present thoroughly enjoyed the evening.

R. M. M.

Dundee Centre

The program arrangements so far have turned out well and, coupled with excellent speakers, the good attendance is making this a most successful session.

Dr. Coombes' lecture "Character Recognition with Excursions into Hyper-Geometry" was, as usual, of very high standard and very entertaining.

Mr. Dollman, our new Telephone Manager, gave a most interesting account of the use of computers within the Post Office.

The two outside speakers, one on "Mountain Rescue," the other on "The Doctor in the Investigation of Crime," proved very stimulating and held everyones attention.

The committee wishes to express its gratitude for the interest shown by members and friends.

R. T. L.

Southend-on-Sea Centre

Our visit program for 1968 ended with a trip to the *Daily Mail*. The tour round Northcliffe House started at 9 p.m. and our members saw one of the greatest dailies in full production.

Prior to this we were entertained by S T & C at their N. Woolwich factory, where, amongst many other things, was seen the making of external telephone cable.

An evening visit to the main London sorting office at Mount Pleasant proved to be both interesting and entertaining. We now have first hand knowledge of how our postal colleagues keep the mail moving.

The Southend-on-Sea Waterworks Company provided a very enjoyable afternoon to some 30 of our members when they showed them round the pumping station at Langfords which is situated between Colchester and Maldon. During the visit they saw both very modern and a splendidly preserved example of old pumping equipment.

The visits were well supported, in fact some were over subscribed. This gives us the hope that the Centre's first Dinner and Dance will be the success we would wish. This function is being held at the end of April.

During the year the total membership has gradually increased. With Grays-Thurrock becoming part of the Southend-on-Sea area, we extend a hearty welcome to their members.

A. W. T.

Exeter Centre

The 1968–1969 program started with an unusual paper given by Dr. P. E. Taylor of Purchasing and Supply Department. London Materials Section entitled "Deterioration of Plastics in Service."

Dr. Taylor described the types of deterioration of the significant properties of those plastics which are commonly used in telecommunications engineering. He explained how both the type of deterioration and its extent depended on service conditions, and how each material behaves under different environments. Making quantitative predictions of the reliability of such relatively new materials is obviously very difficult.

Our second paper of the session was entitled "Power Supplies for Telecommunications Services" by D. A. Spurgin, Esq., Power & Ancillary Systems Branch, P.O.T.H.Q. It is many years since the Centre was addressed on this subject but perhaps through the good offices of the speaker we will hear more in the coming session.

Mr. Spurgin reviewed the evolution of all principal power supplies from the early days of centralized supply on C.B. exchanges up to packaged stand-by engine-sets for smaller power plants, production of which is in hand. A brief mention was made of stand-by gas turbines. The paper also covered distribution and the control of power plant output. In connection with control, the use of solid-state control circuits and solid-state logic control systems were discussed. The printing standard of this paper which was made up in booklet form, suggested a paper of repute and members attending this meeting agree that other centres will enjoy this paper as much as we did.

Many thanks to both our speakers for their visit here.

The winner of the Exeter Associate Centre T.T.A. Award this year is Mr. D. P. Nicholls. The prize is a book on telecommunications or its allied sciences, and from this field he has chosen "Techniques of Transistor Switching Circuits" by J. Budinsky. The presentation will be made at the January meeting by the President, Mr. W. J. Foster.

Congratulations to Mr. Nicholls on winning this award, it is hoped that this small honour will serve as some reward for his efforts during the past year.

The Centre would also like to express its gratitude to the Area Training Officer, Mr. T. W. A. Smith, who analyses the achievements of all the 2nd year TTAs in the area. This is often no easy task when only one award is to be presented.

T. F. K.

Inverness Centre

Attendances this session have been about the same as last year, but with more younger members taking an interest.

Russell Johnston Esq., M.P. for Invernesshire, opened the session with a most entertaining talk on "My Work as an M.P."

Our October meeting took the form of visits to Millburn Distillery and Highland Printers. On that occasion, we had as guests three of the staff from a German ship which was mole-ploughing ducts under the sea-bed at Kessock Ferry. These ducts will be used to take cables from Inverness to the Black Isle. Through the efforts of Mr. W. Copland A.E.E., the staff in Inverness were able to see a colour film of under-water mole-ploughing as developed by the firm.

In November, Mr. Currie, Area Accountant, told the Centre about "Finance and the Area Office" and in fact "Finance in Region" as well.

Mr. J. J. Murray, E.E., was the speaker at our December meeting, his subject being "Radio Propagation." It was obvious to all that Mr. Murray is an expert in this field and that he had gone to considerable trouble to prepare his paper and the slides which accompanied it.

Our first meeting of 1969 took the form of a quiz against Aberdeen Centre, Inverness won by 35 points to 27.

The quiz-masters were Mr. J. W. H. Sharp, Area Engineer, Aberdeen and Mr. J. J. Murray, E.E., Inverness. The Centre is indebted to them and to the staff of R.T.S. who set the questions.

Mr. W. Sheldon, S.E.E., T.H.Q., Scotland, will be our February speaker, his subject will be "Transit Switching" and we expect this to be a well-attended meeting.

W. A. A.

Edinburgh Centre

Our first visit of the 1968–1969 session was to the Ministry of Technology, National Engineering Laboratory (N.E.L.) at East Kilbride on the afternoon of Thursday 10 October 1968

At the N.E.L. we were given a working demonstration of a dumper truck fitted with hydrostatic transmission. All the main laboratories were visited where investigations are being carried out in three main groups dealing with machinery, fluids and materials. Some of the research undertaken was shown to our members. This included the application of air bearings to textile spindles, the measurement and performance of scale-model pumps and turbines. Model layouts of investigations for overseas concerns were also shown.

Visits were also made to the computer section, the optical division and the creepage laboratory. The only criticism of the visit was that a half day was not enough, and to have given the subject a proper coverage would have required the whole day.

Our tour ended in the lecture hall after a discussion about the formation of the N.E.L. and a question and answer period. A lot of time was devoted to the further use of hydrostatic transmission and its commercial applications.

G. A. K. R.

Institution of Post Office Electrical Engineers

Retired Members

The following members, who retired during 1968, have retained their membership of the Institution under Rule 11(a):

J. Gerrard, 2 Lagado Close, Lilliput, Parkstone, Poole, Dorset.

J. E. Porter, 15 Marlborough Court, Walsall Road, Four Oaks, Sutton Coldfield, Warwickshire.

H. T. A. Sharpe, 37 Westhurst Drive, Chislehurst, Kent.

G. E. Styles, 140 Green Dragon Lane, Winchmore Hill, London.

R. E. H. Varney, Hill Farm House, Chediston, Halesworth, Suffolk.

A. B. WHERRY
General Secretary.

Additions to the Library

Library requisition forms are available from Honorary Local Secretaries, from Associate Section Centre Secretaries, and representatives, and from the Librarian, I.P.O.E.E., G.P.O., 2–12 Gresham Street, London, E.C.2.

Members are reminded that Prize Essays, Associate Section Prize Papers, and various unpublished papers are held in the library for loan, and that a list will be sent on request. Field Medal award-winning papers are also held for loan and are listed in the Supplement to the Library Catalogue.

Members are reminded that books not obtainable from the I.P.O.E.E. Library, may be borrowed from Lewis's Scientific and Medical Lending Library. Applications should be made to the Librarian, I.P.O.E.E., in the first instance.

2985 *The Car: Its Engine and Structure.* R. H. Bacon (Brit. 1968).
A book for the practical motor car engineer, describing all the features of the modern private car. A valuable book for the amateur mechanic who wants to increase his knowledge of modern motor car engineering.

2986 *Electricity in Cars.* R. H. Bacon (Brit. 1967).
Well-illustrated book fully covering the basic principles of electricity and its applications to the motor car.

2987 *Worked Examples in Electrotechnology* (7th Ed.). W. T. Pratt (Brit. 1968).
Aimed at students preparing for the Preliminary and Intermediate Grade Examinations of the City and Guilds of London Institute in Electrical Engineering Practice: Part 1 of the Associate Membership Examination of the Institution of Electrical Engineers: and the Ordinary National Certificate in Electrical Engineering.

2988 *Design and Application of Transistor Switching Circuits.* L. A. Denholm (Amer. 1968).
A book from the Texas Instrument Electronics Series. It gives a complete, self-contained discussion of Transistor Switching Circuits and will be of great value to all electronics engineers and technicians in the field of circuit design and construction.

2989 *Solid-State Electronics.* R. G. Hibberd (Amer. 1968).
Another book from the Texas Instrument Electronics Series, especially designed for anyone interested in solid-state electronics, but with little or no electronics background. This volume gives a broad, basic understanding of solid-state electronics, from the fundamentals of semiconductors through integrated circuits.

2990 *ABC's of Transistors.* G. B. Mann (Amer. 1966).
Is written so that anyone interested in the subject can obtain a basic understanding of the principles behind these devices and is recommended as a beginning text for students, technicians, amateurs and hobbyists.

2991 *Semiconductor Devices in Power Engineering.* Edited by J. Seymour (Brit. 1968).
Introduces the semiconductor devices that are of interest to power engineers, and gives their main applications and consideration of equipment reliability.

2992 *Computer-Aided Design of Electronic Circuits.* E. Wolfendale (Brit. 1968).
In this book, the author presents the general concept of computer-aided design and shows how the manual methods of design at present can be made more efficient and reliable by means of a computer. The programming language used throughout is Algol and this is described in the first chapter together with an introduction to the computer and methods of programming.

2993 *Logical Design Manual for Switching Circuits.* D. Zizzos and G. W. Copperwhite (Brit. 1968).
The aim of this manual is to explain the nature of race and hazard phenomena in switching circuits, how to detect their possible presence in circuits and to suggest simple but effective means of climinating them, using step by step techniques at an early stage of the design. A chapter on Boolean algebra has been included for completeness.

2994 *Stereo Handbook.* G. W. Schanz (German 1968).
Intended to give a brief survey of stereophony to facilitate understanding and to give useful directions for the appropriate testing of stereo reproduction equipment.

2995 *Tape Recording for the Hobbyist.* A. Zuckermann (Amer. 1967).
Gives an outline on all the aspects of tape recording. The book is well illustrated and the various uses of the recorder, as well as the maintenance and operation techniques are as thoroughly explained as possible.

2996 *The Practice of Plating on Plastics.* R. W. Furness (Brit. 1968).
The author has sought to place on record his know-how and expertise of electroplating on plastics and other non-metallic materials, and he stresses details which he has found to be most important in practice. The actual equipment, sequences and formulations which he used so successfully in practice, are described and illustrated.

2997 *Basic Mathematics for the O.N.C. in Sciences.* W. Woodcock (Brit. 1967).
Aimed to give the student an appreciation of the basic principles and methods in mathematics which are applicable to the study of science.

2998 *A Manager's Guide to Work Study.* O. Gilbert (Brit. 1968).
A readable book which aims to give the manager an idea of what work study might involve and what can be expected from the technique without going into technicalities.

2999 *Introduction to Telephony and Telegraphy.* E. H. Jolley (Brit. 1968).
Provides not only a firm technical base from which to advance to more detailed knowledge of the practices in the various branches of telecommunication services but also to enable a reasonably broad appreciation of the interrelation of the various parts of the systems.
Covers the syllabus for the Telephony and Telegraphy A examination of the City and Guilds of London Telecommunications Technicians' Course and also the corresponding aspects of the earlier exam in Elementary Telecommunications Practice.

5000 *Critical Path Planning.* P. Barnetson (Brit. 1968).
Examines the basic techniques of the analysis and some newer concepts that have evolved from the original ideas. The use of computers in the analysis and the preparation of schedules is explained.

5001 *Automation in Practice.* D. Foster (Brit. 1968).
Explains in simple and clear language what physical automation is and what it can do. A book for the expert and the layman, it gives a clear picture of the background and history of automation, its theory and fundamentals and their completely practical advice on how to design, set up, and run the best system to suit individual needs in industry and business.

5002 *Introduction to Computers.* K. London (Brit. 1968).
Gives a comprehensive non-technical description to modern electronic digital computer. Aimed at all those who feel that a knowledge of computers at a more than superficial level will be of interest and ultimately of benefit.

5003 *Microminiature Electronics.* I. H. Kalish (Amer. 1967). Presents the basics of the new approaches in design developed in microminiature electronics, for the space and missile programmes, which are spreading to all phases of electronics.

5004 *Transistor Substitution Handbook.* Foulsham-Sams (Amer. 1968).
The information in this handbook is applicable for use by everyone concerned with transistor replacement—be it military, industrial, commercial or home entertainment devices.

5005 *Handbook of Electronic Circuits.* R.A.C. Servicing Co. Inc. (Amer. 1966).
Contains circuit diagrams and circuit descriptions of a number of the most commonly used basic electronic circuits. In addition an analysis of each circuit is included with respect to the most common causes for failure.

5006 *Junction Field-Effect Transistors.* C. D. Todd (Amer. 1968). Provides a thorough understanding of field-effect transistors (FETs). Primarily deals with the fundamentals, characteristics and applications of junction FETs.

5007 *Hi-fi in the Home.* J. Crabbe (Brit. 1968).
For the home music lover, dealing with the whole subject from the nature of musical sounds to the latest refinements in their reproduction, with much practical information for those wishing to move beyond the confines of conventional record players and radiograms.

5008 *Encyclopaedia of Cybernetics.* G. Gilbertson (German 1968).
The purpose of this encyclopaedia is to define and explain the terms which are used in all branches of cybernetics and to illustrate their application in practice.

5009 *Colour T.V. Servicing* (2nd Ed.). W. H. Buchsbaum (Amer. 1968).
An indispensable book for the serviceman involved with colour television repair and installation. Well illustrated with photographs and bold readable diagrams.

5010 *The Economic Management of Research and Engineering.* P. C. Sandretto (Amer. 1968).
Produces realistic answers for administrators who must regard every detail of research and engineering operations in terms of profit and loss. Provides orientation for top-level, non-technical management in establishing Research and Development policies and is equally geared to the problem faced by senior technical management in conducting economically sound technical operations.

5011 *Computer Based Information Retrieval Systems.* B. Houghton (Brit. 1968).
A course of six papers designed to give a conspectus of the major operational systems and feasibility tests now being conducted in the U.K.

5012 *Time-Sharing Computer Systems.* M. V. Wilkes (Brit. 1968).
This book gives a user's view of time-sharing systems and describes how such systems are designed. There is a section on graphical display terminals, including material on their use in computer-aided design, and a final chapter on the operation and management of a time-sharing system.

5013 *Principles of Electrical Engineering.* V. Del Toro (Amer. 1966).
Covers the four major areas of electrical engineering—electric-circuit theory, electronics, computers and control, and electro-mechanical energy conversion—in sufficient depth to impart understanding rather than just a familiarity with terminology.

5014 *The New Mathematics Made Simple.* P. Murphy and A. F. Kempf (Brit. 1968).
Part of a series of books created primarily for self-education. The reader is taken step by step, clearly and methodically, through the course.

5015 *Introduction to Circuits, Instruments and Electronics* J. W. Nilsson (Amer. 1968).
Introduces the engineering student to the basic technique of circuit analysis. This book is written for students who have completed one year's study of physics and calculus at university level.

2745 *Colour Prints* (*3rd Edition*) J. H. Coote (Brit. 1968).
An extensively revised and thoroughly up-to-date edition of the most authoritative work on its own subject.

5016 *Faults in Photography—Causes and Correctives.* K. Fritsche (German 1968)
Alphabetically lists almost every imaginable fault in black-and-white photo technique. Entries discuss, sometimes in considerable detail, every possible cause and source of error.

2887 *Colour Television Explained* (*3rd Edition*) W. A. Holm (German 1968)
The aim of this book is to describe in detail the theoretic bases of colour television and to make the problems arising out of its practical realization, more familiar and intelligible.

5017 *Colour Receiver Techniques.* T. D. Towers (Brit. 1968). Is the first book to give an account of current U.K. practice, coincident with the arrival of colour television. A well illustrated book which students, and especially bench engineers, will find of great value.

E. DOHERTY,
Librarian

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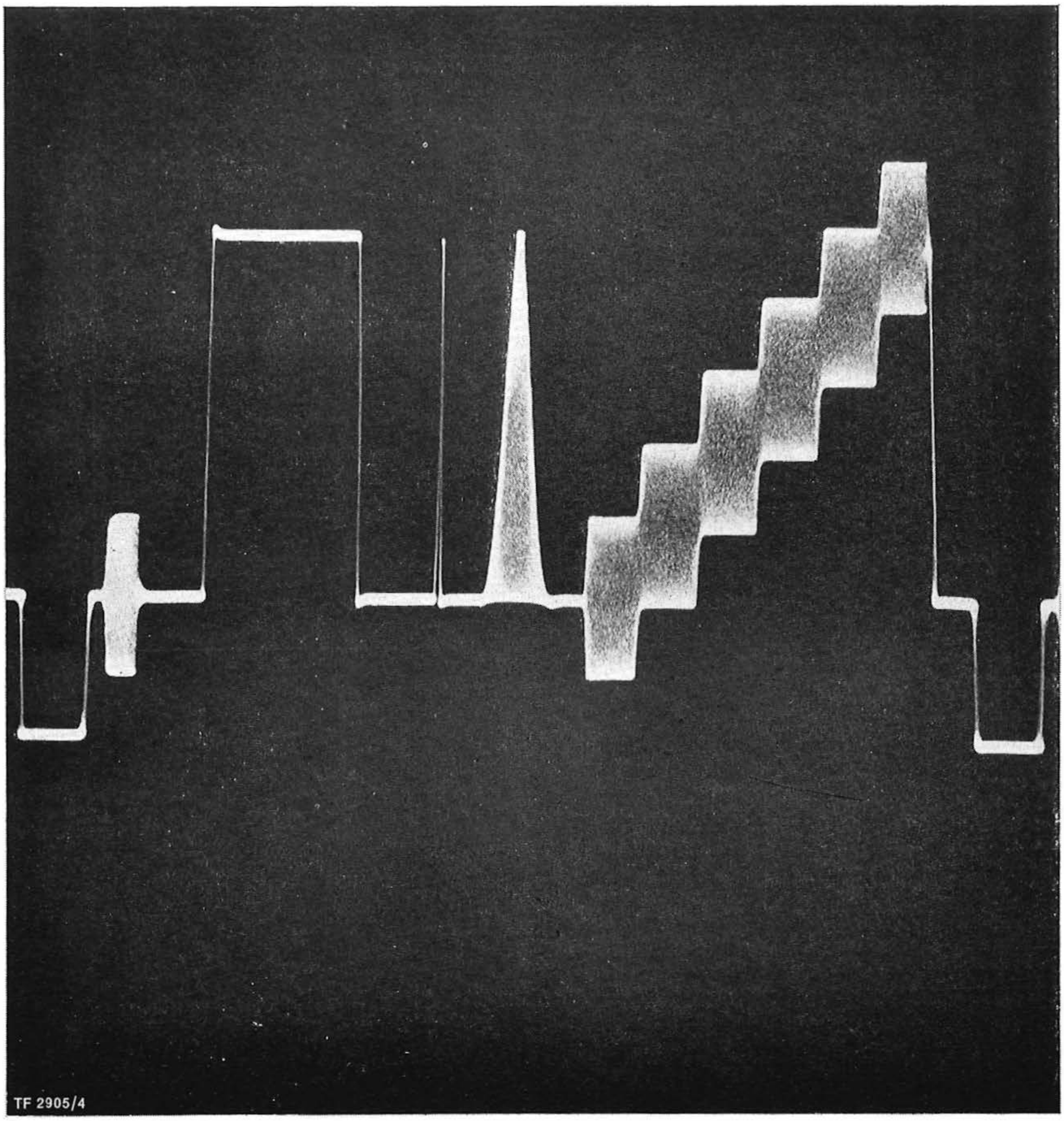

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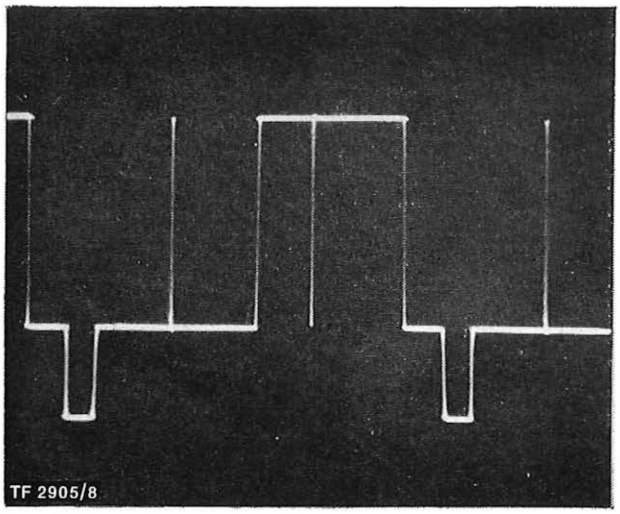

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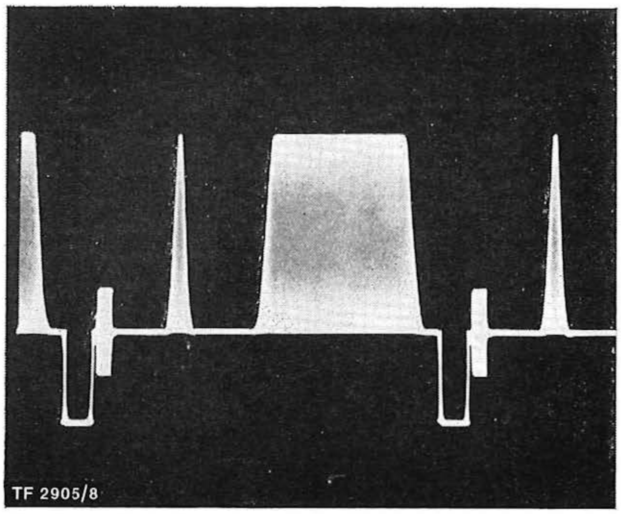

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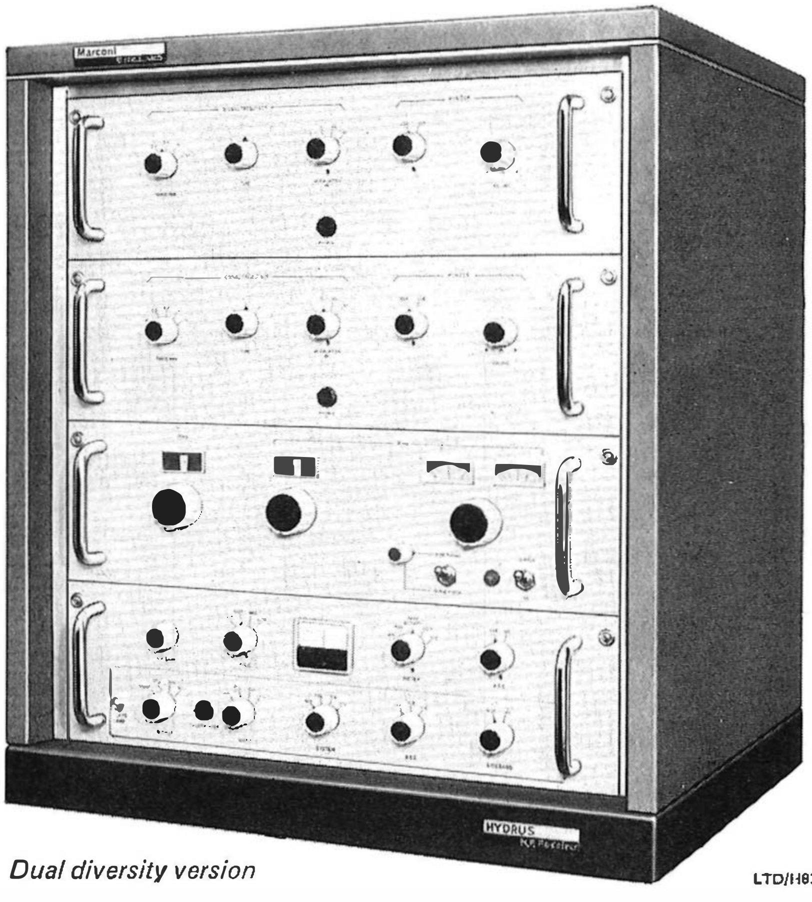

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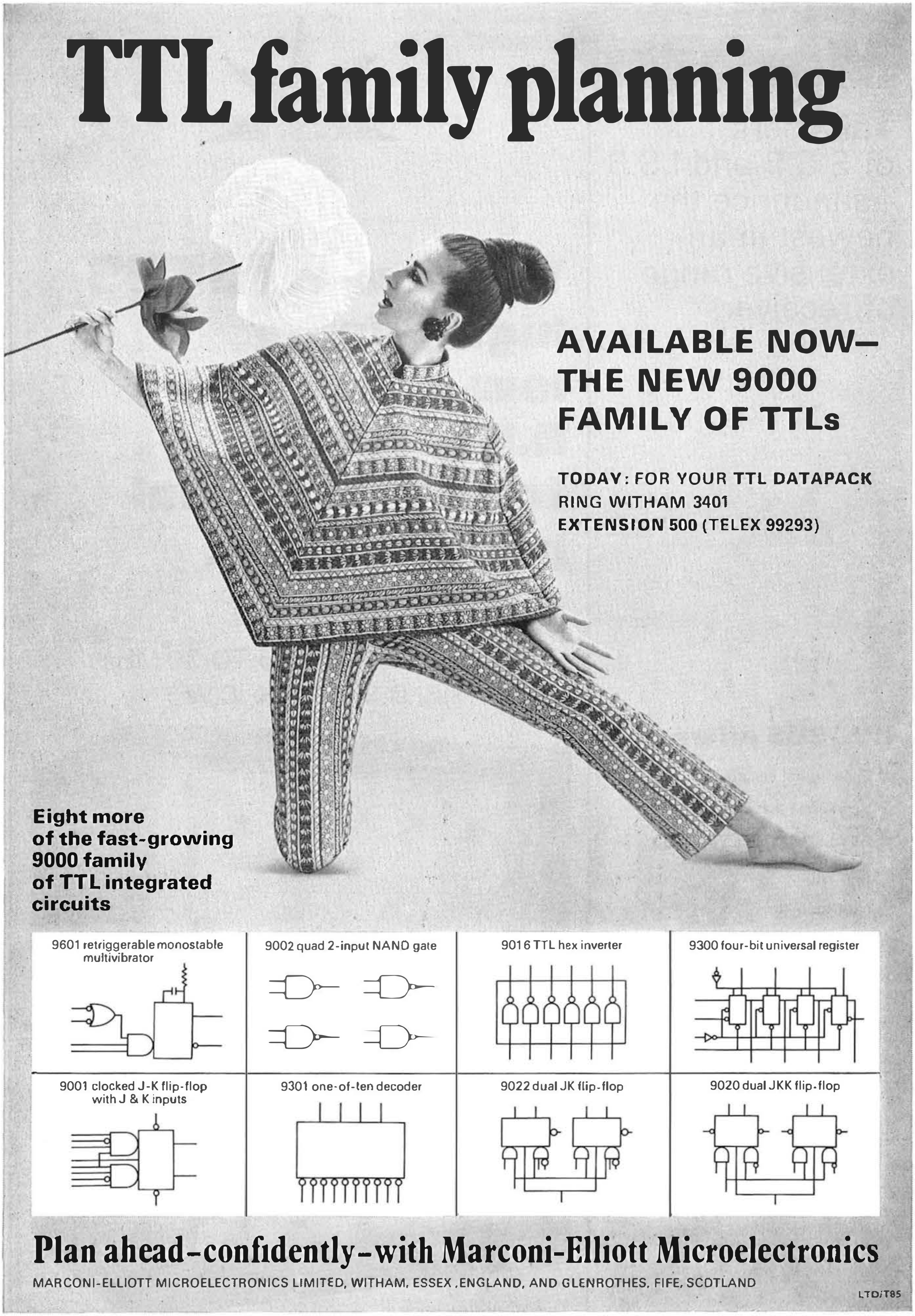
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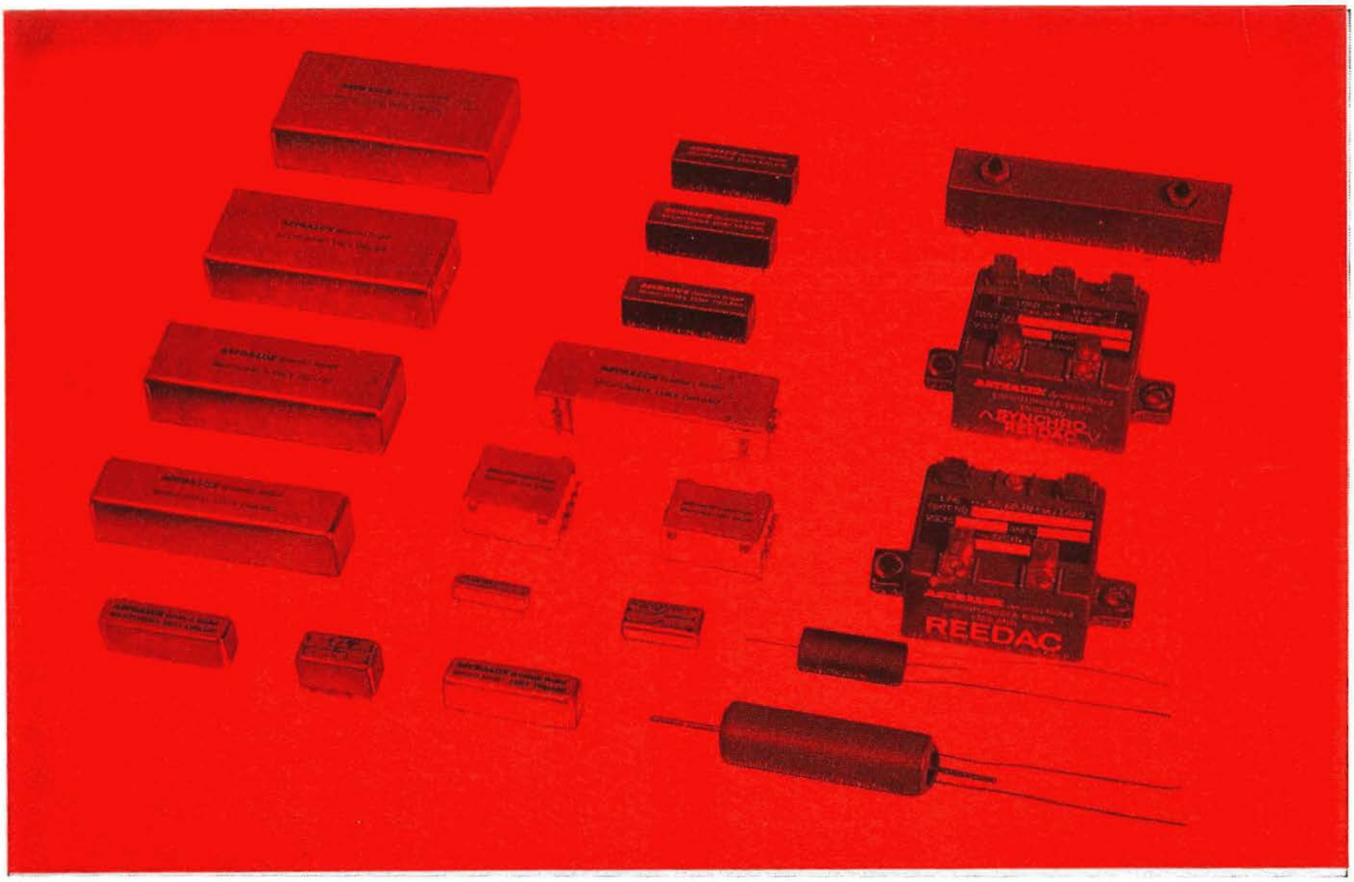

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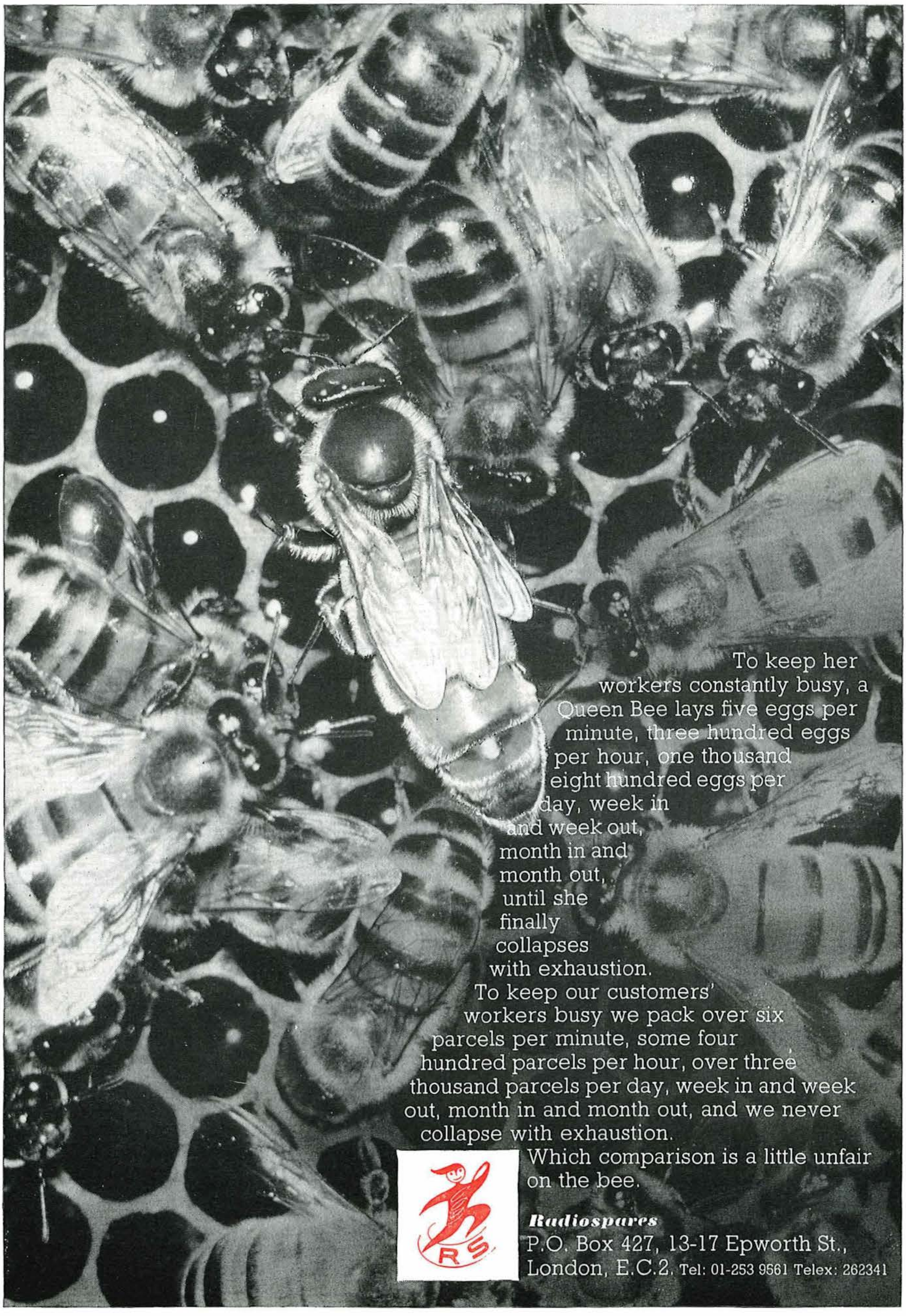
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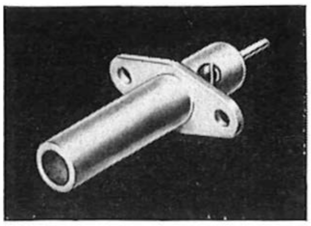

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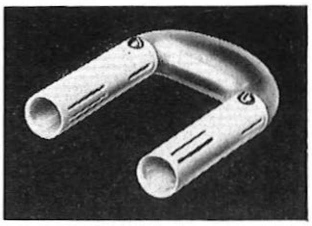

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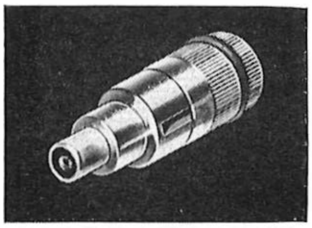

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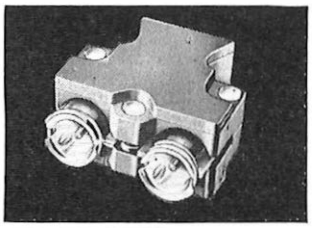

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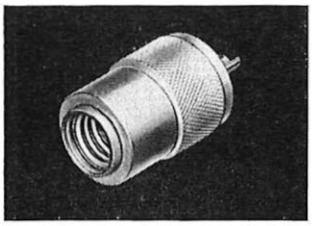

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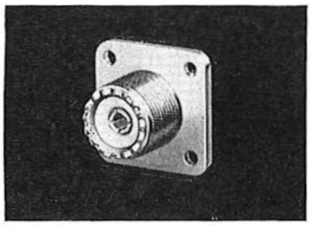

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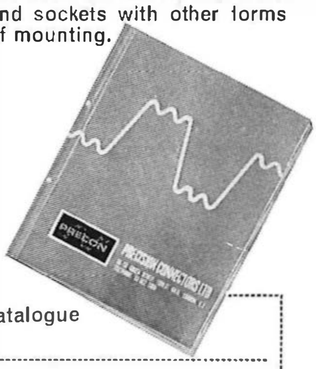

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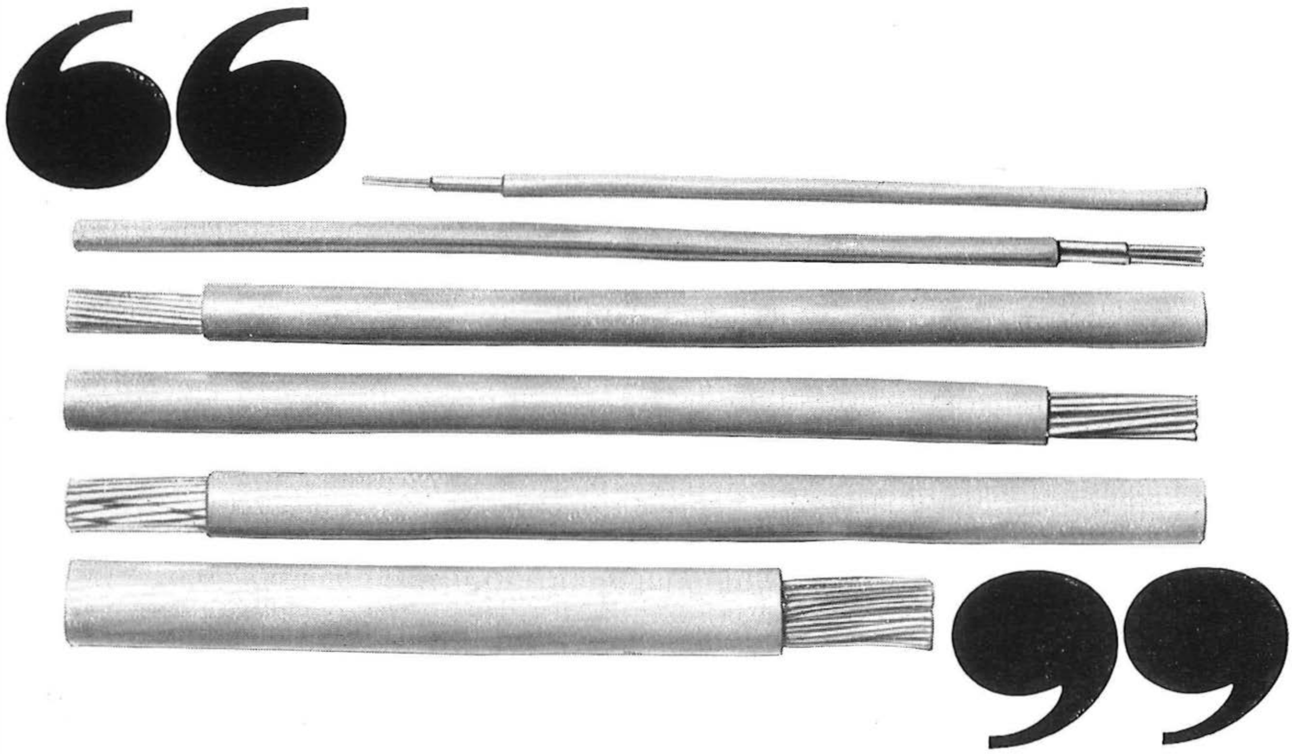

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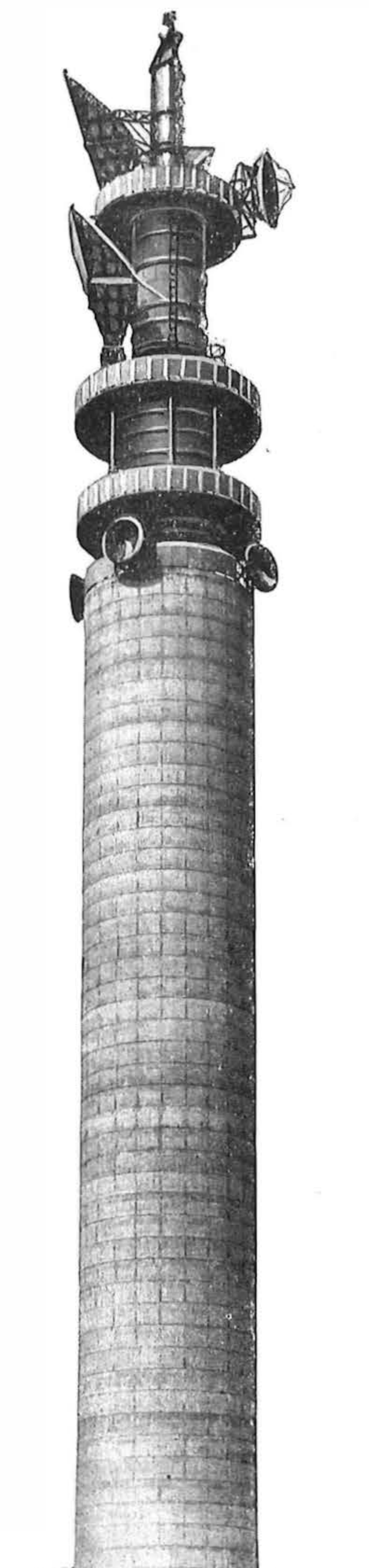

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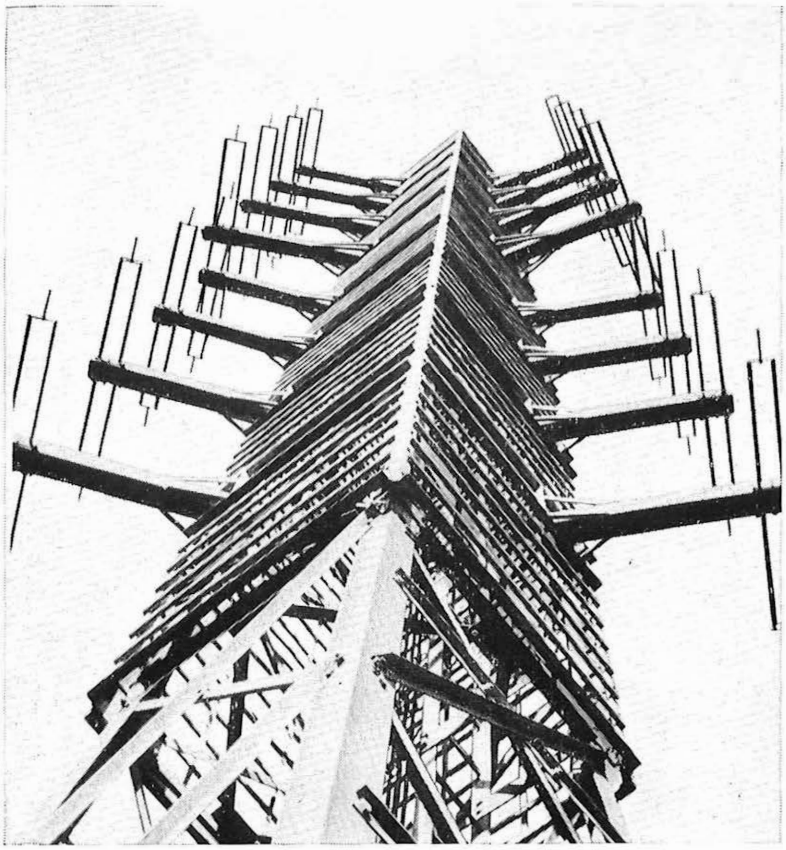

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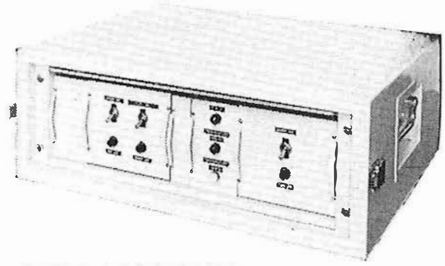

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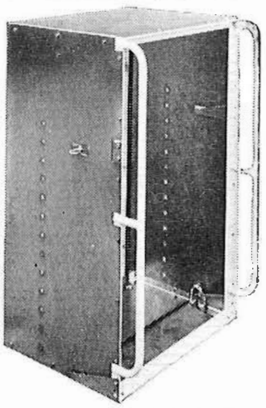

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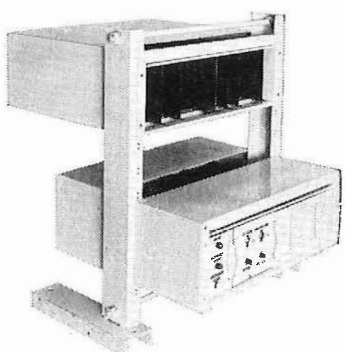

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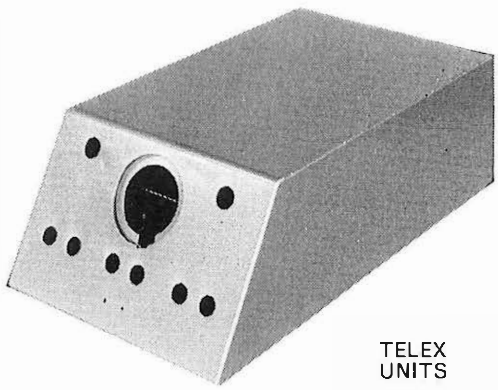

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