

# The Post Office Electrical Engineers' Journal

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**VOL 64 PART 2 / JULY 1971**



# THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

VOL 64 PART 2 JULY 1971

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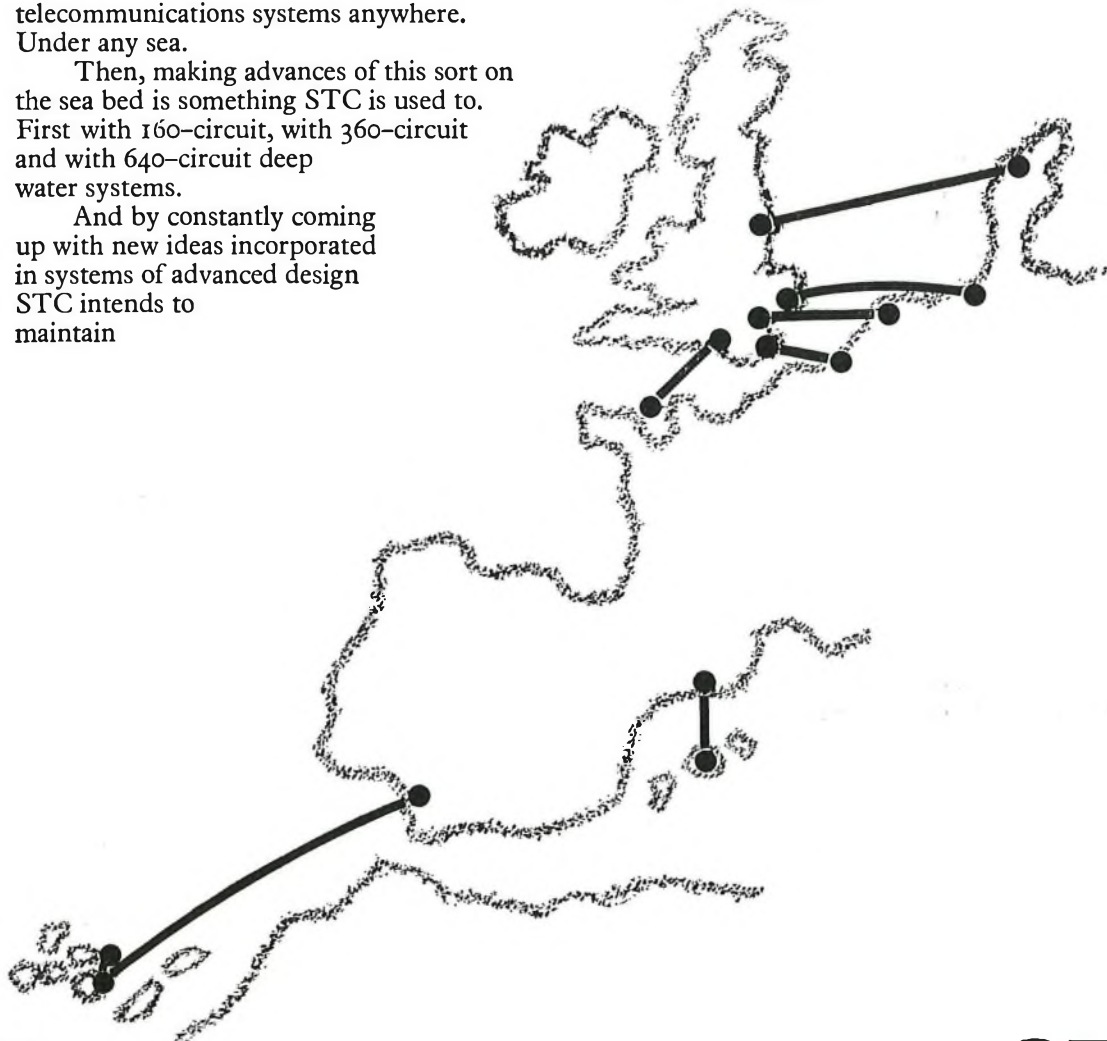
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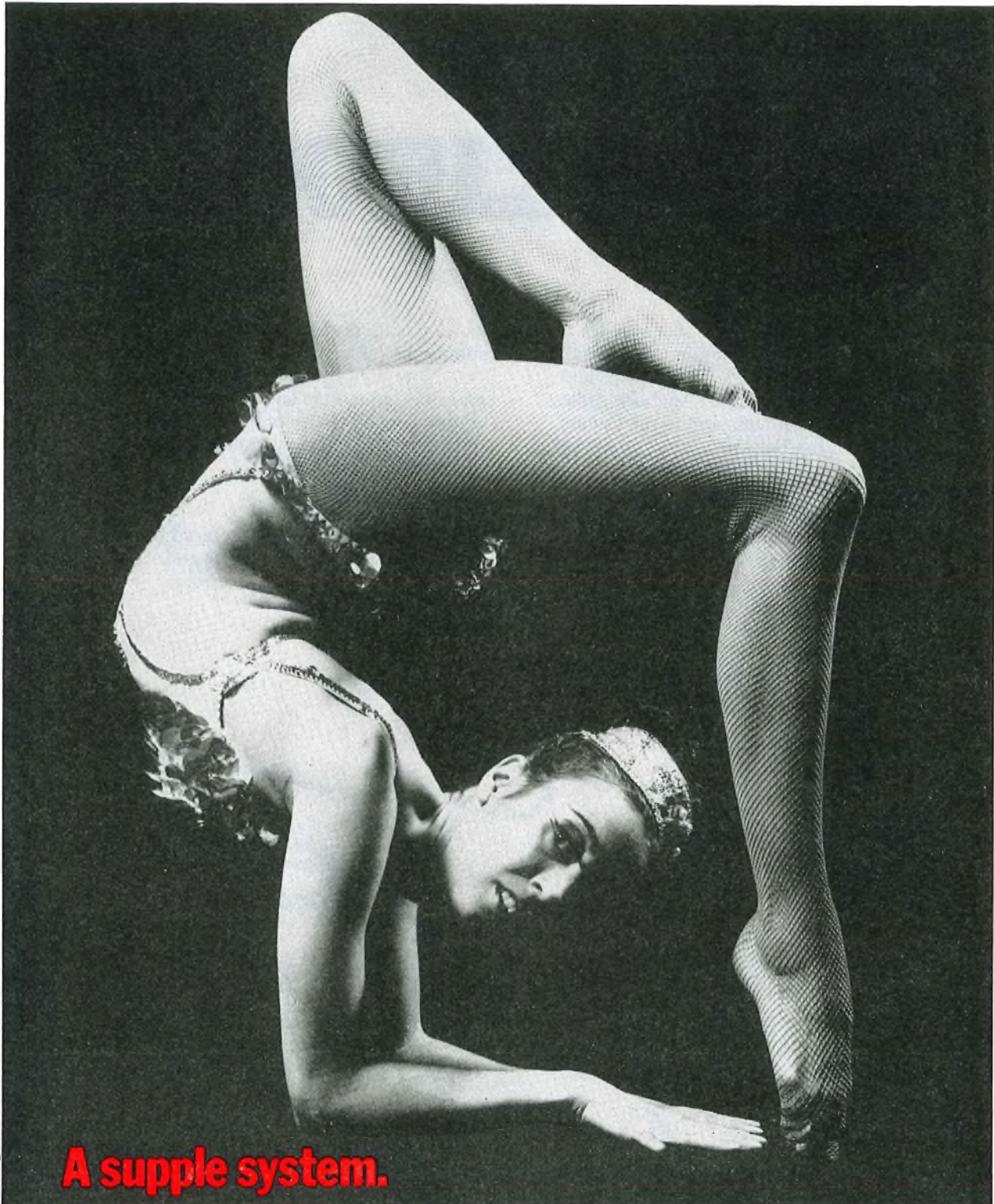


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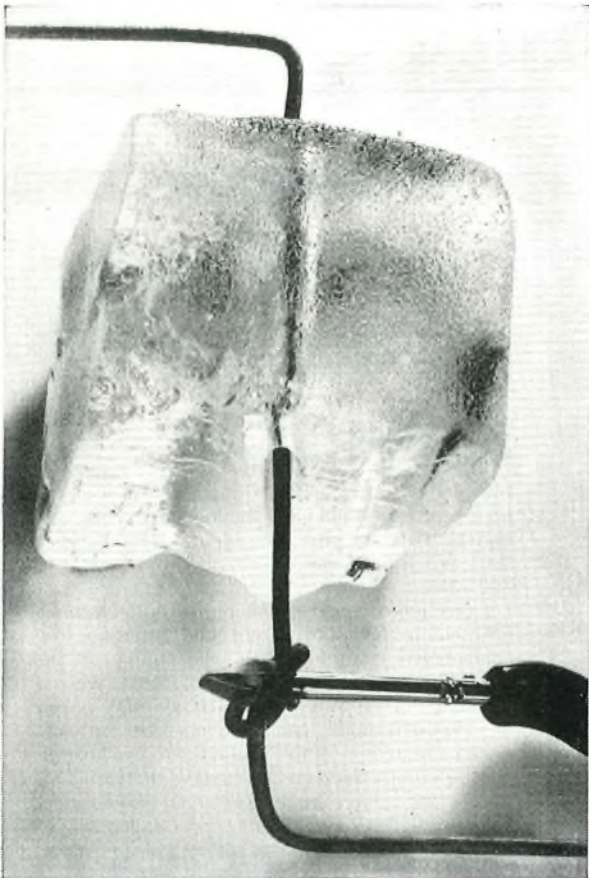
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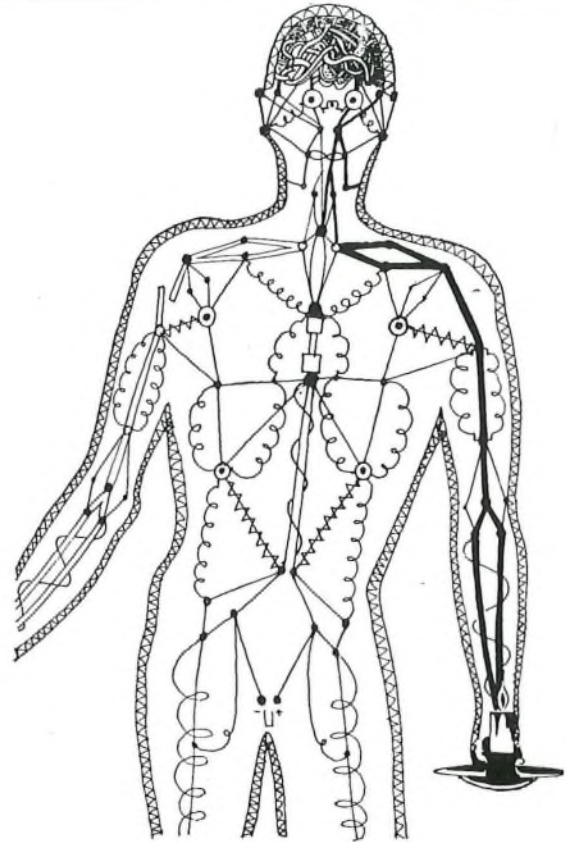


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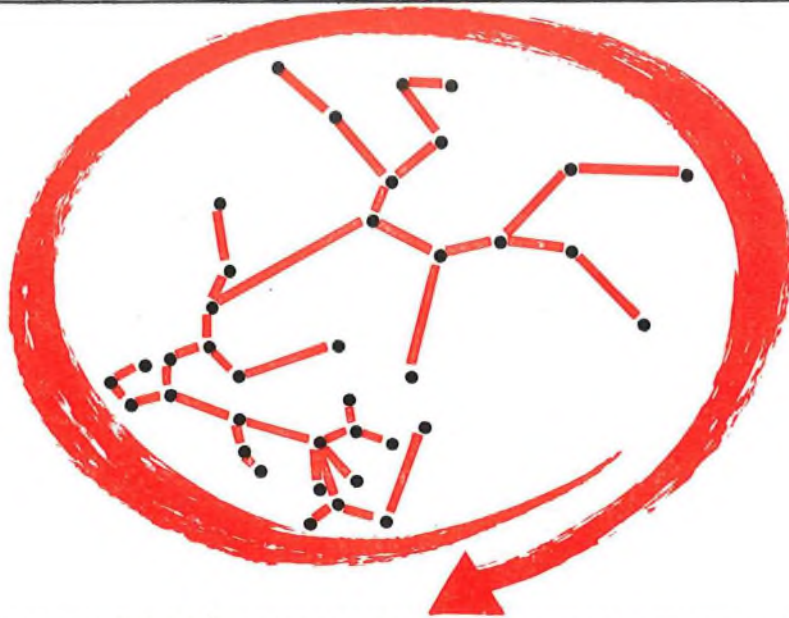


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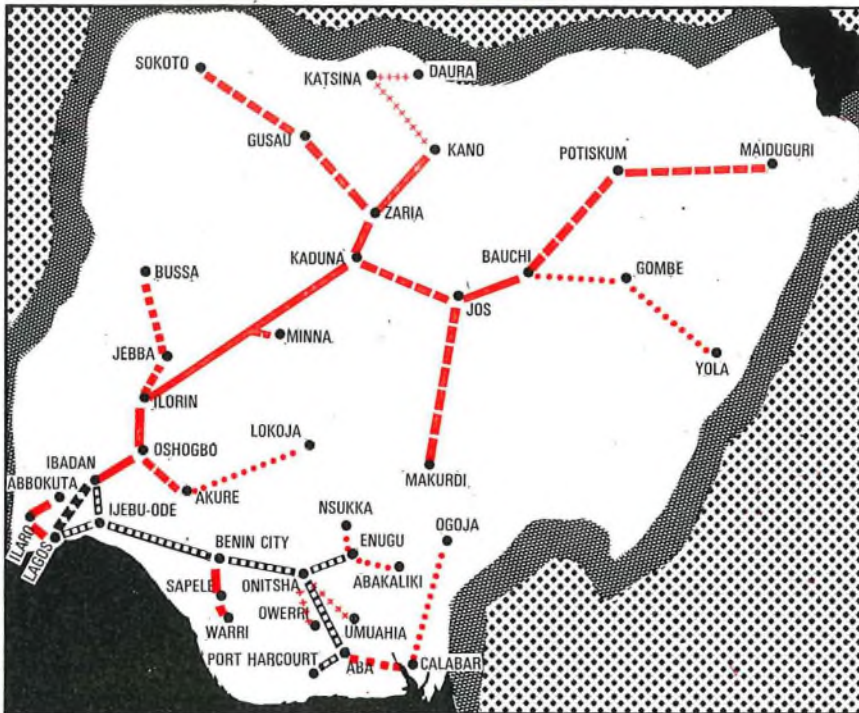
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## EDITORIAL

It is editorial policy to publish, from time to time, articles reviewing the development of broad topics of interest to telecommunication and postal engineers. Previous subjects in this series have included, for example, postal engineering, satellite communications, data processing services and signalling in the United Kingdom network. This issue contains two such articles, the first being a comprehensive review by Mr. M. B. Williams under the title of *Developments in Data Communication*.

Data communication is one of the newest and most rapidly growing services demanded of telecommunication authorities throughout the world. The *Journal* has already published a number of articles concerned with particular aspects of the service but, to many of those not directly associated with the development of the service, the progress has been so rapid that it has proved difficult to gain an overall impression. The present article describes the existing situation from a broad viewpoint and discusses the likely course of development in the future. Mr. Williams is well qualified to write on the subject as he is Head of the Transmission and Computer Division of the Telecommunication Development Department at Telecommunications Headquarters.

The second review article in this issue is concerned with an entirely different but very important aspect of telecommunications. It is the second part of the four-part article describing developments in power supply systems for telecommunications and reviews the present equipment and discusses future methods of providing a.c. standby plant. The whole article is being written by various authors from the Power and Ancillary Services Branch of the Telecommunications Development Department at Telecommunications Headquarters.

# Developments in Data Communications

M. B. WILLIAMS, B.SC.(ENG.), C.ENG., M.I.E.E.†

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*This article reviews the position reached in the development of British Post Office (B.P.O.) data-communications services, indicates the trend in customer demand and reviews technical developments being put in hand to anticipate and meet this demand. These topics are put in perspective against significant developments on the international scene.*

## INTRODUCTION

The demand for data communication in the United Kingdom is growing rapidly and the B.P.O. has introduced a comprehensive range of services (the Datel services) to provide for the need. This article describes, broadly, the systems already in use and outlines current developments.

The scale of the Datel services at 31 March 1971 is shown in Table 1. The Datel 100 service, based on the use of 110-baud telegraph circuits, is not available as a switched service and the growth rate is relatively small compared with the Datel 200 and Datel 600 services. These, operating through modems, exploit both leased and switched telephone circuits and are showing a very high rate of growth, approaching 100 per cent per annum. The Datel 2400 service is primarily adapted to private circuits, although it has alternative 600/1,200 bit/s facilities, which permit operation at the lower speeds on the switched telephone network. Modems for use at 48 kbit/s have been recently introduced both for leased circuits and as part of a small-scale experimental switched network.

Table 2 shows the current forecast for data terminals in the United Kingdom based on the market study carried out by Scientific Control Systems Ltd. (SCICON). The consultants emphasized that technological forecasting in this field is very uncertain and the forecasts are inevitably in terms of present technology and practices. The definition of a terminal presents some difficulties, but it is probably sufficient to interpret these figures as the number of outstations requiring to communicate with a much smaller number of computer centres, and to assume that more than half of the total terminals will be

**TABLE 1**  
**Datel Services at 31 March 1971**

Type of Service	Type of Circuit	Number of Terminals
100-baud telegraph circuits	Mostly on leased circuits	1,840
200 bit/s modems	Mostly on public switched telephone system	5,000
600/1,200 bit/s modems	Mostly on leased circuits	8,000
2,400 bit/s modems	Mostly on leased circuits	700
48 kbit/s modems	Mostly on leased circuits	20
Total	—	15,560

generating or receiving data at relatively low speeds, up to a few-hundred bits per second. In the slow-speed range, a distinction can be made between dedicated data-processing or computing applications and incidental data-collection or enquiry activities. The former is characterized, at present, by the Datel 200 services with a teleprinter, whereas the second activity would be characterized by a very simple terminal existing in large numbers, but originating or receiving only very small volumes of traffic. Table 3 attempts to put the likely applications of data communications into five arbitrary categories whose main distinction lies in the scale of distribution of the terminals. These range from computer installations or mini-processors, numbered in hundreds and thousands, through tens of thousands of computer-bureaux customers to the two million or so business telephone subscribers. Each of these must be regarded as a potential originator and receiver of data, for example, through a Keyphone with voice-response from a distant computer centre.

## DATEL 200

The Datel 200 modem provides duplex data transmission over the public switched telephone system and is the basis of time-sharing computer-bureaux operation. Automatic calling and answering can be affected through auxiliary control equipment<sup>1</sup>. Fig. 1 shows the communications features of a computer-bureau network. The remote terminals gain access to the processing computer either through local telephone calls, or through s.t.d. calls or via leased circuits. The call pattern tends to be very different from normal telephone calls, the average duration of a call being perhaps 20 minutes, and connexions frequently last for an hour or so. However, only a small proportion of the connexion time is actually used in transmitting data. A typical teleprinter terminal might generate characters for only 5 per cent of the connecting time, that is an average of 1 character every 3 seconds. The occupancy of the circuit in the computer-terminal direction might be about 30 per cent, or 2 characters per second. Even so, local-telephone-call charges at 10p per hour are insignificant in relation to the cost of computer time, but maximum-rate s.t.d. charges at £4.50 an hour are comparable with time-sharing bureaux processing charges. One way of extending the scope of a bureau without incurring s.t.d. charges is to use a satellite multiplexer or processor linked by means of private circuits to the computer centre.

As an alternative, the B.P.O. is introducing the Dataplex service to extend the Datel 200 service over the channels of a leased line using a multi-channel voice-frequency (m.c.v.f.) telegraph system. At present, transmission is limited to 110 bit/s but is code independent, provided long reversal sequences are avoided. An interface unit has to be provided at the outgoing end of the connexion to convert the modem interface signals into a form suitable for transmission over

† Deputy Director of Engineering, Transmission and Computer Division, Telecommunications Development Department, Telecommunications Headquarters.

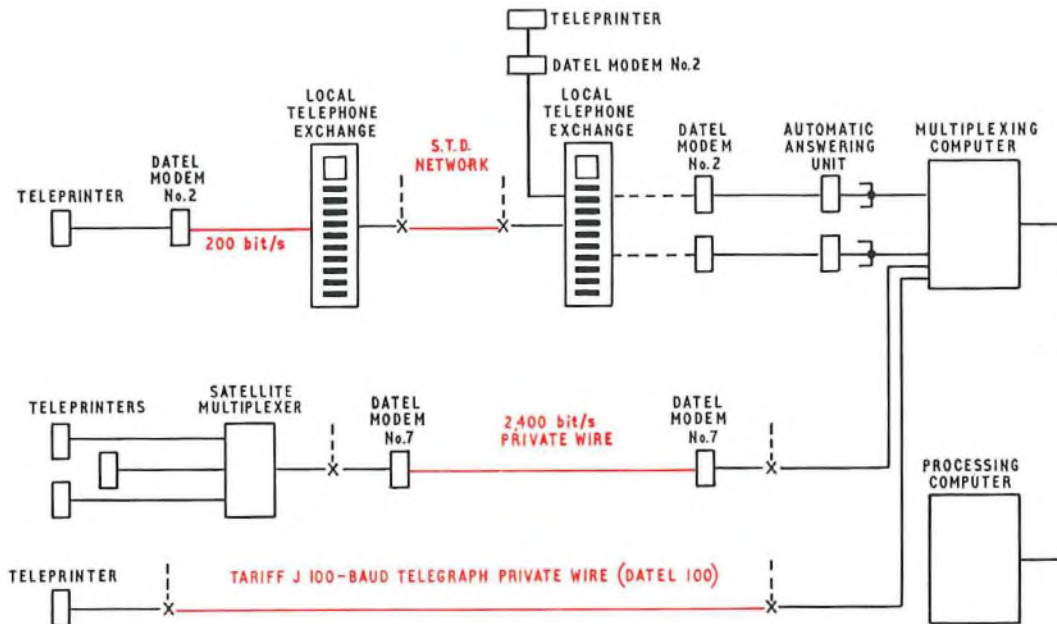


FIG. 1—Typical computer-bureau network

TABLE 2  
SCICON Forecast of Data Terminals

Date	Number of Terminals			
	Slow-Speed	Medium-Speed	High-Speed	Total
December 1973	27,000	24,000	108	51,000
December 1978	169,000	65,000	390	234,000
December 1983	316,000	117,000	637	434,000

TABLE 3  
Data Communications Applications

Category	Typical Remote Terminal
Very-low-cost terminals with low data rates and infrequent use	6-million business-tele-phones
Multi-access conversational-mode computer bureaux	Teleprinter
Outstation interrogating a central file with rapid response (e.g. airlines)	Special keyboard, printer or display unit
Centralized-accounting or processing systems (e.g. banks)	
Transfer of jobs, programs or results; remote job entry	Any of above, file store or processor

the m.c.v.f. telegraph channel, which operates to telegraph standards. The advantages of Dataplex are as follows:

(a) Remote bureau customers are relieved of s.t.d. call charges and any congestion or transmission problems associated with establishing s.t.d. calls.

(b) The problem of providing service to a computer bureau from its local telephone exchange, which would otherwise require tens or hundreds of individual exchange lines and modems, is eased.

(c) The traffic loading of the local telephone exchange is eased since a 200-line bureau has been estimated as being equivalent to some 5,000 residential telephone subscribers.

Computer-service bureaux, comprising time-sharing, remote

job entry and batch processing, represent a very rapidly growing industry. Department of Trade and Industry figures for the second quarter of 1970, reported in the press recently, indicate that the total value of work done in the United Kingdom was nearly £11 million. This represents an increase of over 30 per cent over the same period in 1969 and the major portion of this sum is produced from the hire of computing time. By 1975, turnover might rise to £150 million per annum. The public telephone system, because of its ready availability and wide coverage, has an essential part to play in serving this market. Varieties of Dataplex and other artifices designed to make the best match between the computer-service bureaux and the telephone system will be devised to match this growth.

The Datel 200 service conforms to international standards which were formulated on the assumption that 200 bit/s represented a practical upper limit for electro-mechanical keyboard printing machines. However, the application of electronic techniques into the design of new machines, as well as the practice of associating tape readers with teleprinters, has progressed to the extent that speeds of operation well above 200 bit/s are required. A modern type of semi-electronic teleprinter is capable of a wide range of operating speeds.

The next generation of modems for the Datel 200 service is expected to operate on the same carrier frequencies as at present and so maintain compatibility with existing modems, but with design improvements to permit 300 bit/s operation. The new design will probably have channel-defining filters of slightly wider bandwidth which will involve a loss of some protection against noise interference at the higher speed. This problem will become more important as higher speeds of duplex working are contemplated in the further development of the Datel 200 service.

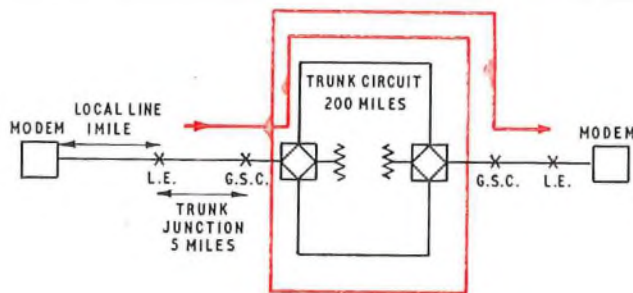
It is useful to consider the justification for duplex working in the Datel 200 service, for example, in the computer-bureau or remote job-entry type of operation, since simultaneous exchange of data in two directions is rarely required. Alternate transmission of information could be achieved by a turn-around arrangement, although this might involve restrictions and complications in the operating system, such as the need to build-in and observe turn-around time delays. Moreover, duplex transmission is sometimes used to provide a local record of the sent message by returning it from the computer centre to the originating terminal as a check on correct operating and transmission.

Assuming that higher-speed duplex service is required on the telephone system, preliminary studies suggest that a new type of modem could be devised for 600 bit/s duplex operation. However, start-stop working might not be entirely satisfactory and it may be necessary to adopt isochronous working to achieve satisfactory error performance. This should not be a serious problem with the semi-electronic machine, which can be buffered and derive its timing from the modem instead of from its own internal oscillator. However, further work on the practicability and demand for such a modem is required before its development and introduction as a new Datel service is put in hand.

### DATTEL 600

The Datel 600 service conforms to C.C.I.T.T.\* Recommendation V21 and was standardized primarily for medium-speed simplex data transmission on switched telephone connexions. At 600 bit/s, its rugged modulation system permits operation over virtually any telephone connexion which is good enough for speech, both national and international. Its use at the optional higher speed, 1,200 bit/s, is necessarily restricted by the variety of the transmission paths that may be encountered on a connexion, the widest scale of use being on the banks' private networks.

The prospect of data transmission at even higher rates over switched telephone connexions within the United Kingdom has been the subject of recent investigations.<sup>2</sup> Although all switched connexions are inevitably subject to random or sporadic disturbances, such as noise or short breaks, the investigations indicated the limitations imposed on s.t.d. data calls by the occurrence of listener echo (see Fig. 2), and



G.S.C. = group switching centre L.E. = local exchange

FIG. 2—Listener-echo on s.t.d. call

showed that 50 per cent of the longer s.t.d. calls might be subjected to a signal-to-listener-echo ratio of 15 dB or less with an echo delay time up to 10 milliseconds or more. A modem to operate effectively over s.t.d. connexions at speeds above 2,000 bit/s would need to exploit modern techniques for waveform correction in the time domain, both analogue (transversal equalizer) and digital (auto-correlators) to minimize both transmission impairments, which can be expressed as signal echoes, and listener echo which can be counteracted in the same way. As the characteristics of switched connexions are likely to vary considerably from call to call, an adjustable,

automatic, preferably adaptive, equalizer would be required. It is hoped to finalize studies in the early part of 1971. Present estimates are that a fixed-speed modem for use on s.t.d. connexions at 2,400 bit/s would be technically and economically feasible and it would possibly be provided with a low-speed supervisory channel at 110 bit/s. Remote job-entry terminals and remote line printing might be able to exploit higher speeds such as 3,600 or 4,800 bit/s, which may be made available on a limited basis, but the most widespread demand for a medium-speed switched service is likely to come when the visual-display terminal becomes well established as an alternative to the teleprinter. A reliable and widespread service at 2,400 bit/s may be the best economic solution until new digital transmission and switching systems become established.

### HIGHER-SPEED SERVICES

Speeds above a few thousand bits per second require wide-band bearer circuits. Development has now been completed and initial service experience has been gained of 48 kbit/s transmission using the group band, equivalent to 12 telephone channels, as the bearer. Some restriction on routing is being maintained, at present, as it is necessary to minimize the group-delay/frequency distortion caused by through-group filters. However, time-domain waveform correction shows considerable promise in widening the scope for 48 kbit/s transmission.

The experimental, manually-switched 48 kbit/s network linking London, Birmingham and Manchester,<sup>3</sup> is being investigated to show the quality of service being obtained. A manually-switched 48 kbit/s service is acceptable for bulk data transfer such as magnetic-tape files or load transfer from one computer centre to another. Accuracy of transmission is essential and overall error control must be applied. Preliminary results from the tests indicate that errors are usually sufficiently infrequent for very long block lengths (e.g. 4,000 bytes) to be used with an acceptable proportion, say 0.5 per cent, of faulty blocks requiring retransmission due to line or terminal faults. Typical results from routine B.P.O. tests of 15-minute durations with 511-bit blocks indicated that the average block error rate was 300 in  $10^7$  blocks.

Successful adaptation of 48 kHz group bandwidth for data transmission shows the scope for obtaining even higher data-transmission rates by the application of similar techniques to wideband transmission paths which can be made available as an alternative to their carrying multi-channel telephony. Two proposals that are now being studied with the aim of providing an inter-city digital transmission capability are as follows.

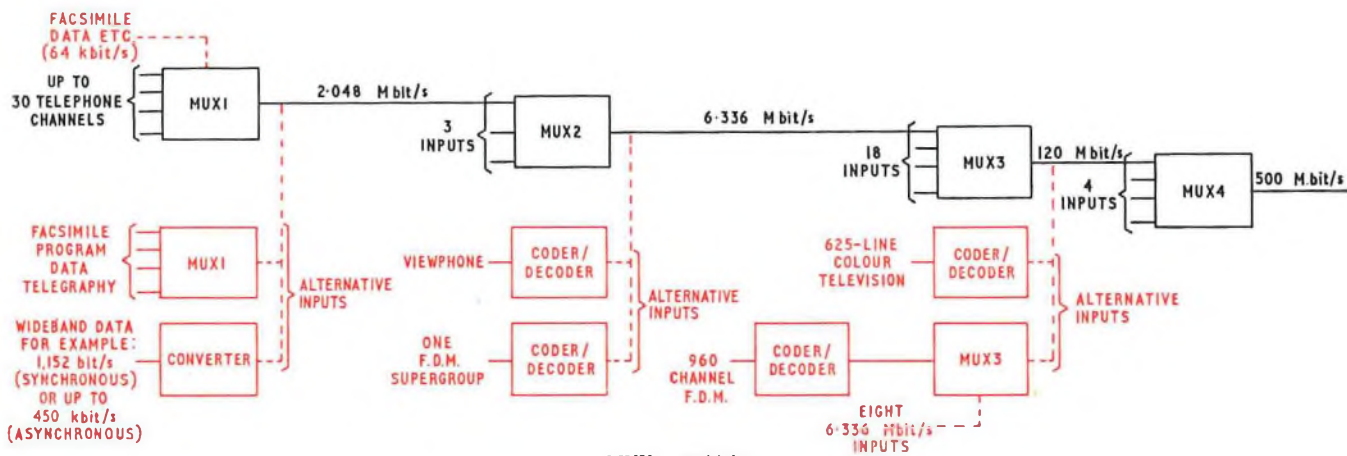
(a) The first proposed modem would handle a digital stream of 2.048 Mbit/s, corresponding to the 30-channel pulse-code-modulation (p.c.m.) telephony multiplex rate, for transmission on a band equivalent to two or three supergroups, that is 120 or 180 telephone circuits.

(b) The second proposed modem would provide two or three 6.336 Mbit/s digital channels within the capacity of 15 supergroups or 900 telephone circuits.

So far, the adaptation of analogue transmission systems to carry digital signals has been considered but, having reached the Mbit/s range, the new era that is beginning with the introduction of digital transmission systems needs to be considered. Telephony systems using 24-circuit p.c.m. are being introduced to provide blocks of circuits in the 15–30 mile distance range, where the economics are favourable, and several hundred such systems are now being installed each year. The next step will be to provide inter-city digital links of high capacity and developments are already in hand to this end. Field trial of a coaxial-cable system operating at at least 120 Mbit/s is expected in 1973, as well as of a new microwave radio system intended to make use of some available bandwidths in the lower 6 GHz band to provide several digital

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





MUX = multiplex

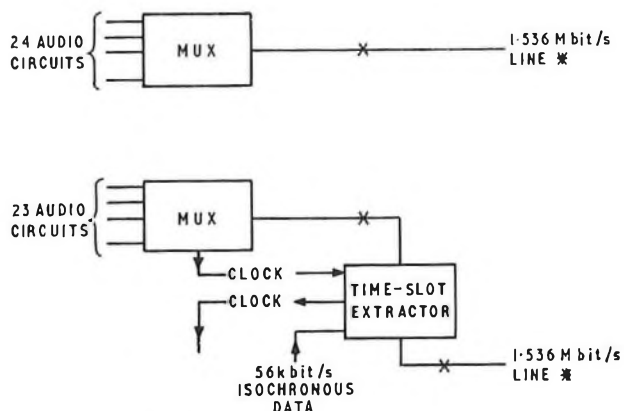
FIG. 3—Possible digital hierarchy

channels operating at 6 Mbit/s. Exploitation of new microwave radio bands and of new media such as waveguides will provide high-capacity, digital-transmission paths in the years to follow. The American Telephone and Telegraph Company (A.T. & T.) has announced that a digital network will link 60 cities in the U.S.A. within the next ten years.

Two major problems have to be faced, however, in adapting digital transmission systems for data communications. The first problem is that of timing or synchronization, because digital-transmission systems are essentially isochronous. The second problem is that of stepping down to the relatively low speeds of data terminal equipment. Fig. 3 shows a possible digital hierarchy showing the levels of 2.048, 6.336 and 120 Mbit/s. As an alternative to the basic p.c.m. telephony multiplex, the assembly of data or telegraph channels is being studied as another way of using this transmission capability. The three possibilities shown in this figure are:

- (a) multiplexers for mixed data and telephony;
- (b) multiplexers for non-telephony signals, and
- (c) a converter to give a wideband-data channel.

The first of these is shown in more detail in Fig. 4 where a time-slot extractor is inserted between the 24-circuit p.c.m. multiplex equipment and the 1.536 Mbit/s digital line. Each telephone channel occupies 64 kbit/s, but, by international agreement, only 56 kbit/s, or 7 bits in 8, can be regarded as freely available for injected data and, moreover, this must take the p.c.m. system timing. The next generation of p.c.m. multiplex equipment will provide 30 telephone channels instead of 24 with a line rate of 2.048 Mbit/s, and consideration is being given to building-in the time-slot extractor for deriving one or more 56 kbit/s isochronous data channels. However, the economic application of either method has not yet been fully determined. The external time-slot extractor



Mux = multiplex \* restricted binary sequence

FIG. 4—Time-slot extraction on p.c.m.

may be too costly for short-distance applications, whereas the built-in extractor may load all telephone usage with an unnecessary cost.

A more attractive scheme, where there is a sufficient concentration, is to separate the data streams from telephony up to the first level and to introduce a range of data multiplexers to exploit the basic line-rate of 1.536 or 2.048 Mbit/s. The synchronous data network, which is to be described later, is built up from digital streams at 64 kbit/s and will have high-level multiplexers deriving 24 or 30 such streams from the digital line and low-level multiplexers to derive low-speed channels for customers' local ends (see Fig. 5).

Fig. 6 shows alternative ways of using the 1.536 Mbit/s line capacity. The low-speed multi-channel anisochronous system, now being developed by the B.P.O. is shown in Fig. 6(a). This is intended to take advantage of the availability of 1.536 Mbit/s junction p.c.m. systems to carry large blocks of low-speed 110 bit/s channels from a switching centre to an outlying concentration. A typical application of this system will be to connect the large clusters of telex subscribers in the London-Airport complex with the London telex exchanges, as an alternative to the conventional m.c.v.f. telegraph systems. In the application to the telex local-distribution network, transmission of telegraph signals at 50 bauds and signalling is required. However, the system has been designed to accept 110-baud telegraph signals so that it can be used for 7-unit teleprinters, and can thus play its part as a general-purpose short-distance transmission system in data-communication developments.

The system shown in Fig. 6(b), which is being developed by a manufacturer to B.P.O. requirements, will provide anisochronous transmission at up to 500 kbit/s for high-speed data transmission. The example shown in Fig. 6(c), which has been developed by a manufacturer for the National Physical Laboratory (N.P.L.) local network, provides isochronous transmission at 6/8ths of the line rate.

A restriction of the present type of p.c.m. line system is that the line repeaters used have to regenerate the signal by means of timing information derived from the digital stream itself. In the telephony application, the multiplexed signal has a sufficiently well-defined structure to maintain a sufficient amount of timing information to ensure correct operation of the regenerators. An unrestricted data stream, however, could contain sequences which would cause the timing circuits in the repeaters to fail. Consequently, restrictions have to be put on the bit sequence and a provisional form could be that a long-term average ratio of 1's and 0's must not fall below 0.3, and there must be no more than 10 zeros in a sequence.

In the introduction of the 30-channel 2.048 Mbit/s junction p.c.m. system, consideration is being given to the adoption of a new form of line signal which would permit bit-sequence

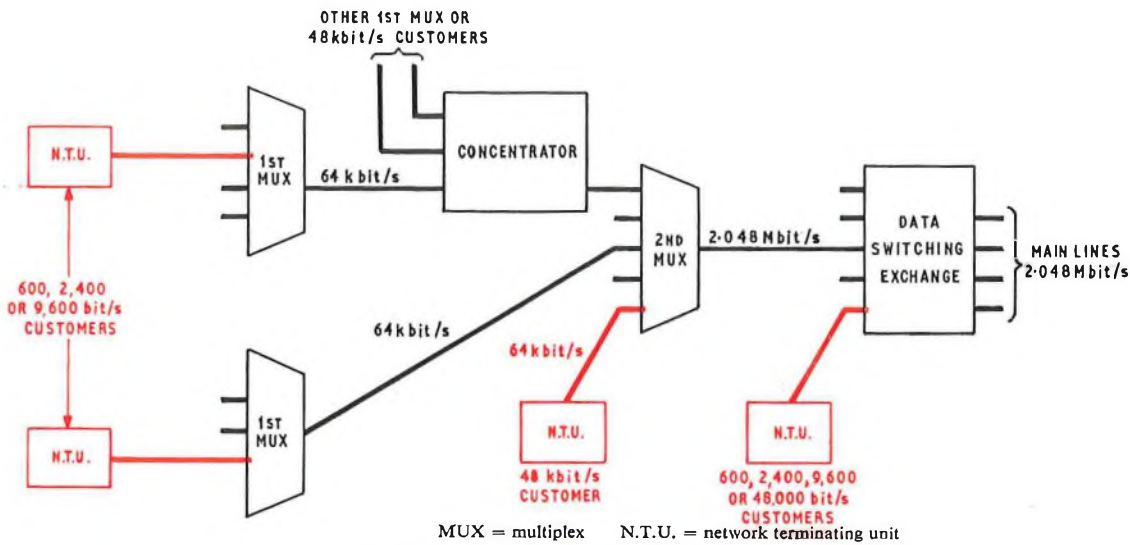


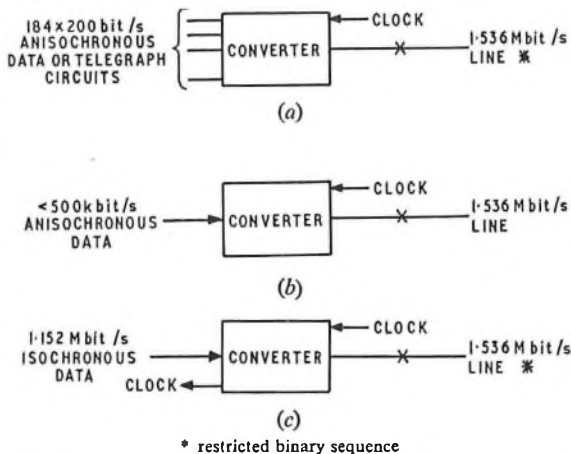
FIG. 5—Simplified schematic diagram of synchronous data network

independence. This could be achieved by using a modified bipolar signal instead of the strict alternate-mark-inversion (a.m.i.) signal used at present.

Fig. 7 illustrates the principle of obtaining anisochronous data transmission over regenerated digital lines. For high-speed data transmission, for example 435 kbit/s, transitions between 1's and 0's can occur at random, but not less than 2.3 microseconds apart. The occurrence of each transition is signalled from one end of the line to the other by means of a 3-bit isochronous code which identifies the approximate instant of the transition and its sign.

## NETWORKS AND SWITCHING

Only the means of transmission, rather than any network or switching configuration, has so far been discussed. Problem-solving computer-bureau operation using teleprinters relies on the switched telephone network. The other major class of data-communication network is typified by the joint stock banks' centralized accounting systems or the airlines' centralized seat-reservation systems. These operate as separate multi-point private networks with polling of terminals, under the direction of the computer centre, to regulate the communications flow. Each network operates its own exclusive internal discipline. As communications systems, the essential features of the bank networks are the large-scale and national coverage and the use at the outstation of local concentrators, or so-called intelligent terminals, which are able to do local processing, including the assembly and storage in a buffer of partly-processed information. A typical example of a bank's on-line accounting system might have 1,000 terminals joined through its private network to the central computer.



\* restricted binary sequence

FIG. 6—Alternative methods of data transmission on p.c.m. digital line systems

The principle of centralized on-line accounting can be expected to spread to other enterprises that deal with their customers through local offices and, if the economics are favourable, a whole series of independent, but superimposed, private networks may evolve. Where sections of the network are superimposed and are under-utilized, there will be obvious scope for cost-savings by integration into a collective network provided by the Post Office, assuming that common procedures can be adopted and agreements reached on priority, security and privacy.

The lines of evolution of on-line accounting systems and of computer bureaux must be towards decentralization to offset the vulnerability of an ever-increasing central filing system and towards intercommunication between separate networks. Both of these requirements lead to the need for high-speed, rapid-response communication links available on demand between computer centres, and progress in that direction will be helped if simple and standardized communication procedures can be developed in advance of the need.

A similar problem is becoming apparent in the development of computer complexes in the university environment. Piecemeal growth of computing power within one or several locations in one university and the independent growth of each separate university's computer power is leading to a demand for interworking. This is best described as giving any one terminal the ability to escape through its local computer into a distant computer where it may gain access to files or processing power or programs peculiar to the remote installation. Some of the packet-switching or store-and-forward techniques, to be referred to subsequently, aim at introducing the basic standardization necessary to permit interworking between different systems.

## Types of Switched Data Networks

### Telephone Circuits with Modems

The switched telephone network with modems, represented by the present switched Datel services, is strictly limited in the facilities that can be offered during the next decade by the rigidity of the present switching systems and the limited transmission capability of telephone channels. Furthermore, although the modem is a simple concept, the modulator and demodulator have to be closely matched. Therefore, the introduction of new types of modems introduces problems of compatibility, if different models are found at the two ends of a connexion.

### Multi-speed Telex-type Network

An alternative approach to the provision of a switched data network is through an extension of telex or telegraph-

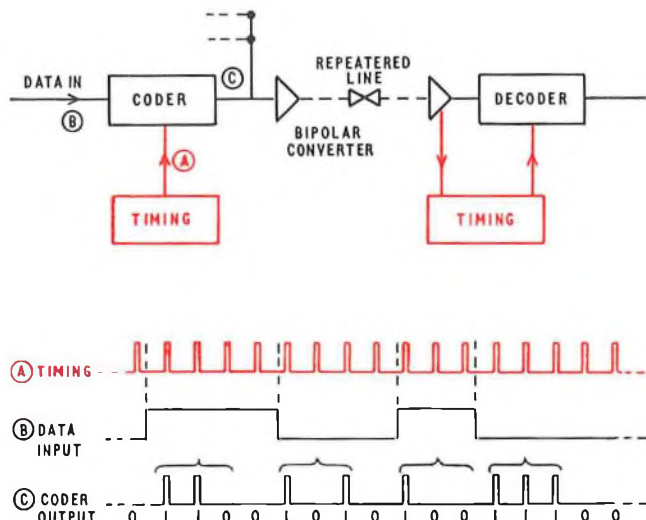


FIG. 7—Possible method of anisochronous data transmission over digital lines

switching techniques. A multi-speed type of switched-telegraph service could offer a range of data-transmission rates together with an exchange designed to match the calling rate and traffic characteristics expected of data communications. This approach is being adopted, typically, in the re-equipment of the German telex system with the Siemens Electronic Data Switching System (E.D.S.).

#### Synchronous Network

An alternative method of providing this type of service is the synchronous network. This is intended to make the best use of high-capacity digital line systems and to be compatible with the principles already being developed for the integration of digital transmission and switching in p.c.m. telephone systems.

#### Store-and-Forward System

Finally, store-and-forward or packet-handling systems, such as those proposed by N.P.L. and the Advanced Research Projects Agency of the United States Department of Defense (A.R.P.A.), may be used as they are designed to handle data having a formalized structure.

#### The E.D.S. System

The E.D.S. system, shown in Fig. 8, is a stored-program-controlled circuit-switching exchange operating on telegraph principles. It is being used by the German Post Office to replace their telex exchanges, to incorporate their existing low-speed Datex service and to provide a range of switched data-communication services. Special baseband transmission systems are used to connect the subscribers to the exchange using a low-voltage bridge-duplex method with d.c. loop-disconnect signalling. Long-distance connexions will use conventional frequency division multiplex to derive low-speed

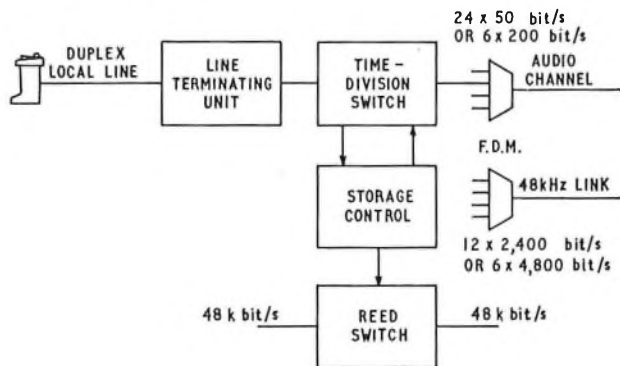
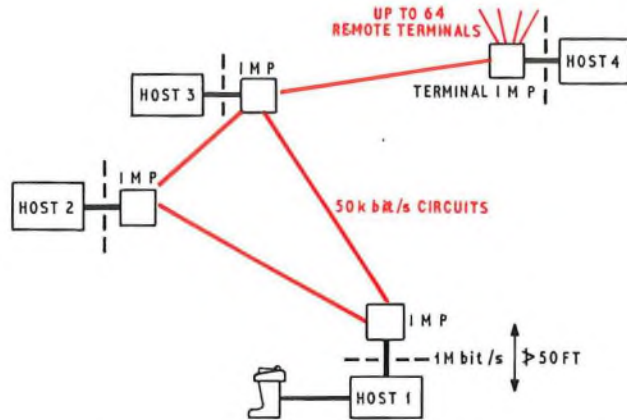


FIG. 8—Electronic Data Switching System



IMP = interface message processor HOST = multi-access computer system  
FIG. 9—Schematic diagram of A.R.P.A. network

channels of 50, 100 and 200 bit/s from a speech channel. It is proposed to derive medium-speed channels of 2,400, 4,800 and 9,600 bit/s by sub-division of a basic 48 kHz 12-channel group.

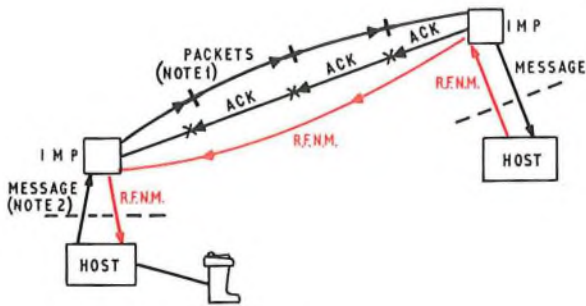
The switching system is entirely anisochronous. Each incoming and each outgoing line is allocated a word in the computer store, the action of establishing a connexion through the exchange being essentially that of writing the address of one line into the store of the other line, and vice versa. Once this is done, any change of state of incoming digital signals on the lines is arranged to interrupt the computer which examines the store and determines which output signal stage has to be changed. In this way, signal transitions are passed through the switch. Signals are not stored within the switch and, because the control cannot operate simultaneously on two or more transitions, short timing delays in relaying the transitions may be introduced. These delays correspond to telegraph distortion which cannot be recovered by regeneration and their magnitude is a function of the transmission speed on the lines and the control cycle time (0.5  $\mu$ s).

For a large exchange which is a possible mixture of lines and speeds, calculation of the total number of transitions per second (on average, binary signals contain half as many transitions as digits) shows that high-speed services impose the dominant switching load. Consequently 48 kbit/s circuits will be handled by a separate relay matrix. 50-baud telex calls will be set up in International Alphabet No. 2 at 50 bit/s. Datex calls will be established in International Alphabet No. 5 at 200 or 2,400 bit/s. The exchange will provide abbreviated calling, or "hot-line", restricted access to simulate a private network and multi-address facilities. The exchange is not capable of providing timing information for a synchronous terminal independently of the bit sequence. Thus, the anisochronous data stream cannot be regenerated, if complete signal freedom is assumed, nor can it be synchronized with a digital transmission system of the type provided for p.c.m. telephony without a coding or sampling process which results in a large loss of capacity. Long sequences of zeros can simulate the clearing signals.

#### A.R.P.A. Network

The A.R.P.A. Network is a long-distance private network for interconnecting several multi-access time-sharing computer systems, which extends across the United States and serves some six university centres out of an initial plan for eighteen. The particular significance of the A.R.P.A. network lies in its practical realization, in a commercial form, of a packet-handling network having much in common with proposals made by the N.P.L. and the B.P.O. data network studies.

Each host is the multi-access computer complete with its local terminals and peripheral equipment (see Fig. 9). The A.R.P.A. network is formed by the provision of interconnected interface message processors (IMPs), one of which



Note 1—Packet length up to 1,008 bits plus header, check, etc.  
 Note 2—Message length up to 8,095 bits plus header.  
 IMP = interface message processor    ACK = acknowledge  
 R.F.N.M. = ready for next message

FIG. 10—Message and packet procedure in A.R.P.A. network

has to be associated in close proximity to each host which requires to communicate via the network with another host. The IMPs are connected by 50 kbit/s circuits and communicate with each other using packets of variable length up to 1,024 bits. Each packet is acknowledged between IMPs (see Fig. 10). A host communicates with its adjacent IMP via a short high-speed link operating up to 1 Mbit/s. The host can dump a complete message of up to 8,000 bits into the IMP, the message being called for on a bit-by-bit basis. A subsequent message would not be called for until ready-for-next message (r.f.n.m.) signals have been received. The r.f.n.m. is an end-to-end message check between the originating host and the last IMP in the chain, although the destination host can control the return of r.f.n.m. so that the message-handling capacities of the two hosts are matched without the need for storage within the network.

There is, thus, a clear boundary drawn between the host computer systems and the IMPs which has the effect of establishing an autonomous communication system.

The prime purpose of the A.R.P.A. network is the sharing of resources, that is files and programs, at all the hosts connected to the network which, subject to any barring which may be built into the controlling software, are available to any terminal. The essential feature from the user's point of view is that a special program is at his disposal on his own multi-access system, so that, using only his local procedures, he can gain access to any other host via his own host. The IMPs can operate in a transit mode, in which case they do no processing except to find an outlet and to return a packet to the preceding IMP if it is found to contain an error when it is received.

At present, terminals can gain access to the network only via a host multi-access computer but a new form of IMP, a terminal IMP, is under development. This will cater for a range of standardized remote-terminal conditions including, for example, connexions via modems to leased circuits and the public telephone system.

Although large in geographical extent, the scale of the A.R.P.A. network, in terms of terminals served and message through-put is relatively small compared with a national network. The capacities of the interconnecting lines and the IMPs handling transit traffic would need to be increased by a factor of 100 or 1,000 to maintain the rapid response which is a feature of the system and the trunk network would probably have to be configured in a hierarchical form. Nevertheless, the A.R.P.A. network is demonstrating the usefulness and practicability of interconnecting multi-access computer systems of radically different types by the use of a standardized packet-handling philosophy. It is important to note that this has been achieved with a deliberate and rigid demarcation between the communications and computing areas. All communications tasks, including the control of transmission errors, are carried out in the communication network whilst information processing remains within the individual multi-access systems.

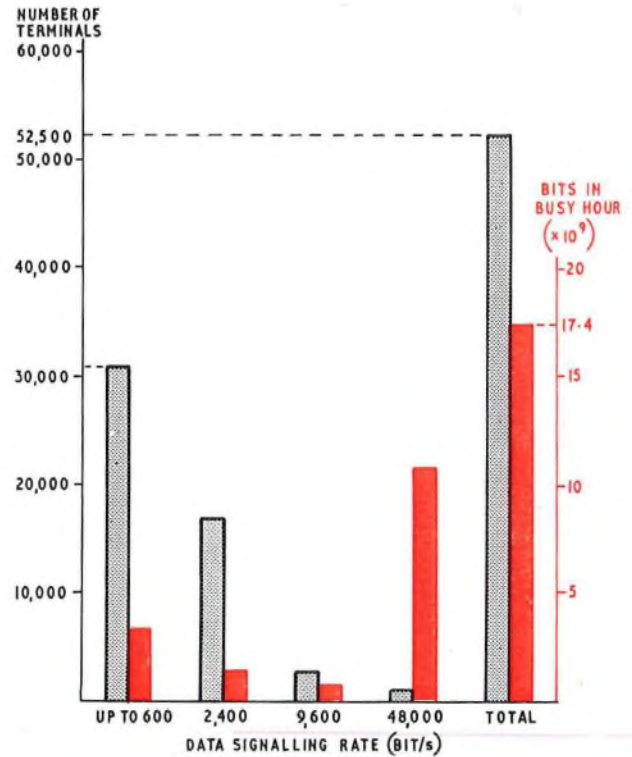


FIG. 11—Hypothetical traffic model—distribution of terminal traffic

### The N.P.L. Proposed Data Network

The concept of a packet store-and-forward system arose independently in the United States and the United Kingdom. The N.P.L. design used a trunk network of small computers, joined by high-speed digital links to provide rapid communication of packets between local areas.

Each local area employs an interface computer which transforms data between the packet form required by the trunk network and the particular form desired by individual subscribers. A model local network was designed, built, and has recently been publicly demonstrated by the N.P.L. The N.P.L. network uses digital pulse transmission over coaxial cables to link terminal units distributed about the laboratory site. The terminal units communicate through a common input-output channel of the computer, and a hierarchical arrangement of statistical multiplexers is used to concentrate signals from terminals onto successively fewer lines as they pass towards the computer.

Subscribers' equipment is connected to the terminal units through British Standard interfaces,\* and subscribers exchange information with each other via packet-sized stores assigned by the computer for active terminals. The packets are accumulated byte by byte, this being the unit used for handling data in the local area. Terminals then request each byte during the output of packets and this maintains strict control of data flow, regardless of the type of equipment connected to the interfaces. In this way, "speed-changing" is possible, and two terminals of widely different speeds may communicate with each other, within the limit set by packet size.

A simple terminal, such as a teleprinter has to be provided with an associated terminal control unit. Calls are set up between one terminal and another, using the keyboard to compose the address. Any message or address formed by the keyboard is held in a local store until released to the interface computer. Control keys and lamps are provided for calling, clearing and supervision.

\* British Standard No. 4421.

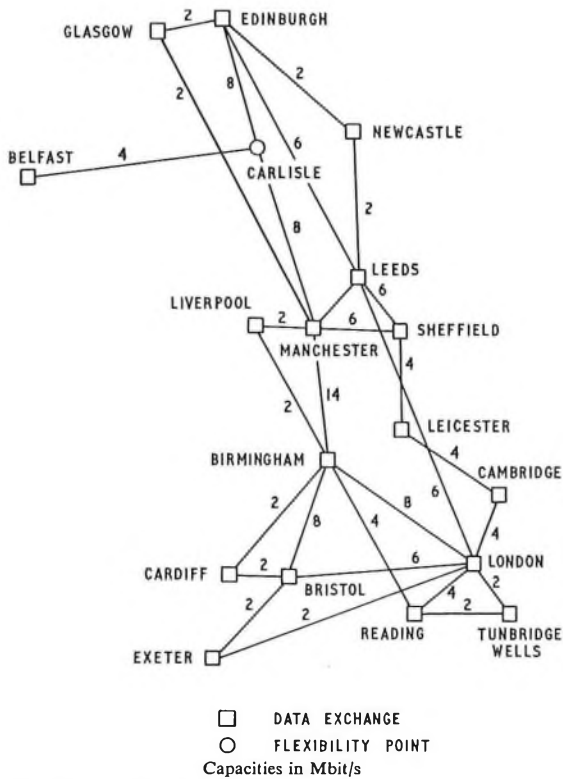


FIG. 12—Possible form of digital data network for 50,000 data terminals

### STUDIES FOR A B.P.O. DIGITAL DATA SERVICE

As a basis for the technical studies, a detailed hypothetical model was devised for 50,000 remote terminals. The model is in broad agreement with the SCICON forecast and, as Fig. 11 shows, recognizes four broad groups of users. These groups are low-speed up to 600 bit/s, medium-speed at 2.4 and 9.6 kbit/s and high-speed at 48 kbit/s. The model had 31,000 low-speed terminals, typically teleprinters, and includes telex, problem-solving computer-bureaux terminals and data-collection outstations. The low- and medium-speed terminals and their traffic are fairly well founded on present experience, but the high-speed terminals, which might represent bulk data transfer between computer centres, are fairly speculative. Thus, the relatively large amount of data traffic which is forecast as being generated by these high-speed terminals has to be viewed with caution. The major part of this is attributable to the large load assumed for high-speed traffic which may be unrealistic.

The geographical distribution of the data terminals assumed in the model shows the need for a main network of high-capacity links interconnecting the main centres of population. Fifteen to twenty centres would need to be provided with data-switching exchanges each catering for some 2,000–4,000 subscribers. Fig. 12 shows these centres, together with a possible interconnecting network to meet the model traffic. The numbers shown are the link capacities in Mbit/s so that, for example, London to Birmingham would require 8 Mbit/s, equivalent to about 100 p.c.m. telephone circuits. The exchanges would not be fully inter-connected and some of them would have to perform a transit-switching operation. The inter-city links do not exist at present and it would be a substantial undertaking, spread over several years, to complete the network shown. The basic unit for the larger capacity links would be 2.048 Mbit/s (equivalent to 30 p.c.m. telephone channels) and, in the initial stages, links of this capacity could be provided on cable or radio systems using modems. Complete integration of the digital transmission plant with p.c.m. telephony and other digital services would be the long-term objective. Fig. 13 shows a simplified functional diagram of a digital data-switching exchange to operate in conjunction with the digital trunk network shown in Fig. 12. Each exchange would operate as a synchronous time-division switch and all the exchanges shown would be linked to a common system of clocks to form a synchronous network. Synchronous time-division switching has been studied for several years in the p.c.m. telephony context and techniques have been developed up to the laboratory stage which give confidence that synchronization of a national network on the scale of the United Kingdom is a practicable proposition. Indeed, a field trial of a system for synchronizing a network of clocks is planned to be carried out in the near future.

The time-division switch shown in Fig. 13 operates on 64 kbit/s highways which are multiplexed up to give the 2.048 Mbit/s main-line channel.

The exchange proposed is dual-purpose and in one mode, the circuit-switched mode, characters coming in on one line are handed on, without processing but with a small fixed delay, to a predetermined output line. This is equivalent to a metallic connexion and hence, the term circuit switching. In the alternative packet-switching mode, either characters or addressed packets can be handled by the exchange. The form of packet and the process of routing packets within the network is similar to that adopted by N.P.L. and A.R.P.A. Its adoption as a national standard would depend upon users' needs and operational experience. The current proposal is shown in Fig. 14.

The packet-handling mode follows the N.P.L. ideas and differs from the A.R.P.A. method in assuming that future

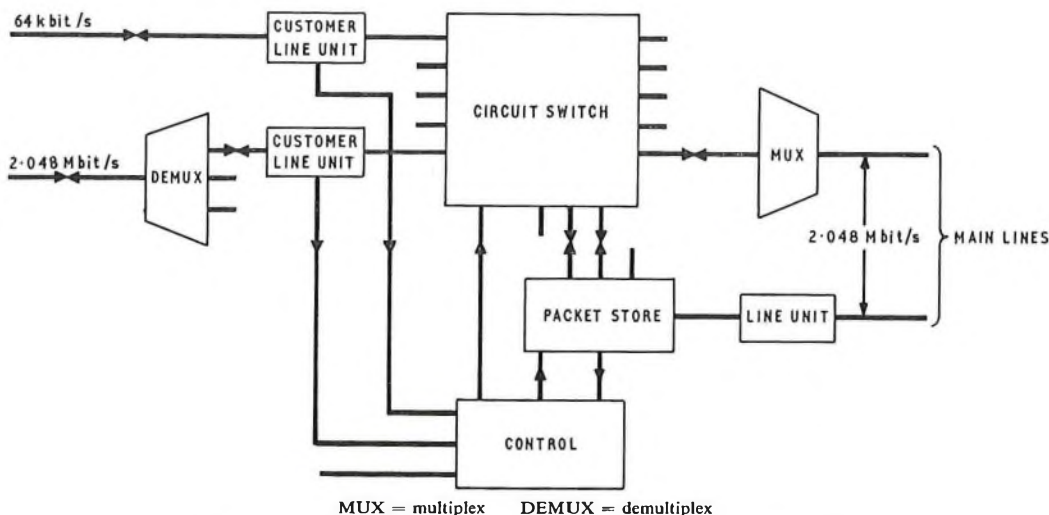


FIG. 13—Simplified functional diagram of a digital data-switching exchange

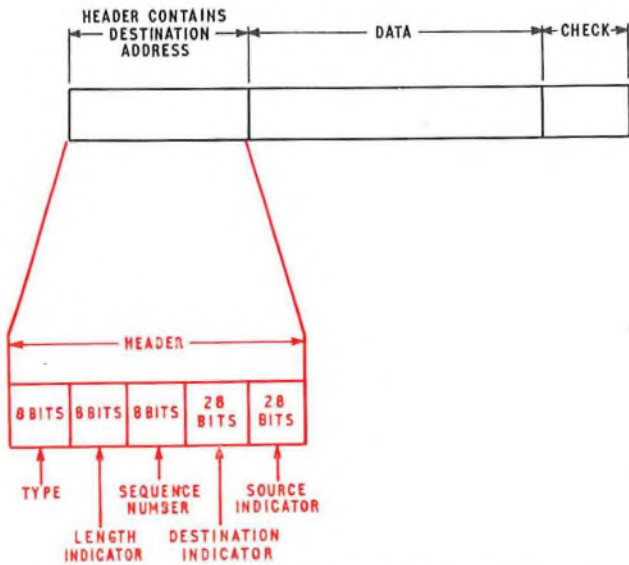


FIG. 14—General form of user packet to and from the data switching exchange

types of terminal, particularly the buffered terminals used with some private networks such as banks and airlines, would be able to generate and receive packets in the standardized format, while future multi-access computers could send and receive interleaved packets over a common highway from a number of terminals.

Present types of unbuffered terminals generate characters, not packets, so the parent data exchange would have to assemble characters into packets and add the heading and check digits. Such terminals would have to be operated according to certain rules which would give an indication to the data exchange of the beginning and end of a packet and to identify such items as address. This could be done with the aid of additional controls or by making use of the control characters in the International Alphabet No. 5.

### Local Network

The local network is required to give access from individual customers to the main digital network via the data exchange. Cost studies show that most of the cost of a national digital network would be within the local part. For the traffic and geographical model previously described, the cost breakdown would be as in Table 4.

TABLE 4  
Distribution of Cost of National Digital Network

Portion of National Digital Network	Percentage of Total Cost
Digital transmission lines between data exchanges	5
15-20 data exchanges (circuit and packet)	25
Local network, including network terminating units (n.t.u.)	70

The dominance of local-network costs reflects the large service area of each exchange (the average distance between users' terminals and his exchange would be about 15 miles) and contrasts with the efficient use of synchronous digital links on the main routes between cities.

It is inevitable that the existing telephone-cable network will be used to provide the data-access network, but economies will be sought by aggregating customers' local ends on to common transmission paths. The studies have led to the concept of a fixed-time-slot digital multiplexing structure, which is compatible with junction p.c.m. line-transmission

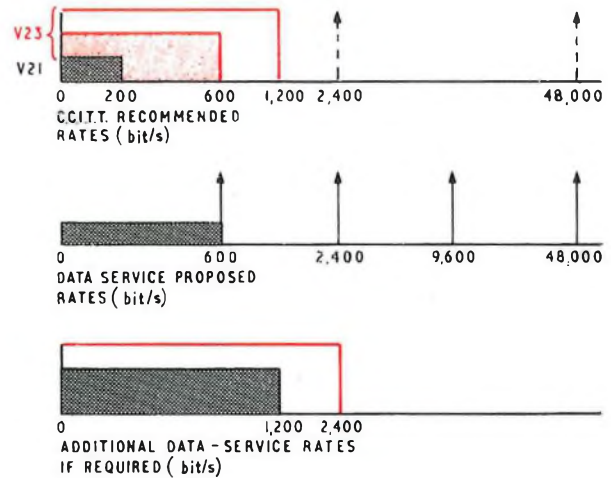


FIG. 15—Data signalling rates

systems, employing direct connexion to the exchange for single terminals and multiplexing where clustering of users occurs. The first-order multiplexers would probably be located in the users' local telephone-exchange building, while the second-order multiplexers would be located in the group-switching-centre (g.s.c.) building. An additional feature is the possibility of using remote concentrators at the g.s.c. under the control of the main data exchange.

The residual problems are the nature of the connexion to the user and the signals exchanged between the user's terminal and the synchronous system. Fig. 15 shows the proposed set of preferred speeds; 600, 2,400, 9,600 and 48,000 bit/s are proposed as isochronous speeds. The most efficient scheme will be to extend synchronous working right down to the user's terminal equipment. This implies a terminal which can operate isochronously, taking its timing from the communications system itself. This is expected to be the form that future terminals will take. Existing electro-mechanical terminals mostly operate in a start-stop mode with a built-in mechanical clock for bit-timing, while characters are generated at random intervals. Interfacing start-stop terminals of defined speed with an isochronous line can be effected through a fairly simple one- or two-character buffer store. It is proposed to identify a few discrete operating speeds representative of contemporary classes of machine for which corresponding converters from start-stop to isochronous working will be available. The speeds might include 50 (e.g. telex), 110, 134.5, 200 bit/s.

The simplest local line for simple start-stop terminals, and the one most easily adapted to the operation of contemporary terminal machines, is to provide a normal telegraph-type metallic line from the customers' terminal to the data exchange or the first multiplexer. At this point, the start-stop characters and the loop-disconnect signalling would be converted to the isochronous envelope format in a special-purpose line-terminating unit.

One of the basic problems with the local connexion to the customer's terminal lies in exchanging control or status signals with the network, independently of data, so as to permit transparency, or more specifically, bit-sequence independence. Such signals include calling, clearing, address of

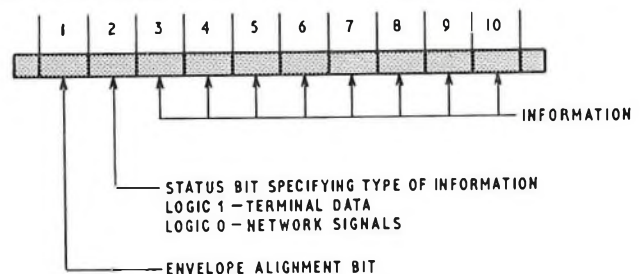


FIG. 16—Envelope format

source and destination, and frame and element synchronization. For unrestricted operation of a synchronous data terminal over a switched communications network, it is, therefore, necessary to provide additional transmission capacity between the terminal and the network.

Methods for achieving this objective have been proposed as a result of the data-network studies. *Diphase*‡ transmission in the local network can carry element synchronization independently of data. In addition, each 8-bit character generated by a terminal could be put into an envelope of 10-bits, as shown in Fig. 16, when it is sent to the data exchange. Bit 1 is used to establish frame or envelope alignment, while bit 2 is used as a status bit. The state of bit 2 indicates to the data switch whether the character is user's data or instructions to the network. Fig. 16 indicates two examples of signalling envelopes; "clear" and "idle" signals with the status bit set to binary zero and one example of a data envelope with the status bit set to binary 1. A very large repertoire of network or terminal-control information can be exchanged in this way. It should be made clear that existing or future types of terminal are not forced to adhere to the 8-bit byte, as the n.t.u. can strip off or insert the network-status and synchronizing bits and accept or deliver a continuous isochronous stream of any character or frame format.

A.T. & T. is understood to be considering an alternative arrangement for local transmission. Line signals will be in high-density or other modified bipolar a.m.i. form, with violations introduced to give an outband-signalling facility and timing information. There will be no character or frame structure and thus, no need for the customer's local line to carry a frame-synchronizing signal.

## INTERNATIONAL ASPECTS OF DATA COMMUNICATIONS

The present range of Datel services all conform to recommendations of the C.C.I.T.T. both as regards line transmission, to ensure interworking between countries, and as regards the interface between the modem and the data-processing equipment, to permit operation with any manufacturer's data-processing equipment. Thus, in principle, data communication is possible among all countries that adopt these recommendations. So far as the public switched-telephone system is concerned, the Datel 200 and Datel 600 services, or their equivalents, are already available in 15 countries, and can be expected to expand both nationally and internationally for many years to come.

However, recognizing the limitations of adapting the existing switched-telephone networks for data transmission, consideration has been given in C.E.P.T.,\* C.C.I.T.T. and I.S.O.† to the need for new data-communications services and the possibility of providing switched digital systems to meet these requirements. C.C.I.T.T. has set up a mixed working party to study this problem and has, only recently, held its first meeting.

The working party defined its purpose in the following way:

"To recommend which data services should be offered on a world-wide basis on public networks and to simplify interconnexion. To this end, the working party will study what services and requirements are needed (taking I.S.O. views into account) and what communications facilities and technologies are available."

The immediate study of new digital data services has been placed in the hands of a number of sub working parties which are planned to hold several meetings during 1971. One

‡ Diphase—phase-reversal modulation (double-sideband suppressed-carrier amplitude modulation) of a carrier having a frequency in Hertz equal to the modulation rate in bauds.

\* C.E.P.T.—European Conference of Posts and Telecommunications.

† I.S.O.—International Standards Organization.

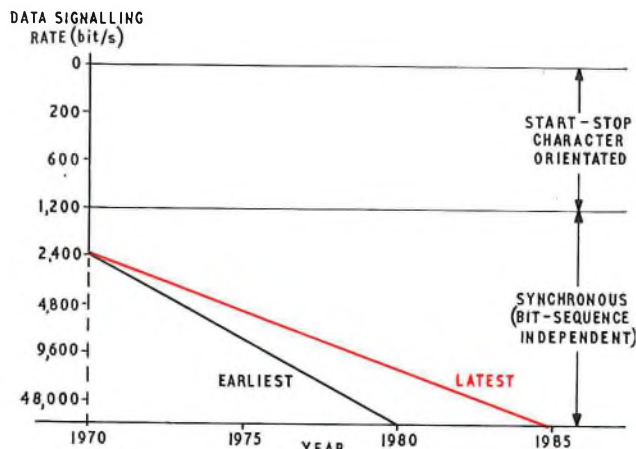


FIG. 17—Trends in data-signalling rates and mode of major use

will deal with the services and facilities to be given, a second will define the customer-network interface functions, while the third will consider network aspects, especially interworking between the national networks of different countries. It is recognized that some properties must be defined by international agreement, others remaining the responsibility of national networks. The essential requirement is to reach agreement on the basic services and facilities to be provided in the future, independently of the switching or transmission technology that is used nationally.

A useful contribution to this end was made at the meeting by the I.S.O. representative, presenting a data-processing industry viewpoint. This is summarized in Fig. 17. The key to achieving international agreement may lie in the proposal to recognize start-stop character-oriented data terminals operating at speeds below 1,200 bit/s and so representing the present generation of terminals, whilst higher-speed terminals would operate in a synchronous mode and would require a digital transmission path, independent of bit sequence, capable of transmitting timing information.

As regards digital data networks, three different viewpoints were expressed at this first meeting. These may be identified respectively as the telex, the p.c.m. and the packet or store-and-forward viewpoints.

### Telex

The telex viewpoint recognizes the similarities between a switched-data service for low-speed, start-stop terminals and the telex service. It also highlights the large investments and long time-scale that are involved in the creation of a new switching system and its establishment at a significant number of centres. Consequently, it is proposed that a limited step towards new digital data services could be taken by the introduction of new and more versatile types of telex exchanges, using computer-type control systems, and by their exploitation for a range of switched-data services as an alternative to adapting the telephone system by the use of modems. This approach has both the advantages and disadvantages of immediacy. It is a straightforward extension of well-established principles, but it has long-term limitations. It cannot readily interwork with synchronous terminals which would like to receive timing from the network, and it cannot exploit the economic benefits of isochronous digital-transmission systems which will play a growing part in the national telecommunications networks of some countries in the next five to ten years. It is significant that the supporters of a straightforward telex approach are found amongst those telecommunications organizations that have no firm plans for p.c.m. telephony.

### Pulse Code Modulation

The p.c.m. viewpoint, leading to a synchronous digital

network, is found among those telecommunications authorities that have firm views on the eventual large-scale introduction of digital-transmission and switching systems for p.c.m. telephony, and also recognize the economies which are to be gained if compatible techniques are used for all other services, including telex and data communications. This is a long-term view and is more easily adapted to future generations of synchronous terminal equipment than to present start-stop machines.

### Packet or Store-and-Forward

Although the operational features of packet or store-and-forward type of network, particularly its speed-changing or decoupling property, have been thoroughly explained to the international committees concerned, there has been little interest taken in the application of these principles to the provision of public-service networks. For the present, therefore, it seems that there is no early prospect of international standards being agreed for a packet-switching public service, and the future of this type of network would seem to lie in private networks or possibly a collective network for groups of users operated on a national basis.

### CONCLUSIONS

Realization of a new digital data system as a country-wide public service conforming to international recommendations

will take several years. For the immediate future, the following objectives are indicated:

- (a) to develop, adapt and improve the Datel services up to the limits of the telephone system,
- (b) to try to reach basic agreement during 1971 through vigorous promotion in C.C.I.T.T. discussions,
- (c) to keep in step with European introduction of new telex-type services,
- (d) to provide interim switched and private-network facilities for urgently-needed services outside the capability of Datel, and
- (e) to lay the foundations for a main and local synchronous-digital-transmission network by establishing inter-city digital-transmission links in units of 2-6 Mbit/s capacity (a wide-spread "thin" network will be more immediately useful than a few very high-capacity routes) and developing corresponding multiplexers and local-line transmission systems (for duplex services at up to 9.6 kbit/s and at 48 kbit/s).

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## Book Reviews

"Electrical Installation Technology." Michael Neidle. Butterworth & Co. (Publishers) Ltd. xvi + 367 pp. 243 ill. £3.80

This book is written for students taking a City and Guilds course on electrical installation work and contains about 90 worked examples as well as the usual exercises at the end of each chapter. SI units are claimed to have been used throughout but Imperial ones frequently appear in the text and examples.

The first four chapters contain simple theory on electromagnetism, inductance, electrostatics, d.c. circuits and a.c. circuits, all with some practical examples.

The installation aspect is first mentioned in Chapter 6 with a reference to the I.E.E. Wiring Regulations followed by cable ratings and coarse or close protection by fuses or circuit breakers. Table sizes are specified in both Imperial and metric units, but the information is already slightly dated by the issue of the 1970 edition of the I.E.E. Regulations.

After a chapter on sub-station layouts, h.v. safety and rising mains in buildings, the main and longest chapter of the book covers, with 39 illustrations, the practical aspects of cabling and conduit work. Armoured cables and plastic conduit, etc. are included. The reference on page 141 to a minimum size of earth continuity conductor over-simplifies the requirements and therefore is not strictly correct.

One chapter each on d.c. and a.c. machines covers mostly theory with some practical illustrations as does the next chapter on transformers. A useful 16 pages on Electricity Board tariffs and power-factor improvement comes next, followed by a chapter on earthing and earth-leakage protection. The latter includes references to protective multiple earthing p.m.e. and earth-leakage circuit breakers of voltage and current operated types.

The chapter on testing includes loop impedence, earth resistivity, and Murray loop tests, and power-factor measurements, while the 23 pages on illumination include simple theory and descriptions of most types of lamps in use today.

The book concludes with chapters on heating, communications systems and elementary electronics. The first covers basic heating calculations for various types of electric heating, the second cells, bells, house telephones, fire and burglar alarm systems, and the last mainly thermionic valves in just

8 pages. The heating example on page 312 appears to have been unchecked as it contains three obvious miscalculations.

This generously-illustrated book provides a good general reference on the various aspects of electrical power installation and, while only simple theory is included, it is directly associated with practical application.

B.H.

"Radio and Line Transmission," Vol. 3. G. L. Danielson and R. S. Walker. Butterworth and Co., Ltd. 308 pp. 181 ill. £1.25.

As the authors state in their summary, the book has been specially written for students taking the Telecommunication Technicians' Certificate examination in Communication Radio C, of the City and Guilds of London Institute, and assumes that they have a knowledge of the subject matter contained in the previous two volumes. These cover the Radio and Line Transmission A and B syllabuses.

A good attempt has been made to provide a self-tutored course in the form of a medium-priced book of reasonable size. The subject matter is divided into a large number of sections which are clearly described by main headings and sub-headings. Worked examples are numerous, and at the end of each main section several questions are set. Numerical answers to all questions are given at the end of the book. The authors style of writing is lucid and concise.

Both valve circuits and transistor circuits have been included in the book. This is to take into account the fact that some circuits can be used at either low or high power levels. At low levels, transistors are invariably used, but at high power levels such as are encountered on long- and medium-wave transmission, it is necessary to use valves because transistors cannot handle such large powers.

As regards the presentation, the type-face is bold and easy to read, and the vari-type symbols, subscripts and indices are especially good for a book of this price. All illustrations are line drawings, which are reproduced very clearly.

The book is recommended for City and Guilds students and could also be of considerable use to those taking H.N.C. and professional examinations which include radio communication.

J. F



# A New High-Voltage Test Laboratory

A. W. N. GARBUTT and D. BILLCLIFF†

U.D.C. 621.317.72.027.6

*A new high-voltage test laboratory has recently been installed at Studd Street, London, N.1. It is equipped for carrying out tests up to 150 kV a.c., r.m.s. and 200 kV d.c. This article describes the laboratory, its facilities and the safety precautions necessary.*

## INTRODUCTION

The recent completion of a new high-voltage test laboratory at the Studd Street, London, headquarters of London Test Section has brought to fruition plans made a number of years ago. Most of the requirements for high-voltage test work in the British Post Office originate in the Quality Assurance Branch of the Purchasing and Supply Department, of which London Test Section is part, and the new laboratory forms an important addition to the existing laboratory and calibration services provided by the branch.

The laboratory was designed and built by London Test Section and the equipment installed by the section's workshop and development group.

## FACILITIES

The laboratory is equipped, at present, to carry out tests in the following three broad categories.

(a) *Voltage Breakdown Tests.* These involve the application for a given time of a specified a.c. or d.c. voltage which the specimen must withstand. Often the rate of increase of voltage is also specified. Up to 150 kV a.c., r.m.s. or 200 kV d.c., positive or negative with respect to earth, can be applied.

Typical of this category are tests of the insulant on cable and wire used by the Post Office in the proximity of high-voltage overhead transmission lines. The cables used by the electricity supply authorities in these situations are obtained from manufacturers approved by the Post Office and are also tested in the same way.

(b) *Ionization Tests.* Internal arc discharges across voids or other flaws in an insulant can occur at voltages much lower than the final breakdown voltage. Apart from the risk of creating static interference in associated circuits, these internal discharges often produce cumulative worsening of the dielectric strength and it is important to know or to specify the minimum voltage at which they occur. Ionization test equipment allows either visual or aural monitoring of the voltage transients as an indication of internal arc discharges over a range of applied voltages. These tests can be carried out in the new laboratory with applied voltages of up to 25 kV a.c., r.m.s. or 20 kV d.c.

(c) *Dielectric Loss Tests.* These measurements are carried out by means of a Schering bridge, its a.c. source being the a.c. high-voltage transformer instead of the usual oscillator.

Applied voltage can be up to 150 kV a.c., r.m.s. The loss angle of cable insulant can be determined by this method.

## Voltage Breakdown Test (a.c.)

A single 5 kVA transformer provides voltages up to 150 kV r.m.s. for the a.c. tests (see Fig. 1). The transformer primary is fed from the output of a motor-driven variable-voltage transformer which can deliver any voltage from 0 to 230 volts at 50 Hz, the output voltage of the h.v. transformer being, of course, proportional to the voltage applied to its primary winding. A 720-volt (maximum) tapping on the secondary winding is connected via a multiplier resistor to a conventional a.c. meter with a full-scale deflexion of 1 mA and scale

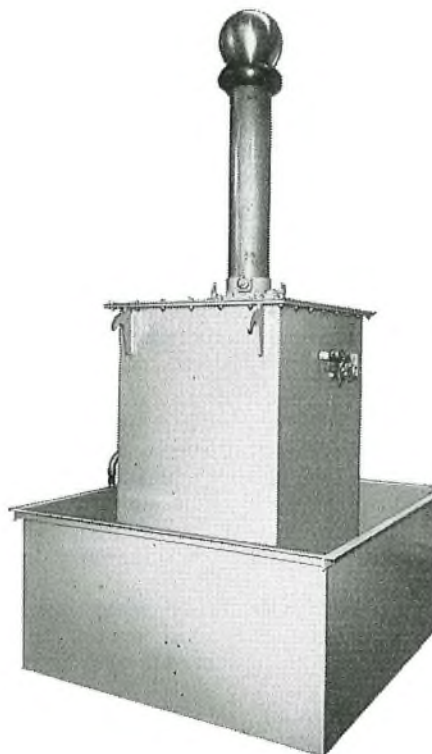


FIG. 1—The 150 kV r.m.s. transformer

† Purchasing and Supply Department, Telecommunications Headquarters. Mr. Garbutt is now retired.

engraved from 0 to 150 kV. The motor-driven variable transformer is controlled from the associated control panel and the motor speed can be set to give the desired rate of voltage increase. The control panel is shown in Fig. 2 and the top half of the transformer is visible in the background.

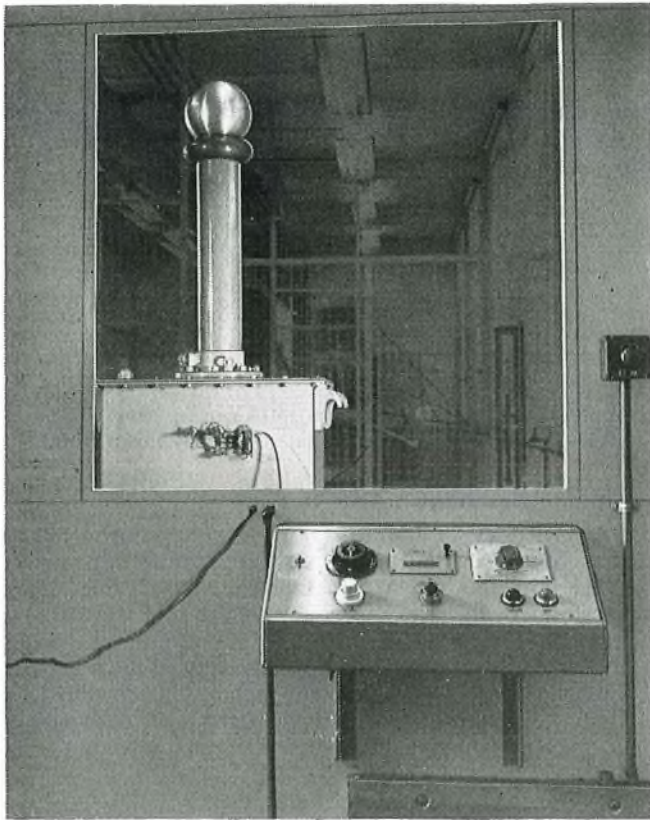


FIG. 2—A.C. control panel

#### Voltage Breakdown Tests (d.c.)

The d.c. high-voltage test equipment produces voltages up to 200 kV, positive or negative with respect to earth. Fig. 3 shows the main circuitry. Again, a motor-driven variable transformer supplies any voltage up to 230 volts r.m.s. to the high-voltage transformer which gives an output of up to 80 kV r.m.s. This is fed into a conventional voltage-doubler arrangement which can easily be strapped to give either a positive or a negative 200 kV output as shown. Each rectifier comprises series-connected low-voltage selenium rectifiers housed inside two high-voltage insulators. A  $50\ \mu\text{A}$  moving-coil meter in series with a 4,000 Mohm oil-filled resistor is used to indicate the output voltage and can be switched to match the polarity in use.

#### Calibration by Sphere Gap

The adjustable sphere gap<sup>1</sup> shown in Fig. 4 is the basic calibrating device relating voltage directly to physical quantities. The gap width (which is adjustable) corresponding to a desired breakdown voltage can be readily calculated from the three quantities—sphere diameter, atmospheric pressure and temperature.

If the output voltage is slowly increased, the conventional output voltmeter can be checked against the air gap by noting the reading at the instant of air-gap breakdown.

#### Ionization Tests (a.c.)

The equipment for a.c. ionization testing was designed by the Electrical Research Association<sup>2,3,4</sup> as their Discharge Detector Model 3 (see Fig. 5). It applies high-voltage a.c. to a test specimen, indicates on a cathode-ray tube (c.r.t.) display

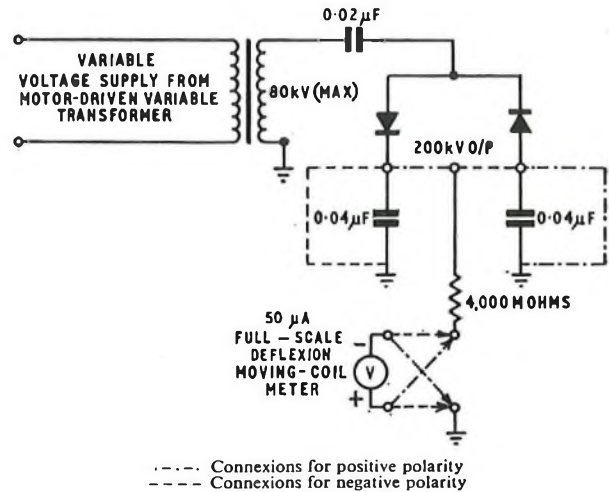
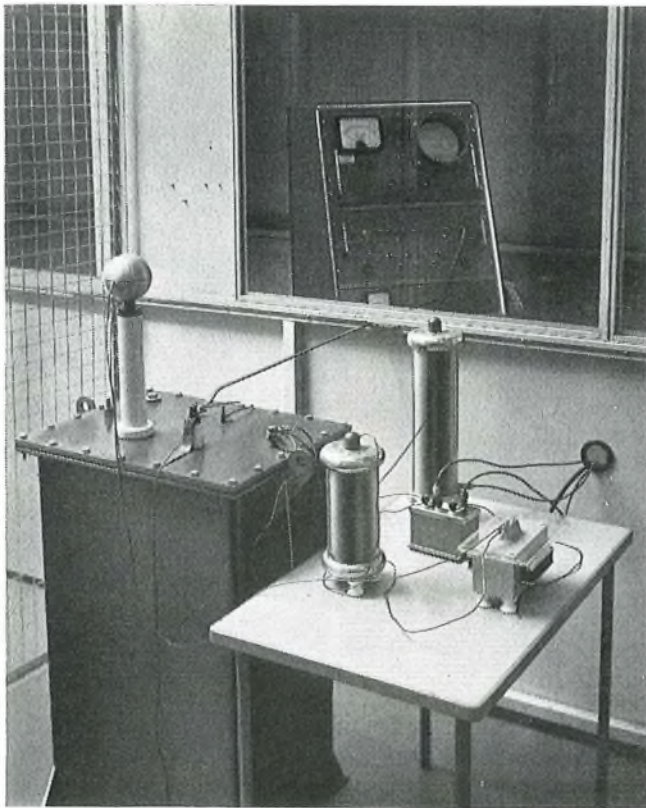


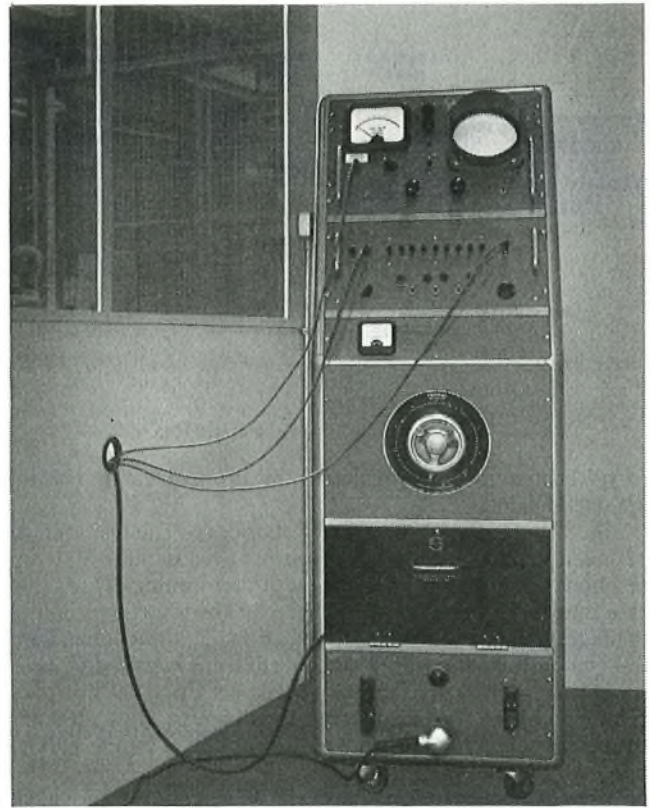
FIG. 3—Circuit diagram of d.c. voltage-breakdown test equipment



FIG. 4—Adjustable sphere gap



(a)



(b)

(a) Components inside high-voltage area  
(b) Control console outside high-voltage area

FIG. 5—The a.c. ionization tester

any internal discharge occurring and its position within each cycle of test voltage and provides a means of assessing the magnitude of the discharge. An outline sketch of the circuit is given in Fig. 6.

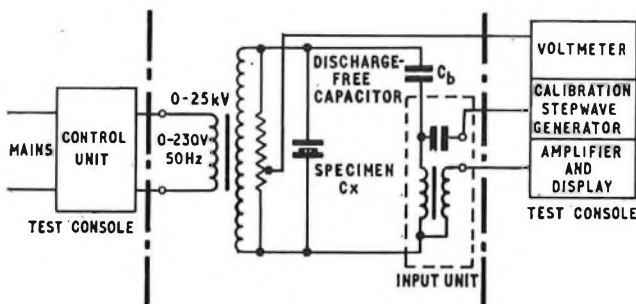


FIG. 6—Circuit diagram of a.c. ionization tester

The test piece  $C_x$  is connected across the secondary of a transformer whose output can be varied up to a maximum of 25 kV by means of a manually-controlled variable transformer feeding the primary. The magnitude of the applied voltage is indicated on a rectified moving-coil voltmeter connected to the tapping point of the 33 Mohm resistor. The specimen is also connected in series with the blocking capacitor  $C_b$  to the input unit. This is a high-frequency transformer tuned by the test specimen capacitance so that its response lies within the response band of the amplifier (15–150 kHz). In this way, the 50 Hz a.c. from the transformer is effectively blocked and the signal passed on by the amplifier to the c.r.t. display consists entirely of the fast voltage transients produced by internal arcing within the specimen. This signal is superimposed on an elliptical trace derived from the mains frequency

and is, therefore, in step with the 25 kV (maximum) potential applied to the specimen. Markers are superimposed on the trace to indicate the zero-voltage points in each cycle so that the positions of transients in relation to zero or positive or negative-going peaks may be seen. All components are designed to be free of internal discharges so as not to produce spurious transients in the display. A built-in generator can inject a calibration step-wave into the test circuit to indicate, by comparison, the magnitude of the observed transients and of the internal discharges they represent.

#### Ionization Tests (d.c.)

The ionization tester used for d.c. is very much simpler than the a.c. tester described above. It comprises a high-tension unit capable of giving any d.c. voltage up to 20 kV. Fast transient voltages due to discharges within the specimen are amplified, to be heard on a loudspeaker or seen on an oscilloscope, and rectified to give a meter indication. Another meter indicates the value of the applied voltage.

#### Dielectric Loss Tests

Fig 7 shows a circuit diagram of the arrangement used for measuring dielectric loss.  $S$  is the specimen dielectric under test and  $C_s$  is the standard loss-free capacitor. This is designed to withstand the 150 kV maximum which can be applied and is filled with dry nitrogen at a pressure of 150 lb/in<sup>2</sup>. Two standard capacitors are held, 50 pF and 200 pF.

Both standard capacitors and bridge are provided with a guard-ring circuit and high-voltage protectors for safety.

#### SAFETY PRECAUTIONS

Where high voltages are involved, effective and foolproof safety precautions are obviously of paramount importance. There is usually no second chance! The design of the labora-

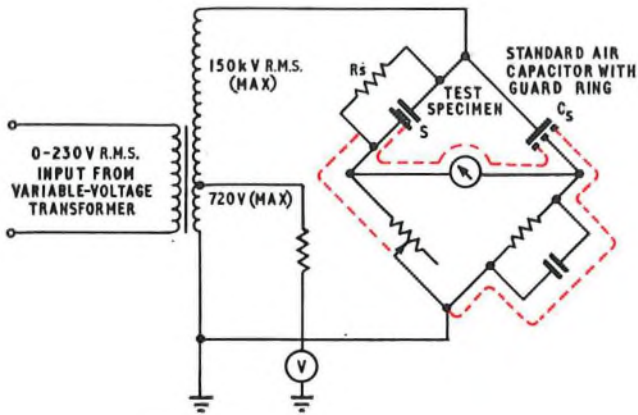


FIG. 7—Circuit diagram of dielectric-loss test

tory was intended to eliminate, as far as possible, any risk to life due to human error.

Fig. 8 shows the layout of the laboratory. The test area is bounded by steel partitioning, glass-panelled to allow tests to be observed from outside. Wire-mesh partitioning divides the area into five rooms as shown. Three of the test rooms house the high-voltage a.c., the high-voltage d.c., and the ionization test equipments, respectively, the fourth being reserved for any special tests which may require to be set up. The fifth and central room can be used to augment the area of any one of the others. Access to and between test rooms is by the sliding doors shown and heavy specimens, e.g. drums of cable, can be brought in on the travelling hoist. A water tank is provided in the central room to cater for those tests in which the specimen is immersed in water during application of the test voltage.

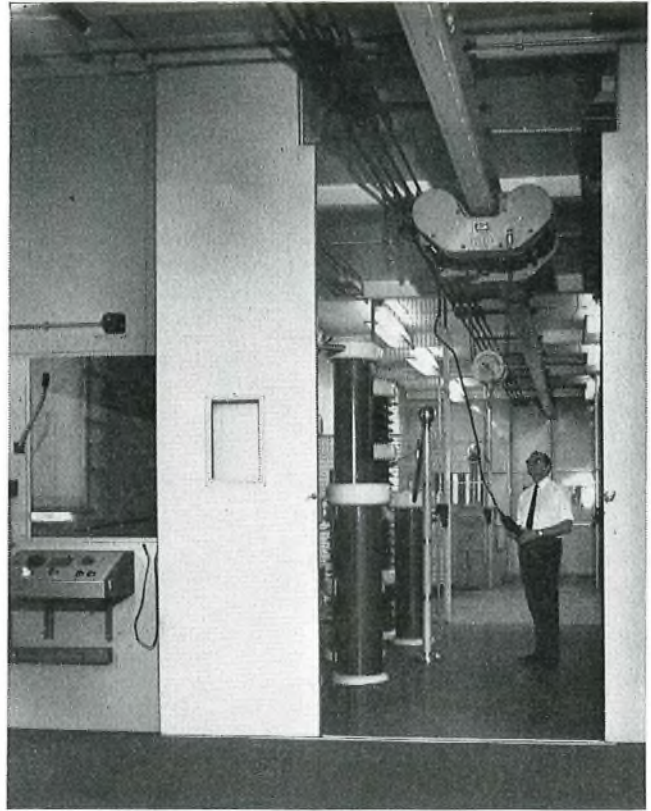


FIG. 9—General view of laboratory showing travelling hoist

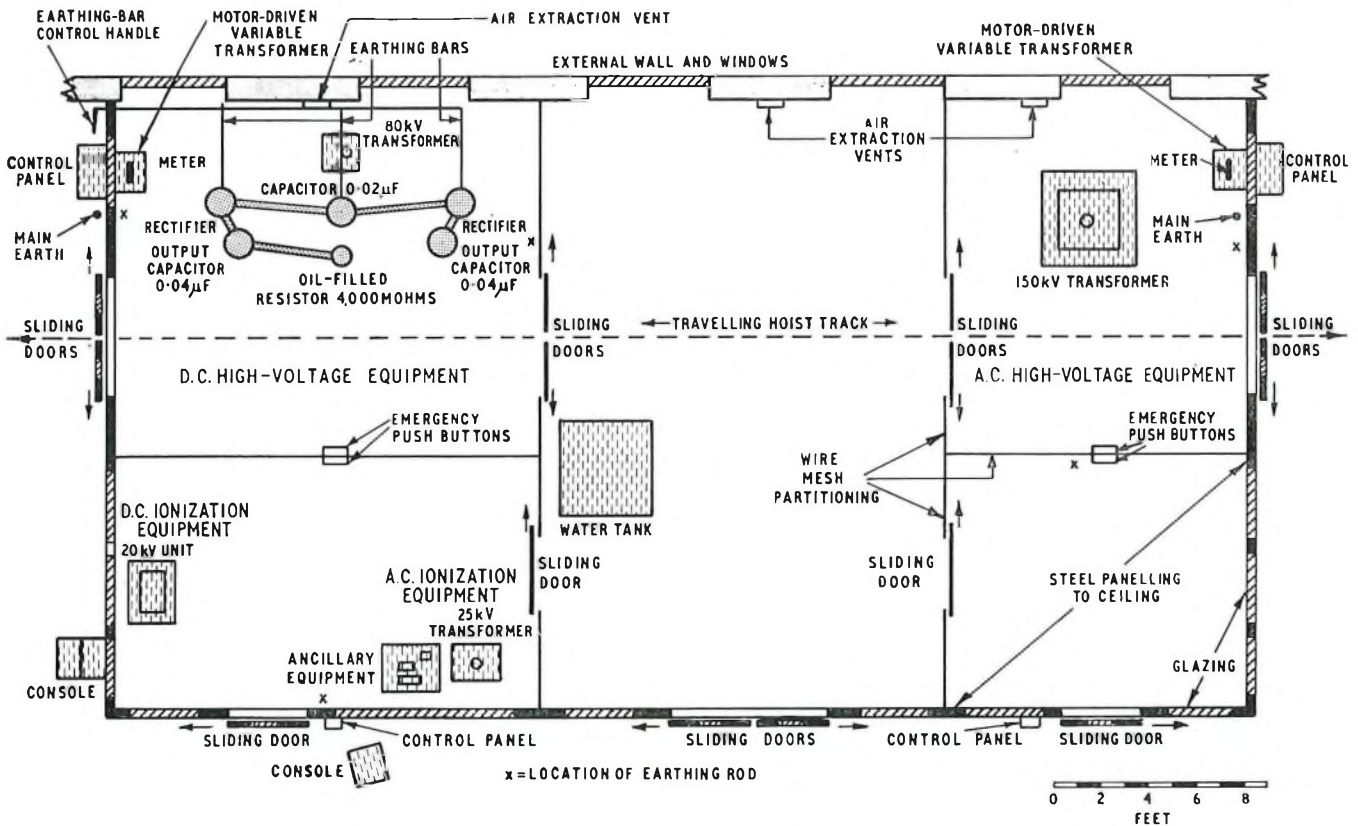


FIG. 8—Layout of laboratory

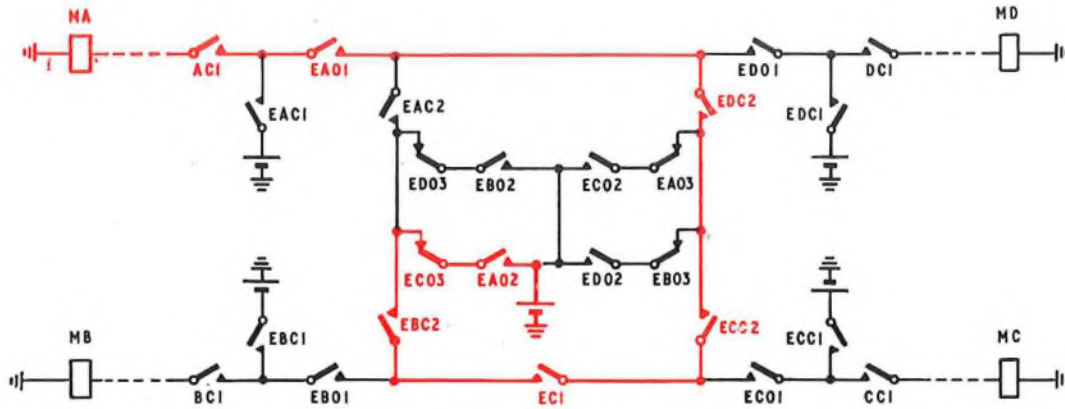


FIG. 10—Door interlock circuit

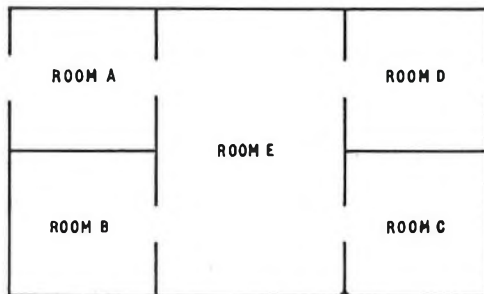


FIG. 11—Simplified layout of laboratory

A separate control panel for each test room is provided on the outside of the main partition and testing is always carried out from outside. Access during tests is prevented by a safety interlock system. Air is extracted through grills let into the outside wall to prevent the accumulation of ozone produced by corona or arc discharge occurring during tests. Since ozone is heavier than air, these grills are at floor level.

### Door Interlock

An arrangement of microswitches on the test-room doors ensures that all doors leading to a test area are closed before power can be connected to the associated high-voltage equipment. Fig. 10 shows the circuit arrangement, and Fig. 11 is a simplified layout of the rooms. MA, MB, MC, and MD are the coils of solenoid switches connecting mains power to the high-voltage equipment in rooms A, B, C and D, respectively. The contacts shown represent the various door switches, e.g. contact AC1 is closed only when the outer door of room A is closed, contact EB02 is closed only when the door connecting rooms E and B is open and so on. Much of the apparent complexity of the arrangement is due to the provision made for room E to be used as an extension of any of the other rooms. The red line in Fig. 10 marks out the interlock circuit path controlling solenoid switch MA when room A is used in conjunction with room E.

A solenoid bolt on each door prevents it from being opened so long as power is connected to the high-voltage equipment in the corresponding room. The interlock circuit allows the solenoid to be energized to release the door only when the power is switched off.

### Earthing

Almost as important as preventing access to high-voltage gear during testing is the efficient earthing of all metalwork to prevent it acquiring, at any time, a dangerous potential. This could be produced across the resistance of the main earth when the breakdown of a test-piece results in a heavy current in the earth circuit. It could also be caused by the electrophorous effect. Any metalwork in proximity to a charged body at high potential contains a captive charge, held by the potential. When the potential is removed, the charge in the metalwork is free to escape to earth. Sudden removal of the test voltage either by switch-off or specimen break-down, could result in a free charge appearing in the metal framework of a test room. Any inductance in the earth circuit would tend, instantaneously, to block escape of the charge resulting in a momentary rise in potential.

It is, therefore, necessary to keep to a minimum not only the ohmic resistance of the earth path, but also its inductance. This was achieved by sinking two half-inch-diameter copper rods vertically and without any bends approximately 20 ft into the floor of the basement below the two main test consoles. All cubicle metalwork and fittings (window frames, etc.) are connected to the earth rods via a thick copper bond linking the entire test area.

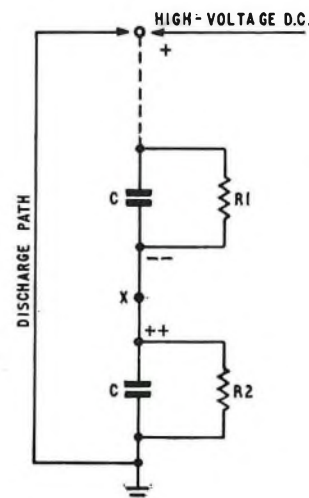


FIG. 12—Residual charge in a capacitor

### Protective Earth Bars

Residual charge left in the capacitors used in the d.c. high-voltage equipment can be lethal. Earthing bars, manually operated from outside the room, have, therefore, been provided to short-circuit the three capacitors when not in use. Microswitches associated with these bars are wired into the appropriate control circuits to ensure that the doors can be opened only when the bars are in contact with the capacitors and the power can be switched on only when they are fully raised.

It is particularly important that the capacitors remain earthed for as long as there is access to the room since, even up to half an hour after a discharge down to zero voltage, a residual charge can still raise the terminal potential to a dangerous level. This effect is due to slight inconsistencies in the capacitor dielectric. A high-voltage capacitor can be considered as a number of low-voltage capacitors in series and may, in fact, be made up that way. Fig. 12 shows two capacitors of equal capacitance  $C$ , each shunted by its own high ohmic resistance  $R_1$  and  $R_2$  respectively. If  $R_1 = R_2$  then there will be the same voltage drop across both capacitors, and the positive and negative charges held at X by any externally-applied voltage will be equal: when the terminals are short-circuited, the charges will cancel each other completely; if  $R_1$  does not equal  $R_2$ , the charges will be unequal and will not completely cancel each other. The discrepant charge, although trapped at first, will eventually seep through the high dielectric resistance to produce again a potential at the terminals.

### Miscellaneous Safety Precautions

Each cubicle is provided with earthing rods which can be hooked on to any component being worked on. The rods are six-foot lengths of perspex tubing with a brass hook at one end, the hook connected by a length of braided copper to the main earth circuit. They give a clear and visible guarantee that a component is earthed. Fig. 13 shows one being used.

Push-buttons are provided in each test room and near the control panels to allow the high-voltage supply to be cut quickly in an emergency.

In addition to the electrical door-interlock system, a castell lock is fitted to each of the outer doors and is operated by a key which can be extracted from the corresponding control panel only by switching off the high-voltage power circuit.

A rotary switch on each control panel imposes a fixed order of doing things during the power switch-on or switch-off operations and operates a warning light and audible alarm at an appropriate stage before power switch-on.

### CONCLUSION

The laboratory offers an effective and well-equipped high-voltage test facility, not only to Quality Assurance Branch

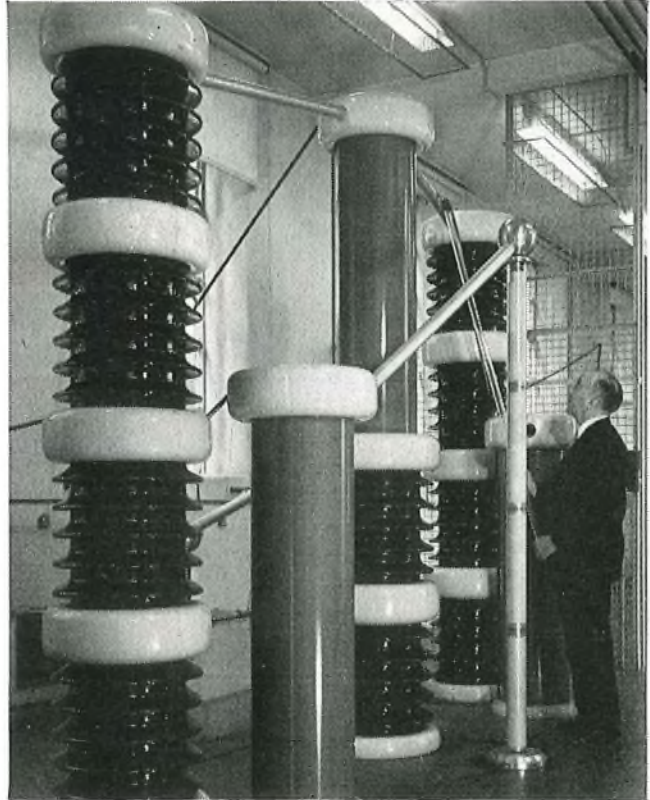


Fig. 13—Earthing stick being used on high-voltage d.c. equipment

itself, but also to the remainder of the Post Office telecommunications and postal businesses.

### ACKNOWLEDGEMENTS

Thanks are due to the staff of the power, workshop and development groups in the London Test Section for their enthusiastic work on this project and to the heads of those other high voltage laboratories, whom we consulted, for advice freely given and gratefully received.

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# Telecommunications Power Supplies— The Next Decade

## Part 2—A.C. Stand-by Plant

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U.D.C. 621.39:621.311

*This, the second part of an article dealing with telecommunications power plant, describes the recent history of a.c. stand-by plant, gives an analysis and description of plant being brought into service, discusses the future development program, and explains how stand-by plant fits into the pattern of modular power systems.*

### INTRODUCTION

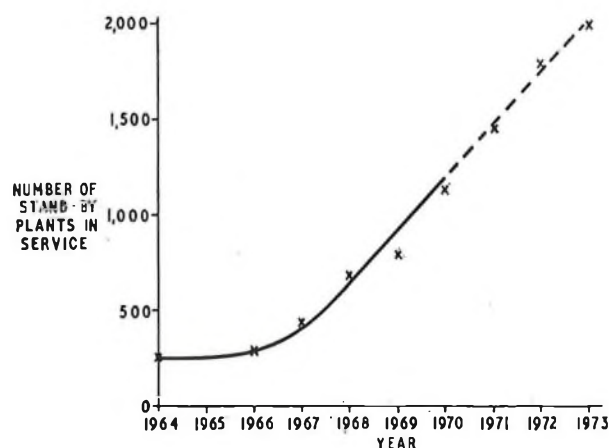
Prior to the second world war, only a few of the more important British Post Office telecommunications centres were provided with stand-by engine-generator plant. All other centres depended upon battery reserve power to maintain essential services during periods of supply-authority mains failure.

During the second half of the 1940s, transmission equipment which operated directly from a.c. supplies was introduced. To provide a source of emergency power for stations using this type of equipment, a number of power plants were developed. These invariably included an engine-generator as a prime source of power and, depending on type, gave an output under mains-failure conditions that was classified as either short-break (less than one second) or long-break (about ten seconds).

By 1955, British Post Office purpose-designed standardized a.c. no-break motor-generator plant, backed up by engine-generator plant, was being provided in most radio and repeater stations. Typical of these were Power Plants Nos. 405 and 407.<sup>1</sup> Telephone exchanges, however, except those in major trunk centres, continued to rely wholly on battery reserve power.

About 1960, two major factors led to a fundamental reappraisal of a.c. stand-by plant design and its scale of provision. Firstly, a policy decision was made that all communications installations should be capable of operating for at least five days in the event of failure of the mains supply. Secondly, transistorized transmission equipment was being rapidly developed, and since this is suitable for direct operation from a low-voltage d.c. source, it was clear that the need for stand-by plant specifically built to supply a.c. operated equipment, (in conjunction with continuity sets), would decline to negligible proportions.

Subsequent studies showed that, except for the smallest installations, to provide a battery large enough to give five days reserve of power was uneconomic, in terms of capital cost of plant and accommodation, compared with the use of a stand-by engine-generator plant and a nominal one-hour battery reserve. It was decided, therefore, that in addition to radio and repeater stations, all telephone exchanges above 600 lines capacity should be provided with a.c. engine-generator stand-by plant. To implement this decision meant providing stand-by plant on a vastly increased scale and this in turn, necessitated a reappraisal of the design considerations and the methods of provision and installation. Fig. 6 shows the growth in the number of stand-by plants in service since 1964.



NOTE: Dotted portion of curve indicates estimated figures  
FIG. 6—Growth of stand-by plant provision since 1964

### THE NEW A.C. STAND-BY PLANT STRATEGY

Prior to 1960, a specialist group planned and arranged for the installation of all stand-by plant on behalf of Regions. With the envisaged volume of work, it became clear that the task of providing all but the most highly specialized plants would have to be devolved to Regions. To enable this to be done, and to meet the expected demand imposed by modern exchange and transmission equipment, a new a.c. stand-by plant design, standardized to the maximum extent practicable, was desirable.

The design objectives of the new a.c. stand-by plant were defined as follows:

- (a) to provide a control system with the minimum sophistication, of high reliability, and easy to make using flow production technique,
- (b) to permit the extension of the plant range without substantial change in the system design,
- (c) to produce the plant in a series of rational sizes,
- (d) to remove any inter-dependent facilities which tie the control of the a.c. stand-by plant to other plants, i.e. to make the a.c. stand-by plant a modular block,
- (e) to enable central bulk purchase of as much of the plant as possible to obtain the maximum cost reduction benefit and permit the introduction of statistical quality control techniques,
- (f) to reduce the on-site time for installation,
- (g) to provide documentation to enable devolution of responsibility for the installation of standardized stand-by plant to Regions.

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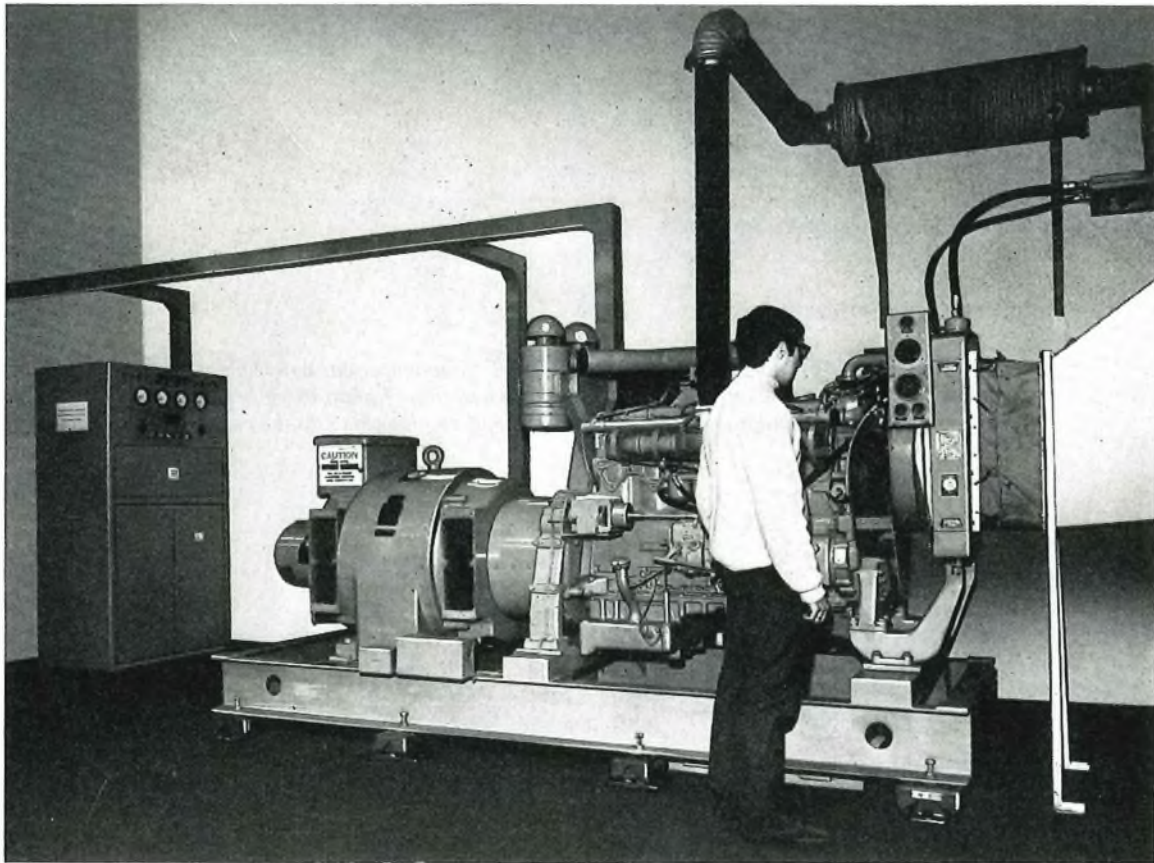


FIG. 7—Typical Power Plant No. 426 installation

By 1964, it was possible to introduce into service a standardized plant, known as the Power Plant No. 426, which satisfied many of these criteria, and enabled responsibility for the provision of reserve a.c. power in telephone exchanges, up to a limit of 200 amp per phase (about 115 kW), to be devolved to Regions. At that time, the control cubicles and the starter-battery cells were being purchased centrally, but the engine-generators were still being bought and installed as discrete units by the Regions.

It was clear that, from 1965 to well into the 1970s, the quantity and power output of a.c. stand-by plants would escalate to keep pace with the massive growth of telecommunications traffic. Accordingly, a second stage of plant development was initiated, which would allow standard plant ratings to be increased to 800 amp per phase, (about 500 kW), with provision for using multiple plant to a maximum capacity of 2,000 kW. The rating for Power Plant No. 426 was increased to a maximum of 300 amp per phase, (about 180 kW), and above that, a similar design, to be known as Power Plant No. 432, was planned to extend the rating to 800 amp per phase.

Later, it became possible to make forward estimates of engine-generator-set requirements by size and number and, as a result, to select a rational number of fixed ratings. This made it possible to standardize these sets, and from this emerged the concept of the package-set which would significantly reduce the time taken for installation, and allow them to be purchased centrally, in bulk. The package-set developed for the Power Plant No. 426 is described in a later section of this article. Although they have not been packaged, the Power Plant No. 432 engine-generator sets have been rationalized to three sizes and associated with standard a.c. control and switching units.

By 1970, the new strategic concept for a.c. stand-by plant had been completed. The system of modular units, permitting easy extension of a.c. stand-by plant capacity was a reality,

maximum use was increasingly being made of the bulk purchase techniques, and standardization of design gave the opportunity to introduce uniform training, maintenance, and planning procedures. Such plant also fitted the overall modular concept of power-system design which has been described in Part 1 of this article<sup>2</sup>.

Additionally, responsibility for the installation of standard a.c. stand-by power plants, up to 2 MW capacity, in all classes of communications centre, had been devolved to Regions.

#### MAIN DESIGN FEATURES

The central feature of an automatic stand-by plant is a prime source of power, usually a diesel engine, coupled to an a.c. generator. The system controlling the operation of the plant is required to monitor the normal mains a.c. supply and detect deviations of voltage outside pre-set limits. When appropriate, the monitoring system initiates the starting and stopping of the diesel engine. Other controls monitor the frequency and voltage of the generator output and automatically operate contactors to connect the a.c. mains or generator output to the load.

Engine plant auxiliaries provide automatic fuel, lubrication, and water make-up facilities, and a small battery system is required to provide energy to the control system and, in most cases, to power an electric motor to start the engine. A comprehensive visual display system is required to indicate the instantaneous condition of the plant and the occurrence of any major malfunctions.

Manually-operated switches are provided to by-pass the automatic control system so that maintenance work can be carried out on the plant. In the event of a catastrophic failure of the plant, emergency switching arrangements are required so that the a.c. mains supply can be directly connected to the load.



## POWER PLANT NO. 426

This plant was developed to incorporate the main design features. It has a power range from about 10 to 180 kW, 3-phase a.c. Fig. 7 shows a typical installation. Four main modular units make up the complete plant.

(a) *Engine Control Cubicle.* These are fully standardized, in rational ratings, and are purchased in bulk.

(b) *Engine Generator Set.* These are at present purchased singly but ultimately will be bulk purchased in rational ratings as packaged sets.

(c) *12-Cell Battery.* Cells are standardized and bulk purchased in rational capacities. They are of a type widely used in batteries forming part of many telecommunications power plants.

(d) *Emergency Switch.* These are standard commercial items to British Standard specifications.

The plant monitor and control system automatically starts the engine and switches the load to the generator output if the a.c. mains supply falls more than 10 per cent below the nominal voltage. A 5-second delay is normally provided before the automatic start sequence is initiated. The load is automatically switched back to the a.c. mains supply, and the engine is stopped, when the supply voltage is restored within 7 per cent of the nominal value for a minimum period of 52 seconds. If the engine plant fails during its start sequence or while it is running, the load is switched to the mains supply irrespective of its condition.

To give environmental control, automatically-operated louvres are provided to allow cool air to be drawn into the room, and permit hot air produced by the engine to be extracted.

The engine is stopped and alarms are extended if its oil pressure is too low, if the cooling water is excessively low or if a fan failure occurs on an air-cooled engine. The engine is stopped 52 seconds after the starting sequence is initiated if the generator voltage and frequency have not stabilized within pre-set limits.

Alarms are extended, (but the set is not stopped), if the starter-battery charger fails, if a fuse fails, or if the fuel or water levels in the tanks fall below certain levels. Counters are provided to show the number of times an engine is called upon to start and to give a cumulative total of the hours run.

Hand controls are provided to allow the engine to be started and stopped without changing over to the load. Other controls simulate low-mains-voltage conditions; these cause the engine to start and switch the generator output to the load. A manually-switched facility is available which causes the engine to continue to run and supply the load following a mains failure irrespective of the subsequent availability of the mains supply. The control system can be completely isolated from the mains supply during periods of maintenance work and the load supplied directly from the a.c. mains.

The components which form the engine control cubicle are illustrated in Figs. 8 and 9. The component modules, which can be assembled mechanically or electrically prior to installation in the cubicle, can be identified by reference to Fig. 10. The cubicles have been rationalized to four ratings, namely, 60, 100, 200, and 300 amp per phase, thus covering the whole power range up to 180 kW.

The basic plant schematic, Fig. 10, shows the main power circuits. The mains supply is normally connected to the load by the manually-operated switches ISA and BSA which are closed, and the electrically-operated contactor MC. Switch BSB is only used when it is necessary to by-pass the engine control cubicle for maintenance work. The automatic engine controls are first inhibited and, hence, the engine prevented from starting, by the operation of an interlocked switch associated with the relay logic; the interlock key is then used to permit the closure of switch BSB. Switches ISA and BSA can then be opened isolating the cubicle from the a.c. mains

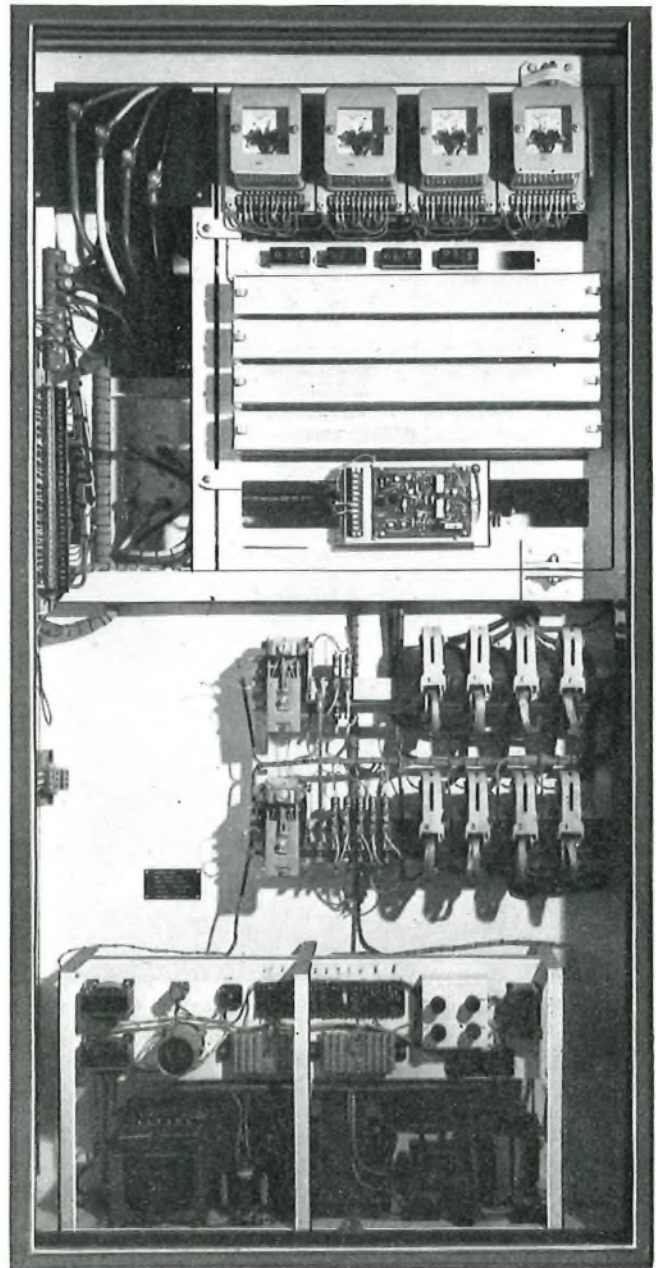


FIG. 8—Engine control cubicle for Power Plant No. 426 (rear)

supply. No interruption in the supply to the equipment load occurs since the by-pass circuit is in parallel with the normal circuit during the by-passing operation and maintains the supply to the load when the isolating switches are opened. As the three switches are always live they are housed in a completely shrouded enclosure and hence personnel can carry out work within the engine control cubicle in complete safety.

Testing operations can be carried out on the control circuit logic (which is energized from a low-voltage d.c. supply at a nominal 27.6 volts) if necessary. The controls can also be manipulated to allow the engine to be started, but the generator output cannot, under these circumstances, be connected to the load. The plant can be restored to normal by reversing the procedure just described.

When the plant is switched to its normal automatic mode of operation, the a.c. supply is monitored. A voltage deviation from nominal of about 10 per cent is usually regarded as a failure, and an output signal from the monitors to the control-system logic will initiate an engine-starting sequence. The engine is cranked to firing speed by a small starter motor and pinion assembly engaging with a gear ring on the engine fly-wheel. Fuel is admitted to the engine by a solenoid operating

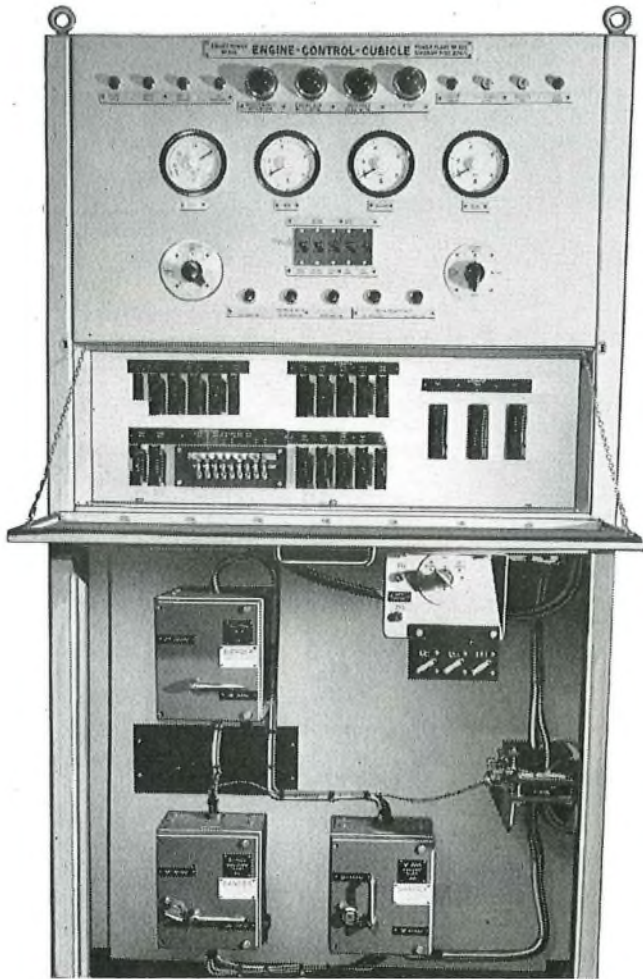


FIG. 9—Engine control cubicle for Power Plant No. 426 (front)

on the injection pump rack. Monitors detect when the engine has reached running speed and the generator output has reached an acceptable voltage. At this time the mains contactor MC is de-energized, and contactor AC is operated, this connecting the generator output to the load. The MC and AC contactors are electrically and mechanically inter-locked to ensure that the two cannot be closed at the same time.

While the generator output is supplying the load, the frequency and voltage are monitored. Other monitors ensure that there is adequate water in the engine cooling system, (radiator cooled) and that the oil pressure is at an acceptable value. An automatic fuel pump is energized via a level switch mounted in the small service fuel tank to replenish the latter from an associated bulk storage tank.

Malfunctions which will ultimately affect the performance of the plant, e.g. low fuel level, are signalled to the main exchange, or to the station deferred-alarm system. Similarly, catastrophic failure of the plant, e.g. loss of oil pressure which causes an engine shut down, will give rise to a prompt alarm condition.

The return of the normal a.c. mains supply is detected by the monitoring equipment. Following a sampling period to verify the stability of the restored supply, the load reverts from the generator to the normal a.c. mains, (contactor AC releases and MC operates), and the engine is stopped. The whole system then resets to its quiescent condition.

Battery capacity is maintained by a constant-potential rectifier arrangement which floats the cells at approximately 2.3 volts per cell. The a.c. supply to the rectifier is maintained from the normal or the stand-by supply.

A plant, with a maximum rating of 60 amp, similar to that described above and known as Power Plant No. 425, is provided where only a single-phase mains supply is available.

## PACKAGED ENGINE-GENERATOR SETS

At present, the engine-generator set forming part of the Power Plant No. 426 is purchased separately for each installation. Each project is planned on an individual basis, and the set and its auxiliaries such as the tanks, fuel pumps, and exhaust system are installed as separate entities. Installation time on site varies from about one to six weeks, and the time taken from commencement of work on site until the completion of the final commissioning trials can, and does, span from about two weeks to many months.

It has now been established that the majority of engine-generators purchased can be rationalized to four main ratings, namely, 12, 25, 35, and 58 kW, 3-phase, 50 Hz, at 0.8 power factor lagging. Plants of these ratings are used in significant quantities, and hence it has become feasible to purchase them centrally, in bulk, to a design which specifies standard interfaces to associated components. Additionally, auxiliary items such as the fuel tanks can be included with the engine and generator on a common base-frame to produce a packaged set. Since there are reasonable quantities of plant involved, manufacturers can standardize production work, and introduce statistical quality control techniques.

Fig. 11 shows a typical packaged set of 12 kW nominal rating. These sets are now in quantity production, and the first will be installed in the latter part of 1971. Orders for the higher ratings of set will be placed by the end of 1971, and production units will be available for installation by the end of 1972. It is intended to continue development of the packaged type of engine-generator set from 58 kW to the full rating of the plant, which is approximately 180 kW. It is probable that the larger sets will comprise two packages, which will be interconnected on site. This arrangement is necessary to ease the handling problems which will become onerous during delivery of a single unit of, say, eight tons.

The packaged engine set has been particularly aimed at standard classes of building. Features of the new standard buildings e.g. the N type, will be the provision of engine-cooling ventilating openings, exhaust pipes to the roof, and fuel connexions to the bulk storage tank, in specified positions. The location of these interface points will line up with the equivalent components on the packaged sets. The development of packaged sets and, in particular, their use in standard buildings is aimed at minimizing the installation and commissioning time on site.

## POWER PLANT NO. 432

The control system and facilities of this plant are similar to those of the Power Plant No. 426. It has, however, a far higher output, with two basic ratings of 400 amp per phase (about 235 kW), and 800 amp per phase (about 500 kW). The proposed rational range of engine-generators is 235, 330 and 500 kW at 0.8 power factor lagging. The main modular units of the plant are:

- (a) twin and triple switch cubicles,
- (b) engine control cubicle,
- (c) engine-generator set,
- (d) contactor switching cubicle,
- (e) compressed-air system for starting the larger plants,
- (f) a 12-cell battery.

It has been necessary to use more modular units with this plant compared to the Power Plant No. 426 because of the physical size of components used with the higher power-rating of the plant.

Given a suitable layout, the various cubicles can be interconnected by bus-bars coupling standard interface connexions. If the cubicles cannot be located side by side, inter-connecting cables can be used.

The lower half of Fig. 12 shows the arrangement of an installation comprising two complete plants. By comparison

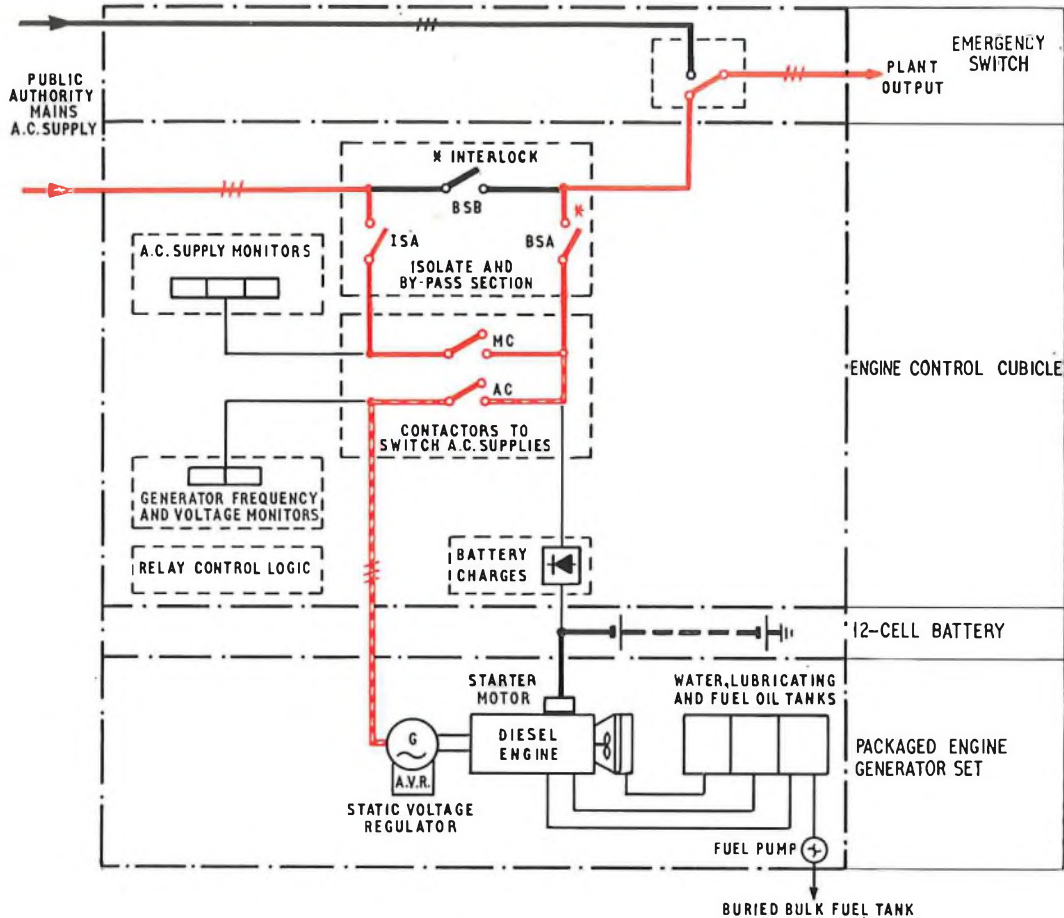


FIG. 10—Power Plant No. 426. Standardized modular units which comprise the plant and which will be centrally purchased in bulk

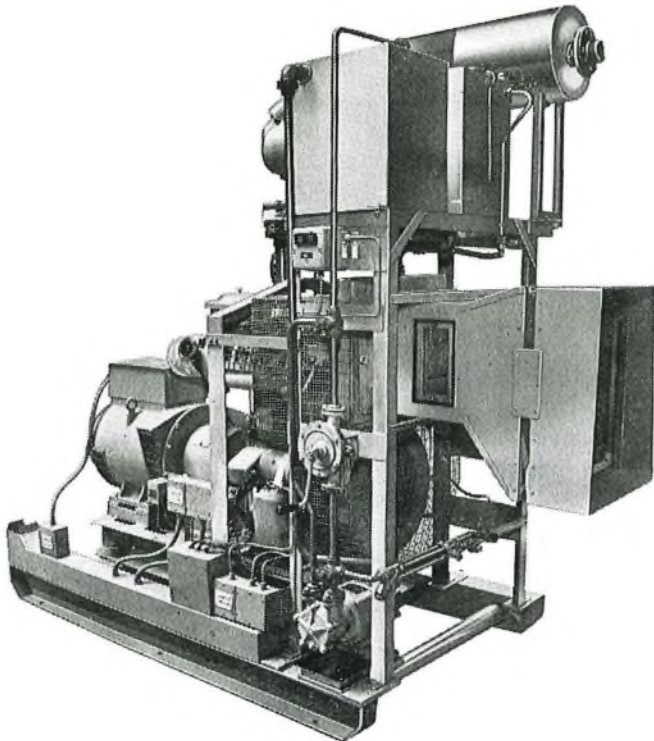


FIG. 11—A 12 kW packaged engine-generator set

with the Power Plant No. 426 diagram it can be seen that the main switching and by-pass operations are similar. A feature shown in the Power Plant No. 432 diagram is the dual purpose of the emergency switching arrangement, which additional to

the by-pass, provides facilities for the connexion of a mobile engine-generator set to replace any one of the permanently-installed sets during periods of scheduled major maintenance or serious failure.

Interlocking keys associated with the manually-operated switches ensure that potentially dangerous conditions such as the connecting of unsynchronized supplies in parallel cannot inadvertently occur due to misoperation of the plant.

The higher power rating of the stand-by generators used with Power Plant No. 432 has necessitated the provision of more comprehensive protection equipment such as earth-leakage and inverse definite minimum time (i.d.m.t.)\* over-current relays, the operation of which will release the alternator contactor AC and cause the engine control logic to stop the engine set. The electrical performance of the generator has been specified to have a protective characteristic which will limit the output under fault conditions to a value within the breaking capability of the contactors, i.e. six times full-load current.

The present intention is to centrally purchase in bulk all of the Power Plant No. 432 modular units except the engine-generator and, where appropriate, the compressed-air starting equipment, these being purchased as required for particular installations. A prototype Power Plant No. 432 was put into service in the latter part of 1970 and other purpose-ordered plant will come into use in 1971. Plant obtained by bulk purchase and associated with engine-generator sets purchased by Regions should start to come into service by 1973.

#### HIGH-VOLTAGE SUB-STATIONS

Where a building has a fairly high power demand, the

\* A device whose operating time is inversely proportional to the overload current but with a fixed minimum operating time.

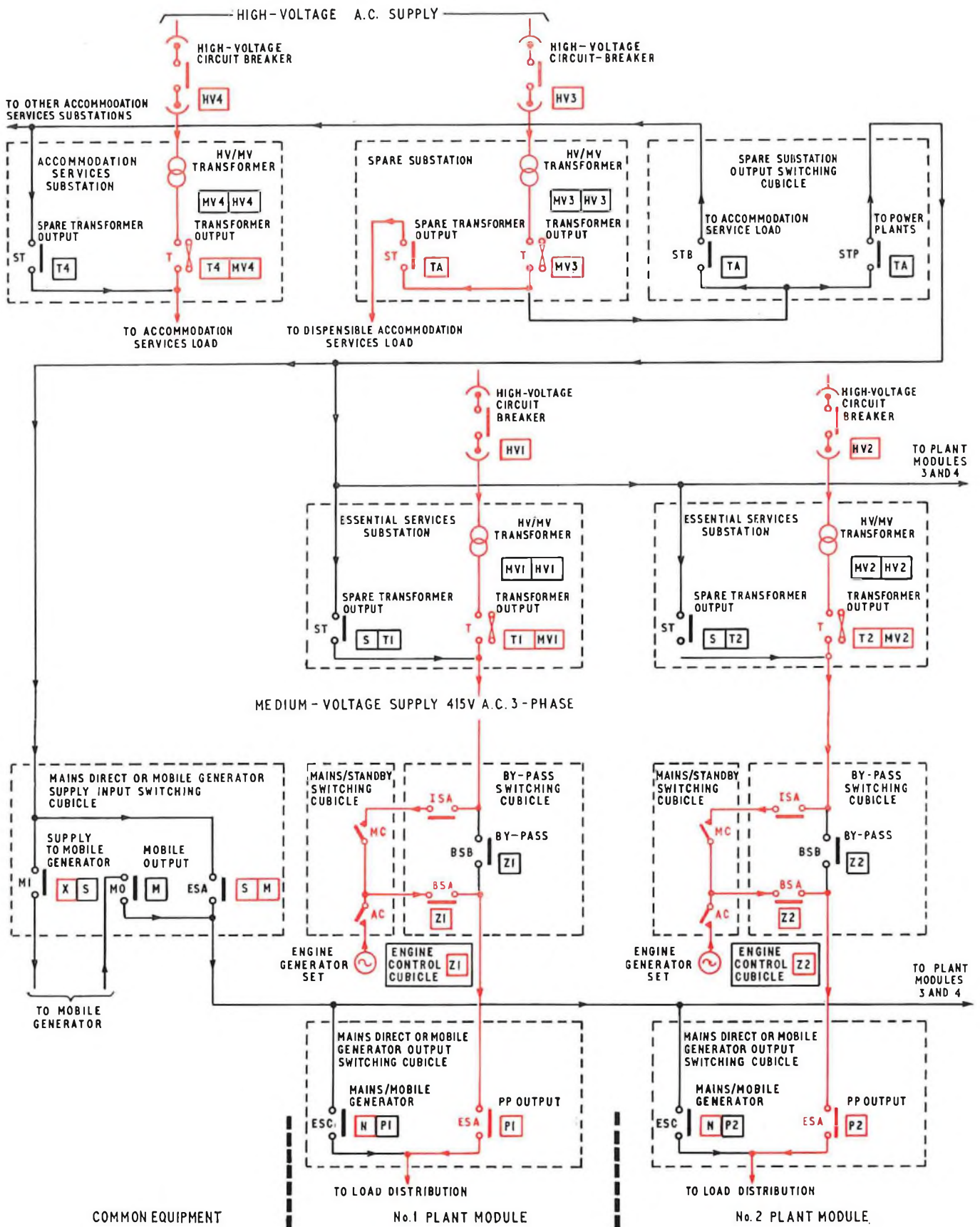


FIG. 12—High-voltage sub-station supplying a Power Plant No. 432

electricity supply authority often prefers to use a high-voltage feeder, commonly 11,000 volts, 3-phase, 50 Hz, 3-wire. This supply is transformed to a nominal medium voltage of 415 volts at a sub-station. Sometimes, the sub-station equipment is wholly provided by the supply authority on, or adjacent to, the Post Office property. Increasingly, however, it is becoming the practice for the Post Office to provide and install its own sub-station equipment.

A standardized packaged transformer unit of 600 kVA has been developed for use in conjunction with a Power Plant No. 432. The transformers are air cooled and may be employed to supply both essential and accommodation loads in a communications centre. Air-cooled transformers have been chosen in preference to the more commonly-used oil-cooled units to avoid the need for pre-planned purpose-built accommodation containing oil catch-pits and comprehensive CO<sub>2</sub> automatic fire-extinguishing systems.

Fig. 12 illustrates how a high-voltage packaged sub-station interconnects with a Power Plant No. 432. Fig. 13 shows the salient features of a typical unit.

The load on an essential services transformer can be predicted with a reasonable degree of accuracy because the power consumed by telecommunications equipment is known. However, in the case of accommodation services such as lighting, the load can vary widely depending on the time of day, weather conditions and the time of year. The actual peak load is dependent, in these circumstances, on various diversity factors. Transformers used for this application have associated with them a temperature indicator unit. The temperature indicator employs not the more obvious arrangement of sensor devices buried in the windings but a purpose-developed unit which acts as a thermal model of the main transformer. The buried sensor arrangement has known limitations because it is difficult to predict the exact position of hot-spots in a winding and hence know where to locate the sensors. The thermal-model arrangement gives a far higher degree of confidence in the indicated temperature since it effectively compares the known heating and cooling curves of the winding ascertained during works trials, under closely defined test conditions, with the actual temperature of the unit under any subsequent operating condition. This comparison can be made to take account of hot-spot temperatures. The setting of the temperature indicator is arranged to give two output signals. The first indicates that the transformer has gone beyond its normal temperature limit, but within its overload capacity. This means that staff can intervene in the operation of the plant, and if the temperature continues to rise, load-shedding can be arranged. In the event of a temperature rise which approaches the point at which the transformer insulation would be damaged, a second signal-output is transmitted to the high-voltage circuit-breaker, which trips, and the supply to the transformer is interrupted.

### MOBILE PLANT

The increase in the number of permanently-installed stand-by plants requires a matching development of mobile plants because the existing mobile fleet consists of time-expired plant having, for the most part, inadequate facilities. Mobile, automatically-started engine-generator plant, in similar rationalized ratings to the Power Plants No. 426 and 432, are in the course of development and will ultimately be available to meet service needs and maintenance programs on the fixed plant.

### THE FUTURE

Present designs of plant, particularly the control-logic systems, are based on proven circuit components such as 3,000-type relays and these designs are already giving a high degree of reliability. Other logic systems such as fluidics and solid state electronic units<sup>3</sup> are being studied to establish

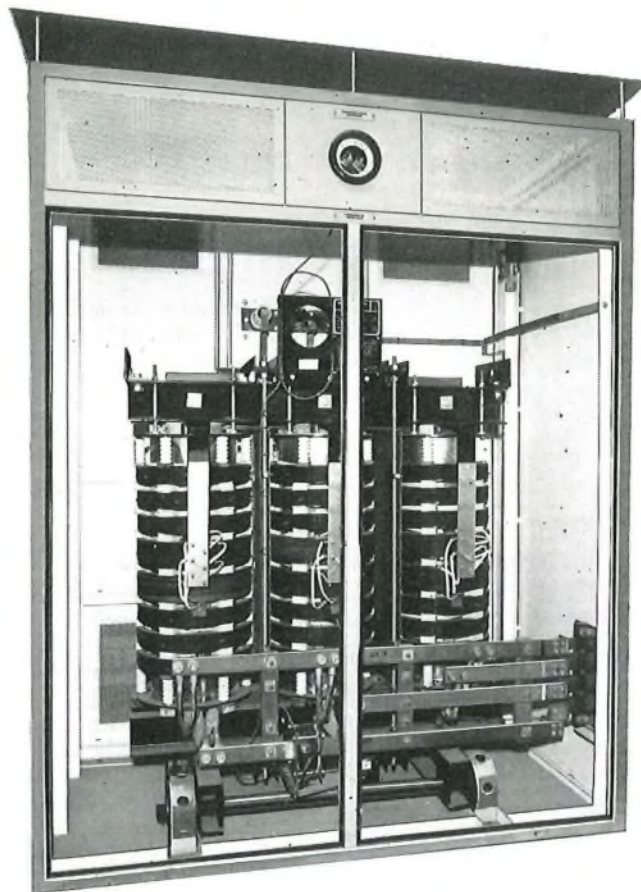


FIG. 13—Packaged high-voltage transformer unit. General view of components

whether future systems should be based on these techniques, and to establish whether they will give an even higher degree of reliability without raising costs. It is known that the highest defect and failure rate of plant occurs in the monitor, logic, and automatic power-switching systems. Ideally, therefore, any new system will contain a self-checking routine function with alarm indication if a failure occurs.

Development of the package concept of plant will be continued and, particularly for lower ratings, it is hoped that a stand-by plant will evolve which is completely self-contained, possibly within a cubicle, with minimum demands on purpose-built engine-room accommodation and installation time.

### CONCLUSION

This part of the article has sought to show the major principles of the a.c. plant which, together with the d.c. plant to be described in Part 3, will form the future back-bone of the power supplies to telecommunications equipment.

An attempt has been made to highlight those features of design and development which implement a policy aimed at an overall a.c. power system which is highly reliable, flexible and cost-effective. The plants described comprise a framework within which innovation can take place as determined by the essential need to accommodate industrial change or take advantage of technological development, and yet provide, by modular construction, a large measure of standardization.

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# Leading External Cables into Telecommunication Buildings

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*An important feature in the design of a telephone exchange is the provision of an entry for external cables. The problems of leading cables into various types of telecommunication buildings are discussed. The developments resulting from attempts to standardize building designs, and the introduction of new types of cable are described.*

## HISTORY

Since the telephone service began, problems have arisen over methods of routing circuits into centralized switching points (exchanges). In the early days, most circuits were carried on overhead routes which terminated on roof gantries and were connected to the main distribution frame (m.d.f.) by one-pair cables insulated with vulcanized india-rubber. (See Fig. 1.)

With the growth of the service, leading-in in this manner became impractical due to the sheer weight and bulk of the gantry, and a system of lead-sheathed cable laid underground was adopted. These underground cables radiated from the exchange to convenient distribution poles, where they were connected to the overhead wires. At the exchange, the cables entered the building below ground level, usually into a convenient basement room. There was no attempt at this time to relate the position of the m.d.f. to that of the basement and all sorts of curious methods were used to accommodate the cables between the entry and the m.d.f. For example, wooden trunking was used to protect the cable run, and the m.d.f. was mounted on a raised plinth so that cables could be laid over the apparatus room floor.

At this time, paper was being used to insulate the conductors in external cables and these, therefore, could not be terminated directly on to the m.d.f. terminal strips. A special terminating cable with wax-impregnated textile insulation was used and because of its poor characteristics compared with paper-insulated cable, the terminating length had to be short. The joint between the two cables had, therefore, to be inside the building, adding to the accommodation problems.

During the period from 1920 to 1930, the increase in telephone density resulted in a considerable increase in the size of exchange units, and buildings began to be designed specifically as telephone exchanges. It was at this time that the first cable chambers associated with an m.d.f. were developed, and these formed the basis of the present lead-in methods. After 1930, certain standards were specified and these resulted in a partial standardization of cable-chamber accommodation, lead-in ducts and duct seals.

In one of the basic systems which emerged, the m.d.f. was situated directly above the cable chamber. Terminating joints were provided in the cable chamber as shown in Fig. 2. In the other system, the m.d.f. was on a higher floor and a vertical riser pipe system was provided in the building wall, to carry the cables to a shallow trench built into the floor of the m.d.f. room. This trench accommodated the terminating joints.

These two methods of leading-in are in use today in many non-standard buildings. For small exchanges up to about

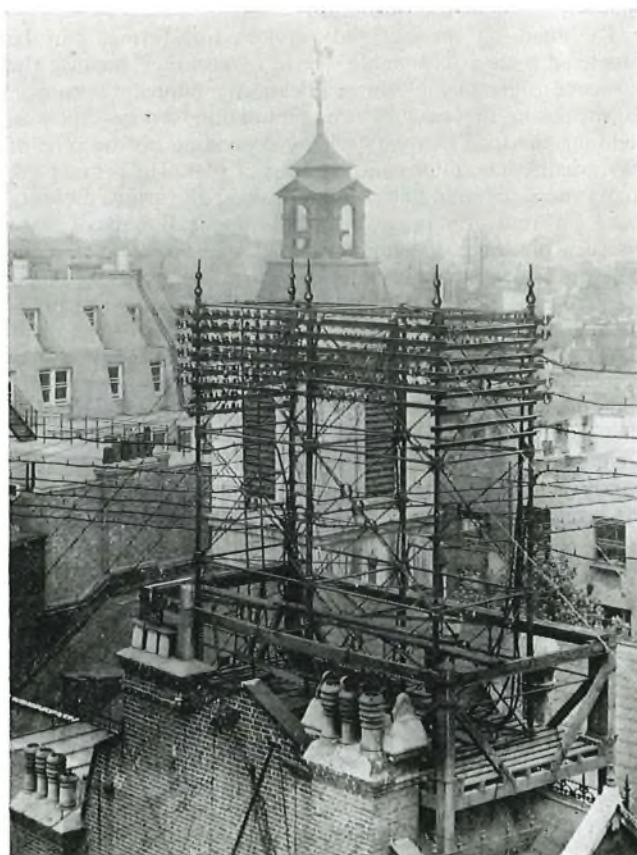


FIG. 1—Typical overhead gantry lead-in, central London, circa 1910

2,000 lines capacity, various small trenches were developed. These were built beside and parallel to the m.d.f. and fitted with wooden covers. Cables usually entered at the end of the trench remote from the growing end of the m.d.f.

## Recent Developments

Since 1946, considerable developments have taken place in the external field, and these have influenced the direction of development of leading-in arrangements. During the early 1950s, work was started on the development of standard buildings, the primary aim being to reduce costs and the time required for building design and construction. The results of this work indicated that the provision of extensive basement areas was a considerable factor in the overall time of construction. It was, therefore, decided to concentrate on ways of providing cable leads-in which reduced or avoided altogether the need for a basement.

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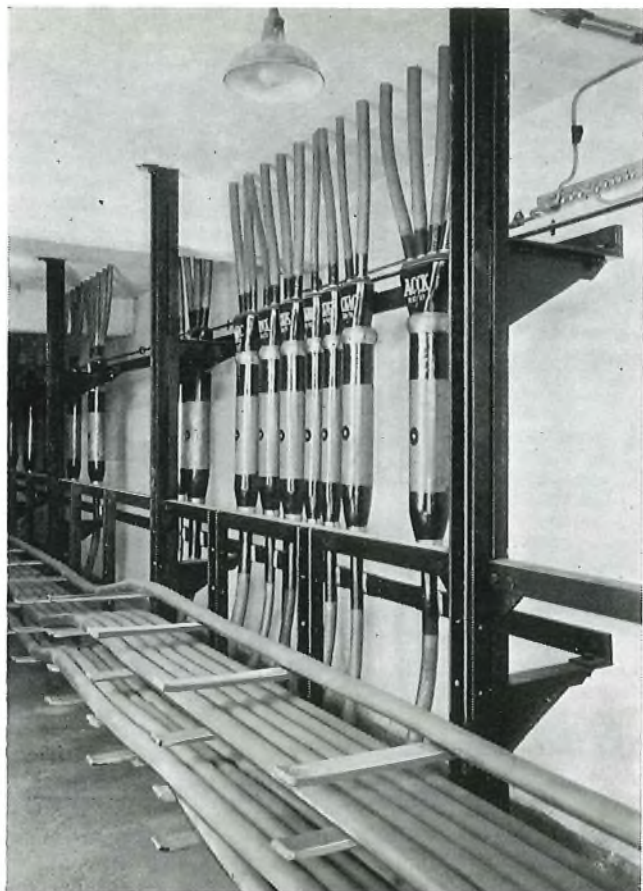


FIG. 2—Cable chamber with m.d.f. above, showing cable, racking arrangement and vertical terminating joints

A prototype exchange was built at Altrincham without basement accommodation. The lead-in was provided at normal ground level in the m.d.f. room and encased in a wooden cable box fixed along the wall behind the m.d.f. The cables were fed from the box to the m.d.f. via a shallow trench in which the terminating joints were housed.

The design was not satisfactory, because sufficient space was not available within the building to deal with large cables. The cable position in the duct nest had to be allocated and maintained from a point outside the building, to ensure that it occupied the correct position within the lead-in and on the m.d.f. The trench was not really large enough to accommodate comfortably the terminating joints and cable bends, and soon became very congested. Parallel with this development, experiments were made with trenches in exchanges of capacity greater than 2,000 lines, to try to estimate the maximum size of exchange that could be fed by a trench lead-in system. It was decided that with the lead-sheathed cables and terminating joints then in use, the maximum size of lead-in possible in an open trench was about 24 ways.

#### Developments in Cable Design

During the period 1950 to 1960, experiments were made with the use of plastics for sheathing and insulating telecommunication cables. Trials were started first with the smaller distribution-type cables up to 100 pairs in size. These cables were insulated and sheathed with polythene and proved to be an acceptable alternative to lead-sheathed cables. Various other types of plastic material were tried, but polythene proved to be the most satisfactory because of its superior electrical and mechanical properties. The success with small cables prompted further trials in the local network with larger sizes, eventually up to the maximum local-cable size of 2,000 pairs. These cables were of two types, polythene insulated and sheathed (Cable Polythene Unit

Twin) and paper-insulated, polythene-sheathed (Cable P.C.U.T. Polythene). Although the paper-insulated cable proved to be slightly cheaper than the polythene-insulated type, the latter was purchased for terminating local cables at telephone exchanges and customers' premises. The introduction of this type of cable with electrical characteristics very similar to existing paper-insulated cables removed the need to make a terminating joint within the exchange building, and opened the way for further developments in lead-in design.

At this time, however, the changes being considered were restricted by the necessity to joint paper-insulated trunk and junction cables to special terminating cables close to the m.d.f. As explained previously, it was necessary to keep the terminating length short. A new type of terminating cable, insulated and sheathed with polythene (Cable Polythene Quad No. 5), with electrical characteristics similar to the paper-insulated trunk and junction cable, has now been developed. This cable is now provided from the m.d.f. to the nearest convenient jointing point and it is no longer necessary to provide space within the building for terminating joints. Provision is still made for the termination of h.f. cables, where required, but these present few problems compared with the large audio cables. The modern standard building designs to be described reflect the reduced space requirements for the lead-in that result from the use of plastic-insulated and plastic-sheathed cables.

#### THE DEVELOPMENT OF STANDARD BUILDING DESIGNS

The primary purpose in developing standard designs for telecommunications buildings is to reduce costs and the time required from the planning stage to completion. If a complete set of plans and specifications is available, it is only necessary to decide the building size and fit it on to the site, thus reducing the planning stage to a minimum. The concept of a standard building requires the design of a standard lead-in which must meet the overall requirement of that building. It was decided, therefore, that the lead-in size would be determined by the ultimate capacity of the standard building, allowing for the total permissible extension envisaged at the development stage. As design work progressed, the approach to the lead-in problem underwent considerable change and the current concept is very different from that considered at the beginning. As the different types of standard building evolved, it was necessary to change the concept of what was necessary for a cable lead-in.

The standard buildings were identified by a code-letter and these are used in the descriptions which follow.

#### The H-Type Building

This was the first building in which changes were made to the conventional methods of leading-in. It was designed for an ultimate capacity of 4,000 lines and the lead-in presented few problems. The lead-in duct consisted of 12 ways, which were ample to meet the designed capacity of the building. Originally, a shallow trench 3 ft to 3 ft 6 in deep was provided beside and parallel with the m.d.f., with a shaped shoulder designed to bend the cables under the m.d.f. to the base of the centre verticals. This trench design proved to be unsatisfactory when constructed and it was later modified to a rectangular section with a vertical wall under the m.d.f. Teak covers, of similar design to those used for many years, were used to cover the shallow trenches.

A considerable number of buildings of this type were constructed, mainly in small centres of population; they were generally successful. Unfortunately, the building was not amenable to extension beyond the planned limit and much structural alteration was necessary where the growth of the system grossly exceeded the forecast. Where extensions were provided, it was necessary to augment the lead-in. The cable trench was extended in line into the building extension, but



FIG. 3—Raised floor system used for the prototype M building showing adjustable metal stools with cruciform plastic tops designed to prevent individual covers slipping when the floor is open

the additional ducts had to be laid beside the existing building and angled into the trench extension. This was not a satisfactory arrangement but was the only method possible.

#### The K-Type Building

The design of this building provided for some measure of flexibility, so that it could be used to cover a wide range of capacities above 2,000 lines. As a result, there was theoretically a need for a flexible lead-in design to cater for the possible range of building capacities. The introduction of this type of building was coincident with the general introduction of polythene-sheathed and polythene-insulated cables. This resulted in a reassessment of the space requirements for the lead-in cables. A flexible lead-in design was undesirable, as the adding of lead-in ducts during the life of a building involves cutting through a basement wall with consequent access and sealing problems. It was, therefore, designed to cater for the maximum building and site capacity. This decision meant that, for many K-type buildings, the lead-in was larger than necessary, but the small increase in cost was considered justified to avoid interference should the building capacity be increased. The building design provided space for an m.d.f. of 64 verticals, so a 36-way lead-in was provided. The ducts were fed into a cable-turning chamber below ground-floor level and then into a stepped trench beside and parallel to the m.d.f. The trench was designed to reduce the amount of excavation required and varied in depth from 6 ft at the turning chamber to 3 ft at the far end of the m.d.f. Again, teak covers of conventional design were used to cover the trench.

#### The L-Type Building

This design was developed to meet the need for a small building catering for up to 4,000 lines on a restricted site. The lead-in, therefore, had to be from the front, although the m.d.f. was sited parallel with the frontage. Space had to be provided in the trench for turning the cables through 90 degrees, otherwise it was similar to the H-type trench. The trench was 3 ft 6 in deep, 20 ft long and was provided with a lead-in duct of 12 ways. Later designs allowed for an alternative lead-in parallel to the frontage. Conventional design teak covers were used to cover the trench.



FIG. 4—M-type cable pit showing cable slope and access under the raised floor in the m.d.f. room

#### The M-Type Building

As a result of experience with the H and K designs, it became clear that a greater degree of flexibility was required in the building layout and capacity. It was proposed, therefore, that a single design would be used throughout the range of capacities required, additional sections being added to the basic building as required by the growth of the system. It was decided that the lead-in provided initially would have to meet the ultimate site capacity, and, to avoid excessive cost on a small building, would have to be as simple as possible.

At this time, trials were in progress with a type of floor widely used in computer rooms to replace the teak covers used for many years to cover cable trenches. These floors consist of 2 ft square plywood panels supported on vertical steel columns fixed to the floor of the trench (Fig. 3). Using this type of floor in the m.d.f. room, it is possible to produce a shallow trench by raising the floor level, provided there is sufficient ceiling height to accommodate the m.d.f. This method of producing a trench was considered to be practical, and was used in the construction of a prototype lead-in. The only excavation necessary was for a cable-entry pit where the lead-in ducts terminated. The cavity under the m.d.f. was 12 ft wide, the total width of the m.d.f. room, and 2 ft deep. A slope was provided from the cable pit up to normal floor level, where the cables were accommodated under the raised floor (Fig. 4). A prototype building was constructed at Toddington and the opportunity was taken to test the leading-in arrangements. Two 24-way blocks of ducts were provided, making 48 ways in all. It was appreciated that this size of lead-in was more than adequate for the range envisaged for this type of building but the design was unique and its limitations had to be assessed. When the building was completed, the whole of one 24-way block of ducts was cabled with a range of cable types and sizes to assess the limitations of the lead-in arrangement. The cables included one 4,800/2½ lb Polythene Unit Twin cable, which was completed to the air-block stage. The limited space under the floor necessitated the provision of a temporary frame in the m.d.f. room to support the cable in a vertical position while the air block was being made (Figs. 5 and 6). When the block was completed, the frame was removed and the cable and block laid below the floor.

The trials at Toddington indicated that the lead-in arrangement adopted was practical, although the provision of 48 ways would result in considerable congestion. It was decided,





FIG. 5—A 4,800-pair cable in position on temporary rack prior to stripping and making air-block

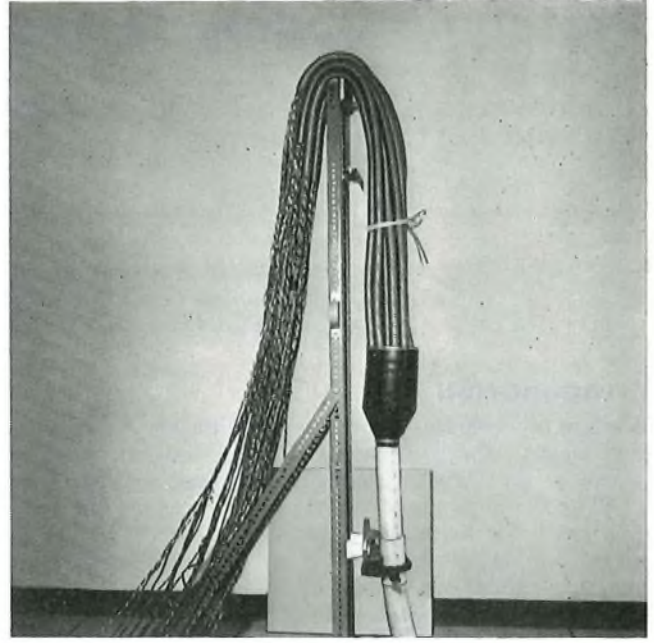


FIG. 6—A 4,800-pair cable stripped, formed into 400-pair groups and the air-block completed before laying under the floor

therefore, that bearing in mind the flexibility of the building design and the tendency for large cables to be installed initially in new exchanges, a lead-in of 24 ways would normally be provided. The final lead-in adopted provides for a raised modular-type floor covering the m.d.f. area and the lead-in pit, with provision for a 24-way duct, entering either from the front of the building or at 90 degrees to the frontage. The duct in the latter case is laid under the power room floor.

This type of lead-in offers considerable advantages from the building-construction point of view, and could be used in buildings designed for capacities up to 20,000 lines. It is proposed that this lead-in shall be used for all telecommunications buildings up to this capacity, whether standard or non-standard. Cable chambers will now only be used in large buildings housing trunk switching centres or multiple exchange units.

#### SUPPORT OF CABLES IN CABLE CHAMBERS AND TRENCHES

During the development of standard buildings, the opportunity was taken to reconsider the methods of supporting cables inside the building. Traditionally, the ironwork and cable supports were custom-made for each building, using broad design parameters laid down in the early 1930s. The ironwork was designed to support lead-sheathed cables and was, therefore, of robust construction. With the general introduction of polythene-insulated and polythene-sheathed cables for terminating both local and trunk audio cables, it was decided that a lighter construction could be used. There would also be some advantage gained by using a unit-type racking, which could easily be extended as required. Cable

chambers and trenches would be equipped initially with only sufficient racking to meet the immediate need, extensions being added as required.

A unit type of racking based on the *Unistrut* design of channel was first introduced for the H-type building and was subsequently extended to all the standard building designs. The majority of future buildings, whether standard or non-standard, will adopt this method of supporting cables, because it has proved to be far superior both in cost and flexibility to the old racking designs. A future article in this *Journal* will describe this type of racking in detail.

#### CONCLUSIONS

The changes that have been made in methods of leading-in cables into telecommunications buildings over the past 30 years have been described, together with the main factors that have influenced those changes. The methods adopted for the M-type building do not complete the development and the final aim is to avoid internal excavations entirely. This could be achieved in various ways, one of which is the possible provision of a raised floor over the whole ground floor, providing cable access from any direction. A second could be concentration on the use of larger cables for the lead-in feed, thus drastically reducing the number of duct ways required, with a consequent further saving of space. The development of electronic switching systems which reduce an exchange to a group of small units linked to a central control by h.f. paths would reduce the lead-in problem to negligible proportions, but this is still in the future. It is probable that the next generation of standard buildings will retain variants of the lead-in design used for M-type buildings.

# Prototype Coding Desks for Letter Mail

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*Address coding is an essential prerequisite for the current national code/sort system of letter-mail processing. It enables mail to be sorted by machine as many times as is necessary to route it to its destination. Equipment for the encoding of the address on letter mail is described and its development reviewed.*

## INTRODUCTION

A recent article in this Journal<sup>1</sup> outlined the plan, now being implemented, for streamlining the letter-mail distribution system in the United Kingdom. One necessary step is to speed up the sorting process and reduce the number of times each letter has to be inspected and handled by a human sorter. Sorting by machine was an obvious alternative to hand sorting and one of the first machines designed for this purpose was the single-position letter-sorting machine (S.P.L.S.M.).<sup>2,3</sup> This machine was capable of sorting letters into 144 selection boxes, the selection being controlled by an operator pressing keys corresponding to the routing decision he had taken from reading the address on the envelope. While successful enough, this method had the disadvantage that if a second or subsequent stage of sorting was required, the letter had to be passed through another sorting machine. Also, the operator was required to memorize up to 144 selections and their corresponding key codes.

The next development was the modification of the machines to cause them to print on the envelope a machine-readable coded form of the address. The code was derived from the address by the operator applying a fairly simple rule and pressing the appropriate keys on his keyboard. This was an improvement on the previous method but was still lacking in some respects. It was realized that what was required was a code that uniquely defined each postal address in the country and if that were marked on the envelope in machine-readable form, letters could be sorted by machine as many times as was necessary to route them to their destination.

The answer to this problem lay in the allocation of a Postcode to every house and business establishment in the country and in successfully encouraging the public to add the Postcode to the address on all items of letter mail. Coding then became simply a matter of the operator reading the Postcode on each envelope, copy-keying it on his keyboard and the machine then marking a binary-coded version of the Postcode on the envelope in machine-readable form. This machine code was then used to control an automatic sorting machine (a.s.m.).

## THE EXPERIMENTAL MACHINES

The S.P.L.S.M. was the test-bed on which much experimental work was done in the early days and valuable experience was gained. In the original machines, a stack of letters was fed forward and each letter presented to the view of an operator seated at a keyboard. After the operator had operated, from memory, the required keys, the letter was conveyed to the appropriate selection box. When the printing of phosphorescent code-marks was introduced, a controlling translator<sup>4</sup> was added. This converted the keying, derived by the operator from the address, into a code suitable for controlling the a.s.m. which subsequently conveyed the letter to the selection box.

The first coding desks and automatic sorting machines were modified forms of the S.P.L.S.M. Although not ideal

in performance, it was expedient to modify existing equipment to obtain as much information in as short a time as possible. The first coding desk was made up by associating the letter-feed and presentation unit of an S.P.L.S.M. with a specially-designed code-pattern printer. Similarly, by replacing the operator's letter-presentation unit on an S.P.L.S.M. with a code-pattern reader, a truly-automatic sorting machine was created.

The main shortcomings of the first machines were:

(a) inefficiency of the "picker-pipe" type of pneumatic letter-feed separators when handling a wide range of letter sizes at high speed,

(b) the vertical orientation of the code marks which led to very close spacing (this had to be adopted in order to adapt the S.P.L.S.M. with minimum modification),<sup>5,6</sup>

(c) the low maximum rate of the experimental coding desks (80-90 items per minute),

(d) complexity of the hot-transfer technique of code printing,

(e) the complex design of the early coding-desk transport system.

(f) the limited range of letter size that could be handled.

When redesign became essential, it was decided that a contractor should undertake production of a coding desk embodying known techniques only, while the Post Office attempted to evolve another desk of more novel conception. At the same time, field work continued at Luton and proved that the code/sort system was practicable. When the new prototypes were introduced, both were brought to a successful standard after field experiments and testing. A choice then had to be made between the two as there was never any intention of having more than one type of machine in general use.

A separate detailed description of each of the two units follows but mention is first made of certain topics which are common to both.

## Code-Marking

It was decided at an early stage that the method of code-marking letters must be unobtrusive so as to avoid defacing the mail. Phosphorescent marking, which becomes clearly distinguishable when viewed in the dark after irradiation by ultra-violet light, was chosen. A rapid-drying ink had to be developed because of the very short time, about 25 ms, between marking the letters and their being conveyed through rollers and belts. The code-marks originally consisted of two columns of dots (now two rows), each providing 4,095 unique patterns. One column represented delivery information and the other, inter-sorting-office routing information. The code-mark was applied, in the form of wax spots impregnated with finely-ground phosphorescent powder, by pressing a specially-coated paper tape with hot marking pins against the front surface of the letter. This is known as the hot-transfer technique and is the only method which has been found, so far, to be practicable.

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## Standardization of Letter Size

When the S.P.L.S.M. was designed and manufactured, the size range for letters in general use was very wide, extending from 2¼ in by 4 in to greater than 6 in by 12 in. It was, therefore, and still is, for the time being, standard practice to separate letters above and below 7 in in length prior to sorting, as any attempt to handle the full range of letter sizes, either manually or intermixed in a single machine, introduces serious difficulties. It was, therefore, decided to limit the handling requirement of the early S.P.L.S.M. to those below 7 in in length.

During this period, international discussion took place in the Universal Postal Union regarding the introduction of some degree of standardization in letter mail in respect of size and quality. The outcome was a recommended range of sizes from 3½ in by 5½ in (90 mm by 140 mm) up to 4¾ in by 9¼ in (120 mm by 235 mm). This has since become known as the Post Office preferred (POP) range of sizes. With its introduction, machinery capable of handling the whole standard range became more practicable and this fact, in conjunction with known imperfections and limitations of the test-bed equipment, introduced the need for basic redesign of the experimental forms of both coding desk and automatic sorting machine.

## Human Factors

A coding desk has two main functions: one is the purely engineering matter of transporting and processing letters; the other is the all-important matter of linking the human operator with the system.

The operator's physical and psychological comfort must be given every consideration. Provision of an acceptable degree of physical comfort is not straightforward because of the wide range of human physical characteristics which have to be accommodated. Nevertheless, the scope of this problem can be appreciated. Conversely, what constitutes the optimum letter-viewing conditions is not so clear and a long period of observation in use is essential before conclusions can be drawn as to whether this and other features of a coding desk are psychologically suitable for the operator. The question is complicated because some mechanism is needed before observations can commence and yet it is the mechanism which one is attempting to design. Progress therefore tends to be somewhat evolutionary. This aspect of the coding problem has been given continuous consideration during field use of the two units. Both give satisfaction; perhaps the human being is more flexible and tolerant in respect of viewing conditions than expected.

## Keyboards and Translators

Although not integral parts of the desks, both keyboards and translators are essential to the operation of the present system. In external appearance, the keyboard resembles a typewriter and the depression of a key results in a binary series of electrical signals being relayed to the translator. Several additional keys, known as order keys, are provided, signals from which by-pass the translator and pass directly into the coding desk. These include the FEED key, used to cycle the desk without letters or to transport untreated, misfaced or illegible letters; the LOCAL key, used to pass local items without printing a code; the FORWARD key, used to pass overseas letters to the sorting system without code printing (required by an international agreement); the REPEAT key, used when consecutive items bear the same address and the CANCEL key, used to prevent mis-routing in the event of keying errors of which the operator becomes aware immediately after making them.

In the translator, each coding desk is allocated an individual electronic store where key-stroke signals are held until completion of the key sequence for one address. This information is then fed to common equipment and, if it is recognized as

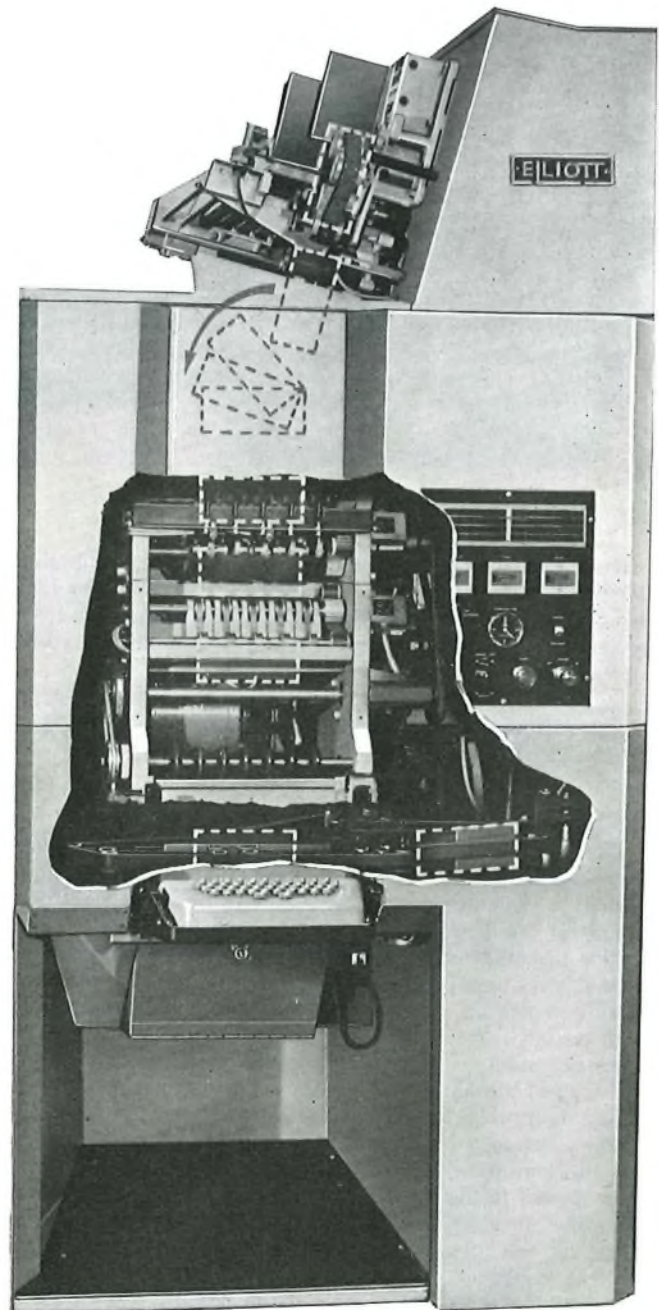


FIG. 1—Prototype E-type desk

a valid signal train, the corresponding code-printer order is returned to the coding desk. The desk completes one cycle and presents a new letter to the operator while storing the code for subsequent printing on the envelope. If the keyed sequence is not recognized in the translator the letter does not move, indicating to the operator that he has keyed incorrectly. This is a valuable self-teaching facility.

## E-TYPE DESK

### General

Apart from the letter destacker, which is basically the same as that used on facing machines<sup>7</sup> modified to give "on demand" letter feed, almost all of the features of the E-type letter coding desk are novel, the majority of them having originated in the Post Office Postal Engineering Laboratory. From the outset, the aim was to produce a machine capable of handling 120 letters per minute without the use of twin routing paths anywhere in the system. Parallel paths through separate

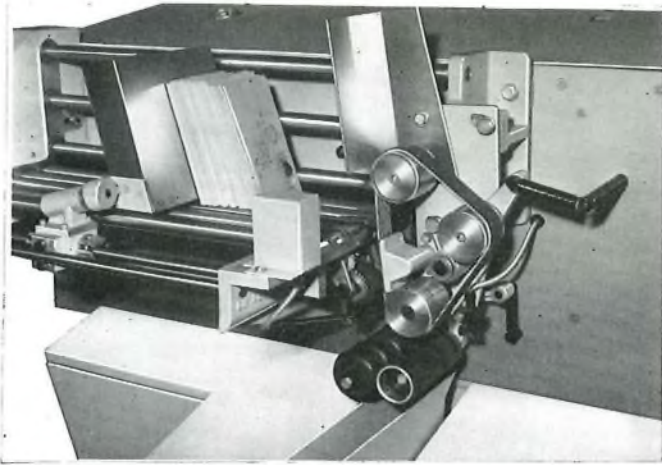


FIG. 2—Destacker as fitted to an E-type desk

printers were provided in the original Luton desks to double the period available for the print cycle. The need for two printers per machine, together with their associated diverter systems, added to the overall complexity and was therefore undesirable.

Fig. 1 is a cut-away view of part of the prototype E-type desk and indicates the positions occupied by a letter as it progresses through the machine.

#### Letter Destacker

The function of this device is to transfer a single letter from the front of a stack to a pre-presentation position. Hitherto, oscillating pneumatic pick-up arms had been used exclusively to perform this function on coding desks and sorting machines but, relying entirely on suction as they did, these devices were inherently difficult to adjust since sufficient suction to pick up a heavy letter would sometimes cause two thin, porous items to be lifted. It was also known that 120 items per minute was approaching the limit of operation of this type of mechanism, especially with the increased length range: it was therefore prudent to seek another technique.

The efficiency of the perforated-belt type of destacker, as fitted to automatic facing machines for continuous feed, had been proved in the field and laboratory experiments showed that, by introducing a clutch/brake combination into the destacker belt drive, the device could be converted from an efficient continuous feeder into an equally efficient "on demand" feeder. A photograph of the destacker as fitted in the E-type desk, is shown in Fig. 2. There are only minor differences between that and the version fitted to the T-type desk and it may be of interest to note that, in addition to its incorporation in the coding desk, this device has also been adopted as the standard in-feed to all Post Office letter-handling machines requiring controlled feeding of letters from a stack. In both desks, destackers are mounted at an angle of 15 degrees to the vertical, this being the minimum inclination required to avoid letters toppling forward as they move from the feed stack to come under the influence of the destacking belt.

#### Destacker Operation

Referring to Fig. 2, on completion of a key sequence by the operator, the perforated belt moves and friction and suction combine to drive the front letter of the stack downwards. The function of the separating rollers is to hold back items which may be clinging to the back of the leading letter. These rollers are very slowly rotated solely to even the wear of their surfaces and so extend the periods between re-adjustment. The destacker, as so far described, converts the horizontal stack of letters into an overlapping (tiled) stream

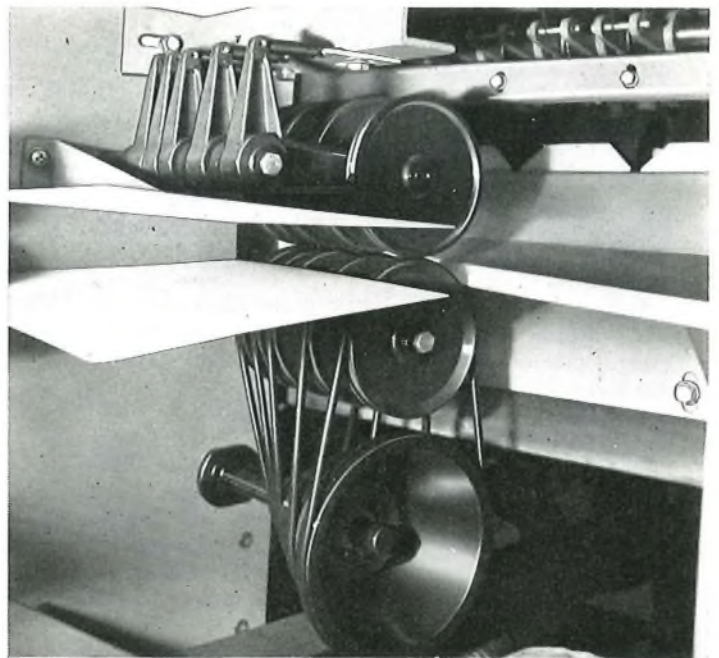


FIG. 3—Orientation rollers

or, at best, a nose-to-tail stream. Each letter must, of course, be processed individually and it is essential, therefore, to open up a gap between successive items. This is achieved by the accelerating rollers whose peripheral speed is greater than that of the destacker belt so that the first and second letters of an adjacent pair move at different speeds for a distance sufficient to produce the required gap.

As soon as a photobeam, acting across this gap, signals the arrival of the leading edge of the first letter, the entire destacker stops with a letter gripped between the accelerating rollers. This completes the first stage in the passage of a letter through the desk. It will be noted that the orientation of the letter gripped between the accelerating rollers is such that it must be turned through an angle of 105 degrees in its own plane before reaching the first viewing position. A further point to note is that clutches and brakes of the type used to start and stop the destacker are recurrent features appearing in every stage of the E-type desk. They are proprietary electro-magnetic devices with stationary field coils so that slip rings are not required. They respond rapidly to energization and transmit very high torques, this latter feature being accounted for, to a large extent, by the fact that there is actual metallic contact between the engaging faces. Unnecessary gaps in magnetic circuits, with consequential loss of efficiency, are thus avoided.

#### Orientation Rollers

The orientation rollers (Fig. 3) are mounted immediately below and at the same inclination as the destacker and comprise a number of pairs of continuously-rotating rollers. The rate of revolution of each pair is so selected that their effect on a letter is the same as would be produced by a pair of contacting cones; that is, they rotate the item in its own plane. Completion of a second key sequence restarts the destacker and causes the gripped letter to fall into the orientation rollers which turn it through approximately 90 degrees before discharging it on to a chute, down which it slides to come to rest against the transporting belts of the next stage. The letter is now in the waiting or priming position, its orientation being correct for reading by an operator. This completes stage two; another letter has, in the meantime, completed stage one. In the remainder of this article it may be assumed that letters advance one stage on completion of a

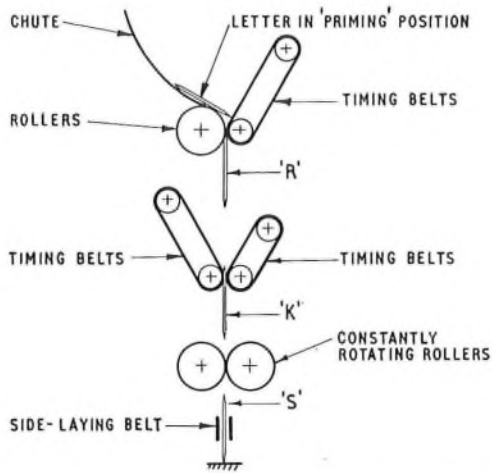


FIG. 4—Presentation unit showing reading and keying positions

key sequence and that, as each step is completed, another letter moves on to fill the vacated position.

### Presentation Unit

It was proved many years ago that the output from an S.P.L.S.M. was greatly increased if two viewing positions were provided, one directly above the other, so that an experienced operator could read the address of the upper letter whilst keying away that in the lower position. Since this fact was realized, all Post Office manually-controlled sorting machines and coding desks have incorporated this facility, the E-type desk being no exception. Fig. 4 shows a schematic representation of a section through the two positions together with a chute above the first position and the rollers below the presentation positions. In this diagram, letters in the reading and keying positions are indicated by R and K, respectively.

A letter waiting in the priming position is drawn down between belts and rollers to a point immediately prior to position R. At this point, its trailing edge is detected by a photo-beam, and belts and rollers stop. After a further key sequence which re-starts them, the letter passes through a similar cycle to reach position K. Thus, at the two viewing positions, letters are suspended by their upper edges giving rise to the description of this method of presenting letters to an operator as *suspended presentation* as distinct from *forward presentation* as employed in the S.P.L.S.M. in which letters were brought directly towards the operator to drop away and uncover another letter as each was processed. It was thought that, because an operator would be more

conscious of letter movement, suspended presentation might not be so acceptable as the other more firmly-established method but, in fact, no hint of such a reaction has been heard, and this new method has met with ready acceptance in the field.

From position K the letter emerges from the grip of the belts and rollers to fall into the nip of constantly-rotating rollers through which it passes to fall on to a plate (position S). Here it waits between parallel sections of the side-laying belt ready to be moved to the printing position. Whilst it is in this position and until the next key sequence is commenced, code information for a letter may be cancelled by a depression of the CANCEL key. With one exception, all other known presentation units require glass windows or thin wires in front of the viewed items to restrain them. One great advantage of suspended presentation is that no such restraint is required, so operators are not subjected to any reflected glare from windows and manual removal of uncodeable letters (e.g. items upside-down or otherwise mis-faced) is facilitated.

### Side-Laying Unit

This unit comprises a single, endless, flat belt so arranged on a series of rollers that a letter may be gripped between two adjacent parallel surfaces of one belt and moved rapidly sideways to the printing position.

Fig. 5 shows the arrangement and it will be seen that eccentrically-mounted rollers enable belt surface B to move into contact with surface A so that any letter gripped between them is driven sideways when the belt drive is engaged. On reaching the position indicated by P, the leading edge of the letter is detected by a photobeam and, meanwhile, the eccentrics continue to rotate to complete a full revolution before coming to rest. By doing so, they re-open the gap between the surfaces A and B ready for the next letter from the presentation unit. Belt drive and letter movement continue until a timer, started by the signal from the photobeam at P, causes the belt to stop as soon as the letter has reached the correct position for code printing.

### Code Printing

The diagram shown in Fig. 6 is a side view of one form of code printer and shows a letter gripped by the side-laying belt at the printing position. Fig. 7 shows an actual printer withdrawn on its hinges from its operating position. (Two alternative printers for this machine were produced.) Immediately the belt stops, as described in the previous paragraph, a pressure plate moves towards the printer and presses letter and gripping belts firmly against the printer masking plate.

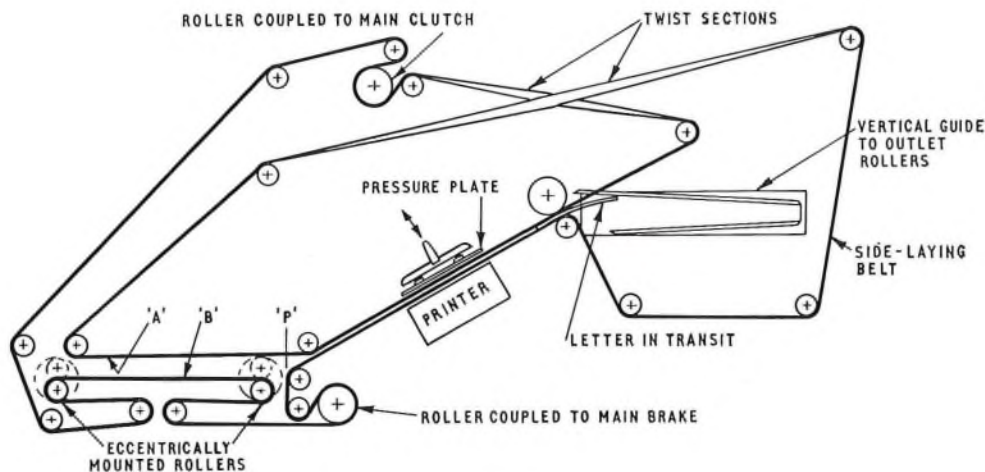


FIG. 5—Side-laying unit

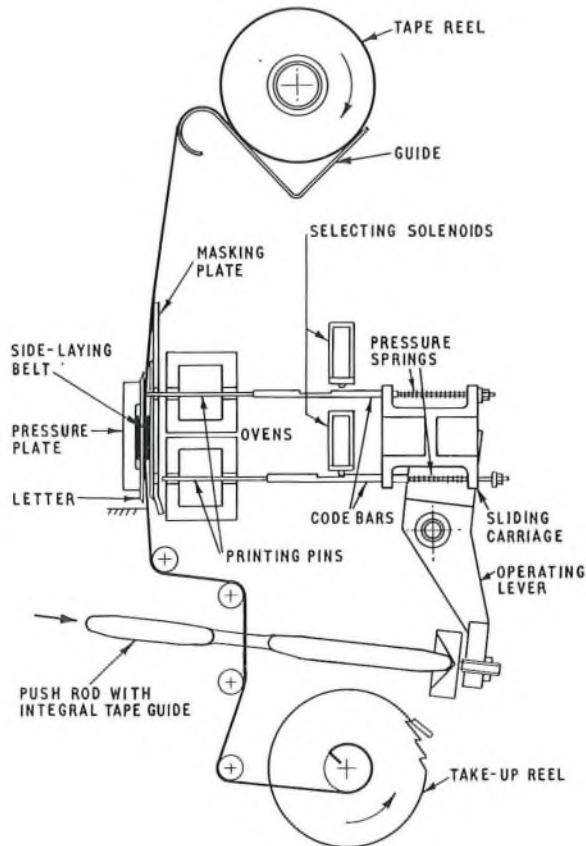


FIG. 6—Code printer with letter in printing position

Heated printer pins are then pushed forward to transfer the required pattern of phosphorescent code marks from the special coated tape to the face of the envelope. Both printing pins and pressure plate are then withdrawn to their rest positions leaving the letter gripped merely by the belt. Printing occurs at the end of the machine cycle and occupies a time of approximately 150 ms. Pins are maintained at a temperature of 150°C by means of the ovens shown in Fig. 6. After each printing cycle, the coated tape must, of course, be indexed forward to present an unused coated surface at the print-pin faces and, for this reason, it is necessary to step the tape on about 3/16 in per cycle. This is achieved by means of a constant-torque motor and a simple ratchet. Tape from which the coating has been removed by the upper row of pins is never presented at the lower pin faces because the two rows of pins are horizontally displaced from each other by half a code-mark pitch.

#### Discharge

At the end of the next key sequence, the side-laying belt moves again to carry the letter to a pair of rollers where it is driven downwards to pass to one side or the other of a diverter, depending on whether the item is for local or distant delivery. Once past the diverter, letters are aggregated with those from other desks at a stacking point.

#### Electronics

Electronic switching is used exclusively to control all movements of the desk. Post Office designed logic units (Dollilogs) have been used in all except the early models and they are now used in all postal machinery which requires electronic switching. In addition to the switching functions required for the control of the electro-magnetic devices in the machine, various alarm and fault-tracing facilities are provided as aids to maintenance. The logic of the E-type

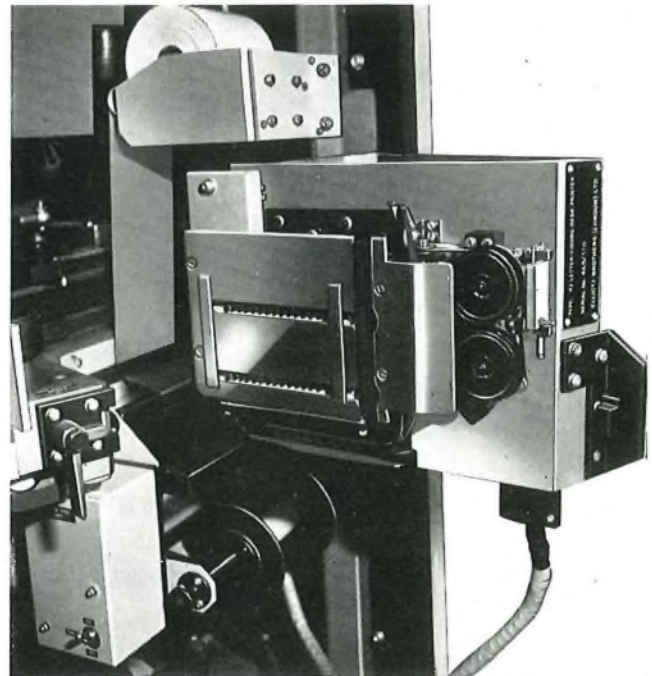


FIG. 7—Code printer

desk is similar to that associated with the T-type desk described below.

#### T-TYPE DESK

##### Letter Destacker

The letter destacker (Fig. 8) is very similar to the corresponding mechanism on the E-type desk described previously, but the machine lay-out renders it less accessible to the machine operator. Should a failure to feed occur, therefore, the operator must enlist the aid of an assistant on auxiliary duties and, to reduce the frequency of such failures, a vibrating tray was introduced between the rotating roller bed of the letter-fed stack and the destacker belt. When the machine



FIG. 8—T-type destacker

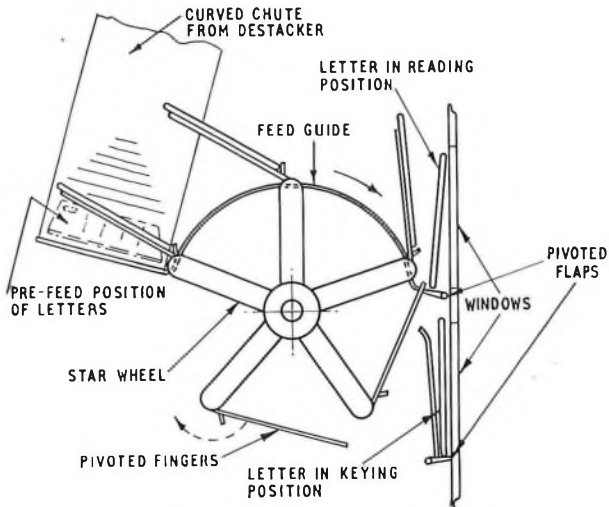


FIG. 9—T-type letter-presentation unit

is started, letters on the feed stack are moved forward by a back-plate until a photo-beam is interrupted but the letters continue to move forward until they contact the destacking belt under the action of the vibrating tray. Operation of the FEED key causes the belt to rotate and carry the first letter down until its leading edge cuts the lower photo-beam whereupon the belt is stopped. Suction from a vacuum box holds the letter in close contact with the belt while separating rollers hold back the second and subsequent letters. The separating rollers are rotated very slowly to equalize wear and are spring-loaded to permit the passage of items up to

$\frac{1}{4}$  in thick. On the next operation of the feed key, the destacker belt again rotates and the first letter enters the accelerating rollers which open a gap between it and the following item and eject it down a chute into one of a moving train of compartments described below. Each subsequent operation of the FEED key advances the letters by one station towards the presentation point.

### Presentation Unit

Two viewing positions are provided for the reasons stated in the description of the E-type desk. Forward presentation is achieved in the upper window by means of an endless train of fingers or paddle blades which form a chain of compartments into each of which a letter is inserted.

After several steps, each letter reaches a position where it is pushed on to a trap by the paddle fingers and comes into the operator's view. When an operator completes a valid key sequence a code pattern is returned from the translator to the coding desk printing store within 50 ms. The trap opens and the front letter is drawn rapidly down by snatch rollers to drop on to a second trap below. The following letter appears stationary to the operator as it is moved only very slightly forward by the fingers on to the trap which closes to receive it.

Fig. 9 shows a section through the two viewing positions and the paddle. An interlock switch is fitted to prevent operation when the window is open and an overload clutch prevents damage to letters, or to the mechanism, if a jam occurs.

### Cancel Position

Each letter passes from the lower viewing position via a trap and rollers to a cancel position where it settles squarely

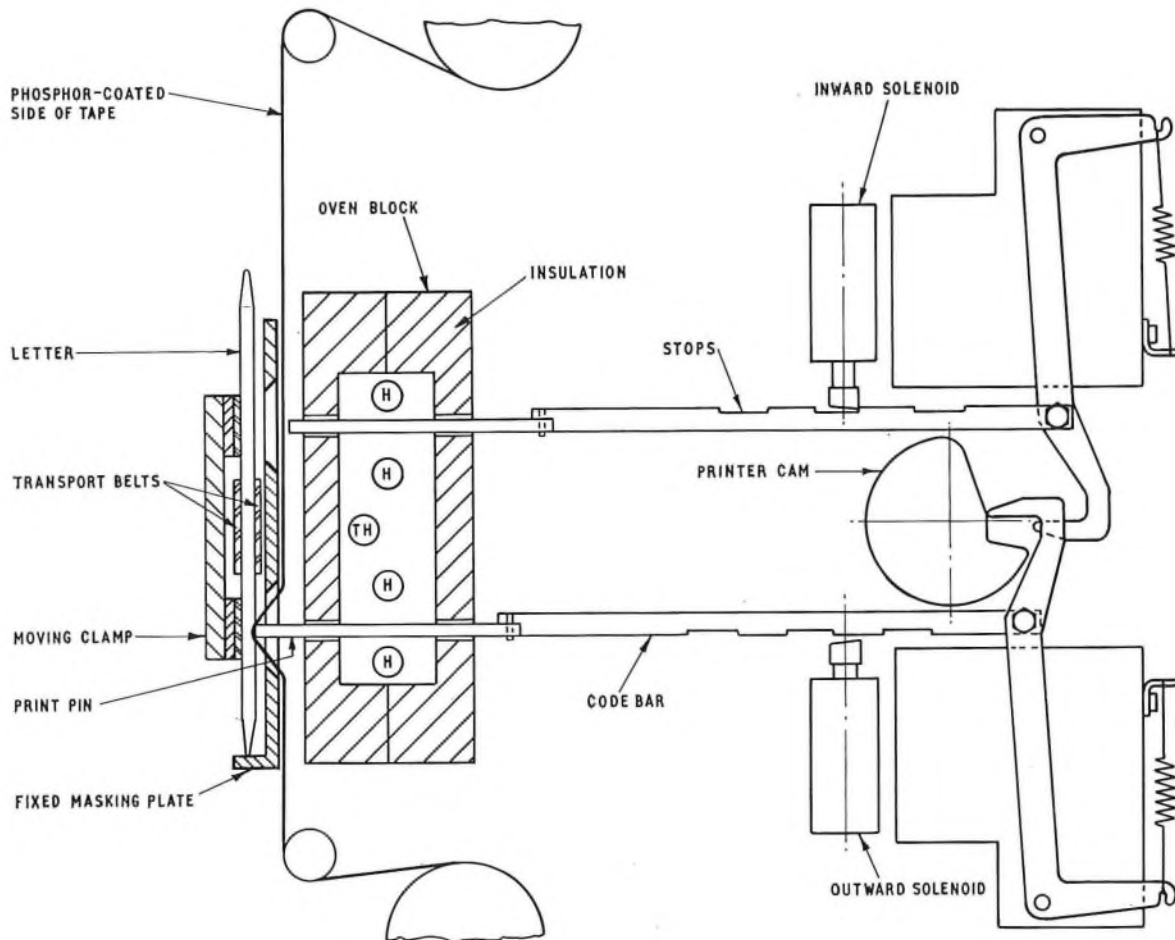


FIG. 10—T-type code-printer unit



FIG. 11—T-type code-printer unit

and remains until the translation for the next letter is received. Should an operator realize that he has made a keying error he can operate the **CANCEL** key and the letter is subsequently directed to the reject box without printing.

When the next translation is received, the letter is pressed against a moving belt by a set of rollers and carried sideways to the printing position. The rollers then retract fully to receive the following letter and the belt is stopped with the former letter correctly positioned for printing.

#### Printer

The printer comprises a selector assembly, a print-pin-and-oven assembly, a paper-tape-feed mechanism, a back-plate assembly, a desk-identification assembly and a temperature-control unit. Figs. 10 and 11 illustrate the unit. The temperature of the print pins is controlled by a solid-state circuit with a sensing thermistor in the oven. A separate close-tolerance thermistor provides external monitoring. As a letter arrives in the printing position, solenoids are energized corresponding to the desired pattern. This unlatches the appropriate print pins for subsequent operation. When the letter is correctly registered, the back-plate assembly clamps it against the printer front plate whereupon the selected hot pins are released by a single-revolution cam, pressing the phosphor-coated printing tape firmly against the letter face and transferring code-marks on to the required positions. On completing its revolution, the cam returns all pins to their rest positions. Although this transfer system is complex, a very clear print is obtained. When print pins and back plate are restored, the letter is free to move away at the start of the next print cycle, and the paper tape is fed on 3/16 in ready for the following cycle. 300 ft of tape, sufficient for 18,000 letters, is contained on each reel. During the printing operation, a visible desk identification is printed on the envelope from an inked ribbon by a metal die similar to that used on a typewriter. This enables missorted and mis-treated items to be traced to the coding desk which processed them so that attention may be given to mechanical failures and keyboard faults. Automatic indexing and drive reversing is provided on the inked ribbon used for the identification print and the die can easily be changed by the machine operator.

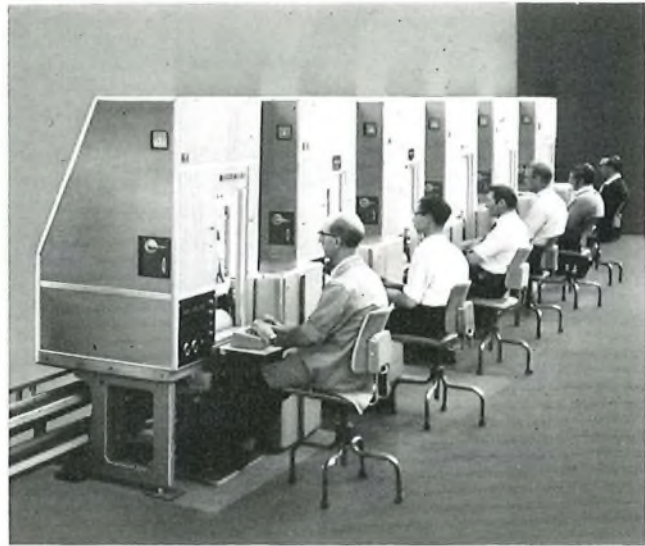


FIG. 12—Coding desks at Norwich

#### Outlet Section

When the desk completes another cycle, the letter passes from the printer to a reject diverter. At this point, any letters that could not be coded because they were misfaced or illegible or were cancelled following a keying error are directed to a reject box at the right of the machine. All other letters pass on to a diverter which separates those for distant delivery from local items. The two outlets eject letters on to flat aggregating belts which collect the outputs from a row of up to eight desks for stacking at the end of the suite.

#### Machine Control

Postal Engineering logic units are used for control of the machine. The electronic circuits may be divided into two categories, namely, information stores and machine control. The information store receives a code pattern from the translator and steps it through as the letter passes from the coding window through the cancel position to the print position when it controls the selection of code pins. This section also determines whether a letter is directed to the forward, local or reject outlets. The machine-control circuits govern operation of the feed stack, arrest the letter in the correct position for printing and give alarms to warn the operator of letter jams. Other circuits ensure correct conditions when the desk is started and stopped, and fault-tracing facilities are provided to aid maintenance.

#### CONCLUSIONS

T5 coding desks have been in daily use at Norwich since August 1967 and process all the POP letter traffic which passes through that office. Fig. 12 shows one row of desks with the associated aggregating output stacker.

Although these desks are giving satisfactory performance, this design has not been chosen as standard and all other mechanized offices are, or will be, equipped with E-type desks. The decision to adopt the E-type desk was made mainly because of the advantages, compared with the T-type, as listed below:

- (a) It occupies less floor space.
- (b) Operators have easy access to the feed stack and so are less frustrated or delayed by jams at this point.
- (c) No windows are required at the presentation positions.



(d) Manufacture is simpler and cheaper since fewer close-tolerance machined components are used.

(e) Machine access is easier.

Several offices, notably Croydon, are already equipped with E-type machines and the national installation program continues.

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# Automatic Calling and Answering of Datel Calls on the Telex Network

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*A recently-introduced equipment that can be installed at a customer's premises enables a customer's data-terminal equipment to originate and answer telex calls automatically for the purpose of data transmission. The usual teleprinter and telex unit may be dispensed with if the customer has no requirement for handling telex traffic manually.*

## INTRODUCTION

It is inherent in the design of the telex network that calls are answered automatically. If suitable equipment is installed at a customer's premises it is possible for a data call to be answered and, upon recognition of a code recommended by the C.C.I.T.T.\*<sup>1</sup> (character No. 19 of the International Alphabet No. 2 received four times in succession(SSSS)) for the line to be diverted from the teleprinter to data-processing equipment.

With the increasing use of the telex network for data transmission, a need has arisen for data-processing equipment to be able to establish outgoing calls without the intervention of a human operator. Data-Control Equipment No. 3A (D.C.E. No. 3A) and the complementary Auto Dial No. 901A have been developed, conforming to C.C.I.T.T. recommendations,<sup>2</sup> to enable this to be done under the control of a suitably-programmed computer. The equipment can be installed in lieu of the usual teleprinter if the user wishes to use the line only for data calls, or it may be installed in conjunction with a teleprinter if normal telex facilities are required as well. If required, the D.C.E. No. 3A may be installed without an Auto Dial No. 901A if it is desired only to answer data calls automatically. Similar equipment<sup>3</sup> has been developed for use on the telephone network.

## DESCRIPTION

Fig. 1 shows the external appearance of the D.C.E. No. 3A. The equipment incorporates a dummy module, which may be replaced by an Auto Dial No. 901A, also shown in the

photograph, to convert the mode of operation from answering-only to calling and answering. The case is finished in two shades of grey and conforms to the Post Office house style for datel equipment; the width is 19½ inches. A novel feature of the case is the use of a toggle-action stay which holds the front cover in either the raised or lowered position. The new design enables customers to gain ready access to certain controls beneath the front cover for fault-identification purposes. A masking plate, which can be seen in the photograph, deters customers from removing modules or tampering with controls and test points to which they are not entitled to have access. Post Office engineering staff can remove the masking plate to gain access to these items.

The D.C.E. No. 3A case is fitted with guides which accommodate 62-type equipment practice modules. The modules that perform logic functions employ double-sided plated-through hole printed-wiring boards on which are mounted dual-in-line diode-transistor logic (d.t.l.) silicon integrated circuits and other components. The power unit is designed for operation from 200–250-volt 50 Hz mains. Two 25-way sockets are provided at the rear for connecting the equipment to data-terminal equipment (d.t.e.), and screw-terminal strips are provided beneath the rear cover for terminating the telex line and other external connexions. Fig. 2 shows the way in which the equipment is linked to the d.t.e. and line, and includes the C.C.I.T.T. names and numbers of the interchange circuits used.<sup>4</sup>

## OUTGOING-CALL OPERATION

The procedure at the interface between the D.C.E. No. 3A and the d.t.e. corresponds as nearly as possible with that used for the D.C.E. No. 1A and D.C.E. No. 2A operating on the switched telephone network<sup>3</sup> except as dictated by the different

† Telecommunications Development Department, Telecommunications Headquarters.

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

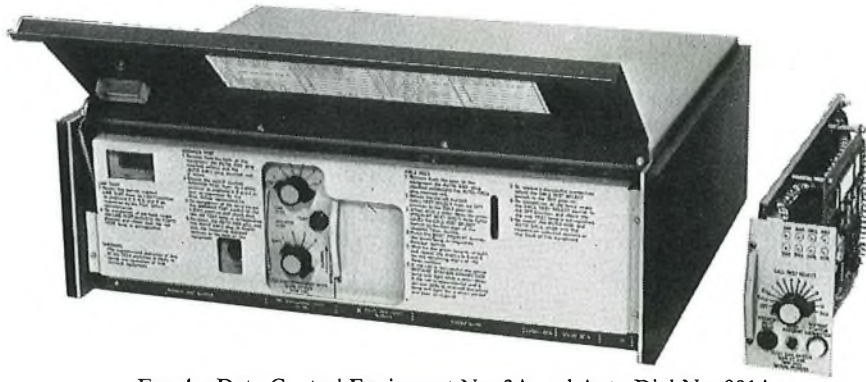


Fig. 1—Data Control Equipment No. 3A and Auto Dial No. 901A

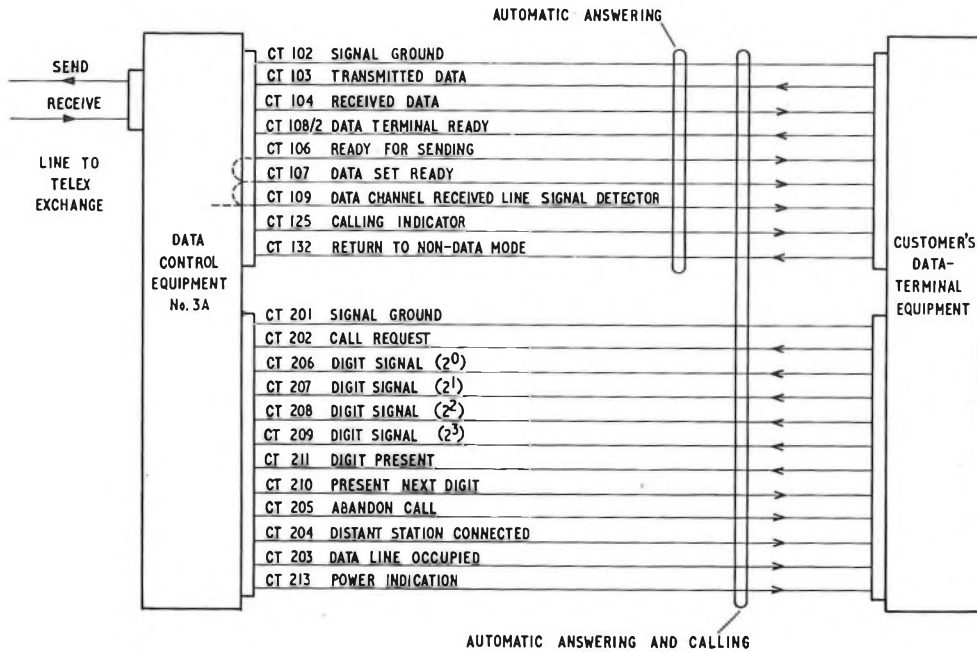


Fig. 2—Interconnexion of Data Control Equipment No. 3A, data-terminal equipment and line

characteristics of the networks, and by the inclusion of a non-C.C.I.T.T. interface procedure for dealing with the dual seizure (head-on-collision) situation.

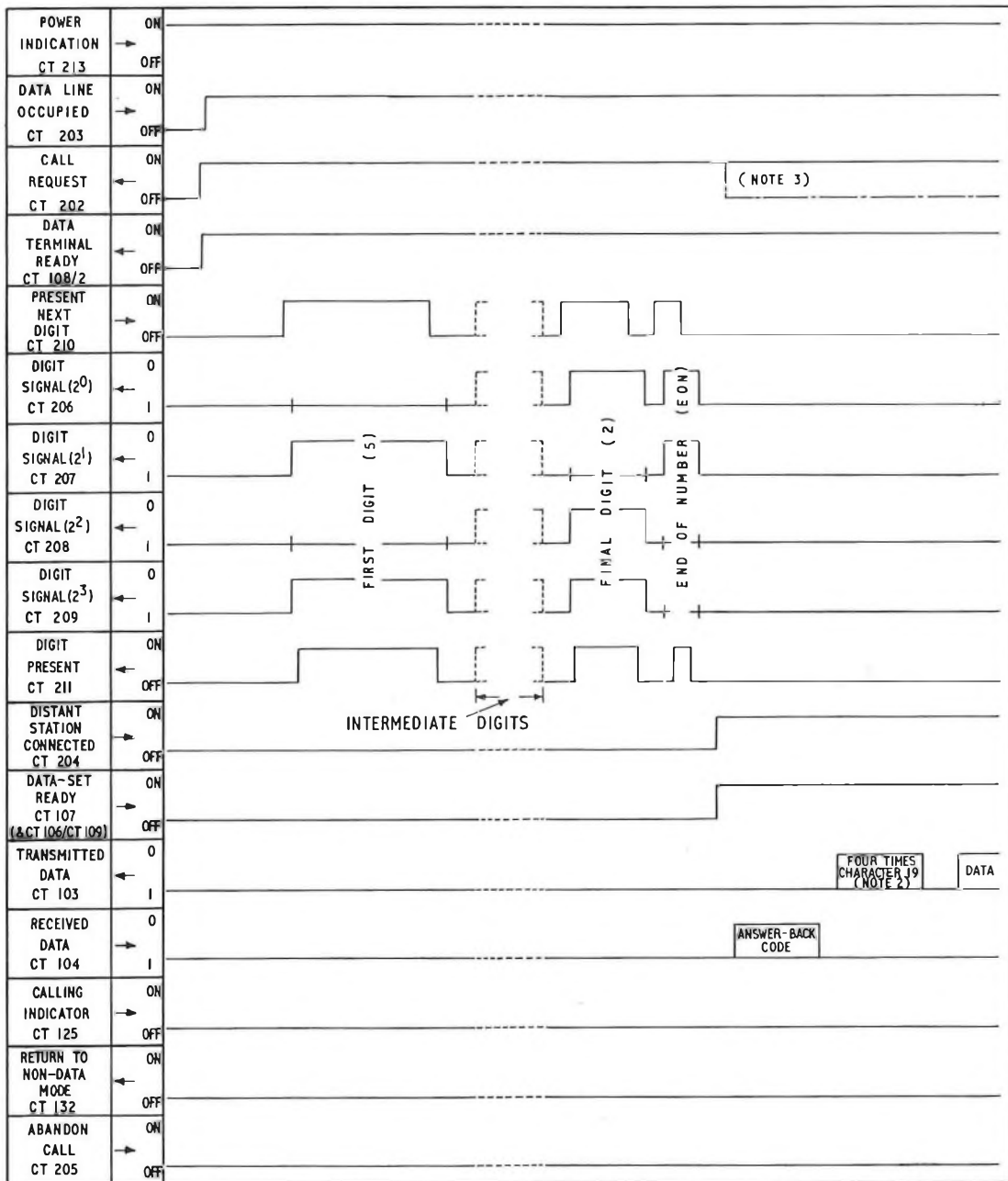
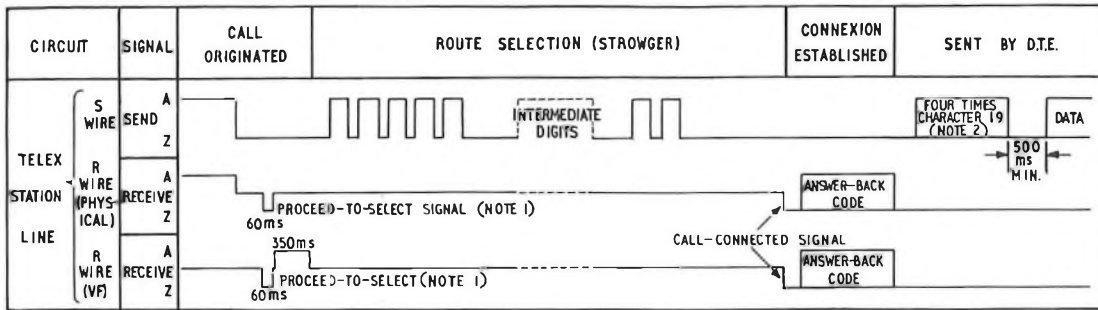
Fig. 3 shows the sequence of signals appearing at the interface between the D.C.E. No 3A and the d.t.e. and on the line during the establishment of an outgoing call. When a call is to be set up, the d.t.e. first turns ON the CALL REQUEST circuit, which has the effect of causing a call-origination signal to be transmitted via the send (S) wire to the telex exchange, which replies with a proceed-to-select signal on the receive(R) wire. The D.C.E. No. 3A recognizes this signal and requests the first digit of the number to be "dialed" by turning on the PRESENT NEXT DIGIT circuit. The d.t.e. presents the first digit in parallel binary form on the four DIGIT SIGNAL circuits and indicates its presence by an ON condition on the DIGIT PRESENT circuit. The D.C.E. No. 3A converts this digit into  $\pm 80$ -volt Strowger pulses for transmission to line and inserts an interdigital pause. This procedure is repeated for the remainder of the digits.

Upon completion of dialling, a call-connected signal will normally be received on the R-wire, causing the S-wire and R-wire of the line to be coupled by means of signal-level conversion circuits to the TRANSMITTED DATA and RECEIVED DATA circuits of the interface with the d.t.e. An answer-back code will be returned by the called station in response to a who-are-you (WRU) signal sent automatically by the originating

exchange. This answer-back code is checked by the calling d.t.e. to ensure that the connexion has been established correctly. It is a feature of the telex network that a period of stop, or Z, polarity, followed by a service code, may be received before dialling is complete. If this happens, the D.C.E. No. 3A will extend the signals to the d.t.e., which must be prepared to interpret them and take appropriate action.

If data are to be exchanged, the d.t.e. transmits a sequence of four No. 19 combinations (SSSS or ''') of the International Telegraph Alphabet No. 2 to indicate the instant of change-over from telex message mode to data mode. The D.C.E. No. 3A recognizes this signal and renders its answer-back generator inoperative. The signal is also recognized at the called station, where appropriate action is taken, either manually or automatically, for the exchange of data. It is necessary to render the answer-back units inoperative before exchanging data, in order to avoid the mutilation of signals that would otherwise occur should the WRU signal happen to be simulated within the data. The D.C.E. No. 3A reverts to telex message mode on clear-down or when the RETURN TO NON-DATA MODE circuit is turned ON.

The initial stages of establishing an intercontinental call are the same as those for a telex call in the United Kingdom, i.e. access to the intercontinental exchange is gained by double-current Strowger routing pulses derived directly from a dial or indirectly from a d.t.e. controlling a d.c.e. On gaining



→ Signalling from data-control equipment to data-terminal equipment  
 ← Signalling from data-terminal equipment to data-control equipment

Notes:

1. Timings shown are typical only
2. Four consecutive characters No. 19 of the International Alphabet No. 2 inhibit the answer-back code generation
3. CALL REQUEST may or may not go off following receipt of the call-connected signal.

FIG. 3—Signalling sequence of outgoing call

access to the intercontinental-exchange equipment, an inversion to stop polarity is received on the R-wire. The D.C.E. No. 3A detects this and switches the DISTANT STATION CONNECTED interchange circuit to ON, effectively connects the S and R wires through to the TRANSMITTED DATA and RECEIVED DATA interchange circuits and changes the DATA SET READY circuit from OFF to ON.

All line signals, with the exception of the answer-back code, are now derived from, and received by, the d.t.e., which must be programmed to generate the appropriate selection signals in International Telegraph Alphabet No. 2 format.

Because of the nature of the telex network, some limits have to be imposed on the data-transmission codes which may be used. For calls within the United Kingdom any modulation rate and code may be used provided the modulation rate does not exceed 50 bauds and the longest duration of start polarity does not exceed 300 ms. This allows the use of both International Telegraph Alphabets No. 2 and No. 5<sup>5</sup> at 50 bauds without restriction. Periods of start polarity exceeding 300 ms are, however, liable to be interpreted by the network as a clearing signal. On international calls the longest permitted duration of start polarity permitted is 140 ms, which precludes the use of the NUL combination in International Telegraph Alphabet No. 5. Some foreign administrations prohibit the use of codes other than the International Telegraph Alphabet No. 2 or its equivalent, and the use of this code is necessary on international routes equipped with time-division multiplexing, error-correcting or regenerative-repeater equipment. This type of equipment restricts the modulation rate to 50 bauds and a 5-unit start-stop format must be used.

After a call has been set up, the connexion is maintained by an ON condition applied by the d.t.e. to the DATA TERMINAL READY circuit, and the connexion can be released by turning the circuit OFF momentarily. This results in the transmission of a continuous start polarity on the S-wire to clear the connexion. When the exchange equipment has cleared, a clear-confirmation signal is received on the R-wire to cause the DISTANT STATION CONNECTED and DATA LINE OCCUPIED circuits to be turned OFF by the D.C.E. 3A. When the distant station clears first, the D.C.E. No. 3A receives a clearing signal and returns a clear-confirmation signal on its S-wire.

Due to chance and to system delays, it is possible for outgoing and incoming calls to occur simultaneously (dual-seizure) at a telex terminal equipped with data-control equipment. As with a normal telex station, it is intended that an incoming call should have precedence, and this is effected by the D.C.E. No. 3A in the following way. An outgoing call is commenced when the d.t.e. turns ON the CALL REQUEST circuit. If followed by the ABANDON CALL and CALLING INDICATOR interchange circuits going to ON, this indicates dual-seizures and the d.t.e. should turn the CALL REQUEST circuit to OFF. The d.t.e. call-answering program should then be initiated and the DATA TERMINAL READY circuit turned ON within 2 seconds of the CALLING INDICATOR circuit going to ON. Failure to follow this procedure will result in the calling subscriber receiving the answer-back code sequence followed by ABS and a clearing signal.

### INCOMING-CALL OPERATION

A conventional telex terminal can behave in either of two ways when called. If the terminal is available to receive a call, the call is answered whether the terminal is attended or not and the terminal's answer-back code returned automatically from the teleprinter in response to a WRU signal from the originating exchange. If the terminal is not available to receive a call, for example because its power supply has been turned off, the absence of line current from the terminal causes the local exchange to return the subscriber absent code (ABS) to callers.

A terminal incorporating a D.C.E. No. 3A behaves similarly,

but can also respond in a third way. If the power supply of the D.C.E. No. 3A is switched on but the customer's terminal equipment fails to respond to an incoming call within 2 seconds, the d.c.e. will transmit the answer-back code followed by ABS and a clearing signal. The circumstances when this is likely to happen are when the customer's terminal equipment is overloaded and is unable to respond quickly. The caller will be charged a unit call fee because as far as the Post Office is concerned such calls are successful and information concerning the state within the terminal has been obtained by the caller.

Fig. 4 shows the sequence of operations when an incoming call is answered. The D.C.E. No. 3A responds to the stop-polarity calling signal received on the R-wire by returning a stop-polarity call-connected signal on the S-wire. It also turns ON the CALLING INDICATOR and DATA LINE OCCUPIED circuits to the d.t.e., which must respond, if the call is to be answered, by turning ON the DATA TERMINAL READY circuit within 2 seconds if it is not already ON. When the WRU signal is received from the telex exchange it is recognized within the D.C.E. No. 3A, which then transmits its answer-back code on the S-wire. At the end of the answer-back transmission the S-wire and R-wire are extended, via signal-level conversion circuits, to the TRANSMITTED DATA and RECEIVED DATA interchange circuits, respectively, and the DATA SET READY circuit is turned ON to indicate that the d.t.e. will shortly receive telegraph signals. If the calling station is about to send data which may contain the WRU signal it will first send a sequence of four consecutive combinations No. 19 of International Telegraph Alphabet No. 2, as previously explained, to inhibit the answer-back generator.

### EQUIPMENT DESIGN

A number of novel features have been incorporated in the design of the equipment.

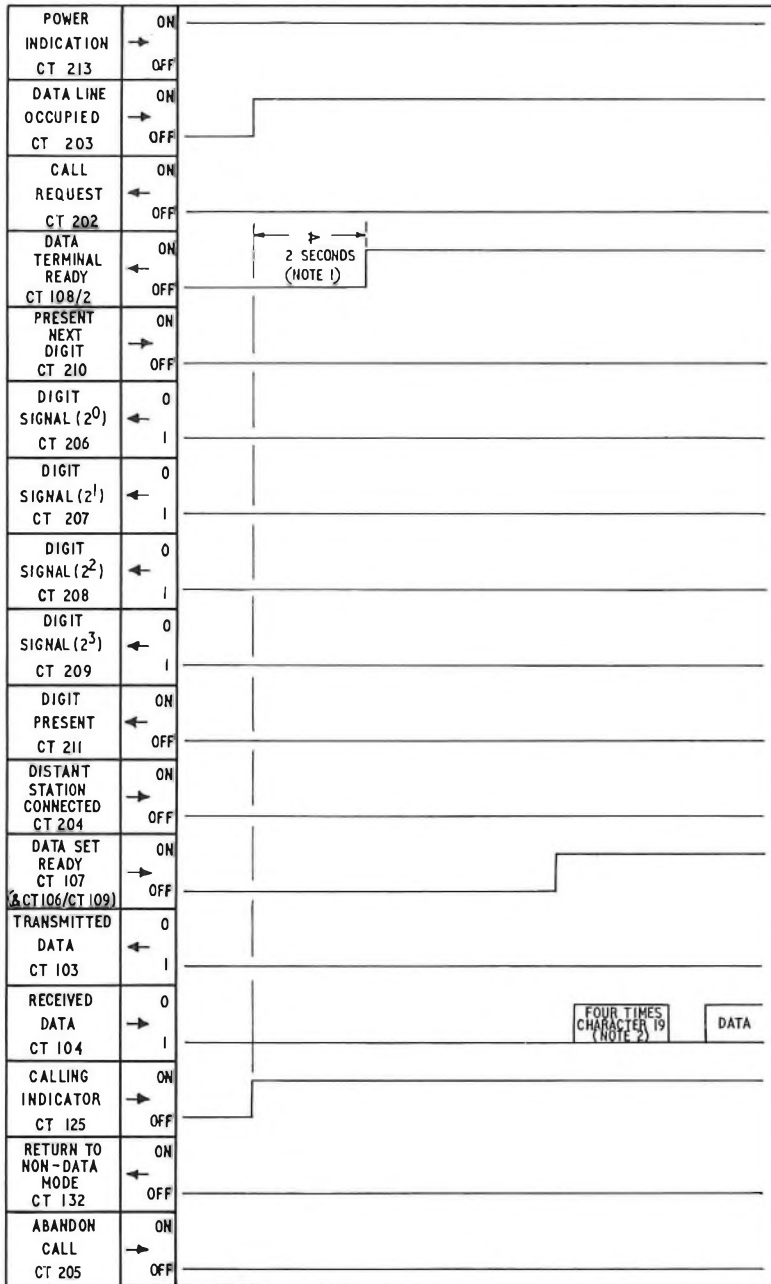
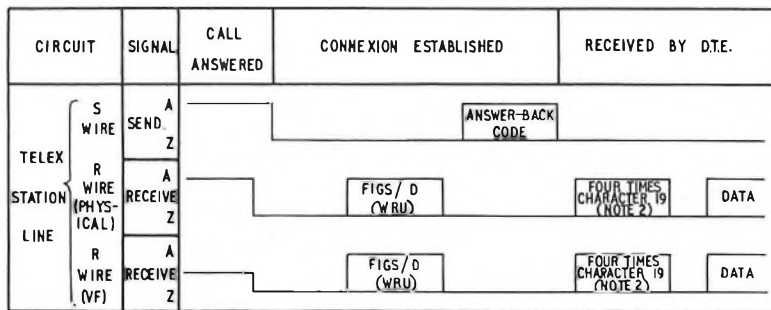
#### Answer-Back Generator

The answer-back and ABS character sequences are generated by a module known as a Coder No. 4A. The code elements are stored in the form of hole/no-hole positions in a removable, optically opaque, polystyrene disk. The non-variable information is inserted into the disk by the supplier, and it is only necessary for the installer to make further holes, in appropriate positions, for the customer's answer-back code sequence to be effected. A coder and code disk are illustrated in Fig. 5.

So as to minimize the number of holes to be made in the disk when setting up the answer-back characters, and to prevent the unintended incorporation of the all-space character (combination No. 32), the equivalence between hole or no hole and start or stop potential has been reversed compared with that usually employed in telegraph communications. This causes LETTER SHIFT, the C.C.I.T.T. recommended fill-in character, to be transmitted to line when a column of no-hole positions exists, thus leaving only columns containing characters other than LETTER SHIFT to be perforated.

In addition to the five tracks of hole positions for code elements, a sixth track, prepared by the suppliers, is provided for control purposes and serves to identify the two sectors occupied by the answer-back and ABS sequences.

The codes stored on the disk are read optically, the holes being illuminated by four 28-volt, long-life, lamps; silicon photo-diodes are used for sensing. To prolong their life, the lamp filaments are maintained at cherry-red brightness until receipt of a WRU signal causes them to be operated at 24 volts for the duration of answer-back code transmission. A glass diffuser is fitted between the lamps and the disk; this enables the equipment to function correctly even when one of the lamps is extinguished. A viewing window is provided in the masking plate to enable maintenance staff to check for lamp failure before the equipment becomes unserviceable. The



→ Signalling from data-control equipment to data-terminal equipment  
 ← Signalling from data-terminal equipment to data-control equipment

Notes:

1. If data-terminal equipment is to be connected to line, CT 108/2 must be ON within 2 seconds of CALLING INDICATOR (CT 125) going ON
2. Four consecutive characters No. 19 of International Alphabet No. 2 inhibits the answer-back code generation

FIG. 4—Signalling sequence of incoming call

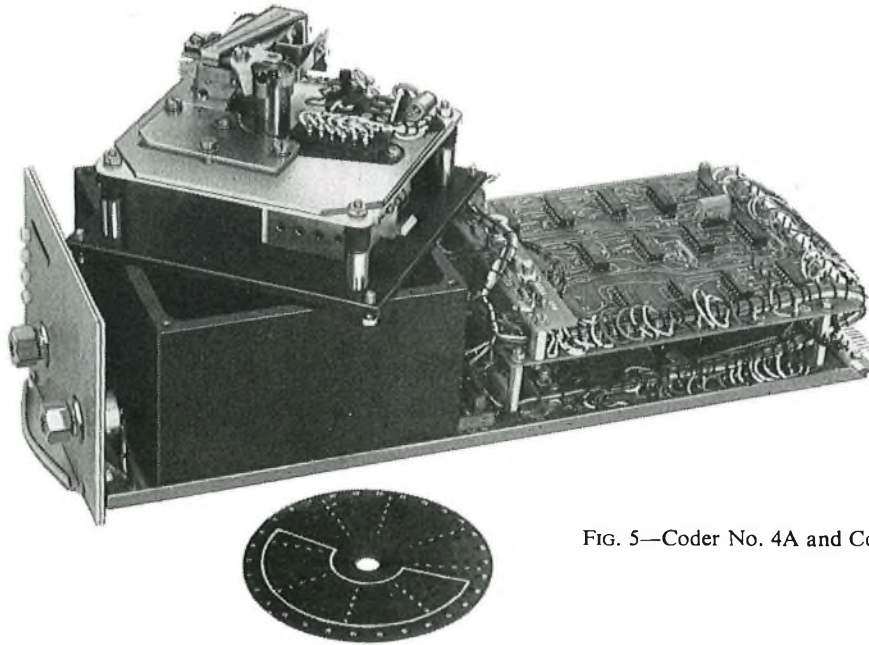


FIG. 5—Coder No. 4A and Code Disk No. 1A

mechanism of a 30-point uniselector is used to step the code disk as required, the disk and mechanism being mounted on resilient mountings inside a cast-aluminium box. This arrangement results in the equipment being quiet in operation.

#### Signalling Power Supply

The transmitted line signals from the D.C.E. No.3A are connected by a mercury-wetted contact relay, which is supplied with current from +80-volt and -80-volt supplies derived from the power unit. The most commonly used method of limiting current under fault conditions is to supply the contacts of such a relay via either a twin-filament, or two single-filament, ballast resistors. This method was investigated in the early design stages of the equipment, but was abandoned because of the difficulty of mounting the ballast resistors in a position where the heat they would generate under fault conditions could be safely dissipated. Under relay-contact-bunching conditions the power dissipated could be more than 16 watts. The design adopted utilizes an electronic circuit in the power unit to give a regulated 80-volt supply for a load up to 30 mA. The current is limited to about 47 mA under short-circuit conditions compared with about 115 mA with a ballast resistor. Thus, the power dissipated under fault conditions is much reduced.

#### Dialling Pulse-Ratio Selection

The Auto Dial No. 901A is suitable for use in a D.C.E. No. 1A<sup>3</sup> on the telephone network or a D.C.E. No.3A, without modification or adjustment once it has been correctly set up, even though the pulse ratio is different for the two applications. The pulse timing is derived from a multivibrator, and when the auto dial is plugged into a D.C.E.No. 3A, part of the resistor chain associated with one charging circuit of the multivibrator is short-circuited by a strap between two pins on the connector, so that a start potential to stop potential pulse ratio of 60 : 40 is given. Different pins are strapped on the connector in a D.C.E. No. 1A, so that when a dial unit is used in this equipment a resistor in the other charging circuit of the multivibrator is short-circuited, thus giving the required  $66\frac{2}{3} : 33\frac{1}{3}$  break-to-make ratio which is appropriate for the telephone network. In both equipments the pulse-repetition rate of the multivibrator is 10 pulses/second.

#### TESTING

Comprehensive testing facilities are provided to enable line tests and functional tests to be carried out. Line tests can be carried out remotely by Post Office staff with the co-operation of the customer, who would be asked to operate the LINE TEST switch to each test position in turn. The test conditions applied to line are shown in the table.

#### Test Conditions Applied by Line Test Switch

Switch Position	Test Condition
2	Open circuit
3	S-wire and R-wire looped
4	S-wire earthed and R-wire disconnected
5	R-wire earthed and S-wire disconnected
6	Spare position

Functional tests may also be carried out remotely by Post Office staff with the co-operation of the customer, and require the use of another telex station from which to establish calls to or from the D.C.E. No. 3 under test. The d.c.e. should be disconnected from the customer's terminal equipment before commencing tests in order to avoid misleading results. If a test call is made to the d.c.e. from another telex terminal, the d.c.e. will behave as described below when the ANSWER TEST switch is set to one of the test positions.

*Position 2:* In Test Position 2 an ON condition is applied to the DATA TERMINAL READY interchange circuit to simulate the customer's terminal equipment being ready to accept a call. When a test call is made to the d.c.e. it should respond with an answer-back code. A sequence of four combinations No. 19 transmitted to the d.c.e. should render the answer-back generator inoperative, and this can be confirmed by transmitting a WRU signal several times and confirming that no answer-back code is returned.

*Position 3:* In Test Position 3 an OFF condition is applied to the DATA TERMINAL READY interchange circuit to simulate the customer's terminal equipment not being ready to accept a call. A test call under these conditions should give rise to the answer-back code followed by the ABS code and clear-down of the circuit.

*Position 4:* The test conditions selected by Test Position 4

are similar to those of position 2, but additionally the RECEIVED DATA and TRANSMITTED DATA circuits of the interface are looped. This allows a call to be set up and data signals to be sent round the loop to confirm that the transmission path is complete and that excessive distortion is not being introduced. It is essential that this type of test should be done only under the supervision of Post Office engineering staff because the results can be misleading. For example, if the test is done from a telex station producing a local record, a garble or double printing will occur depending on the propagation time of signals round the loop. Furthermore, if the tested and testing stations are far apart, the limits for satisfactory transmission could be exceeded on the loop path, since the d.c.e. reconstitutes but does not regenerate the signals.

When an Auto Dial No. 901A is fitted, a connexion may be established to any telex station using the call-test facility. Rotation of the CALL TEST SELECT switch to the CALL position initiates an outgoing call in the normal way by simulating a CALL-REQUEST interchange ON condition. Receipt of the proceed-to-select signal from the exchange lights the PRESENT NEXT DIGIT lamp (green), whereupon the CALL TEST SELECT switch is rotated to select the first digit of the required telex station number. The DIGIT PRESENT button is then operated, causing the pulse train to be transmitted to line, and the PRESENT NEXT DIGIT lamp to be extinguished. At the end of the intertrain pause the PRESENT NEXT DIGIT lamp again lights.

The CALL TEST SELECT switch is then rotated to the next digit position, and the same procedure repeated. When a call has been established, the DISTANT STATION CONNECTED (white) lamp is lit and the called station may proceed with caller identification and functional checks. Should the calling station encounter a service code whilst attempting to establish a call, the PRESENT NEXT DIGIT lamp is inhibited and the DISTANT STATION CONNECTED lamp lights for the duration of the code signal and is then extinguished, following receipt of the clearing signal.

The answer and call test facilities effectively simulate the d.t.e. originated interchange conditions indicated in Fig. 3 and 4, therefore the test results at a remote terminal, e.g. test desk, are a strong indication of the operational state of the D.C.E. No. 3A.

To indicate that the D.C.E. No. 3A is in a test mode, and to minimize the possibility of any test switches being left in other than the normal operational setting, a red TEST lamp lights whenever any test switch is rotated from its OFF position.

#### AVAILABILITY AND USE

A number of D.C.E. No. 3A are in customer service. A time-sharing computer bureau was the first to use the equipment to enable telex customers to have access using their telex installations. It is likely to be necessary for telex stations making use of a bureau in this way to have means for disabling their local record; the equivalent record would then be given by signals returned from the bureau. This enables a user to confirm the correct receipt of his signals at the bureau. Other uses for the equipment are likely to be connected with those organizations offering specialized computer-based services, e.g. insurance and seat-reservations.

#### ACKNOWLEDGMENT

The Data-Control Equipment No. 3A was developed to British Post Office Specifications by Trend Electronics, Ltd.

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- <sup>3</sup> BOTT, A. J. and CASTLE, W. C. Automatic Calling and Answering for Datal Services. *P.O.E.E.J.* Vol. 63, p. 253, Jan. 1971.
- <sup>4</sup> BOTT, A. J. Interfaces for Digital Data Transmission. *P.O.E.E.J.* Vol. 63, p. 113, July 1970.
- <sup>5</sup> CHESTERMAN, D. A. International Telegraph Alphabet No. 5. *P.O.E.E.J.* Vol. 62, p. 89, July 1969.

## Book Reviews

"Dictionary of Telecommunications." R. A. Bones, B.Sc., A.C.I.S., C.Eng., M.I.E.E., A.Inst.P. Newnes Butterworth, vii + 200 pp. 104 ill. £2.25.

As the author says in his preface, the majority of the terms and definitions in this book are either reproduced from, or based on, those in British Standard (B.S.) 204 (1960). The aim of the work is said to be the documentation of the developing language of telecommunications but very few terms dealing with modern techniques have been added to the material taken from the Standard. Some of the definitions given are out of date. Thus, one of the definitions for "Binary Digit" is given as "The amount of information described by a single either-or decision"—a concept to which the term Shannon is now applied. Similarly, the definition for "Black Level" includes the statement "In the British Television system black level is 30 per cent of the maximum carrier amplitude".

The terms are presented in alphabetical order, those consisting of two or more words being cross-referenced with the definition appearing—it is said—under the most significant word. This leads to the definition for time-base appearing under "Base (Time)" and that for coil loading appearing under "Loading Coil", i.e. the technique is defined under the term for the device. Alphabetical presentation also

results in the association under generic headings of terms used in widely different contexts, sometimes with confusing results. The logical grouping adopted in international glossaries and British Standards has much to recommend it.

Some of the terms are accompanied by explanatory drawings, graphical symbols or circuit diagrams. In a book published in 1970 it is strange to find a sketch of a triode valve with a five-pin base and another depicting a directly-heated cathode structure. No constructional drawings for semiconductor devices are given, however, and indeed the book includes only about half-a-dozen terms concerned with this subject. Valves rather than transistors are also shown in the circuit diagrams. Some of the symbols used have been superseded by those in B.S.3939. The symbols for contact units are shown in the operated position, which does not accord with normal drawing practice or the guiding principles of B.S.3939. The ones shown under the definition of a telegraph key are actually the symbols for telephone switchboard keys. There are also quite a number of editorial errors in this edition including the omission of some complete lines.

In summary the work adds little to the British Standard and cannot really be recommended to the serious student.

S. J. A.

# An Experimental Design for a Telephone for Noisy Locations

K. A. T. KNOX, B.SC.(ENG.), C.ENG., M.I.E.E.

U.D.C. 621.395.721.1.001.5; 534.83; 628.517.2

*The standard telephone instrument is not very efficient in noisy locations. An experimental telephone has been designed, therefore, to offer easy telephone conversation in most of the noisy situations commonly encountered. To be economically viable this instrument would need to be produced in fairly large numbers in microcircuit form. However, there are now known customer objections to the use of voice-switched instruments under normal or less noisy conditions. This has restricted the potential penetration of this instrument. This article sets out the reasons why such an instrument is required, explains the principles of voice switching and describes the circuit operation of this telephone.*

## INTRODUCTION

The ordinary handset telephone is not designed for use in very noisy environments. Though it is much more expensive than the standard instrument, the experimental telephone circuit described in this article offers a technical possibility of telephone conversation in some very noisy situations where this is now impossible.

## ACOUSTIC NOISE

Acoustic noise interferes with telephone communication in the following ways:

- (a) noise reaching the free-ear masks received signals,
- (b) noise picked up by the telephone transmitter appears in the receiver as sidetone, and
- (c) the noise referred to in (b) is also conveyed to the distant correspondent, superposed on and intermodulated with the speech, by the non-linear characteristics of the transmitter.

These difficulties are emphasized if the connexion has high attenuation: at present, the end-to-end loss may amount to 47 dB, though it is planned to reduce this limit to 40 dB.<sup>1</sup>

Noise-cancelling microphones can provide up to 15 dB of discrimination between close-talking speech and distant noise sources, but do nothing to reduce the effect of noise on the free ear. Amplification of the received signals is needed, and should desirably be adjusted in accordance with the prevailing noise-level. To avoid risk of instability and to limit sidetone, loss must at the same time be inserted into the transmit path. These operations can be performed by a *press-to-talk* switch, but with obvious inconvenience to the user, so telephones with speech-controlled send and receive sensitivities have been designed. Previous attempts have had some limited success in coping with ambient noise up to +85 dB (C) (see Appendix 2) at most. The design described in this article has proved usable in laboratory noise fields in excess of +100 dB (C). At this level, direct person-to-person conversation is virtually impossible.

## VOICE SWITCHING

Voice-controlled switching is already familiar in such devices as echo-suppressors and loudspeaking telephones. In a loudspeaking telephone it is usual for the receive path to be normally connected and for switch-over to the send path to occur only when the signal to be transmitted exceeds a specified threshold. While on send, the receive path is attenuated (so that the sidetone is reduced) and, when the transmitted

signal ceases, the circuit reverts to the original state after a prescribed delay period (the hangover time) typically 210 ms–250 ms (see Appendix 1). The technique clearly imposes the necessity to accept, at any one time, significant attenuation in either the send or receive path. At the 2-wire outlet it is not possible, in practice, to distinguish, by means of a speech detector, between outgoing and incoming signals. Thus, satisfactory operation can be achieved only with the speech detector operated solely from locally-generated signals. With high values of switched attenuation, this has a number of disadvantages. Firstly, the distant user is unable to break in while the local-user of the voice-switched device is talking. Secondly, the former is frequently aware of the disappearance of the background noise during the latter's speech pauses. Less serious are the difficulties faced by the local talker. Under quiet conditions he will be aware of the removal of the received signals on speaking and of the absence of sidetone which otherwise can assist him in pitching his voice at the right level.

If a 4-wire circuit was available to the telephone, many of these problems would be eased, as the "go" and "return" signals could be separated. This advantage is of course already made use of in echo-suppressors.

The difficulties of voice-switching can be minimized, where circumstances permit, by restricting the magnitude of the attenuation which is applied alternately to the send and receive paths. So-called shallow voice switching, involving attenuations of 10 to 15 dB in each path, is currently regarded as the preferred approach in the special circumstances that enforce voice-switching at the subscriber's location. Unfortunately, with an instrument destined for use in noisy situations, the large receive amplification (up to 30 dB) necessary to counter high background-levels necessitates deep voice-switching. Consequently, when the telephone is used in high-noise conditions, the distant user will be acutely aware of the variation in background as the local voice-switch operates. In the circuit to be described, this disturbing effect has been minimized by shaping the low-frequency response of the speech microphone. Clarity of the transmitted speech has not been impaired although slight recognition difficulties could arise with some talkers.

## PERFORMANCE IN A VARIABLE NOISE ENVIRONMENT

A self-evident requirement of a noisy-situation telephone is that it will function under quiet conditions without the user having to raise his voice. This implies that the voice-switch threshold setting referred to earlier must, like the receive path gain, be related at all times to the level of the environmental noise. Automatic variation of these two

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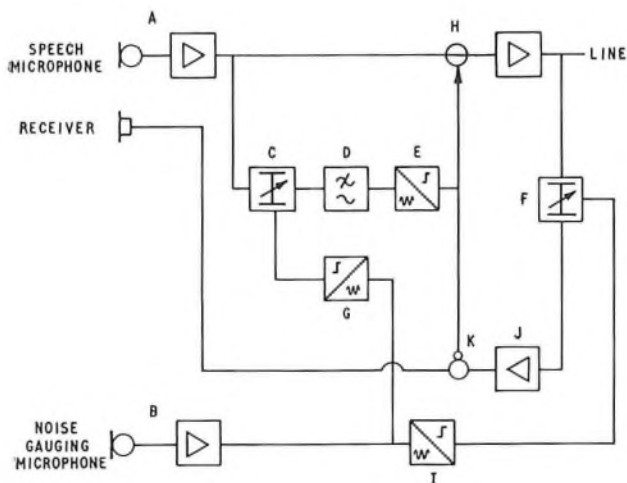


Fig. 1—Block diagram of the functional units of the telephone

important parameters has been achieved in the present design by a control signal derived from a second microphone, responsive to noise. The range of control needed was determined by preliminary free-conversational tests made with various levels of room-noise. Correct voice-switching should, therefore, be obtained with the voice pitched naturally against noise backgrounds of up to +104 dB (C) and blocking of the receive channel owing to misoperation of the voice-switch by noise should be minimal.

#### APPLICATION OF SWITCHING PRINCIPLES

A block diagram of functional units to achieve a practical interpretation of the above switching principles is shown in Fig. 1.

Two linear microphones are used. Microphone A is mounted in the handset in the normal way and picks up both speech and background noise. Microphone B is termed a gauging microphone and is so positioned as to favour background pick-up. After amplification, the noise signals from the gauging microphone are applied to a.c./d.c. converters G and I which provide the control currents for variable attenuators C and F respectively. Element C, linking speech-signal amplifier A with speech detector E, serves as the automatic threshold-control which enables the telephone to work satisfactorily against a variable background-noise level. Attenuator F adjusts the received signal level in accordance with the ambient noise. The low-pass filter D confers a useful degree of discrimination between speech and most types of background noise, enabling the instrument to function in an ambient noise 15 dB higher than otherwise. Elements H and K are linear transmission gates switched in complementary mode by the speech detector E.

#### CIRCUIT OPERATION

In the circuit diagram (Fig. 2) the letters correspond to the functional elements shown in the block diagram (Fig. 1).

The complementary symmetry pair of transistors, TR5 and TR6, provide unidirectional current pulses which charge capacitor C12 and capacitor C13 to potentials which are functions of the ambient noise. The resulting d.c. flowing through the rectifier elements D1 to D8 defines the a.c. impedances to set the receive gain appropriately (by shunting resistor R24) and the threshold (by attenuator action with resistor R42). The variable attenuators are assembled from inexpensive selenium rectifiers of the type used in the 700-series telephones as volume regulators operated from line current. These embody "double-voltage" disks found by extensive measurement to give, at small direct currents (up to 300  $\mu$ A),

a consistent forward incremental impedance/current characteristic suitable for the control function.

The speech detector E comprises transistor stages TR9 to TR12, with provision on the first interstage coupling (P2) for the threshold sensitivity to be pre-set on manufacture. Transistor stages TR10–TR12 function as a charge amplifier during the turning on of the detector and as a current amplifier subsequently. In the absence of an input all three transistors are non-conductive. Thus transistor TR13 and transistor TR14, which together with resistors R43 and R45 constitute the transmission gate H, have a low impedance ensuring heavy attenuation (by at least 75 dB) of the speech signals. When the positive peaks of the signal at the base of transistor TR10 exceed the offset voltage, the transistor momentarily conducts, discharging the shunt capacitor C31. The recharging current of this capacitor flows in the emitter-base junction of transistor TR11 causing capacitor C34 to be discharged and transistor TR12 to be heavily saturated within a few hundred microseconds of initiation. Thus, although the low-pass filter D will introduce a delay in the switching action when "soft" consonants are poorly enunciated, the time to switch on should generally be well below the desirable maximum of 5 ms. With the change in potential at transistor TR12 collector, heavy attenuation is applied to the receive path (by transistor TR15 and via diode D11) while the transmission gate H allows signals to pass to the line-drive transistor TR16. The attenuator switching action has an incorporated dead-space, essential for stability, such that transistors TR13 and TR14 turn off after transistor TR15 and diode D11 commence to conduct, and turn on before transistor TR15 and diode D11 restore to their high-impedance state. These delays arise from the shape of the waveform appearing at transistor TR12 collector and the method adopted for driving these gates.

The purpose of the diode combination D9 and D10 in the negative-feedback path of the receive amplifier is to restrict the loudness of local calls. The power supply, derived from the line current, is conventional but, owing to the operating requirements of the selenium rectifiers in the automatic control circuit, needs a higher voltage than would otherwise be necessary for an electronic telephone. As a consequence, the use of this telephone is limited, on account of minimum signalling current requirements (26.5 mA), to lines where the loop resistance does not exceed 800 ohms. This is not considered to be a serious disadvantage since 99.5 per cent of coin-box lines in the Post Office network are within this category.

#### PERFORMANCE

The instrument performs satisfactorily in both noise (see Appendix 2) levels up to 98 dB(A) or 104 dB(C) on a limiting connexion under laboratory conditions. In field trial it has been used successfully on poor circuits in noise up to at least 96 dB(C). It is believed that the upper limit of operation in noise has been set high enough to deal with most types and levels of background encountered in buildings and their environs.<sup>2</sup> It should be remembered that the most recent proposals on hearing protection set an upper limit of 90 dB(A) for continuous (40 hour/week) exposure to wide-band noise. With the higher noise intensities quoted above, it would be desirable for users to provide themselves with ear protection where exposure is likely to exceed about 15 minutes per working day.

At noise levels somewhat below the extreme values for which the present circuit has been designed, most users would probably find that the disadvantages of voice switching outweigh the advantages offered by the elimination of noise heard via the sidetone path.

As arranged, the circuit is intended for use in conditions of relatively steady noise, the accommodation time-constant

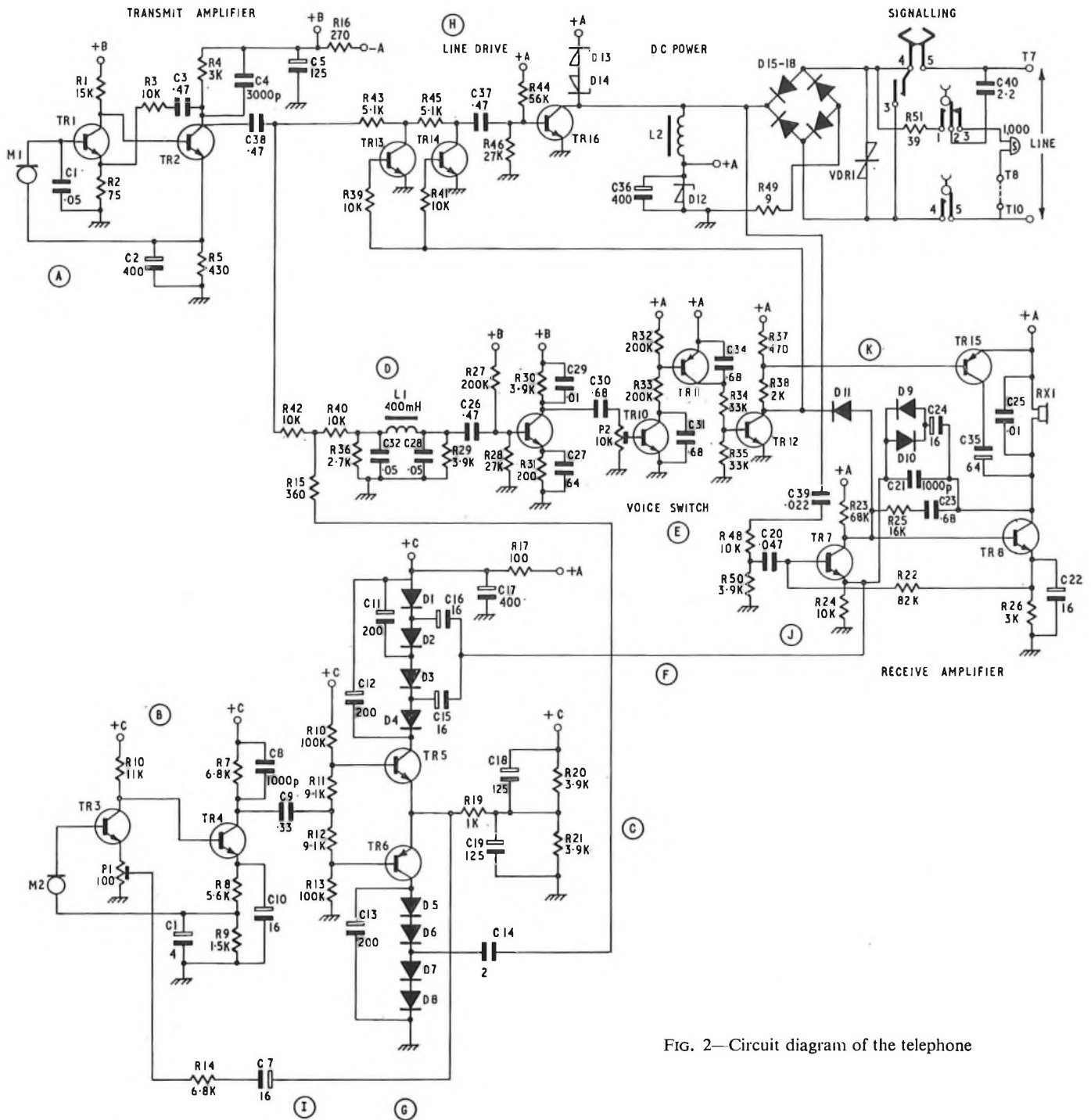


FIG. 2—Circuit diagram of the telephone

**ACKNOWLEDGEMENTS**

Appreciation is recorded of the co-operation of Mr. W. J. B. Stephens with circuit design and associated laboratory work and of the contribution made by Mr. H. W. Fensom in measuring objective performance.

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to a higher noise level being 500 to 750 ms and the recovery time-constant around two seconds. In situations where the background level fluctuates rapidly, but not impulsively, provision could be made for a faster control action. One of a number of possible modifications would be to replace capacitor C13 (200 μF) with two smaller capacitors (25 μF) and a resistor to form a pi-section resistor-capacitor filter which would then become necessary (with the reduction of the time-constant resistor R19 and capacitor C13) to prevent ingress of noise signals into the path being controlled.

In its present form the design is not suitable for use in transient noise. A solution here might be to utilize a noise-cancelling microphone in a standard hybrid circuit.

## APPENDIX 1

Some of the objections to deep voice-switching would be removed if it were possible to devise a switching system in which the receive path attenuation characteristic followed either the instantaneous excursions or, alternatively, the fine structure or envelope of the transmitted speech waveform. It would then, in principle, be virtually impossible for each subscriber to detect any constraint placed on the free interchange of speech. Unfortunately, owing to electrical and mechanical memory (resonance) effects and air-path delays, such a technique is not practicable and, to avoid instability, it is necessary to delay reversion for an appropriate period. To satisfy stability criteria this need be only a few milliseconds, but for the transmission of speech, the hangover requires to be considerably longer—between 180 and 300 ms depending upon circumstances.

The reason lies in the complex nature of the speech waveform and in the silences within utterances (for example, those found in words such as REST, START and PERHAPS) which are commonly-occurring features of phonetic element structure (Fig. 3(a)). If the

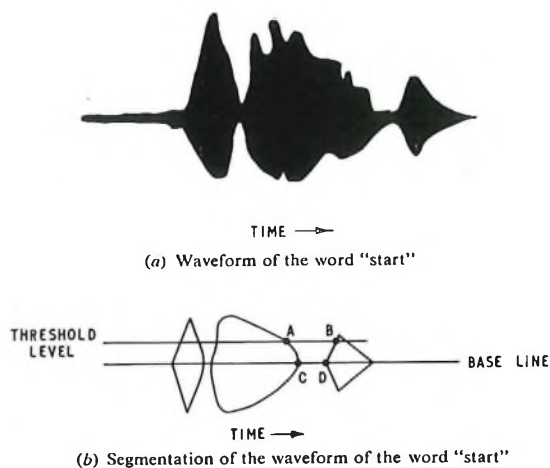


FIG. 3—Diagrams illustrating the complex nature of the speech waveform

transmitted speech is to have an acceptable quality, these structural silences must be accurately preserved; in particular, spurious extension must be avoided. Complicating the effect that these silences (termed closures or plosives) may have in determining the hangover time is the practical need to incorporate a threshold such that background noise peaks, at a level perhaps 15 dB below the level of the mean power of the speech, do not operate the voice-switch. From the segmented waveforms, the effective gap, relevant to the operation of the voice-switch, can be seen to depend upon the level chosen for the threshold. In the example (Fig. 3(b)) the closure C-D referred to the base is about 75 ms, but with a threshold defined by A-B the effective silence is more than 100 ms. Significantly, the final consonant has a much lower energy than the main element and, if diction is poor, may lie entirely below the threshold level. The time-out of the voice-switch commencing at point A will not then be re-started at B as implied in the Figure. It may be concluded that, if distortion owing to premature operation of the

switching circuits is to be avoided, the hangover time must always be related to the maximum threshold setting. The refinement of a variable hangover time optimized for the instantaneous threshold setting was not considered to be justified with this telephone and, instead, a fixed hangover of 230 ms nominal was adopted. This is sufficient to avoid distortion arising from the above cause without imposing undue demands on conversational discipline.

## APPENDIX 2

Noise figures obtained from published tables cannot be relied upon to give other than a very general indication of the levels to be expected. Prior to installing an instrument such as this in very noisy places, it would be prudent to conduct a sound survey. Since this can yield very misleading results, unless the correct precautions are taken, the following observations may be of value. The main difficulty arises from the desire to obtain a single figure from an objective measurement which accords with the subjective impression of loudness formed by a listener, irrespective of the type of noise. Two entirely different noise sources could, however, yield grossly different sound-level meter readings simply on account of differences in their frequency spectra whilst a listener judged them as equally loud. Other differences exist, e.g. in time structure (impulsive noise and steady noise) and complex, but expensive, types of instrument have been built to overcome most of the difficulties. The sound-level meter as described below remains the basic instrument for measuring sound-pressure levels but needs care both in its use and in the expression of results obtained.

The commercial sound-level meter consists of a stable measuring microphone, amplifier and moving-coil meter, circuits to give fast and slow dynamic responses and three frequency-weighting networks, termed A, B and C, are intended to simulate the response of the hearing mechanism by possessing characteristics that are approximately the inverse of the 40, 70 and 100 phon equal-loudness contours for pure tones. In practice the networks are selected according to the loudness of the noise—level A network for 24-55 dB, level B network for 55-85 dB and the level C network for all readings above 85 dB. Their use is admitted to be purely conventional.<sup>3, 4</sup> Since this procedure is not universally satisfactory for all types of noise it has recently become common practice to use the level A weighting for all noise levels.<sup>5</sup> Frequently the reading so obtained is converted empirically into loudness (in "Stevens" phons) by multiplying by 1.05 and adding on 10. In the absence of a set of filters associated with the sound-level meter, the A, B and C responses are useful in determining the general distribution of energy in the noise and it is often desirable to give the results for two weightings. In addition, to take into account sporadic components, the dynamic characteristic used, i.e. whether slow or fast, should be stated. With enlightened interpretation of the meter indication and with readings expressed in this form (e.g. 90 dB (A) or 105 dB (C) slow) the noise levels, at least for smooth broadband spectra, can be arranged in rank order which, for the present purposes, will convey a reasonably accurate indication of their respective subjective loudness effect.

When subjectively testing telephones, it is common practice to provide a background room-noise of a controlled nature. Usually this is Hoth spectrum noise derived from random (white) noise by applying the weighting prescribed by the originator.<sup>6</sup> It is intended in a general way to represent the average noise spectra found at non-industrial telephone locations. Although not necessarily achieving this object precisely it has the merits of reproducibility and convenience.

# Modems for 48 kbit/s Data Transmission

R. W. BIGG†

U.D.C. 621.394.4:681.31

*A new data-transmission service, Datel 48 K, has recently been introduced by the Post Office to cater for future data systems using computers. This service consists of either point-to-point circuits or a manually switched network, both having facilities for isochronous data-transmission. The transmission system adopted and the novel features of the modems used in providing this service are described.*

## INTRODUCTION

The increasing use of computers by business and industrial concerns, in a great variety of applications, is giving rise to an increasing demand for the existing British Post Office Datel services. The range of transmission rates offered by these services is being extended as the likely requirements of the more complex systems of the future are foreseen.

Systems whereby one central processor performs the same operation on data received from a number of scattered sources and returns processed information to these sources, are normally adequately catered for by the low and medium-rate services. Future systems are, however, likely to require a number of such processors, or computers, to be interconnected in order to achieve increased flexibility and increased computing power at reduced cost. To avoid the loss of valuable computing time, the interconnecting links will need to be capable of a far greater rate of transmission than the previously available services offer. It is with this in mind that the Datel 48 K service has been introduced.

## THE DATEL 48 K SERVICE

The Datel 48 K service is, at present, in two forms: point-to-point circuits for those customers requiring full-time or frequent long periods of use, and a manually switched experimental network,<sup>1</sup> for those customers requiring such facilities infrequently or for short periods only.

On point-to-point private circuits, facilities are offered for isochronous data transmission at 48 kbit/s, or exceptionally at 40·8 or 50 kbit/s or, alternatively, for anisochronous transmission of a 2-level, high-definition, facsimile signal. The switched network is limited to isochronous data transmission at 48 kbit/s. An end-to-end telephone coordination circuit, using in-band signalling at 2,280 Hz, is optional on point-to-point circuits, or, alternatively, this may be used for low-rate data. A similar circuit is also offered on the switched network at present but this facility may be withdrawn eventually.

## TRANSMISSION SYSTEM

When the modulation rate on line in bauds is equal to the data rate in bit/s, the maximum theoretical frequency it is necessary to transmit in order to convey serial binary data information without mutual interference between elements is numerically equal, in Hz, to half the data rate in bit/s.<sup>2</sup> Frequencies down to and including d.c. are all present in the signal spectrum at significant amplitudes. Thus, for data transmission at 48 kbit/s, frequencies up to at least 24 kHz must be transmitted. If a sharp cut-off at this frequency were to be introduced, however, the ringing effect produced would

result in inter-symbol interference occurring at signalling rates other than 48 kbit/s. By using filters with a slower roll-off characteristic the ringing is reduced and the system becomes more tolerant of variations in transmission rate. Also, it is prudent in any anisochronous (or asynchronous) telegraph or data transmission system to provide some over-speed capability, otherwise an element which has become shortened by distortion during transmission will be further distorted by the bandwidth deficiency of the system. The passband of receiving filters needs to be kept as narrow as possible in order to exclude unwanted out-of-band noise signals. It is advantageous, therefore, for a 48 kbit/s binary transmission system to pass frequencies approaching 30 kHz without attenuation and for the receive filters (which determine the bandwidth at the detector) to have a slow roll-off, utilizing a total bandwidth of the order of 36 kHz. This frequency range is termed the baseband.

Previous Post Office modems for low data rates have made use of telephone circuits having a nominal bandwidth of 3·4 kHz. Clearly, these are unsuitable for a 48 kbit/s data system. The national telephone network consists of local, junction and trunk circuit plant. Local-line plant consists generally of unloaded cable that has no cut-off frequency and, therefore, can be used for transmission of frequencies far in excess of 3·4 kHz. The distance over which wideband signals can be transmitted is limited by the attenuation which can be tolerated at the highest frequency, and by noise and crosstalk levels.

Junction plant consists, in the main, of loaded cable which, because of the cut-off frequency introduced by the loading coils, is unsuitable for wideband transmission unless the loading coils are removed. The trunk network makes use of frequency-division multiplexing (f.d.m.) techniques which enable access to be gained to wide-band circuits, the bandwidth depending upon the stage of multiplexing. The 12-circuit telephone groupband, 60–108 kHz, is convenient to use for 48 kbit/s data transmission.

Thus, a 48 kbit/s data-transmission circuit is composed of three distinct sections and two different modem equipments are necessary. The major portion of the route utilizes a groupband circuit between carrier terminals as near as possible to the serving exchanges. At each carrier terminal a Modem No. 9 translates the data baseband signal into the 60–108 kHz groupband and vice versa. The two local ends utilize local or deloaded junction cable pairs to convey the data baseband signal between the carrier terminal and the Modem No. 8, which is situated in the customer's premises and provides an interface with his data terminal equipment (d.t.e.).

## Groupband Section

The 60–108 kHz groupband accommodates the data channel, and a telephone channel for end-to-end co-ordina-

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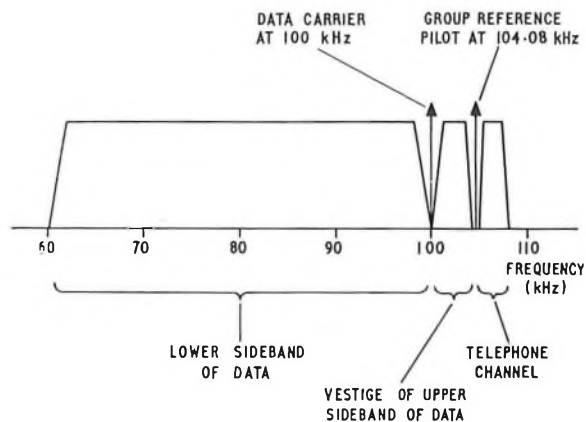


FIG. 1—Group frequency-band allocation

tion purposes. The telephone channel is allocated the nominal 4 kHz band 104–108 kHz which corresponds to channel 1 of the standard 12-channel telephony group, leaving a 44 kHz band 60–104 kHz for the data channel. Fig. 1 shows the bandwidth allocation in the group frequency band.

Since data signal-components down to d.c. are of importance, single-sideband amplitude-modulation with suppressed carrier, as used for the telephony systems, is not easy to use for data transmission. The bandwidth available is insufficient for frequency, phase, or any other type of double-sideband modulation at a rate of 48 kbauds, and since the anisochronous 2-level facsimile transmission facility is also required, this precludes the use of multi-level modulation techniques, as these are essentially of isochronous nature. The modulation system chosen, therefore, is vestigial-sideband amplitude-modulation with carrier suppressed. The carrier frequency could have been located towards the upper or lower end of the band available, but by choosing a higher carrier-frequency, interference difficulties caused by higher harmonics of the modulating frequency are more easily avoided.

To make maximum use of the available bandwidth the vestigial sideband needs to be as small as possible. However, as the vestigial sideband is reduced, filter design becomes increasingly more difficult, the sharper characteristic needed requiring closer tolerances and also introducing increased group-delay/frequency distortion. It has been found satisfactory in practice for the lower-sideband-to-upper-sideband ratio to be of the order of 10:1. This is obtained by using a carrier frequency of 100 kHz, and this figure has been chosen as an international standard for 48 kbit/s data transmission by the C.C.I.T.T.†

In single-sideband, suppressed-carrier telephony systems, unless the carrier signal used for demodulation is in frequency synchronism with that which would have been present in the received signal, had it not been suppressed, a frequency shift will occur in the components of the demodulated signal. The phase of the demodulating carrier is of no consequence since the ear is not particularly sensitive to phase variations or delay distortion. Data systems of this type, however, are sensitive to small phase shifts because this gives rise to telegraph distortion and also reduces the margin against errors caused by noise. A large phase shift approaching 180° would result in a binary 1 being interpreted as a binary 0 and vice versa.

In a vestigial-sideband data system, therefore, with carrier suppressed, if the performance of the system is not to be impaired, the demodulating carrier must be locked in frequency and phase to the carrier component in the received

signal. In order to achieve this, the modulating carrier is transmitted at a low level for use as a reference in the receiver. It is necessary, in order to extract this carrier signal at the receiver without interference from the data signal, to attenuate the power of the frequency components in the data signal in the region of the carrier frequency. Hence, prior to modulation, the d.c. component of the data signal is removed and the low frequency components are attenuated by a high-pass filter having a 3 dB point at 1.92 kHz and a characteristic falling at 6 dB/octave below this. As previously stated, these low frequency components are of considerable importance and must be restored again in correct proportion prior to restitution. The characteristics of this filter must be well defined and are specified by the C.C.I.T.T. in Recommendation V35.<sup>3</sup>

Since the mid-band group reference-pilot used on telephony systems would interfere with the data signal, a reference-pilot signal located between the data and telephone channels at a frequency of 104.08 kHz is used.

The f.d.m. systems of the trunk network are designed to give satisfactory performance for the telephone circuits which they normally carry, where the signal energy is distributed over the band. If a short repetitive pattern were to occur on the data channel, energy would be restricted to a few discrete frequencies spaced at regular intervals across the band, the spectral-line spacing  $S$  being determined by the length of pattern and the transmission rate, i.e.

$$S = \frac{\text{data rate (bit/s)}}{\text{pattern length (bit)}}$$

It would be inconvenient for the customer if restrictions were placed on the type or format of the signal he could transmit, but there is a possibility that these high-level discrete frequencies could cause interference with other circuits in the wideband system. Therefore, it is necessary to ensure an even distribution of energy. This is achieved in the Modem No. 8, by encoding the customer's data before transmission and decoding again in the receiver. The encoder ensures that the data pattern sent to line is sufficiently long that the spectral-line spacing is kept very small even when the input signal (from the customer) is one bit reversals or a continuous binary condition. A secondary benefit gained by encoding is that the recovery of timing information at the receiver is simplified owing to the large number of transitions which must always be present in the received signal.

In order to encode and decode the signal it is essential to know when transitions will occur, i.e. the signal must be isochronous. Encoding cannot, therefore, be applied to a facsimile signal. However, since a maximum element length is stipulated and short repetitive patterns are unlikely to occur on such transmissions, encoding is not considered necessary. The rules for encoding have been agreed internationally and the logic arrangement, shown in Fig. 5, is defined by the C.C.I.T.T. in Recommendation V 35<sup>3</sup> Appendix 1.

Certain restrictions must be placed upon the routing of groupband circuits carrying wideband data, owing to the presence of reference-pilot signals which would interfere with the data signal and also owing to the incidence of group-delay/frequency distortion. In general, edgeband positions must be avoided because of the group-delay/frequency distortion introduced by through-supergroup filters and the midband position must be avoided because of the presence of the supergroup reference-pilot, i.e. only groups 2 and 4 should be used. Where a through supergroup is not available and group-links are connected in tandem, the through-group filter used must be delay equalized. It is possible, using Modems No. 9, to operate satisfactorily over three such group-links in tandem.

## Baseband Section

The baseband data-signal is transmitted over local cable between the Modem No. 8 at the customer's premises and the

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

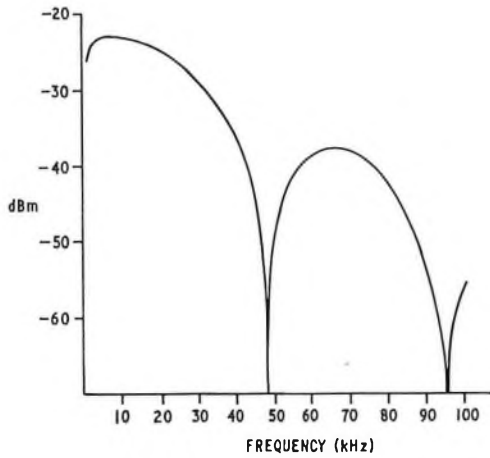
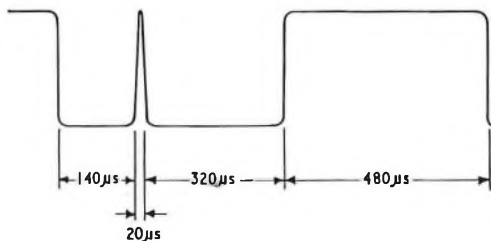


FIG. 2—Energy spectrum of the Modem No. 8 line signal (wideband signal level 0dBm)

Modem No. 9 at the carrier terminal, one cable pair being required for each direction of transmission. The telephone channel is routed separately either as a 2-wire or as a 4-wire circuit.

For reasons previously stated, it is necessary to remove the d.c. and attenuate the low-frequency components of the data signal prior to modulation in the Modem No. 9. This could be carried out in the Modem No. 9; however, if it is done in the Modem No. 8, baseband transmission is simplified in that the signal may be a.c. coupled between the modems and line and also to line amplifiers if necessary. The high-frequency content of the data signal is also attenuated by a low-pass filter, with a 3 dB point at 75 kHz, in order to avoid undue interference with other circuits in the local network. The spectrum of the line signal from the Modem No. 8 is shown in Fig. 2.

During transmission, the data-signal waveform becomes distorted by the attenuation/frequency and phase/frequency characteristics of the line, and this distortion must be corrected before onward transmission by the Modem No. 9 or before application to the restitutor in the Modem No. 8. Since it is the waveform of the signal which is of importance, it is logical to use a method of correction and assessment based on a test waveform, rather than to equalize the attenuation/frequency characteristic in the manner customary on telephone circuits. This latter course would take no account of the phase/frequency characteristic and although on local cable this generally makes only a small contribution to waveform distortion, it cannot necessarily be regarded as negligible. The method adopted by the Post Office is manual adjustment of a variable waveform-corrector using a pulse-and-bar test waveform, the characteristics of which are given in Fig. 3.



NOTE: The pulse is of approximately sine-squared shape with 20 μs half-amplitude width

FIG. 3—Pulse-and-bar test waveform

The distance over which satisfactory baseband transmission on local cable can be achieved is limited by the insertion loss which can be tolerated at the upper end of the signal-frequency spectrum and by noise and crosstalk levels. With a transmitted signal level of 0 dBm, using 20 lb/mile conductors, and as-

suming the noise level is not abnormally high, a distance of 8–9 miles is possible without amplification. It is expected that it will be possible to increase this distance by a combined amplifier-equalizer, but a suitable equipment has not yet been developed. In the meantime, this distance can be approximately doubled by the use of special cable.

Joints in the local-cable network are not soldered, and there is a possibility that difficulty may be encountered owing to an increase or instability of resistance at these connexion points. To counteract this it is proposed to wet the baseband transmission path with a direct current. This will also serve to identify the cable pair as a data circuit and thus avoid inadvertent interruption by working parties.

## DATTEL MODEM NO. 8

### Customer's Interface

A simplified functional block diagram of the Datel Modem No. 8 is shown in Fig. 4. For simplicity, interchange-circuit control functions are shown diagrammatically as relays, but in practice these functions are carried out by integrated-circuit logic elements (d.t.l.). Control interchange-circuits are unbalanced and in accordance with the C.C.I.T.T. recommendation V 24<sup>4</sup>. Interchange circuits carrying data and timing signals are balanced and in accordance with the C.C.I.T.T. recommendation V 35.<sup>3</sup> The characteristics of these interchange circuits have been described previously in this *Journal*.<sup>5</sup> Each interchange circuit is terminated within the modem by a circuit which converts the signals to modem logic or vice versa.

If the power supply to the modem is on and all test keys are normal, then a DATA SET READY signal will be given to the customer. No signal is transmitted to line until the modem receives a REQUEST TO SEND signal from the customer when, if the isochronous mode of transmission is to be used, random data from the encoder is passed to line; 35 ms later the customer will be given the READY FOR SENDING signal, and he may then commence to transmit his data. Within this 35 ms period the intermediate Modems No. 9 and the distant Modem No. 8 must be conditioned so that they are ready to accept and pass the customer's data without error.

The data signal is passed through the encoder in the modem under the control of a timing waveform. A suitable timing waveform is generated within the modem, and this is passed to the customer's data-terminal equipment (d.t.e.) via a balanced interchange circuit. Optionally, the customer may use his own source of timing in which case this waveform is passed to the modem via a separate balance interchange circuit. The source of timing used by the modem is determined by the condition on the TRANSMITTER CLOCK CONTROL interchange circuit. On the receive side of the modem a timing waveform is generated and synchronized in correct phase with the incoming data-signal and used to regenerate and decode it. This waveform (receive clock) is also passed to the d.t.e. for the customer's use if required.

If the anisochronous mode of transmission is to be used the ALTERNATE USE TRANSMIT/RECEIVE interchange circuits are placed in the ON condition, either by the customer or by strapping within the modem. This has the effect of by-passing the encoder and decoder, and also increasing the time-constant of the automatic gain control (a.g.c.) circuits, to allow the transmission and reception of facsimile signals which may have longer periods of steady state. Baseband shaping, as previously described, is applied to the signal before transmission, regardless of the mode of operation selected. The transmit level is nominally 0 dBm but facility is provided to vary this by  $\pm 3$  dB in 1.5 dB steps.

### Test Facilities

The operation of a test switch, which is not accessible to the customer, causes a test signal corresponding to binary

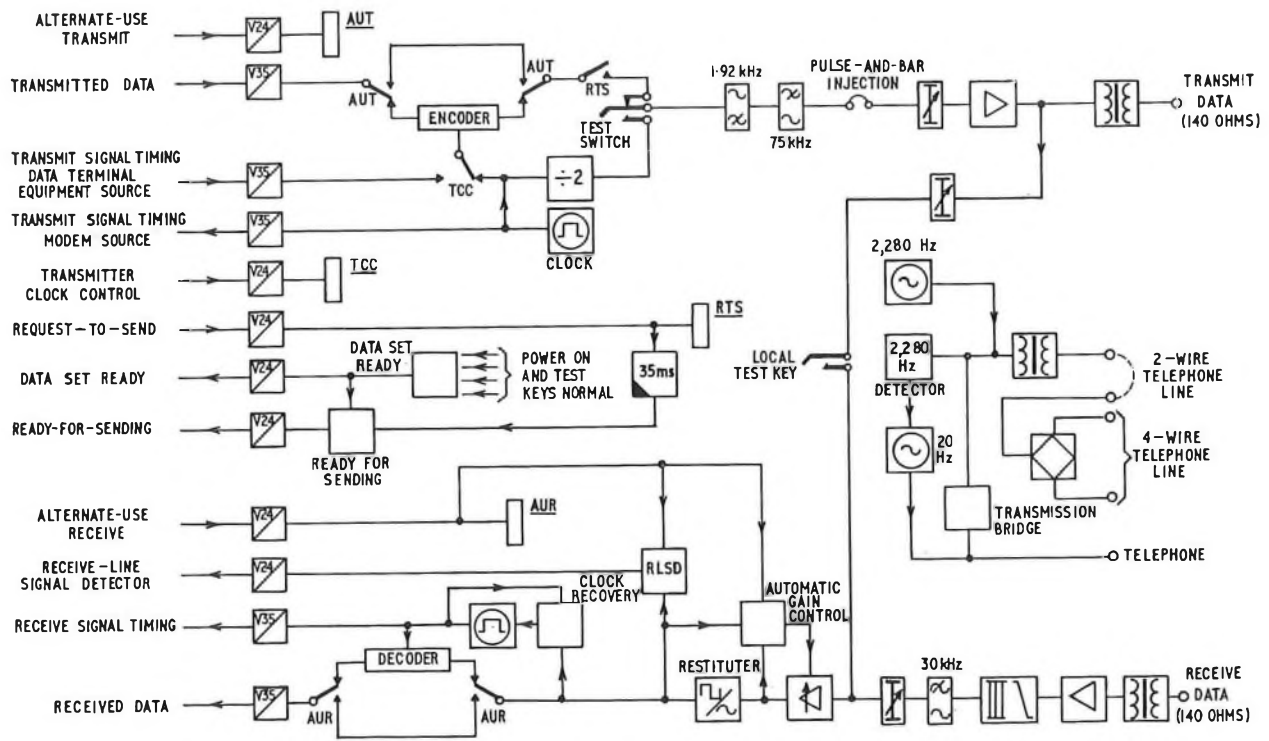


FIG. 4—Simplified block diagram of Modem No. 8

reversals at the data rate, to be transmitted to line. This is used for test and adjustment throughout the system.

Two controls which are accessible to the customer are the LOCAL TEST key and the REMOTE TEST switch. The LOCAL TEST key causes the transmitted data to be looped back to the receiver via a major portion of the modem to enable the customer to test his own equipment and the modem, in combination. The REMOTE TEST switch loops the RECEIVED DATA interchange circuit to the TRANSMIT DATA interchange circuit and also the RECEIVE SIGNAL TIMING circuit to the TRANSMIT SIGNAL TIMING circuit which, together with various other interchange circuit connexions, facilitates remote testing of the modem from the datel test centre, the repeater station or the distant end. Two positions of the REMOTE TEST switch are provided. In one position the receiver is placed in the isochronous mode whilst the transmitter is placed in the anisochronous mode, and in the other position these conditions are reversed. In the event of a fault developing in a modem, the datel test centre can deduce, in the majority of cases, which module is faulty, by considering the original fault report, the results of local testing and the results of remote testing.

### Encoding and Decoding

The encoder comprises a 20-stage shift-register with feedback from the third and twentieth stages via EXCLUSIVE OR gating, as shown in the simplified diagram Fig. 5(a). The truth tables of the logic gates are shown in Fig. 5(b). Data applied to one input of gate G1 will pass without inversion to the output when the other input is a binary 1. When the second input is a binary 0 i.e. the output from gate G2 is binary 0 (ignoring gate G3 for the moment), the data will be inverted and this will occur when the binary states of stages three and twenty of the shift-register are similar. The output from gate G1 is the output from the encoder and is also the input signal to the shift-register, thus the circuit forms a closed loop. If the data input to the encoder is a steady binary condition then this circuit will generate a pattern  $2^{20} - 1$  bit in length. Any data input signal is, therefore, modified by the basic pattern generated

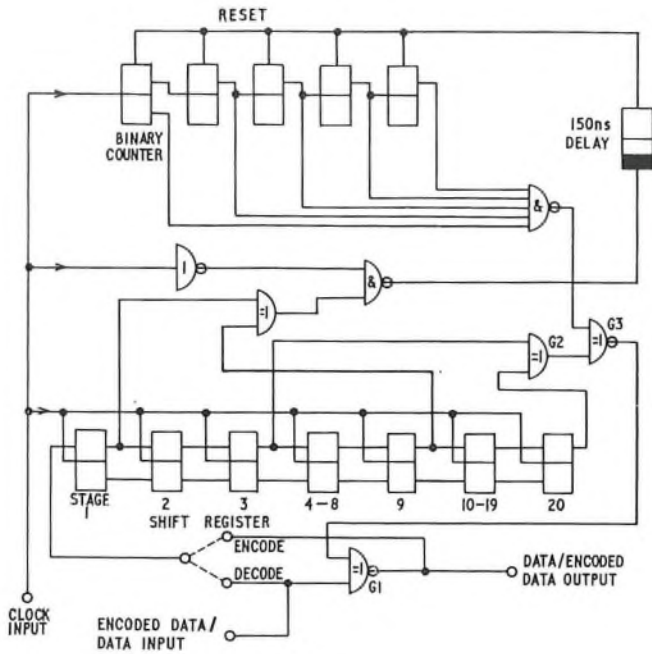
by the encoder logic and this encoded data is fed directly into the shift-register of an otherwise identical logic circuit, the decoder. Since the decoder has an identical logical circuit arrangement, it performs the same logical operation on the encoded data, which in effect extracts the basic encoder pattern, leaving the original data signal at the output.

The combination of a particular data pattern and the basic encoder pattern could result in a steady state or reversals at the encoder output. To guard against this, the adverse-state detector, a 5-stage binary counter, is connected to stages one and nine of the shift-register. Whilst these two stages remain in a similar binary state the counter counts the clock pulses which are driving the encoder. Each time stages one and nine differ in binary state the counter is reset. If the counter reaches 31 without being reset i.e. 31 consecutive bits of similar binary state, then gate G3 causes an inversion of the following bit, thus breaking up the sequence. As a result of encoding and decoding in this manner, a penalty is paid in that, any single element error occurring on line is multiplied by three at the decoder.

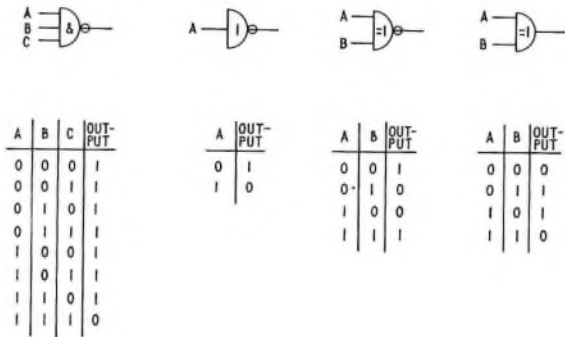
### Automatic Gain-Control, D.C. Restoration and Restitution

Automatic gain-control of a data signal from which the d.c. component has been removed, cannot be achieved by simple detection of the peak-to-peak amplitude, since this varies with the data pattern. This difficulty is overcome in the baseband a.g.c. unit of the Modem No. 8 by deriving a reference signal which also varies with the data pattern but in the opposite sense to that derived from the line signal.

A simplified block diagram of the baseband a.g.c. unit is shown in Fig. 6. This unit performs the functions of gain control, d.c. restoration and restitution. The waveform-corrected signal is applied to a circuit using a field-effect transistor acting as a variable attenuator. A signal derived from the gain-control loop is applied to the gate of this transistor and enables the signal level at the input to the restitutor to be maintained constant to within  $\pm 0.1$  dB for changes of line signal level of between  $\pm 6$  dB. The output



(a) Simplified block diagram of the encoder/decoder



(b) Truth tables of the logic elements

FIG. 5—Encoder/decoder of the Modem No. 8

signal from the restitutor is clamped to ensure a constant amplitude and then fed back via an RC integrating circuit to its input, reinserting the d.c. component to the line signal. The restitutor consists of a linear integrated-circuit with feedback connected so that it behaves as a bistable circuit, the output changing from one condition to the other rapidly as the input signal passes through the threshold. The reference signal previously mentioned is obtained by taking an output from the restitutor, removing the d.c. component and peak detecting. The gain-controlled line-signal is applied to a similar peak-detecting circuit. The output from both detectors is applied to a d.c. amplifier that has a large amount of a.c. feedback to make it behave as an integrator. Since the outputs from the peak detectors are arranged to be of opposite sense, variations in d.c. level due to pattern cancel, and the output of the integrator registers only changes of line signal level relative to the reference signal. In the absence of an output from the restitutor (line signal absent or level low) the integrator conditioner circuit detects the absence of an output from the reference peak detector and applies a condition to the integrator, which causes the gain in the transmission path to be increased to a maximum (determined by the gain clamp) preparatory to the receipt of a line signal.

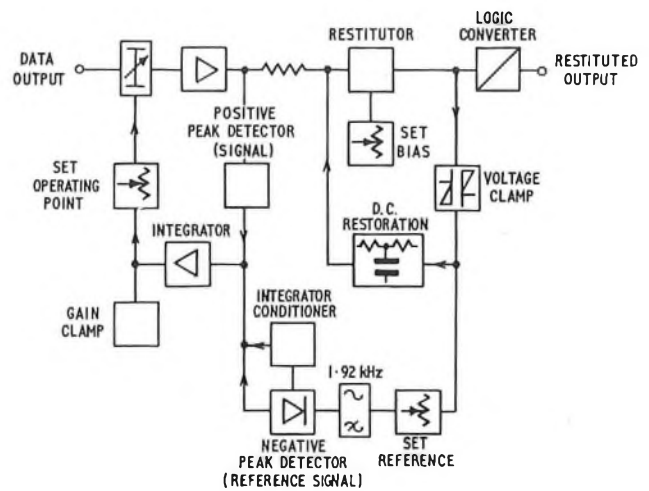


FIG. 6—Block diagram of the baseband automatic gain-control unit

### Recovery of Timing Information

In order to decode and regenerate the received data signal, it is necessary to generate a timing waveform in the receiver (receive clock) in frequency synchronism with the timing waveform used at the transmitter and in correct phase relationship with the received data signal. A block diagram of the essentials of the clock-recovery circuit is shown in Fig. 7. The restituted data signal from the a.g.c. unit, bears telegraph distortion accumulated during transmission. This is applied to a circuit which generates a short-duration pulse for each data transition received. These pulses are amplified and applied to a circuit of relatively low  $Q$ , tuned approximately to the required clock frequency. The circuit is stimulated into oscillation at the transmitting clock frequency by the component of that frequency, contained in the applied pulses. The flywheel effect of the tuned circuit smoothes out the effects of telegraph distortion on the received signal and so reduces jitter on the receiver timing waveform.

The output signal from the tuned circuit is compared, in two phase-comparator circuits, with a locally generated signal of approximately the correct frequency. The output from phase comparator 1 will be zero when the locally generated signal is in correct phase in relation to the incoming data. A positive or negative error signal will appear as the phase relationship deviates from this condition. The error signal is amplified by a d.c. amplifier and is used to control the frequency of the local oscillator, thus correcting its phase. The d.c. amplifier has a large amount of a.c. feedback applied, resulting in low gain at high frequencies but high gain at d.c. The output, therefore, can only vary relatively slowly, and effective integration of the error signal is achieved, avoiding rapid changes in frequency of the local oscillator and excessive jitter on the clock waveform. It is essential that the receive clock achieves synchronism and correct phase rapidly when a signal is first received, in order that the modem is ready to receive the customer's data after the elapse of the REQUEST TO SEND/READY FOR SENDING delay. To achieve this, the circuit operates at maximum gain initially and the d.c. amplifier (integrator) operates with a wide frequency response. The output from phase comparator 2 and its associated low-pass filter is low whilst the circuit is hunting for frequency and phase, but begins to rise as correct phase is approached. This signal is used to reduce the gain in the circuit and thus the error signal which is applied to the integrator and also to detect when phase lock is achieved. When correct phase has been achieved the feedback circuit on the d.c. amplifier is modified to give it the characteristics previously described.



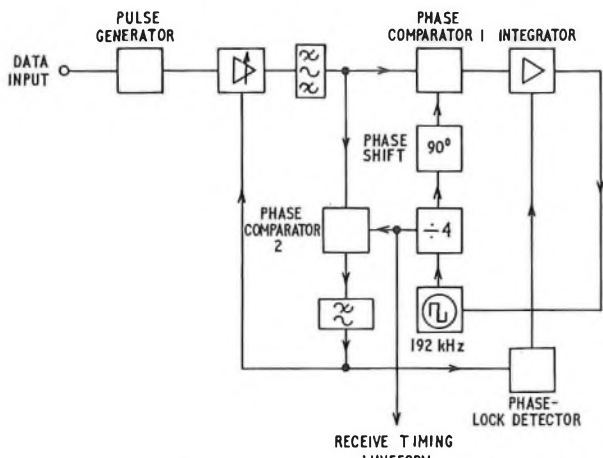


FIG. 7—Block diagram of the clock-recovery circuit

## DATEL MODEM NO. 9

### Transmit Path

A block diagram of the principle elements of Datel Modem No. 9 is shown in Fig. 8. The baseband signal received from line is applied, after waveform correction, to a baseband a.g.c. unit similar to that used in the Modem No. 8. This restitutes the data signal and thereby converts residual waveform distortions to telegraph distortion enabling a known waveform to be applied to the modulator regardless of the line conditions. This signal must have the d.c. component removed before modulation and a low-pass filter is also necessary to prevent the higher harmonics causing fold-over distortion at the modulator. A double-balanced modulator is used which would normally suppress the carrier, but a controlled degree of unbalance is deliberately introduced in order to transmit the carrier along with the data signal at a reduced level. The transmit filter has 3 dB points at 62 kHz and 102 kHz and is delay-equalized. The telephone channel is conventional and consistent with channel 1 of a 12-channel group. The as-

symetric sideband signal from the data channel and the lower sideband from the telephone channel, together with a group reference-pilot signal (104.08 kHz) are combined in a common amplifier stage and the aggregate signal can then be taken from one of two outputs. The group output to the carrier is a 75-ohm unbalanced output at a level of  $-37$  dB $\uparrow$  or alternatively at a level of  $+5$  dB, intended for direct connexion to group translating equipment (g.t.e.). The group output to the line is a 140-ohm balanced output at a level of  $+5$  dB, intended for transmission to a line where the modem is remote from the g.t.e. The data signal is transmitted at a level of  $-5$  dBm0.

The carrier supplies for both modulators are derived internally from a crystal-controlled oscillator operating at 10.8 MHz. Alternatively external supplies may be used.

### Receive Path

The aggregate groupband signal, received from line or carrier equipment, is terminated in the appropriate impedance, and applied to an a.g.c. unit. Gain control is dependant upon the level of the 100 kHz carrier present in the data signal. The demodulated data-signal is fed back to the carrier a.g.c. unit where the d.c. component resulting from demodulation of the carrier is extracted by means of an integrated-circuit d.c. amplifier with a large amount of a.c. feedback acting as a low-pass filter. The d.c. is amplified and used as a control signal on the gate of a field-effect transistor which acts as a variable attenuator in the transmission path. Following the a.g.c. unit, band-pass filters separate the telephone and data channels.

The telephone channel is demodulated, using a carrier signal from the same source as that used for modulation on the transmit side of the modem. The level of the demodulated signal to line may be adjusted to any nominal value in the range  $-5$  dBm to  $+10$  dBm.

The receive band-pass filter on the data channel is delay equalized and the signal then passes through a low-pass filter

$\uparrow$  Level in dB relative to the standard repeater station reference level.

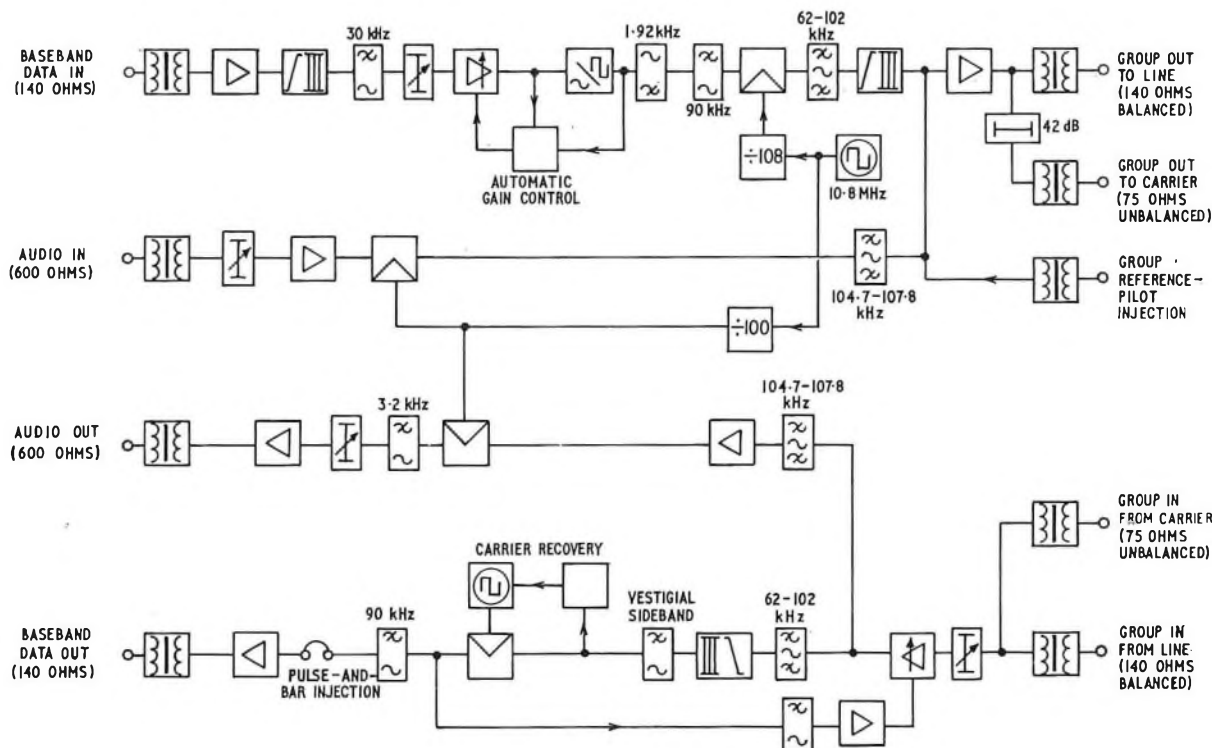


FIG. 8—Simplified block diagram of the Modem No. 9

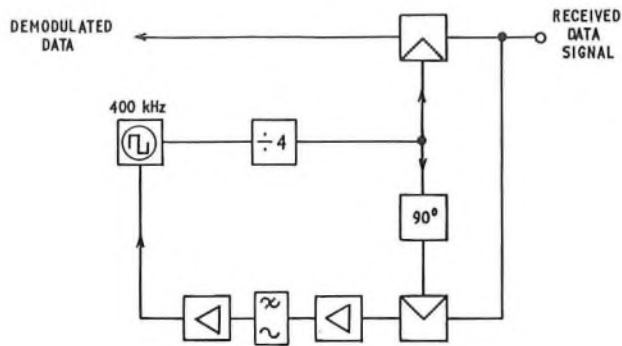


FIG. 9—Block diagram of the carrier-recovery circuit

which imparts the required vestigial-sideband characteristic. Demodulation of the data signal takes place in a balanced demodulator using a locally regenerated carrier signal. The lower sideband of demodulation is selected by a low-pass filter and after amplification appears at the baseband output terminals. The transmit level is nominally 0 dBm but facility is provided to vary this by  $\pm 3$  dB in 1.5 dB steps.

### Carrier Recovery

A locally generated signal is locked in frequency and phase to the carrier accompanying the received data signal; a block diagram of the elements of the circuit used to accomplish this are shown in Fig. 9. The received data-signal is applied to two similar balanced demodulators. The main one in the data transmission path uses the locally generated 100 kHz signal as its carrier supply and the second one, in the carrier recovery phase-lock loop, uses the same signal but shifted in phase by  $90^\circ$ . The output signal from both demodulators will contain a d.c. component owing to the presence of the carrier in the data signal; that from the main demodulator is used for a.g.c. as previously described; that from the second demodulator will be zero when the locally generated signal and the incoming carrier are in frequency synchronism but in phase quadrature. As the two signals deviate from this ideal a positive or negative error signal appears which is amplified and used to control the frequency and, therefore, the phase of the multivibrator generating the local signal.

It is necessary to include a low-pass filter in the loop in order to prevent the data-signal components affecting the frequency of the local oscillator and to ensure that its frequency can only be changed relatively slowly, thus reducing jitter on the waveform, which produces telegraph distortion on the data signal. Data-signal components close to the carrier are attenuated prior to modulation to assist in this respect. The filter needs to be narrow band to keep jitter on the recovered carrier-waveform to a minimum but the narrower the bandwidth of the loop the smaller the initial pull-in range of the circuit and the longer the pull-in-time. To

minimize frequency drifts in the local oscillator its component parts are enclosed in a temperature-controlled oven. This enables the loop bandwidth to be smaller than would otherwise be necessary. The low-pass filter in practice, is in the form of an integrated circuit d.c. amplifier with a large amount of a.c. negative feedback.

### GENERAL DESCRIPTION OF MODEMS

Both modems are constructed to Post Office 62-type equipment practice. The equipment may be housed in a case conforming to current Post Office practice for desk-top mounting of datel modems or alternatively the modules may be plugged into a chassis unit mounted on a standard 62-type rack.

The Modem No. 8 occupies a single 62-type shelf and the rack-mounted version requires an additional module to provide a location for test keys, interface socket and other facilities which are associated with the chassis of the desk mounted version. The Modem No. 9 occupies two shelves which are bolted together to form a double-shelf unit. Both versions of both modems use the same power supply unit, which is operated from a.c. mains. Linear integrated-circuits and logic elements are used extensively in both modems.

### PERFORMANCE

In the limited experience gained up to the time of writing this article, using modems on the experimental switched network in the isochronous mode of operation, element error rates better than 1 in  $10^6$  were generally obtained, with long periods during which no errors occurred. It will be interesting to observe whether customers find a similar performance in their use of these modems.

Tests carried out by the manufacturer, using back-to-back modems in the anisochronous mode of operation, indicate that the impairment of two-level facsimile signals is sufficiently low as to be undetectable by subjective examination of the transmitted copy.

### ACKNOWLEDGEMENT

The Datel Modems No. 8 and 9 were developed to a Post Office specification by Muirhead and Company Limited, Beckenham, Kent.

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# A New Miniature Relay—The Post Office Type 23

W. L. SCOTT, C.ENG., M.I.E.E. and J. PATERSON†

U.D.C. 621.318.56:621.395.659

*Trends in design, manufacturing techniques and procurement policy make it opportune to extend the use of small relays in British Post Office telecommunications equipment. A novel type of miniature relay is described for which a performance-type specification has been adopted to enable suppliers to exploit a variety of methods of physical design.*

## INTRODUCTION

Components of reduced size and weight are being used on an increasing scale in telephone exchange equipment and in customers' apparatus. It is logical that the same processes of size and weight reduction should apply to the telephone type relay.

The British Post Office has long been aware that advantages would accrue if a small standard relay, suitable for a range of applications, could be produced. During the last war the Post Office made a notable contribution to the development of miniature relays for use by the Services<sup>1</sup> and small relays of standard types have been used for some years for customers' line circuits.<sup>2,3</sup> It is only comparatively recently, however, that performance, costs and general procurement policy have become sufficiently favourable to justify larger-scale application of small relays for standard equipment. The use of manufacturers' proprietary products, provided they meet essential Post Office requirements, now forms the basis of Post Office procurement policy. This gives manufacturers scope for exercising their technical expertise to produce designs suitable for the British Post Office as well as for other markets, thereby increasing the scale of production and reducing costs. To achieve this, British Post Office specifications are, as far as possible, performance-based, and are intended to widen the range of prospective manufacturers and increase competition. The Relay Type 23 is the first item specified in this way.

## DESIGN FEATURES

The original aim was to introduce a relay of small size, weight and cost, and specified performance, suitable for use in portable items such as testers. The potential field of use has been extended to printed-circuit boards and subsequently to equipment using standard 3,000-type relay mounting plates.

Circuit applications are limited to simple on/off functions without special features such as controlled timings and marginal current characteristics.

Although detailed design has been left to the manufacturers, some features need to be subjected to specification constraints, to cover essential Post Office requirements. For example, small size obtained with a penalty of poor reliability would not be acceptable, nor would small size and good reliability obtained at high cost. Careful trading of design features has been necessary, and compromise decisions inevitable. Some of the more important of the aspects are discussed below.

† Telecommunications Development Department, Telecommunications Headquarters.

### *Service Readjustment and Parts Replacement*

In view of the small size and consequent difficulty in carrying out readjustments, no parts will be replaced, or readjustments made in service. Rigorous performance and endurance requirements have been laid down to ensure a long operational life and minimize the "throwaway" value.

### *Contact Points*

The contact points are of 40:60 silver-palladium alloy, which is more costly than silver, the principal alternative material considered. This silver-palladium alloy is not subject to the severe tarnishing commonly experienced with all-silver material, and it is less likely to produce harmful polymerization products at the contact interfaces than is pure palladium.<sup>4</sup> Here, increased cost has been traded for overall reliability in conduction performance. Reliability performance is further improved by using twin contact-units,<sup>5</sup> instead of the single contacts more usual with small low-cost relays of this kind.

### *Contact Gaps*

These are 8 mils minimum for break, make and changeover contact units, and 6 mils minimum for make-before-break changeover units. Gap values for the Post Office 3,000-type relay are normally 10 mils, but exceptionally a reduction to 5 mils may be permitted.

### *Contact Unit Sequencing*

To ensure compatibility with traditional Post Office design practices for exchange switching equipment, contact sequencing is the same as for the 3,000 type relay. Briefly, all break contacts are required to open before any make contact closes. Similarly, make-before-break changeover units are required to bunch during actuation.

### *Contact Force*

The contact force is 10 grams minimum for all contact units except make-before-break changeover units, where a lower minimum value of 7 grams takes account of the possible use of short contact bearer springs for the break actions. Bearing in mind present relay-design practices, it is probable that the contact forces will be well in excess of these specified minimum values.

### *Contact Timing and Bounce*

The operate and release times must not exceed 10 ms, including transit time and contact bounce. A separate requirement sets a 5 ms limit to the contact bounce.

### Contact Ratings

The contact ratings are as follows: current, 1 amp maximum; voltage, 100 volts maximum; wattage, 50 watts maximum with resistive load. With inductive loads, these values are appropriately derated and, where necessary, a suitable quench needs to be provided.<sup>6</sup>

### Springsets

The range of springsets is limited to six different arrangements of contact units as follows:

**Size A** 6 springs comprising either two changeover units or two make-before-break changeovers.

**Size B** 12 springs comprising 4 changeover units; or 2 changeovers plus 2 make-before-break changeovers; or 6 makes; or 6 breaks.

These springsets cover a wide range of switching functions. Any potential redundancy in the way of spare springs is considered to be more than offset by reduced costs arising from longer production runs during manufacture.

### Coil Assembly

A rationalized list of coil designs has been prepared to cover switching applications at the voltage ranges in use for Post Office equipment. General requirements are limited to:

- (a) designation of terminal connexions,
- (b) approved terminating techniques for winding wires,
- (c) prohibition of joints within the winding. This precludes the addition of resistance wire to pad-out the winding resistance,
- (d) dissipation characteristic, 3 watts at 20°C.

For an individual coil, the only details specified are resistance and resistance tolerance, and minimum turns. A non-mandatory wire-size is quoted as a manufacturing guide.

### General Construction

Constructional requirements are intended to ensure mechanical interchangeability between the products of different manufacturers without restrictive effect on other details.

(a) Modular dimensions are the same for Size A and Size B springset relays except for the height. A reduced height for Size A designs permits greater utilization of these relays where space is restricted.

(b) The base must be suitable for mounting on a specified Post Office standard drilling.

(c) Wiring tag layouts are specified for wire-in or printed-circuit uses. The latter conform to British Standard hole dimensions and 2.54 mm grid spacing.

(d) Each relay is to be fitted with a cover of transparent polycarbonate.

(e) The weight of the relay must not exceed 30 grams.

## SPECIFICATION

The specification for the new type of relay has three broad functions: general requirements, approval procedures for manufacturers' products, and quality assurance requirements for bulk production. The scheme finally decided upon has some similarity to British Standard 9000: "Specification for General Requirements for Electronic Parts of Assessed Quality", which includes a system of *Qualification Approval* for products. This similarity will make it easier to adapt to the BS 9000 specification scheme at a later date.

### General Requirements

Broad performance requirements on the lines described earlier are laid down, together with associated drawings and Post Office and British Standard specifications of a more general nature. The features essential for Post Office purposes

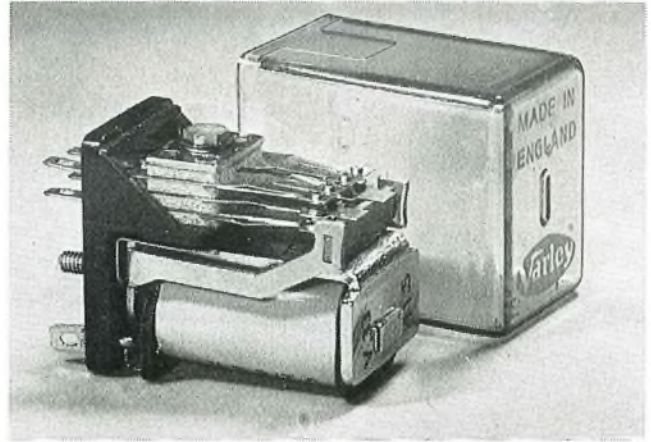


FIG. 1—Relay type 23—Size A

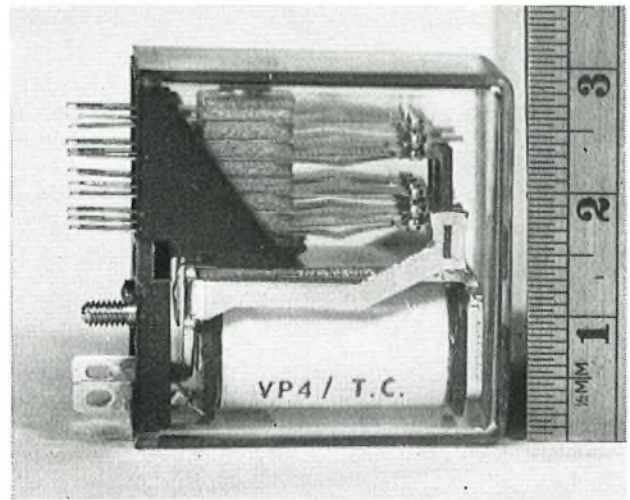


FIG. 2—Relay type 23—Size B

are covered in greater detail. This section of the specification, together with the relevant Post Office relay-sheet, roughly corresponds to the detail specifications used in the BS 9000 series of specifications.

### Qualification Approval

The specification sets out in detail the procedures to be followed and the tests to be carried out to support a manufacturer's application for qualification approval. The manufacturer may carry out the tests at his own works provided the facilities are Post Office approved. Alternatively, he may have the test carried out by any other suitably approved test house. A total of 48 relays must be submitted and in the test program these are divided into five groups involving tests of similar nature.

The test conditions and checks are, of necessity, extremely rigorous. For example, contact force is checked at periodic intervals during the mechanical endurance test, and on the completion of  $50 \times 10^6$  operations the samples must meet the minimum requirement of 10 grams. Similarly, during the electrical endurance test, contact resistance is checked at every operation and the relay must complete one million operations without conductivity failure. These exacting endurance tests are carried out in a test chamber at an elevated temperature of 55°C.

To obtain qualification approval, the manufacturer must give full details of his product, the results of the specification test program and details of the testing authority. Provided these are satisfactory, a formal qualification approval certificate is issued by the Post Office.

Qualification approval signifies that the manufacturer is eligible to tender for supplies of Type 23 relays intended for use in Post Office equipment.

### Quality Assurance

The quality of conformance of bulk production to the design specification is defined by the Quality Assurance Branch of the Purchasing and Supply Department of the Post Office. Suppliers need to establish an acceptable system of quality assurance which is monitored by Quality Assurance Branch throughout the contract.

### APPROVED DESIGNS

A number of manufacturers have submitted designs and three have so far been granted Post Office qualification approval.

It is perhaps not surprising in view of the performance requirements and the prospective fields of use that all designs submitted to date have features which are common to a generic class of small relay known as the cradle, or comb-type, production of which is rapidly expanding in various parts of the world. The characteristic features of this class include a telephone-relay-type magnetic circuit and rear-end armature, which actuates the contact points by means of two lever-arms and a lifting comb.

Compared with the traditional front-end armature action, this form of construction permits a substantial reduction in size, particularly in the length. It also gives effective and well-balanced mechanical actuation of the contact-bearer springs.

Fig. 1 shows an approved design for size A relays, the smaller of Type 23. Maximum dimensions in millimetres for this item are: height 24.4; width 19; length 31.

Points of interest include the plastic base into which coil and springset tag numbering details are moulded, and the small hole provided in the base to enable the relay to be operated manually by means of a pin or rod. The entire springset assembly is fixed with a single screw. Kinked contact bearer springs rest on straight buffer springs. This arrangement simplifies final adjustment during manufacture. The transparent polycarbonate cover is arranged to be lightly locked by lugs on the moulded base as it is intended that it should not normally be removed in service.

Fig. 2 shows an approved design for Size B relays, the larger Type 23. Maximum dimensions in millimetres for this item are: height 30; width 19; length 31. Apart from the greater height to accommodate the larger springset, constructional details are similar to those of Size A.

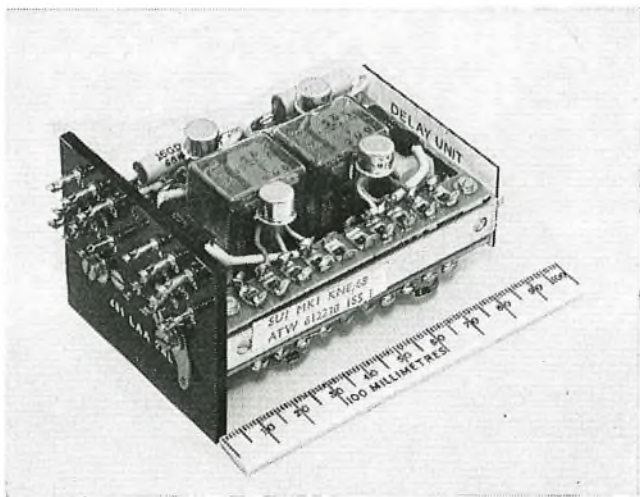


FIG. 3—Relays Type 23 used in association with solid-state devices

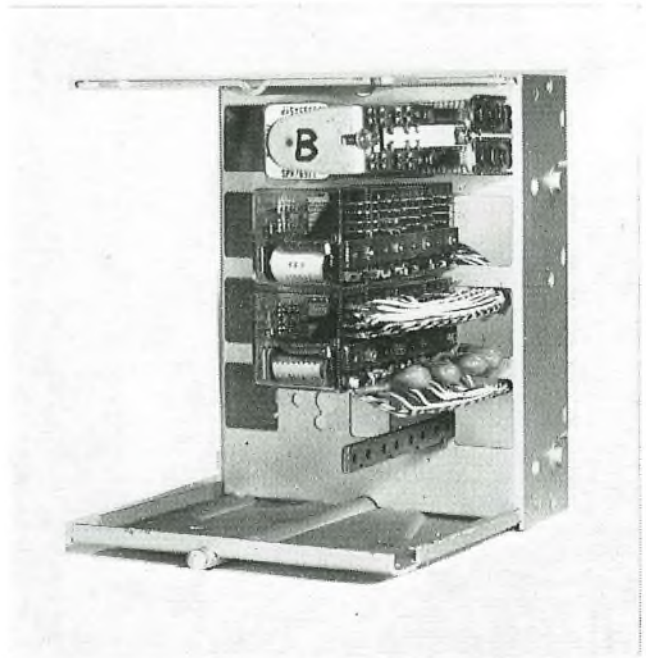


FIG. 4—Relays type 23 on a bracket occupying modular space of one 3,000-type relay

### APPLICATIONS

The Type 23 relay has already proved to be a most useful addition to the circuit engineer's range of switching devices for use in Post Office equipment.

The small size and weight have been exploited in portable testers, customers' plan telephones, special installations, data equipment and the like. Fig. 3 shows a particularly ingenious combination of Type 23 relays and solid-state devices in which the advantages of both classes are utilized to form a compact unit, requiring a small mounting space only.

Where Type 23 relays are to be mounted on 3,000-type relay mountings, a Post Office standard bracket is used as an adaptor and can accommodate up to four relays in the modular space required for one 3,000-type relay. This is of great advantage where space is restricted, for example, where it is required to modify existing equipment.

Fig. 4 shows "worst case" conditions: four size B relays fully wired, each with a non-linear resistor connected across the coil as a quench.

### ACKNOWLEDGEMENTS

Acknowledgements are made to: Messrs. Oliver Pell Control Ltd; Pye-T.M.C. Ltd; S.T. & C. Ltd; B & R Relay Ltd, for information and assistance in the preparation of this article.

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# Notes and Comments

## Letters to the Editor

Dear Sir,

May I say that I agree wholeheartedly with your correspondent Mr. J. C. Endersby on the need to update and broaden the scope of the *Journal*.

As a technical journal it deservedly has a very high reputation indeed but I suggest that by concentrating as it does on technical articles it does not adequately reflect the breadth of activities which are the concern of Post Office engineers.

I would suggest that some articles be commissioned which would demonstrate the relevance of engineering to planning, operating, and managing the many activities of the Post Office. The *Journal* has also tended to be a headquarters organ, possibly as a consequence of its concern with technical matters and I, for one, would very much like to see some articles of relevance and interest to field staff. May I suggest that suitable topics might include work study, manpower planning, productivity achievements, etc., preferably written from the point of view of regional and area staff?

Yours faithfully

T. LOMAS

Management Services Department,  
Telecommunications Headquarters,  
207 Old Street,  
London EC1V 9PS

Dear Sir,

I refer to the letter from Mr. J. C. Endersby in the April issue of the *Journal*.

Surely the chief merit of the *Journal* lies in its excellent technical content which is no doubt illustrated by the extent to which it is in demand outside the Post Office, in the Universities and Technical Colleges and overseas.

If the Editor agreed to the suggestion of Mr. Endersby this technical excellence would be bound to give way to the more racy, pseudo-technical management jargon type of journaleze that is apparent elsewhere. I am not necessarily against the intent of Mr. Endersby but he really should choose another forum in which to proclaim his message.

If he reads the articles presented in the *Journal* I hope he will accept that they are aimed at presenting the latest technical developments in the telecommunications in this country with some knowledge and authority. If he reads the Notes and Comments he will get some knowledge of the people behind the articles and those people within the Post Office whom the *Journal* serves. The laudable activity sampling carried out by Mr. Endersby clearly indicates that in this age of rapid technological change people still matter, and long may it remain so.

Yours faithfully

D. P. SIMMONS

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Telephone House,  
4-20 Woodgrange Road,  
London E7 0BA

## Publication of Correspondence

The Board of Editors would like to publish correspondence on engineering, technical or other aspects of articles published in the *Journal*.

Letters of sufficient interest will be published under "Notes and Comments". Correspondents should note that, as it is necessary to send copy to the printer well before publication date, it will only be possible to consider letters for publication in the October issue if they are received before 26 July 1971.

Letters intended for publication should be sent to the Managing Editor, *P.O.E.E. Journal*, Post Office Factories Headquarters, Bovay Place, London, N7 6PX.

## Notes for Authors

Authors are reminded that some notes are available to help them prepare the manuscripts of the *Journal* articles in a way that will assist in securing uniformity of presentation, simplify the work of the *Journal's* printer and draughtsmen, and help ensure that authors' wishes are easily interpreted. Any author preparing an article for the *Journal* who is not already in possession of the notes is asked to write to the Managing Editor to obtain a copy.

It is emphasized that all contributions to the *Journal*, including those for Regional Notes and Associate Section Notes, must be typed, with double spacing between lines, on one side only of each sheet of paper.

Each circuit diagram or sketch should be drawn on a separate sheet of paper; neat sketches are all that are required. Photographs should be clear and sharply focused. Prints should preferably be glossy and should be unmounted, any notes or captions being written on a separate sheet of paper. Negatives or plates are not needed and should not be supplied.

## Model Answer Books

Books of model answers to certain of the City and Guilds of London Institute examinations in telecommunications are published by the Board of Editors. Details of the books available are always given at the end of the Supplement to the *Journal*. The Board of Editors has reduced the price of Line Plant Practice A to 37½p (42½p post paid).

The Telecommunication Principles B Answer Book is out of print at the moment but a revised issue is in preparation and an announcement will be made in the *Journal* when it becomes available.

## Articles on Current Topics

The Board of Editors would like to publish more short articles dealing with topical subjects. Authors who have contributions of this nature are invited to contact the Managing Editor.

## Supplement

Students studying for City and Guilds of London Institute examinations in telecommunications are reminded that the Supplement to the *Journal* includes model answers to examination questions set in all the subjects of the Telecommunication Technicians' Course. Back numbers of the *Journal* are available in limited quantities only, and students are urged to place a regular order to ensure that they keep informed of current developments in telecommunications and receive all copies of the Supplement.

## Syllabuses and Copies of Question Papers for the Telecommunication Technicians' Course

The syllabuses and copies of question papers set for examinations of the Telecommunication Technicians' Course of the City and Guilds of London Institute are not sold by *The*

*Post Office Electrical Engineers' Journal*. They should be purchased from the Department of Technology, City and Guilds of London Institute, 76 Portland Place, London, W1N 4AA.

## Board of Editors

Mr. R. A. Sudell is resigning from the post of Deputy Managing Editor of the *Journal*, having served the *Journal* since 1959. Mr. D. Millington, at present Assistant Editor, has been appointed Deputy Managing Editor and Mr. Crump, at present Advertising Manager, has taken the vacant Assistant Editor Post. Mr. M. Rothery is the new Advertising Manager.

The Board takes this opportunity of thanking Mr. Sudell for his long and valuable service.

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# Institution of Post Office Electrical Engineers

## Institution Field Medal Awards—1969-70 Session.

In addition to the Institution Senior and Junior silver and bronze medals, the Field Medals are awarded annually for the best papers read at the meetings of the Institution on Field subjects primarily of Regional interest.

Field medals were awarded to the following authors for papers read during the 1969-70 session:

A. G. J. Fagg and D. A. Gray, South East Centre. "The Innovator—Efficiency Engineers in Regional Planning and Works Execution".

J. D. Thomas, North East Centre. "Network Co-ordination".

## Result of Essay Competition, 1970-71.

A prize of £6.30 and an Institution Certificate have been awarded to the following competitor:

P. W. Arber, Mechanic A, Dagenham. "My Five Years with the Post Office".

Prizes of £3.15 each and Institution Certificates have been awarded to the following competitors:

J. Maxwell, Technical Officer, Glasgow. "Strowger Maintenance—A Stated Case".

D. E. G. Coles, Technical Officer, Birmingham. "The urgent re-siting of a Circuit Provision Centre with minimal impairment of service availability".

E. Eastham, Technical Officer, Blackburn. "The Board".

D. Ellingham, Technical Officer, Leeds. "Motorway Emergency Telephones on the M1".

Institution Certificates of Merit have been awarded to the following competitors:

D. J. Griffin, Technical Officer, Glasgow. "Some Problems in Industry".

R. P. Mowle, Trainee Technical Apprentice, Telecommunications Headquarters Circuit Laboratory. "The Telephone Transmitter".

J. S. H. Emm, Edinburgh. "Towards Infinity".

G. E. Coucher, Technical Officer in Training, Mount Pleasant. "A Day in the Life".

J. Morrison, Dundee. "Telecommunications in Sweden".

The Council of the Institution records its appreciation to Messrs T. J. Morgan, S. Rata and A. W. Welsh, who kindly undertook to adjudicate upon the essays entered for the competition: it is also indebted to them for the following report on the prize-winning essays. The prize-winning essays will be

kept in the Institution Central Library and will be available to borrowers.

## Review of Essay Competition, 1970-71

There has been a considerable increase in the number of essays presented this year. The range of subject has been very wide and included such topics as "Industrial Psychology", "Line Transmission Systems", "Apprenticeship Training in the Motor Transport Section", "Sorting Offices in America", "Telecommunications in Sweden", and "Promotion Boards". The standard of writing and drawing has greatly improved and it has been a most difficult task to select the winners.

In his winning essay, "My Five Years with the Post Office", Mr. P. W. Arber covered his apprenticeship in a Motor Transport Section and his early years as a motor mechanic. Although essentially a non-technical essay it shows considerable insight into the attitudes of student apprentices. It deals with the author's first meeting with people in the transport section, his fellow students at the training college, and by giving his own reaction to both them and the lecturers, reveals his awareness of the importance of one's attitude to people—those we have to work for and with, and the customers with whom we come into contact. The essay shows that he has appreciated the importance of the theoretical as well as the practical training involved in his apprenticeship course.

Another essay which showed some penetration dealt with the attitude of mind of three prospective promotion board candidates and made very interesting reading. It clearly detailed the thought processes which most of us have experienced when receiving our first notification to attend a promotion board, and the feelings following success and failure.

A number of essays reported in some detail activities in which the authors had been intimately concerned, and while the details of these operations were often clearly reported, the papers themselves, being more in the nature of operational reports than essays, were not particularly interesting to others not directly involved.

The paper, which dealt with the possible design of a theoretical parcel facing machine, contained a considerable amount of original thought but failed in its presentation because it did not lead convincingly through the various stages of the design. In one or two instances the presentation was marred by the use of colloquialisms and slang. However, on the whole the standard was quite high and showed an increased interest in the competition.

A. B. WHERRY

### Eastern Region

#### *Overnight Transfer of Navestock M.N.D.X.*

With the exchange equipment at Coxtie Green u.a.x. and associated mobile non-director exchange (m.n.d.x.) Navestock fully utilized, as well as protracted delays in the equipping of the new T.X.E. 2 exchange, it was evident that an extensive waiting list would build up unless action was taken. A composite rack connected to the m.n.d.x. would provide for 200 new subscribers but no accommodation was available for a rack in the u.a.x.; nor was this desirable from a line plant aspect because the existing cable routes had little spare capacity, and new cables were already being laid to the new exchange site some  $1\frac{1}{4}$  miles distant in anticipation of the opening date.

It was decided that the problem could be solved by shifting the m.n.d.x. to the T.X.E. 2 site. This would entail a large part of the exchange transfer scheme being completed in advance and cause interruption of service to Navestock subscribers. However, the cabling program could be accelerated to meet the proposed date and it was physically possible to disconnect, tow the vehicle to the new site and re-connect it within a few hours. To minimize inconvenience to the subscribers a Saturday night, 28 November, was chosen for the operation.

All subscribers were notified by letter, or visited in the case of p.b.x.s, and requested to note the position of the nearest public kiosk, or neighbour with a Coxtie Green telephone number, in case of emergencies. Any with special difficulties were encouraged to write to the Telephone Manager's office.

Before the external cables could be intercepted and diverted to the new exchange, terminating records, particularly those of the m.d.n.x. cables, had to be verified and schedules prepared. The cabling and jointing work was then put in hand and completed two weeks before transfer. Existing tie cables at the m.n.d.x. were labelled and pairs identified, and the five cables were then duplicated and teed-in in readiness at the new exchange main distribution-frame.

The police were informed of the operation and the route and their co-operation sought.

On the night of the transfer staff assembled at 2000 hrs and began work shortly afterwards in the pouring rain. Fortunately jointers tents had previously been erected at both sites over the tie cables and these areas were kept relatively dry. Floodlights provided illumination on both sites.

At the old site a fence was removed for the tractor to be driven up to the trailer, a hawser was attached and all was ready. At 2300 hrs the Electricity Board electrician disconnected the power supply to the mobile exchange and at 2330 hrs, when it was established that no calls were in progress, the battery fuses were withdrawn and the exchange earth disconnected. Immediately the tie cables were sawn through, the ends insulated and the slack cable tied-up beneath the trailer. The main road was closed to traffic by the police whilst the vehicle was being towed off the site and manhandled into position behind the towing vehicle. Shortly afterwards a small convoy of vehicles set off for the new exchange led by a police car. At the Ongar Road junction and outside the new site traffic was again held up by the police. The trailer was in position at 0030 hrs.

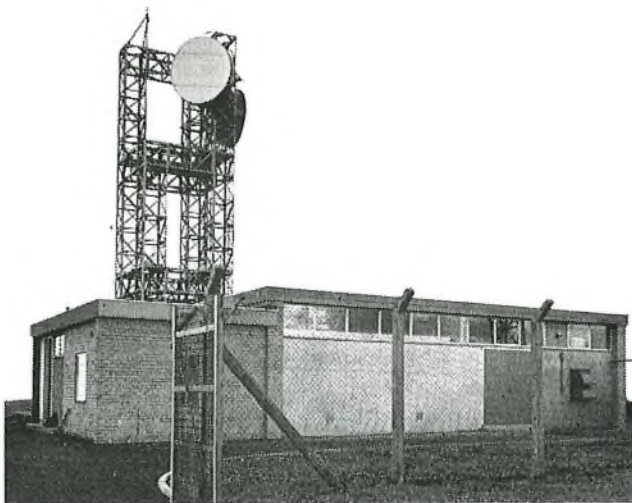
The exchange earth-connexion and power supply were quickly re-connected as five jointers, each with a 100 pair tie cable to work on, began jointing the severed cable ends over the new exchange cables. At 0415 hrs this work was completed, the fuses were replaced, and Navestock Exchange was back in service. Junction testing was begun immediately but the testing of subscribers' lines was delayed until later in the morning. Nevertheless one sleepy customer complained bitterly that 0900 hrs was much too early to be awakened on a cold Sunday morning in November! His was the only complaint.

P. G. TAIT

#### *Belfast-Dublin Microwave Radio System*

A microwave radio-link between Belfast and Dublin has been brought into service to provide additional telephony channels between the Republic of Ireland and Northern Ireland and also between the Republic of Ireland and England. The existing arrangement consisted of an S.T. & C. 600 circuit 2.6 MHz regulated line co-axial system.

This is the first radio-link to be installed in the British Isles by Philips of Holland. The installation and testing of the radio equipment was carried out by seven Dutch technicians. The route distance covered between Belfast and Dublin is 179.6 km of which approximately 70 km are in Northern Ireland and 109.6 km are in the Republic of Ireland. The route consists of two stations in Northern Ireland, Standing Stones (Terminal) and Deadman's Hill (Intermediate) (shown in the Fig.) and three stations in the Republic of Ireland, Mount Oriel and Cappagh (Intermediate) and Dame Court (Terminal).



Deadman's Hill Intermediate Radio Station

The radio-link has a maximum capacity of six main channels and two protection channels, each channel being capable of carrying one colour television signal or one direction of transmission of a 960-circuit telephony system. Initially, one main and one protection channel have been installed in each direction. The first extension to the system is due for completion in March 1972 and will provide one additional main telephony channel in each direction. The protection channels are used for television occasional broadcasts, the most notable up to date being the Eurovision Song Contest which was transmitted from Dublin in April this year. This radio-link operates in the upper 6 GHz frequency spectrum. It is a solid-state radio system except for the travelling-wave tubes which are required to give an output power of 10 watts. This is necessary owing to long spacing between intermediate stations. Automatic baseband switching is provided between main and protection channels in case of failures. The supervisory system is transmitted via the radio-link using the vacant sub-baseband portion of the first main channel. On failure of the first main channel, the telephony traffic plus the supervisory system are automatically switched to the protection channel. In the radio stations, logic techniques are used to monitor and switch the radio channels. The equipment is of 62-type construction except for the transmitters and receivers which are accommodated as separate units on the radio bays. The two British Post Office stations use a 24-volt power supply to feed the radio equipment, while the three stations in the Republic of Ireland use a 48-volt power supply. In Northern Ireland the radio and power equipment are installed in standard Post Office radio link station buildings known as type AK 1/8.

The towers used in Northern Ireland are of a standard daffodil modular construction form. The 10 ft diameter



Cassigrain aërials used are connected to the radio equipment by Flexwell waveguide. An unusual feature of these aërials is the use of radomes to protect the aërials against adverse weather. The radomes degrade the signal level by approximately 0.5 db.

The radio system is extended to Belfast repeater station by means of a C.E.L. 1006 small-bore co-axial system. All circuits between Dublin and Great Britain are transferred to Belfast-Cross Channel systems without being demodulated beyond group configuration.

R. PATTERSON

## Midland Region

### Datafair 71

More than 70 companies, the highest number at any British Computer Society exhibition, were displaying their wares at Datafair 71, Nottingham University, 29 March to 2 April.

The main exhibition of equipment was in the Sports Centre and Education Building with lectures and presentation taking place in other buildings on the campus. All required some telephonic or data service and, being spread over so large an area, posed a problem of cable pairs which had to be given early consideration. Companies were asked to let us have their requirements early, but some late comers were inevitable, the final one being for a Modem No. 2 at 0900 hrs on the opening day. We were able to supply this service by 0915 hrs to the gratification of the customer.

For the 76 exhibitors we provided 112 exchange lines, 53 Datel exchange lines, 62 modems, 28 private circuits and 3 telex installations.

Two junction cables had to be cleared and diverted to the university p.a.b.x. main distribution-frame (m.d.f.) and a new 400 pair cable to Basford Exchange was brought forward as a standby, whilst an outlet to Beeston Exchange was used for the extra coin-box telephones we provided. A 200 and a 250 pair cable completed the arrangements between the m.d.f. of the university p.a.b.x. and the m.d.f. in the Sports Centre. The main telephone distribution was to Archer Exchange, and the 0 level outlets had been augmented to the s.t.d. equipment. Falcon and Outlaw Trunk Exchanges had also been equipped with more outlets to Birmingham, London, Cambridge, Leeds, Manchester and Reading to carry the anticipated long duration calls (all day in some cases) set up by the exhibitors.

A large 32 ft by 10 ft Porta Cabin was hired for three months which provided an excellent centre for installation staff to set up and store modems, telephones etc, so that they could be provided in the various buildings ready for immediate service.

A Datel test centre at Brook Street Trunk Test, and a repair centre at Castle Exchange for all fault reports, completed the testing arrangements. The Sports Centre presented a problem of distribution. An m.d.f. was erected in the store room near the centre of the building and the 200 and 250 pair cables terminated. Cable was then fed from this m.d.f. and slung over the girders of the very high ceiling, as and when permission could be obtained, so as not to disrupt students sports activities. This took about two months to complete and the cables were coiled up ready to drop down over the stands. Only a minimum of preparation was possible in all the other buildings on the campus at this time.

On March 19 the students had left and access to most buildings was possible and work had to be done in close co-operation with the stand contractors. When the stands were ready and furnished the telephones, modems and other equipment was connected, and this was not completed and circuits tested until 28 March.

Many voices of appreciation of the Post Office Services were heard and it was interesting to hear Prof. J. H. H. Merriman, Senior Director of Development in the Post Office, in the closing lecture comment on the good service the local Telephone Manager's Staff had provided. He mentioned one complaint, from the Post Office Data Processing Service, perhaps to illustrate that we treat all customers, even ourselves, the same.

And so we are to be entrusted with Datafair 73 which is again to be held at Nottingham University.

A. H. DENNIS

## Midland Postal Region

### New Leicester Parcel Sorting Office Nears Completion

The two interesting features of this office are the tallest vertical risers so far installed, and the solid-state parcel-sorting machine controller. The vertical risers are 95 ft tall and introduce some interesting problems regarding chain tension. The parcel-sorting machine controller is the simplest and most compact solid-state controller that has been produced to date. One of the unique features is the total elimination of the diode matrix from the keyboard. The keyboard is simply key switches. This simplification reduces the cost of the keyboard and does not place at risk a vital component of the sorting machine's circuitry. The controller will form the major part of the Post Office's exhibition at the I.E.E. centenary celebrations at Aston University in Birmingham.

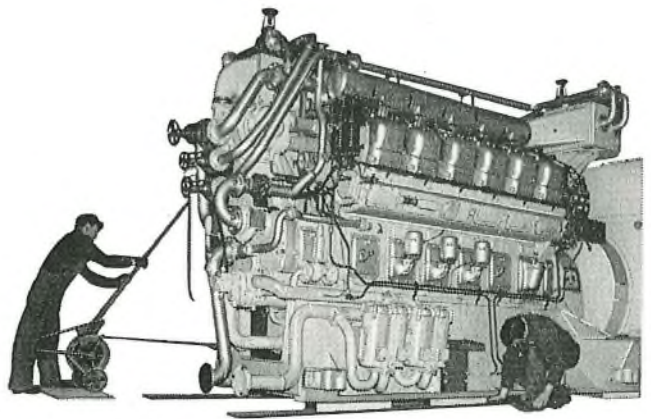
S. W. GODFREY

## Scotland Directorate

### Engines For Dial House, Glasgow

Standby power for Dial House, Glasgow is supplied from diesel-engine generator-sets and the load at the 20 year date is 5,000 kW, the initial provision being three sets at 1,100 kW each. These have now been delivered and installation work is nearing completion, but delivery and manoeuvring them into position was a sizeable handling job.

The engine room is on the ground floor, but design of the basement areas made it impracticable to leave the engine-room floor on solid ground so consequently this is a suspended floor. It was designed to take the static and dynamic loads imposed by the engines and to take a rolling load of 20 tons over the area between the apparatus entrance and the engine positions. The engine specification, therefore, had a clause limiting the largest single piece of equipment for delivery to be within 20 tons. At this stage, of course, it was not known what make of engines and generators would be used. In due course the engine contract was let, the engine-generator sets were built and it transpired that their weight was 24.3 tons each. If these could be delivered complete, in spite of the 20 ton load restriction, then partial dismantling, after works test and subsequent re-assembly on site would be avoided. This would benefit both the Post Office and the contractor. The proposal was put to the Department of the Environment and their structural engineers pronounced that, with certain provisos, the floor could withstand the additional load over and above the design figure, so agreement was given for delivery of the assembled engine-sets.



Generator-set being winched across the engine room floor

The engine room floor is 7 ft above the level of the outside roadway, and, therefore, entry into the room had to be preceded by a lifting operation and the 20 ton lifting beam which had been installed in the building for this purpose could not now be used. Instead, the delivery vehicle was positioned as close as possible to the apparatus entrance door then the vehicle trailer, complete with the engine-set on it, was jacked up to be level with the door threshold. The set, nearly 20 ft long by 6 ft wide, was then manhandled through a 90° turn into the 10 ft wide door-opening and on to the floor.

A double track of rollers was used for moving the sets. Each section of track consisted of a frame holding a series of fixed, pivoted rollers at about 4 in centres. The track sections were moved from behind the engine-set to in front of it as it progressed along the room, the effect being that of a continuous roller-conveyor. Half-inch steel plating was placed beneath the roller tracking to protect the floor surface. The figure shows this operation in progress, a winch being used to pull the set along.

The engines are British Polar 'F' series, 12 cylinder 'V' form with exhaust turbo-charging and inter-cooling, developing 1,600 horse power each, at 750 revolutions/minute. They drive brushless alternating-current generators made by the Brush Electrical Engineering Co. producing 1,100 kW each, at 415/240 volt, three-phase, 50 Hz. British Polar Engines Ltd is a Glasgow firm which operates primarily in marine engineering but is currently extending its activities into the industrial field. The nautical lineage of the new engines can be seen on the dip-stick for the crankcase lubrication oil. It has maximum and minimum markings for "Even Keel" and "3° Aft Trim".

Transportation and handling of the engine sets was carried out by the Glasgow branch of Pickfords Ltd.

A. NESS

### South Eastern Region

#### Guildford Town Centre Duct

In July 1969 proposals were received from the Guildford Borough Council for road works in the vicinity of the River Wey, at the western end of the main shopping area. These proposals included a new road-bridge over the river, a section of new highway and alteration to existing roads.

The Guildford telephone exchange and repeater station are situated in the centre of the town, and for economic and town planning reasons the decision had already been made to cater for future requirements by extending onto adjacent sites. There is to be an ultimate capacity for three exchange units plus the repeater station, and this complex will require a new 160 way lead-in plus a 48-way duct route increasing to a 54-way duct route to the west of the town and crossing the river Wey.

Negotiations with the local council established that the design of the proposed road bridge would only accommodate a 24-way duct. The approaches to the bridge would also create difficulties and neither could sufficient accommodation be found in the existing bridges. Finally four schemes were costed and examined and the one eventually agreed provided a duct route almost on a straight line and giving good facilities for long-length cabling. To achieve this, the route had to pass under an area of private re-development, under the River Wey and under the bus station. (see Fig.)

At the time of our negotiations the private re-development

was in advanced stages of design. The buildings under which our route would pass were to be constructed on a network of piles and considerable discussion was necessary with the consulting engineer to agree the best possible line and level. Agreement was finally reached with the stipulation that we should use the "pipe jacking" technique to provide a 36 in (internal diameter) concrete pipe. (The necessary 54-way duct would then be laid within the pipe.) It was further stipulated that the pipe would have a deviation of no greater than 6 in at any point over its entire length, as it would pass within the network of piles.

Owing to the positioning of the bridge foundations it was necessary to make a small deviation on the line once clear of the buildings. This was achieved at the thrust pit with a horizontal deviation of 11 degrees and a vertical deviation of 3 degrees, the pipe then continued under the river to the bus station. In all, some 112 yards of pipe were scheduled and the remainder of the route was constructed using duct No. 55 in standard timbered heading.

Owing to the depth and angle of the route it was necessary to design three non-standard manholes including one of two-level design. The location of all these manholes was very critical because of other services and site restrictions.

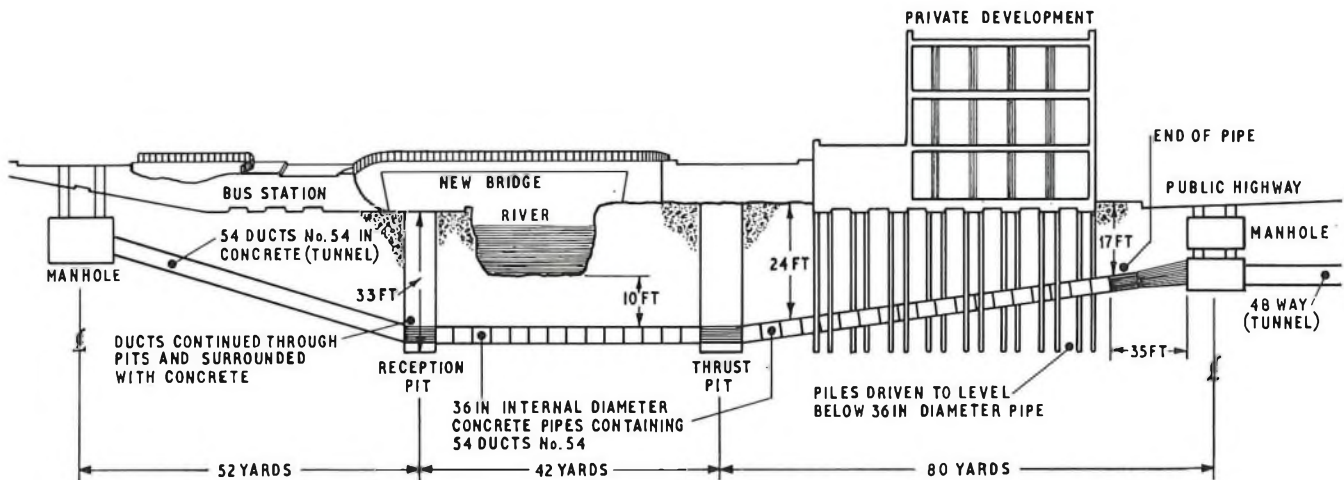
Wayleave negotiations were very complicated and protracted and, although initially it was hoped to complete the pipe jacking in advance of the piling, by the time the necessary permission was obtained the piling was completed and the buildings erected. In addition to all the usual authorities, agreement also had to be reached with the street market superintendent, taxi-rank operators, the public transport authorities and the National Trust.

At the planning stage it was necessary to establish that it was practical to place 54-way ducts in the 36 in pipe, bearing in mind that the ducts would have to terminate in the manholes in the correct sequence. A scale model was constructed by the drawing office and, following experiments, it was established that the ducts should be installed in 5 ft lengths and that a vertical central spacer should be used with no filling material. It was also decided that at least 20 ft would be required to change the ducts from pipe to manhole formation.

Before finalizing the specification two further considerations had to be settled. The flow of traffic in the area concerned is exceptionally heavy and so the co-operation of the police was obtained at this stage. The other requirement was to know the nature of the subsoil, and in this connexion we were helped as trial holes had been taken out in the area of re-development for the Council, therefore, it was decided to buy this information rather than take out a further series of trial holes.

The contract was awarded to J. Murphy and Sons Ltd, and the work commenced on 28 September 1970.

Pilot holes were sunk opposite Haydon Place to a depth of 23 ft. The area was found to be clear of other services so the hole for the turning manhole was excavated to this depth. The hole was used as the main shaft for the tunnel being driven down the hill, on a line parallel to the surface of the highway.



Sectional diagram showing the duct passing under the private development, the river Wey and the bus station

Air shafts were sunk at approximately 50 yard intervals. The whole of the excavation was in soft virgin rock (chalk) which was dry except for seepage from various water and sewer leaks. These were repaired by the other utilities as and when they were found.

Work proceeded for 280 yards, with one intermediate manhole at the 130 yard mark, terminating at the two-level manhole at the junction with Friary Street. This manhole excavation was 24 ft and well below the water in the river but fortunately no water appeared in the excavations. At approximately 75 yards before the Friary Street manhole position was reached the chalk changed to running sand. This tended to run through the joints in the tunnel timbering, but was overcome by packing straw in any cracks that showed.

The ducts were laid in the tunnel using concrete spacers and packing and filling all voids with quality F concrete. Great care was taken with the packing of the tunnel to avoid subsidence at a later date.

Whilst the conventional tunnelling work proceeded, work was also proceeding on the pipe jacking section. The deviation in the horizontal and vertical plane referred to earlier was to be accommodated in the thrust pit and the section of pipe from the thrust pit to Friary Street had to pass between the piles carrying the new development. This line was laid out by the contractor's surveyor and when laid the pipe appeared in Friary Street within 6 in of the desired point. The thrust pit area was 12 ft by 22 ft and was sunk to a depth of 29 ft, the bottom being concreted to provide a solid foundation for the hydraulic jacking equipment. The reinforced concrete pipes which weighed 2½ tons were 8 ft 3 in long and each thrust was made in 4 ft lengths, climbing to the higher level of Friary Street.

The commencement of the thrust was in chalk but after 12 yards the chalk gave way to running sand and special measures had to be taken to prevent voids forming above the thrust shield. These consisted of blanking off the top half of the shield and packing with straw. When the pipe thrust had passed the 200 ft mark the thrust wall began to show signs of stress. It was, therefore, decided to extend the tunnel from the Friary Street manhole and enlarge it sufficiently for the shield recovery operation.

Throughout the operations the possibility of being troubled by water was always a consideration, especially as the thrust pit was only a few feet from the river bank, but fortunately no water appeared in the workings. Initially the weather also favoured the operation, but then during the early part of November the rains came and we had several anxious days as the level of the River Wey rose to within about 6 ins of flooding the workings. To pass under the river the thrust equipment was turned round and thrusting continued up a slight rise, so that any water entering the workings would run back to the thrust pit, where it could more easily be dealt with. However, once again no water appeared and this was especially surprising as this part of the work was about 10 ft under the river bed which is 10 ft deep at this point. One can only assume that the old navigators did a first class job of canalizing the river and that the bed is still waterproof. Will our work be as good in 150 years time?

The reception pit on the south side of the river was excavated to a depth of 30 ft. This was also used as the drive shaft for the final tunnel to the Park Street manhole and the pick-up point on the existing track—which was found to be accurately recorded.

When laying the ducts across the thrust pit it was not found possible to hold them in the pipe formation owing to the deviation on the route at this point. The problem was overcome by taking a set of 5 ft lengths of duct No. 54 to Messrs Capper Niel of Horsham. They set the lengths to a radius of 20 ft ± 6 ins and these bends then laid naturally in the pit and allowed the surrounding concrete to be placed without tension on the ducts.

All operations in connexion with this project were finally completed in February, after 20 weeks, with 12 hour working 7 days a week. It has been a splendid example of all round co-operation not only by the Area Planning Works and drawing office but also by the contractors and the public authorities.

P. G. H. RIDDLE  
H. E. STEPHENS

### Cable Distribution To Six Mobile Telephone Exchanges At Chatham A.T.E.

Owing to the lack of exchange equipment at the Chatham exchange, up to six mobile non-director exchanges (m.n.d.x.) will be required to cater for the growing list of waiting applicants for telephones.

As each m.n.d.x. requires 500 pairs of wires the nearest cable large enough to feed the site was a 3,200 pair polythene unit-twin cable.

When dealing with a cable this size, it becomes necessary to reduce it to several subsidiary cables, the normal method of achieving this is to make a joint between the 3,200-pair cable and three 1,000 pair cables, each 1,000 pair cable in turn being jointed to two of the 500 pair mobile-exchange cables.

However, a manhole would be required adjacent to the site to accommodate cable joints of this size which, when combined with the cost of the jointing made this method prohibitive. After consultation between the planning and works groups involved the following method was put into operation.

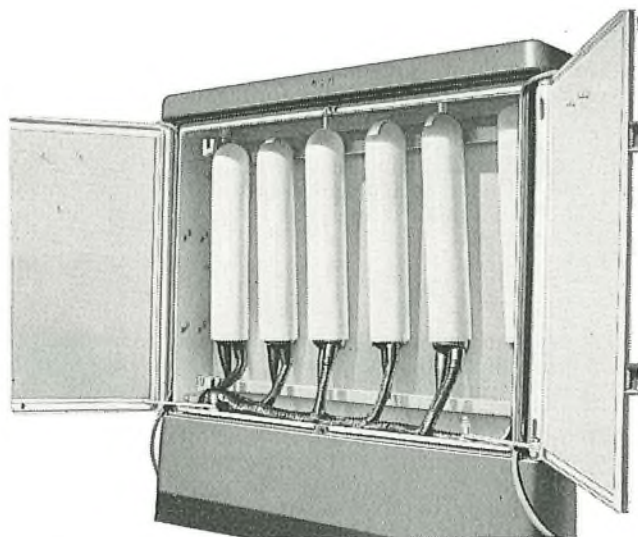


FIG. 1—The cross-connexion cabinet showing the six completed joints

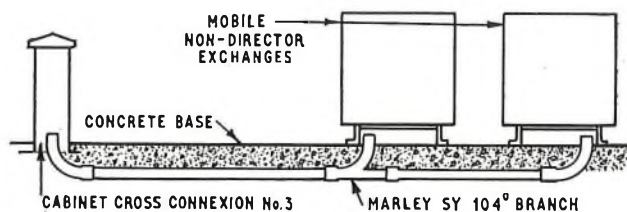


FIG. 2—Cross section showing use of Marley SY Branch 104° bend

A Cross-Connexion Cabinet No. 3 (c.c.c.) was erected at one end of the proposed site, this in turn was connected to the exchange using two duct tracks to accommodate the 3,200 pair cable and associated earth wire.

The 3,200 pair feed-cable was pulled-in in one length from the main distribution-frame to the c.c.c., thereby cutting out any subsidiary joints and the need for an associated manhole. At the c.c.c. the cable was split into six 500-pair forms and protected, using self amalgamating tape.

As each mobile exchange was brought on site the 500-pair cable was pulled in from the m.n.d.x. to the c.c.c. and jointed to the appropriate 500-pair form. The completed joint was then sealed using a polythene Sleeves No. 3A (Fig. 1). Finally, owing to the limited space available in the base of the c.c.c. it was only possible to accommodate a further three ducts in addition to the two provided towards the exchange. This meant that two of the ducts would have to feed more than one m.n.d.x. To achieve this without building boxes Marley SY 451 branch-bends were used (Fig. 2).

Excluding costs common to both schemes a saving of approximately £600 was made and the job completed three to four weeks earlier than anticipated.

A. R. Fox

# Associate Section Notes

## Ayr Centre

The 1970-71 session opened with a visit to Prestwick Airport Control Tower in September. The radar and navigational equipment on the ground floor was fully explained by the duty staff and the operational controllers were seen at work on the upper floors.

In December a talk, originally planned for November but postponed owing to the illness of the speaker, was given by one of our members Mr. Ross, entitled "The Irvine Wide-band System". This system, which represents a new venture by the Post Office in providing telephone, piped television and potentially other high frequency services, was very capably explained by our speaker and associated testers and equipment were on view. By special interest and request a second visit was made to Dalry T.X.E.2-type exchange in January. The system was studied with great interest by all present and thanks are due to Mr. Mason the assistant executive engineer and local staff for making this very enjoyable visit possible.

The subject of our February meeting was a talk entitled "Navigation" by Captain Corse. With the aid of many different types of chart including Decca and Loran, very many aspects of the subject were covered and a lengthy question session followed.

A. BAGNALL

## Dundee Centre

The program, shown in the January issue of the *Journal*, has been a most interesting one. Attendances have been slightly down on previous years but none-the-less enthusiastic. The best attended meeting was that given by two of our members, Messrs R. M. Burns and J. M. Low who talked about and demonstrated the many varied new pieces of subscribers' apparatus.

We are happy to note success came to our Assistant Secretary A. W. Smart for his paper on the P.A.B.X. No. 6. Also included in the program was a day visit to the B.P. Refinery, Grangemouth, and a Distillery at Camelon. The annual general meeting, attended by Dr. Bray, was held on April 20.

The Committee wish to thank members for their support and ask that they "spread the gospel"—to their fellow members who don't attend.

R. T. LUMSDEN

## Exeter Centre

At the time of going to press only the annual general meeting remained to conclude the 1970-71 winter program. The year has been very successful with an average attendance of 85. This is lower than last year but still reflects the remarkable enthusiasm of the membership and as this is the last report I shall write as Secretary I would like to thank them for their very active interest in the Centre during my seven years of office.

The success of any Centre, however zealous its Officers might be, can only be measured in terms of the interest shown by the membership in its activities. In this respect the Exeter Associate Centre can be proud of its achievement.

Owing to the increasing activity within the Centre and in their endeavour to obtain a successor to the Secretary the Officers have, over the past two years, embarked on a program of devolving work to the committee members. This has proved worthwhile in many ways and the incoming committee will find themselves increasingly involved in the organization of the Centre's affairs.

We are indebted to our speakers who have given us an enjoyable winter program. Of all the papers presented those which gave the greatest satisfaction were given by our own colleagues Donald Craig and Colin Knapman. It is a pleasure to have such eminent ability to call on and any prospective speakers must have been encouraged by the support given to these two members.

It is hoped we will be given two more papers by our own members during the next session, they will be entitled "Twenty-Three Years of Radio Interference" and "The Wells of Mersa". More information will be available on these papers by the time this report is published.

During my time as Secretary I have leaned heavily on the Officers and Committee members, may I thank them most sincerely for their help throughout this period. Also, on behalf of the Centre, I would like to take this opportunity to thank both past and present management of the area for their help. We are indebted to them for the privileges they have afforded us to help us in the running of the Centre.

Our financial position is very sound and the incoming Committee will be able to take advantage of this and the enthusiasm of the membership to invest a little more heavily in obtaining recognized outside speakers in order to ensure the continued success of the Centre.

T. F. KINNAIRD

## Glasgow Centre

The 1970-71 session opened in October with a talk on "Long Term Planning and £. s. d." by Mr. Revell, Director, Telecommunications Headquarters, Scotland. All members and friends present enjoyed the talk thoroughly.

Our second meeting in January took the form of a film show. Films shown were "Environment in the Balance", "North Slope Alaska", "The Cattle Carters" and "The Rival World". All films were supplied by the Shell-Mex and B.P. film library.

"Tape Recorders and Unit Audio" was the title of the talk given by Mr. Wilson of Philips Electrical at our third meeting in February, the talk being amplified by a display of elegant Hi-fi equipment and tape recorders. During the month of March we enjoyed a most interesting talk on "Old Glasgow", the guest speaker that evening being Mr. J. House, the well known Journalist and Author.

Our only arranged visit during the session was to the Southern Scotland Electricity Board grid-control centre at Kirkintilloch in November, where an interested party of members was given a short informative talk on the functions of a grid-control centre, by the System Operations Engineer, Mr. Davies, before being shown round the main control-room, and telecommunications apparatus room. A second visit had been arranged to the National Engineering Laboratories at East Kilbride, for December, but owing to the work to rule by the electricity board employees, this visit had to be cancelled.

An extra visit, however, was made to the Usher Hall in Edinburgh to hear the Faraday Lecture "Changes and the Future in Electrical Engineering", presented by Mr. S. Z. de Ferranti.

The final two meetings of the session were "Submarine Cables" by Dr. Bray, Principal of the Technical Training College, Stone, in April, followed on the 7 May 1971 by the annual general meeting.

R. I. TOMLINSON

## Gloucester Centre

Our winter series of lectures commenced with a survey of amateur radio techniques given by Mr. Ron Bee at the Gloucester Telephone Manager's Office. His fascinating lecture was followed by a live demonstration to a fellow radio amateur in Cheltenham, who vividly described his rather uncomfortable transmitting position ('shack') beneath the stairs.

An audience of over fifty was welcomed to the first of what is hoped will become a regular film evening in December 1970. A total of five films were shown illustrating the Dutch reclamation of the sea, the 1969 Greaves Motorcycle Championship, the building of the M 50 motorway, the history of the Turkish nation, and the sailing of a tiny dinghy across the North Sea in a force nine gale.

Undoubtedly the most popular lecture of our winter session was given by Mr. Bert Foord of the London Weather Centre. Despite threats of a heavy snow-storm, over 100 members and wives enjoyed a completely spontaneous and amusing lecture regarding the difficulties encountered in forecasting the vagaries of the British weather.

In February 1971 Mr. Howarth from the National Data Processing Centre gave a detailed description of data processing with particular emphasis on the Post Office Long-Line Computer Project.

At the end of March an experimental slide competition was held at the Gloucester Telephone Manager's Office. Over 90 colour slides were submitted by our members and were shown in a random sequence accompanied by a delightful commentary recorded by Daphne Neville, a local television personality. The annual general meeting which followed immediately afterwards led to the re-election of Mr. Proctor as our president, and the appointment of Mr. A. K. Franklin as chairman following the recent promotion of Mr. J. H. Bowen. Mr. P. G. White was re-elected as Secretary and the remainder of the committee was also re-elected. Two additional members were also appointed, Mr. C. Perks of Cheltenham and Mr. G. H. Adams of Stroud.

J. R. SMITH

### Motherwell Centre

The first meeting of the New Year, held on 26 January, took the form of local papers, when two of our colleagues gave talks on their hobbies. Mr. W. R. Anderson discussed the use of various cameras, pointing out the advantages and disadvantages of types as varied as the simple box camera, the single-lens reflex, and the Polaroid land-camera, along with their ancillary equipment. Mr. R. Mathews, who is well known in local philatelic circles, guided us through a history of telecommunications as depicted on postage stamps. Both talks required much research and for this we gratefully thank the members concerned.

The visit scheduled for 23 February, to Glasgow Central Signal Box was postponed until 6 April at the request of British Rail.

On Friday 5 March, the annual dinner and dance of the Associate Section was held in The Belmont Restaurant, Wishaw, when 120 members and friends attended.

"Communications for the Commonwealth Games", was the subject discussed on 23 March, when Mr. W. N. Lang, Controller Services, Scotland, described the difficulties which had been encountered when organizing the telephone and telegraph network to serve the Commonwealth Games in Edinburgh, 1970. An interesting subject ably described; our thanks to Mr. Lang.

D. K. RAINEY

### Plymouth Centre

By the time this report goes to print we shall have completed another successful winter session. Visits have been made to Hurley (Marine) Ltd. the fibre glass yacht manufacturers, No. 666 Aviation Squadron workshops who fly support helicopters, and Devon and Cornwall film services, one of the premier processors of colour and black & white prints in the West Country.

Lectures have been given on the "Transit Switching Network" by Mr. A. E. Manley from Bristol and "Central Heating" by Mr. J. J. Evans, a lecturer at the Plymouth Polytechnic.

The last meeting was a paper entitled "Electronics in Telephone Exchanges" read by Mr. R. J. Bluett and Mr. R. A. Hill from Telecommunications Headquarters. This was of special interest to our members because Ray Bluett started his Post Office career in the Plymouth area.

J. B. LAFFORD

### Sheffield Centre

The opening event of the 1970-71 session was the regional lecture at York on 13 October. The subject was "Satellite

Communications in the '70s". A party of 17 of our members was able to attend.

On 20 October 72 members travelled by coach to London and whilst the visit was largely a social occasion it was arranged to coincide with the Motor Show.

The Chairman of the Regional Promotion Board, Mr. E. A. Scholey, presented his paper "Appraisements and Promotion Boards" before an audience of some 60 members. The meeting was held at Sheffield University. On 19 November Mr. R. D. Cull, also of Regional Headquarters, read his paper "An insight into transmission" before the Centre. He discussed the development of transmission systems from early days and extended the subject to cover future trends and possibilities.

Mr. G. Rowell of Newcastle-upon-Tyne area presented his paper on 8 December entitled "The Hadrian Tunnel". The tunnel is exclusive to the Post Office and is of circular section. It provides cable access at deep level to the proposed Hadrian exchange, and is some 400 yards long by about 7 ft diameter. The meeting at which Mr. J. Hornsby was to present his paper "From Valves to Transistors" had to be cancelled owing to the illness of the author. We offer him good wishes for a speedy recovery and look forward to hearing his paper at a future date.

On 11 March Mr. Newman, DIP. TP (LON), A.M.T.P.I., of the Department of Planning and Architecture, Sheffield Corporation, read his paper "The Future, a Challenge to Planning". Mr. Newman explained the impact and importance of today's planning on the cities of the future. A party of 20 members visited G.E.C./A.E.I. at Coventry on 21 April.

Some changes have occurred recently in the committee membership and retiring members take with them our thanks for their contribution to the success of our past activities.

J. STEGGLES

### Stirling Centre

The formation of this new centre is well under way with approximately 60 members which I am sure can be increased before the 1971-72 session starts. The following officers were elected to serve for this present session.

*President:* Mr. E. Taunton; *Chairman:* Mr. T. S. Young; *Vice Chairman:* Mr. I. Smith; *Secretary:* Mr. J. Hannah; *Treasurer:* Mr. R. Henderson; *Committee:* Messrs. I. Cowan, G. Derby, and J. McLaren.

For their efforts in bringing about this new centre we must thank Mr. Troup and Mr. G. Derby who were organizers in the beginning.

As this report goes to press we shall have completed our first program of talks and visits which we hope has been of interest to most members. Our first annual general meeting was held in May.

In closing we express sincere thanks to the Glasgow, Dundee and Edinburgh centres for their aid and our formation.

J. HANNAH

### Nottingham Centre

After a long period of inactivity, the centre held a general meeting on 28 April 1971 and selected a committee for session 1971-72 as follows:

*President:* Mr. T. Courtis; *Chairman:* Mr. B. Smith; *Secretary:* Mr. H. Osiransky; *Treasurer:* Mr. D. Mitchell; *Librarian:* Mr. D. Seals; *Committee:* Messrs. L. G. B. Clay, R. Taylor, G. Martin, D. Cameron, R. Chambers, L. D. G. Thorpe.

By the time this item appears in print the committee will have arranged a program of socials, visits and lectures for the current session.

The committee hope that members will give their full support with good attendances in order that further popular and interesting programs may be arranged in future years.

H. OSIRANSKY

# Press Notices

## More International Telephone Links with New U.K.-Spain Cable

The first direct telephone call between the United Kingdom and Spain was made on April 1 over a new £2.2 million submarine cable that runs for 475 nautical miles from Kennack Sands, Cornwall, to Bilbao on the north coast of Spain. Until now all telephone calls between Britain and Spain have gone either by submarine cable to Portugal or through France.

The new cable is capable of carrying 640 simultaneous telephone calls. In addition to providing the first direct telephone link between the U.K. and Spain, it will also connect with the transatlantic TAT 5 cable between Spain and the U.S.A. (brought into service in April last year) and give this country more telephone links with North America. Calls made from Northern Europe to Spain through London will also go by this cable.

At Kennack Sands the cable connects with an underground cable running to Goonhilly Downs, four miles away; and from Goonhilly calls are routed to and from London over the microwave-radio and underground-cable links which also handle calls from the Atlantic and Indian Ocean satellites received on Goonhilly's two giant dish aerials.

The cable was manufactured by Standard Telephone and Cables Ltd. and laid by Post Office cable ships ALERT and ARIEL. This new cable is the second to run from Kennack Sands to Goonhilly. The other is the cable to Sesimbra in Portugal, laid in 1969.

The cable is polythene insulated over its entire length. For more than 200 miles—in the shallow waters of the Continental Shelf—it has the protection of an armoured sheath; and for a couple of miles at each shore end it has two layers of armour for extra protection against damage from sea movements on the seabed and from fishing vessels at work.

It has 52 transistorized repeaters lying on the seabed at 7½-mile intervals in shallow water and at 11½-mile intervals in deep water.

## Europe of the Future Examined by London Telecommunications Conference

A look ahead at life in Europe in the next 30 years, to see what public telecommunication services people may need, was taken by representatives of 10 countries meeting in London in March 1971.

They were delegates to the first meeting of a Long-Term Studies working group of CEPT (European Conference of Posts and Telecommunication Administrations).

The working group has been set up to look into the technological, social, economic and other factors likely to affect the nature and volume of telecommunications between 10 and 30 years ahead. The group examined a variety of international factors that could affect telecommunication services in the long term—such as growth in national economies, people's living standards, the manner in which business is conducted, urban development plans and changes in transport patterns.

The results of the study programme will be made available to CEPT administrations as well as to other CEPT working groups.

The British Post Office, which set up a Long-Range Studies Division in 1967, provided the chairman for this new group.

Other countries represented were Belgium, Denmark, France, West Germany, Italy, Netherlands, Norway, Switzerland and Sweden. Four other countries—Austria, Finland, Portugal, and Spain—have indicated close interest in the Group's work.

The CEPT delegates were welcomed to the United Kingdom by Mr. J. S. Whyte, head of the Post Office Long-Range Studies Division, Mr. D. Van Den Berg, President of the Telecommunications Committee of CEPT (Assistant Director-in-Chief of the Netherlands P.T.T.) attended the first day's sessions.

## New UK-Canada Cable

Telephone cable links across the Atlantic will be more than doubled by a new large-capacity submarine cable to run between the United Kingdom and Canada.

Mr. Edward Fennessy, Managing Director, Post Office Telecommunications, announced that the British Post Office and the Canadian Overseas Telecommunication Corporation has signed an agreement for a new coaxial cable, to come into service in 1974.

"This cable will provide a massive new highway for the fast-growing volume of telephone calls between Europe and North America," said Mr. Fennessy. "Calls from Britain to Canada and the United States of America are already running at 6,000 a day.

"With 1,840 telephone circuits, the cable will have over 400 more circuits than all the existing transatlantic cables put together and, in addition to telephone calls, it will be used for telex, telegrams and data transmission.

"It will be produced to an advanced design based on work at the Post Office Research Station at Dollis Hill, North London," said Mr. Fennessy.

The cable's route will span 2,840 nautical miles between the British cable station in Widemouth Bay, Cornwall, and a new cable terminal to be built near Halifax, Nova Scotia.

To be known as CANTAT 2, it will be the second U.K.-Canada submarine cable. Of the eight transatlantic cables already laid, it will be the fifth to land in Britain and the fifth to land in Canada.

CANTAT 1 was constructed between Oban, Scotland, and Hampden, Newfoundland, in 1961, with 80 circuits.

The two countries' administrations expect to be in a position to make an announcement shortly on a contract for the cable's manufacture.

## Operators Handle a Million International Telephone Calls in a Month

For the first time ever, operators at the International telephone exchanges in London have handled a million calls in one month from customers in Britain to places abroad. The total in March was 30 per cent higher than the 760,000 international operator-handled calls made in March last year.

Dialled International calls made by U.K. telephone users already number more than a million a month.

The Post Office expects the overall volume of international calls to grow by about 20 per cent a year over the next four years.

## Goonhilly Computer to Sample for Comsat

Computer monitoring of transmission and receiving system performance at Goonhilly Downs, the Post Office satellite earth station in Cornwall will be introduced during the next few months.

Automation of the system-checking facilities is part of the Post Office's plan for ensuring that the reliability of satellite circuits will continue to keep pace with the rapidly expanding use of this type of international telephone service.

Performance data, gathered by all operational earth stations participating in the scheme, will be analysed by COMSAT, the American Communication Satellite Corporation who manage the INTELSAT system on behalf of the international consortium INTELSAT. Derived statistics, especially those relating to momentary disturbances, will point the way to technical improvements aimed at increased operational efficiency.

The Post Office has ordered from Ferranti Limited an Argus 500 computer configurations including a central processor, electronic interface units and peripheral equipment, at a cost of £40,000.

Post Office engineers at Goonhilly will write the main programs using standard Ferranti library programs wherever possible. These programs will enable the computer to monitor

the two existing aerial systems at present working to satellites over the Atlantic and Indian Oceans and will include the third aerial system when it is brought into service in 1972.

The computer is able to sample the monitored parameters at the required rates and can record measured values as they occur. Mean values of the data collected will be calculated at one minute intervals and these can be displayed, printed on paper or held in the core stores of the computer until required.

"Supervision by exception" techniques will be employed to minimize the need for scrutiny of printed records and, so long as the monitored parameters remain within pre-set limits,

measurement results will not be printed. Variations beyond the limits will be measured and recorded, and the computer will alert engineers immediately.

At Goonhilly Downs, significant characteristics will be monitored for each of 15 transmitted carriers and 60 received carriers. The computer will also keep check on the availability of reserve common equipment indicating, for example, which of the high-power transmitters are carrying traffic and which are standing by.

The monitored parameters will include the radiated power which will be measured at 100 millisecond intervals and the noise level in the receiving channels which will be checked every 20 milliseconds.

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## Book Review

"The History of the Marconi Company." W. J. Baker. Methuen and Co., Ltd. 414 pp. 28 ill. + 23 plates. £5.00

The Marconi Company has played a major part in the technical and commercial development of radio-communication in practically all its manifestations. The effect of these developments on the course of human history has been profound, and needs no emphasis. Apart from its purpose as a factual record, any responsible account of the growth of such an organization will, therefore, possess considerable importance as social and technological history. This calls for an awareness of these larger issues on the part of the author, who must also possess a sound appreciation of the nature and significance of technical developments over the years in virtually the whole field of communication engineering, and an ability to organize a formidable amount of detail into a comprehensive narrative. The Marconi Company has been particularly well-served in these respects by their technical editor and historian, Mr W. J. Baker, who has adequately met these exacting requirements in producing a straightforward, readable account of a far from simple subject.

For the technically-minded reader the first and second of the three parts into which the work is divided, will probably provide the main interest, covering as they do the period of Marconi's early experiments, which are clearly described in detail, the subsequent birth of the infant "Wireless Telegraph and Signal Company Limited" in 1897, and its fortunes and vicissitudes until the death of its founder in 1937. These were, so to speak, the pioneering years of many of the dramatic technical and commercial developments that have helped, in the words of Marshall McLuhan, in "the recreation [*sic*] of the simultaneous 'field' in human affairs, so that the human family now exists under the conditions of a 'global village'": "We live," McLuhan continues, "in a single constricted space resonant with tribal drums".

Not that Guglielmo Marconi was entirely unaware of the implications of his activities. Discussing the title of his inaugural address—"The Role of the Inventor"—as newly-elected Lord Rector of St. Andrew's University shortly before his death, he is reported as asking in a Johnsonian aside, "Have I done the world good, or have I added a menace?", at the same time remarking that his original objective was confined to eliminating means of communication beyond merely optical ranges. He was perhaps the first inventor to put the question to himself, at any rate in public.

Marconi's role as inventor was not, however, by any means the only, or necessarily the most important, facet of his many-sided personality; indeed as C. S. Franklin was to comment later, he was not even a great scientist. Had his talents been thus confined, a very different history would have emerged, with he himself perhaps relegated to the relative obscurity of the "backroom".

As it was, however, Marconi possessed a range of remarkable attributes seldom found combined with technical ingenuity. It was, for example, his sound, independent, if at times, adventurous commercial foresight and acumen that were responsible for the successful development of the Company in its early years in spite of the inevitable setbacks caused by the first World War and growing foreign competition. At his instigation, a generous proportion of the profits were invested in training, research and development, not invariably with the whole-hearted support of the more cautious financial experts. He also never ignored the value of the right kind of publicity as a help in gaining public and official confidence in his enterprises. In addition, beside retaining, through many adversities a tenacious confidence in the fundamental soundness of his vision, Marconi had a gift for attracting and retaining the technical support and assistance of many brilliant minds, who contributed lifetimes of devoted service to the practical realization of his aims. He was the first to acknowledge the importance of their contribution, for which they also receive full credit in the pages of the present work.

Part 3 finds the Company facing unprecedented demands on its manpower, production capacity and technical resources from a home government with another war on its hands, one moreover, of which the outcome was to depend in the long term on technical supremacy as well as tactics. Although the Company successfully survived these pressures, making many notable contributions to the technological struggle, its days were numbered as a wholly independent organization. The decision in 1946 to nationalize Cable and Wireless Limited, with which the Company had been closely associated since 1929, precipitated an offer by the English Electric Company for the whole of the share capital of Marconi's Wireless Telegraph Company as it was then known.

The Company had been in existence for fifty years and some reorganization was an inevitable necessity if an expansionist policy was to be maintained in the face of post-war competition. It is a tribute to the fundamental soundness of its original constitution that, nevertheless, The Marconi Company successfully retains today many of its early characteristic qualities.

Readers of this *Journal* will be interested in the changing relationships with the Post Office over the years, from the days when the latter's main concern was the jealous preservation of its monopolistic powers.

The book itself is well produced and illustrated. The index is inclined, however to be, selective, and a more copious bibliography than is supplied by occasional footnotes might have been helpful to students. A misprinted date in the List of Figures needs correction in any future edition.

D. A. J.

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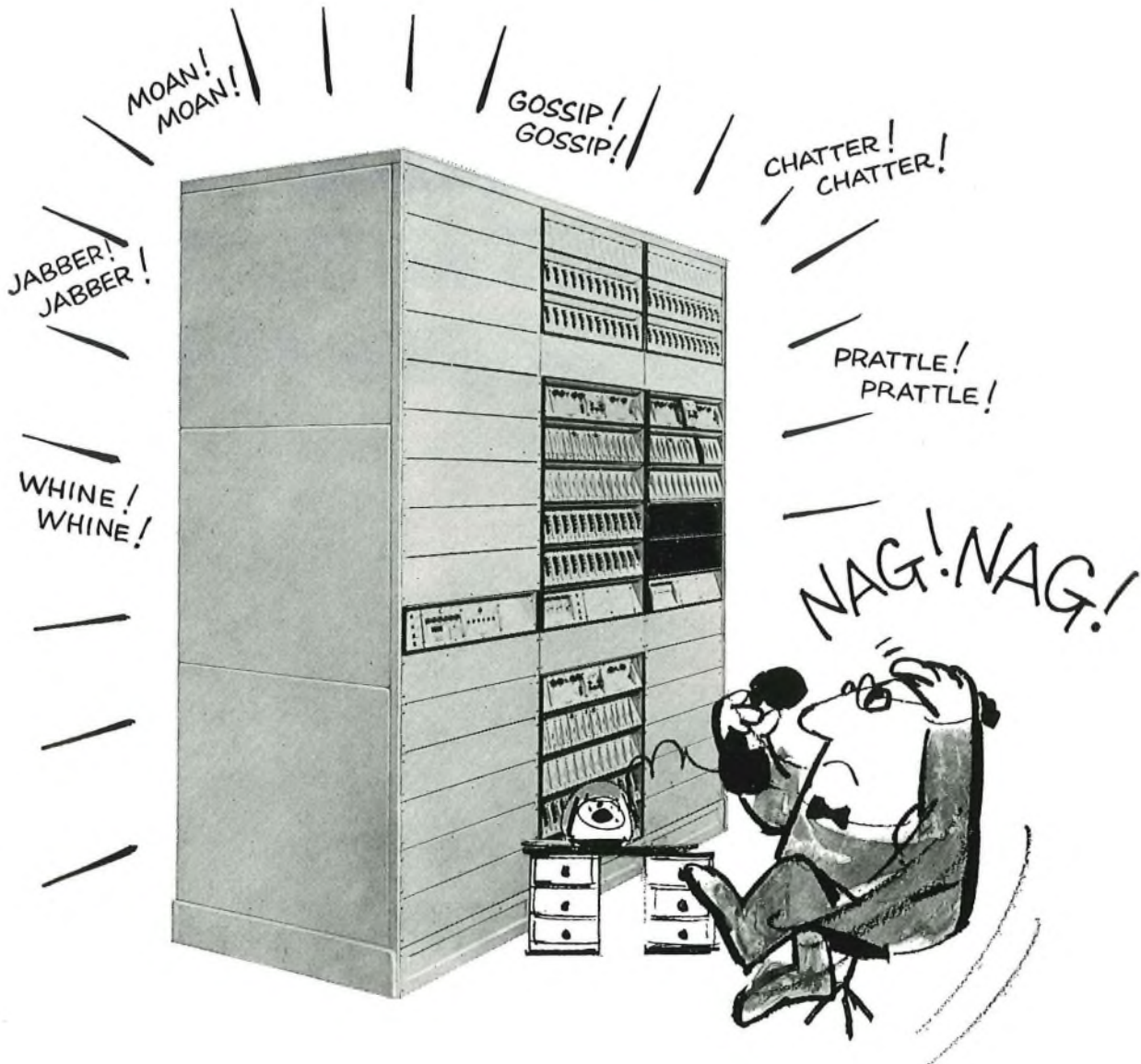
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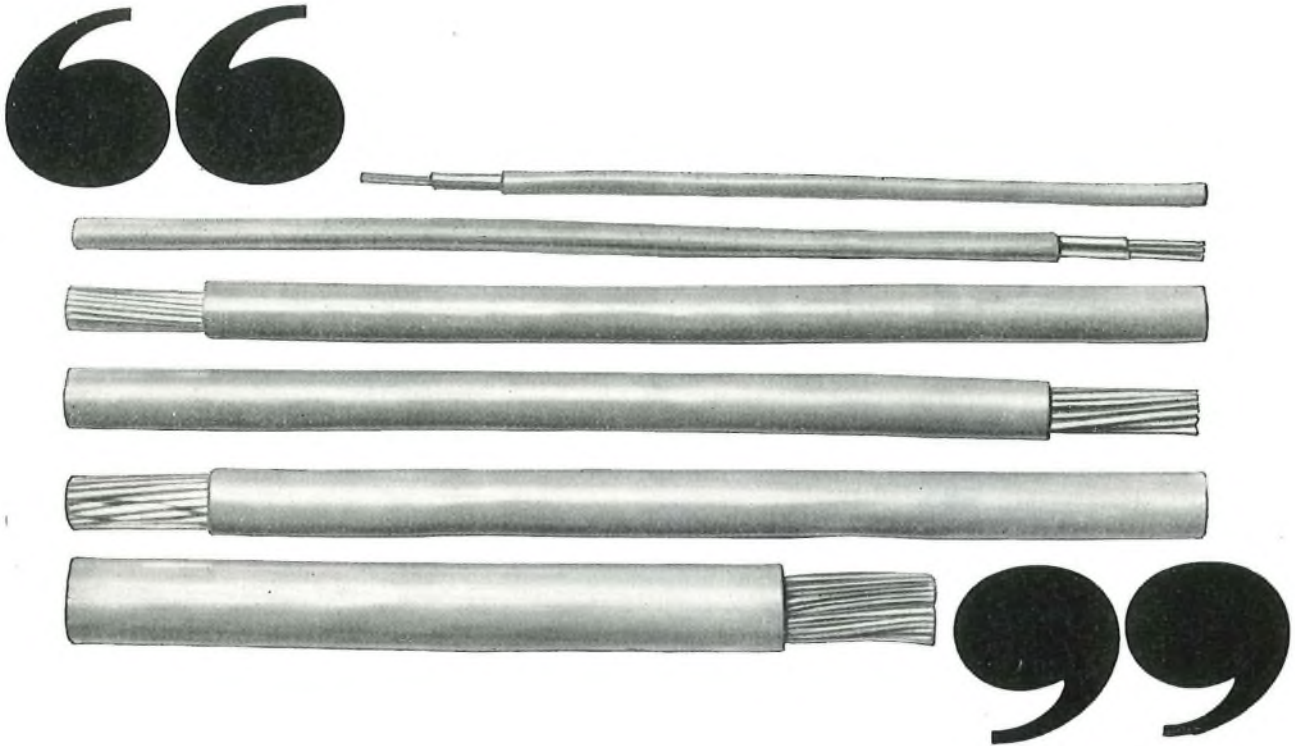
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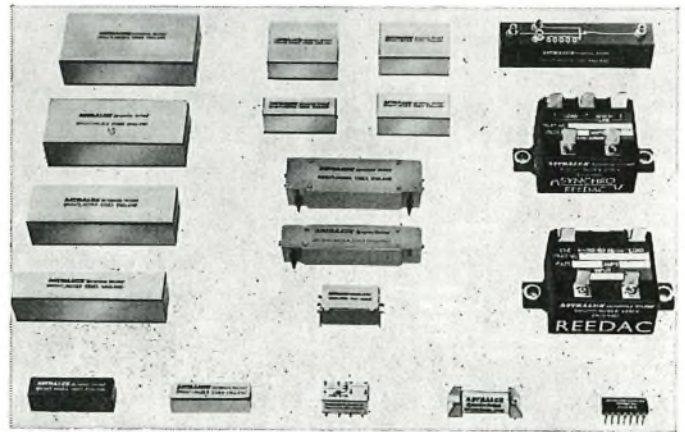
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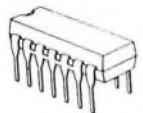
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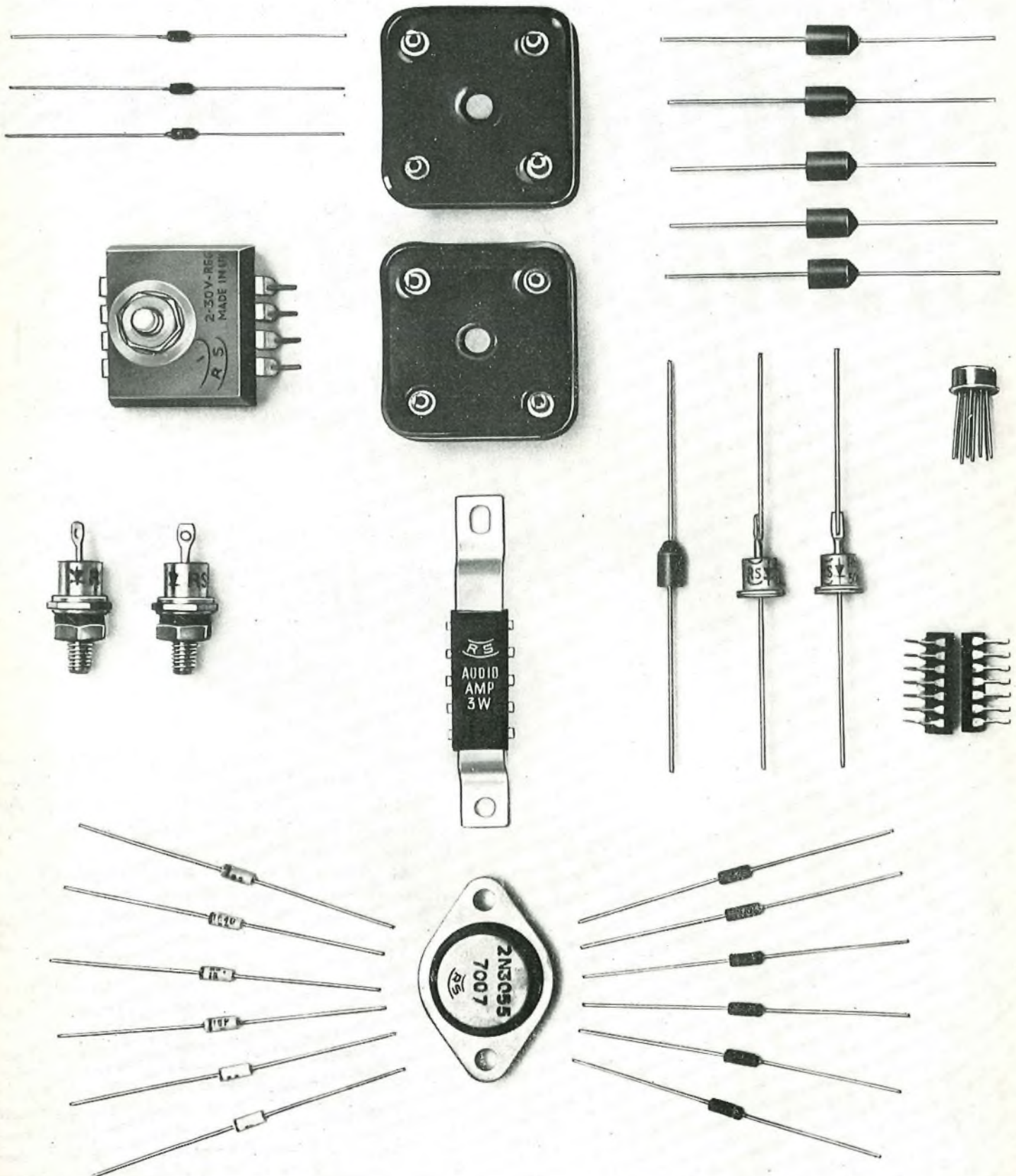
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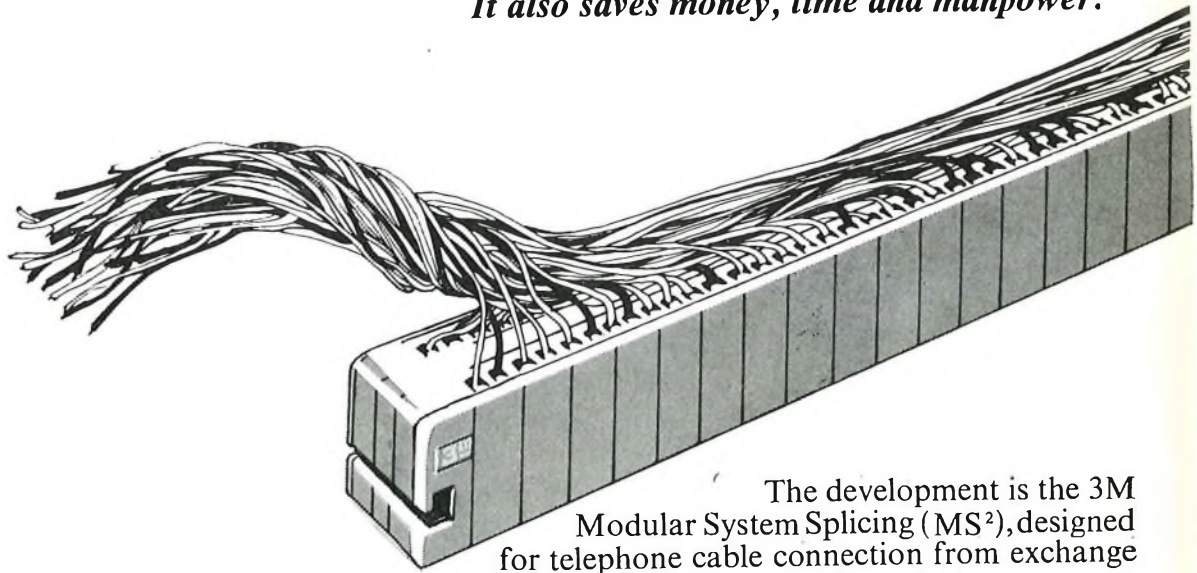
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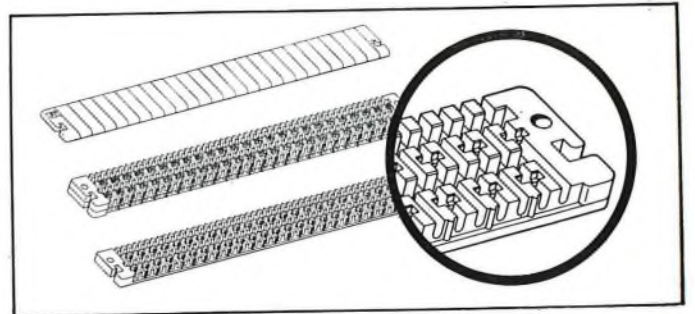
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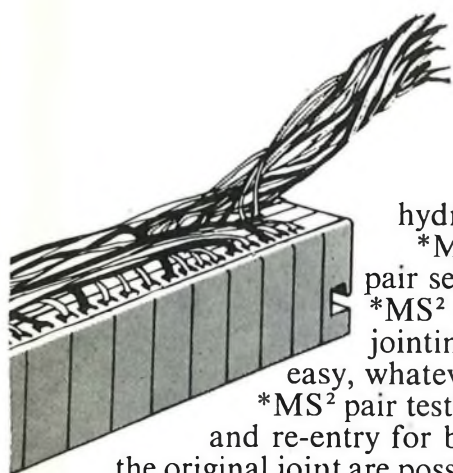
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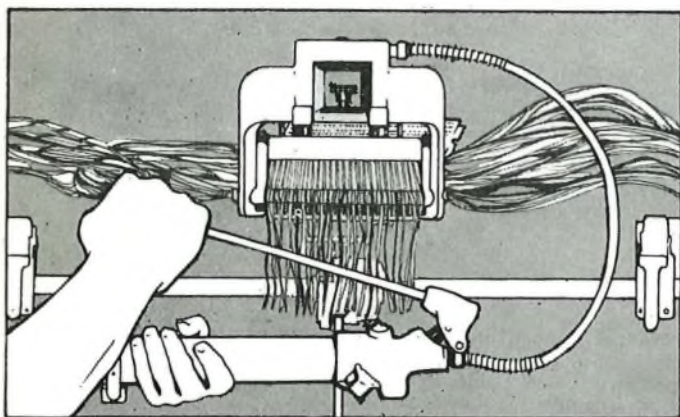
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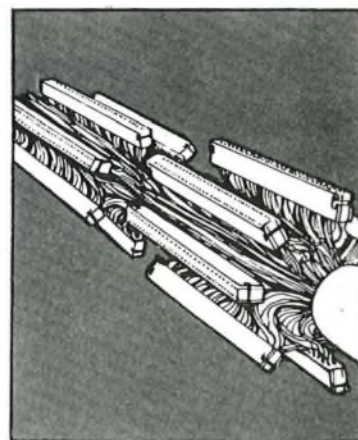
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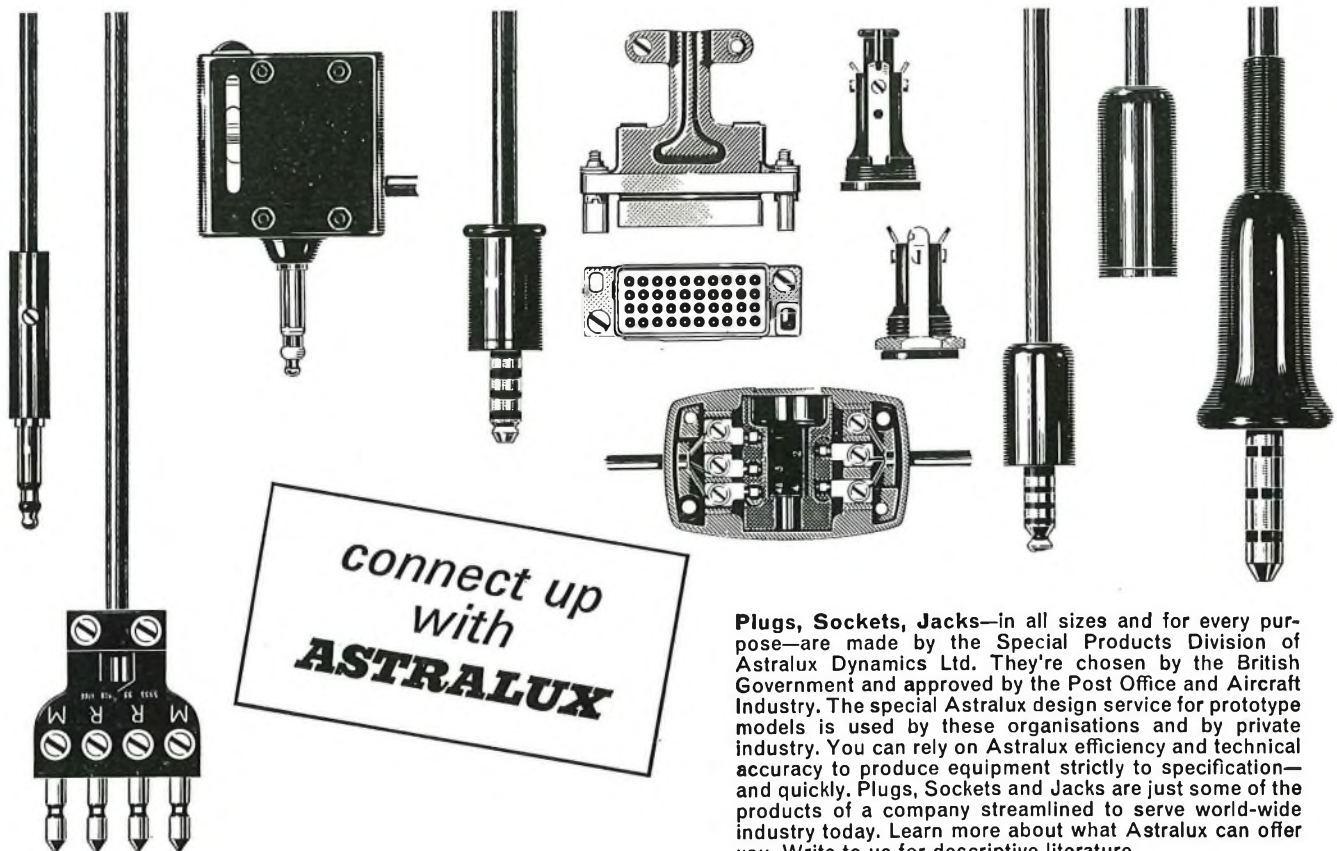
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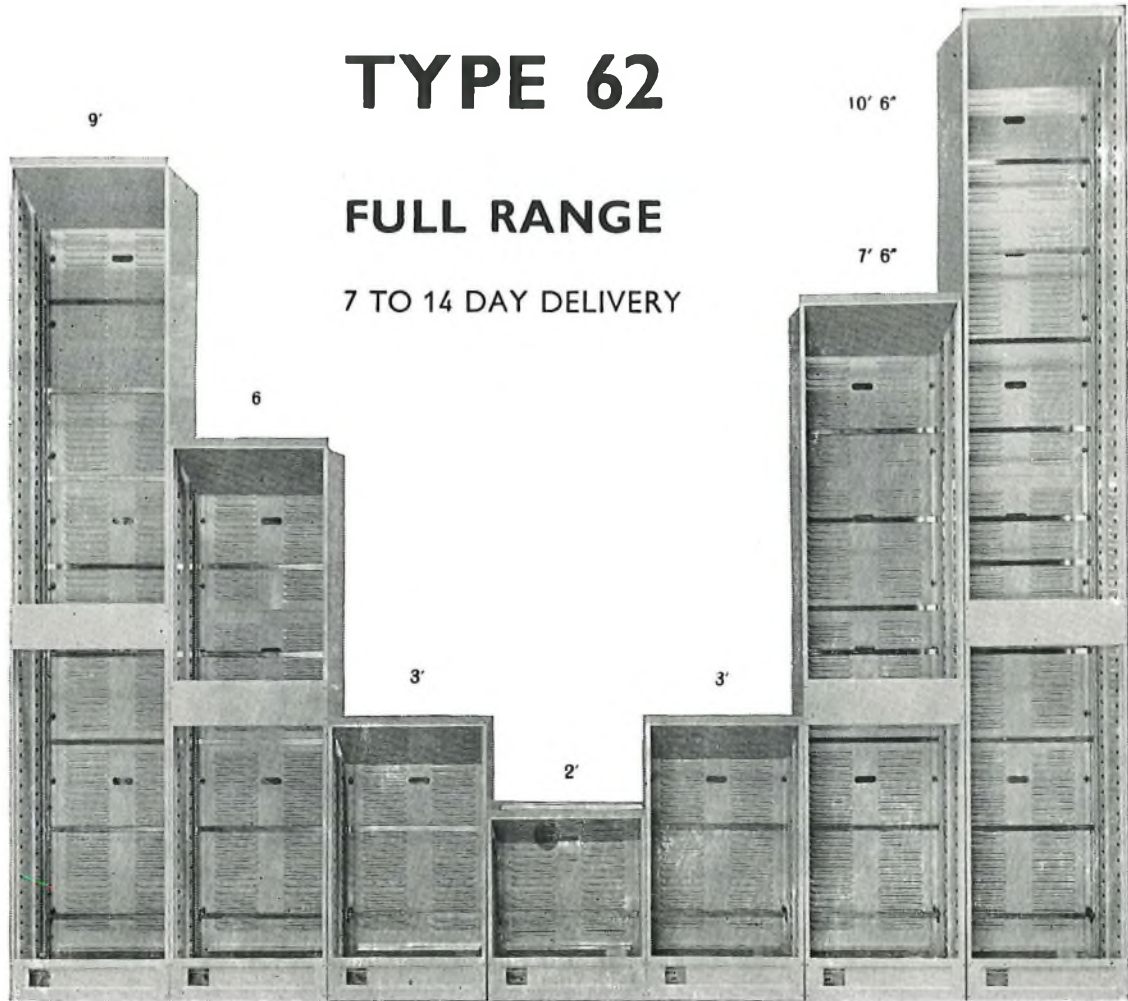
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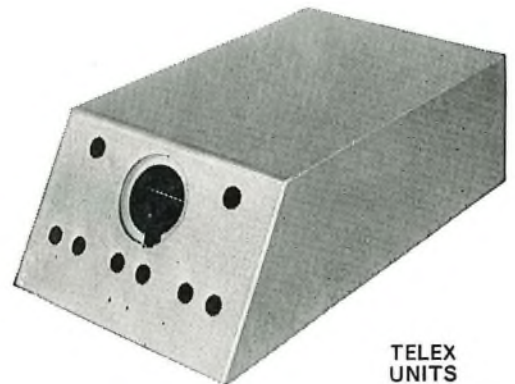
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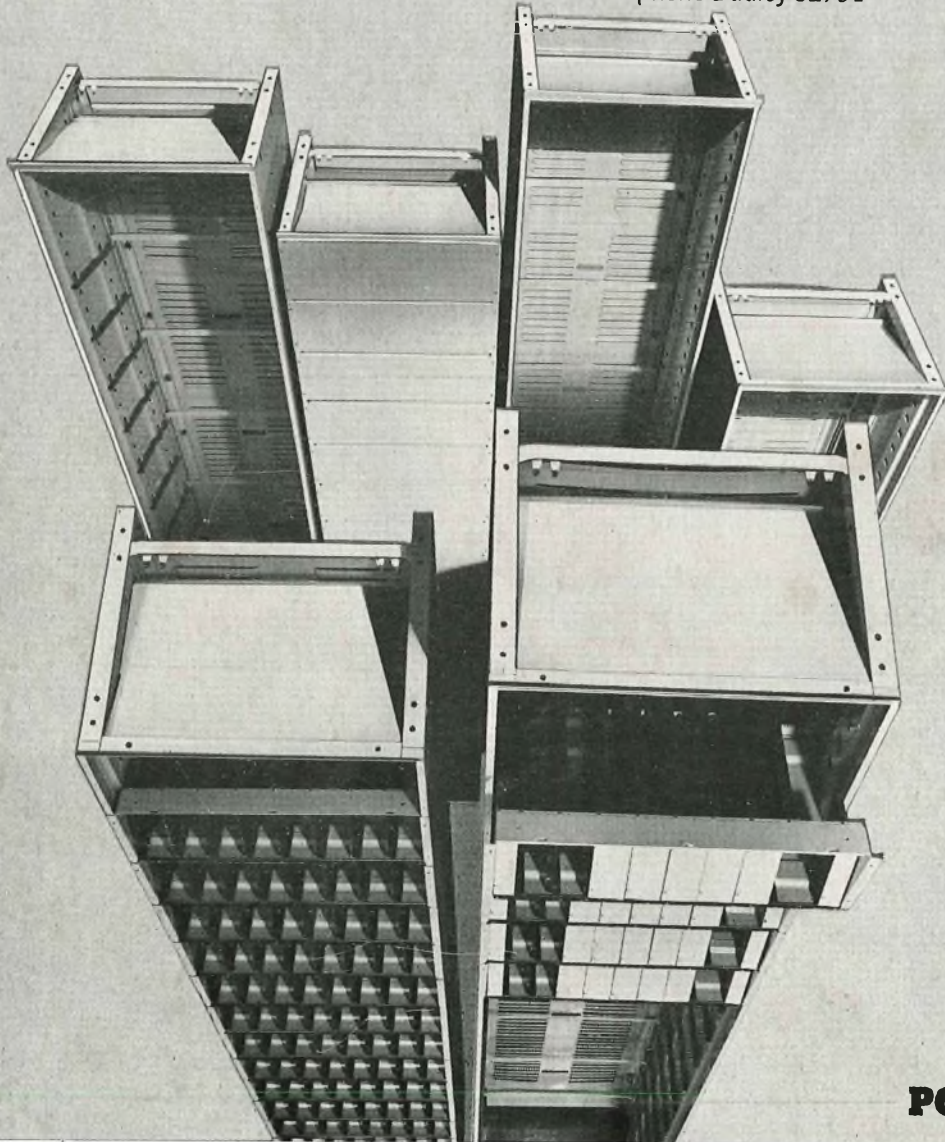
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