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# British Telecommunications Engineering



## EDITORIAL

The passing of the British Telecommunications Act by Parliament has heralded the beginning of a new era for telecommunications in the UK. One of the many changes taking place is the renascence of *The Post Office Electrical Engineers' Journal* as *British Telecommunications Engineering*; the *Journal* will, however, continue to cover a wide range of theoretical and practical aspects of telecommunications engineering. The experience of Prestel, which was developed in, and is operated in, a liberal attachment policy environment, is discussed in an article in this *Journal*. Over the next few years, an increasing amount of telecommunications equipment will be opened up to competitive supply. An important factor in such a liberal attachment policy is the need for the proper administration of standards. These standards are necessary not only to ensure electrical safety and satisfactory interworking of the equipment, both nationally and internationally, but also to ensure customer satisfaction with the service. The British Electro-Technical Approvals Board has been nominated as the authentification body under the new procedures. It is incumbent on the equipment designer, however, to ensure that both the human and the technical implications of the design are considered in attaining the agreed standard of performance.

As part of its programme to improve customer service, British Telecom is to replace its existing pay-on-answer coinboxes with new electronic payphones. The new range of self-contained payphones and their applications is also covered in an article in this *Journal*.

# Payphones in the Nineteen-Eighties

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UDC 621.395.721

*Although coin-collecting boxes, or payphones, used in public call offices have been available almost since the advent of telephony, radical changes in concept or design have been made only infrequently. Now, the pay-on-answer coinbox, introduced in 1958 in conjunction with STD, is to be replaced by a completely new range of electronic pre-payment payphones. This article describes part of the history of the coinbox and goes on to outline the facilities of the new self-contained payphones.*

## INTRODUCTION

Early in 1978, the Board of the British Post Office (BPO), now British Telecom (BT), authorized a plan to re-equip its coinbox services with modern payphones over a period of about 10 years; the 77 000 public call offices (PCOs) were to be replaced during the first half of this programme, with the 270 000 rented coinboxes replaced more gradually. This decision was taken following an extensive study of the payphone services in the mid-1970s, which culminated in the recommendation that the *pay-on-answer* (POA) system should progressively be replaced by *self-contained* payphones in accordance with trends in the rest of Europe.

## HISTORY

The first coin-collecting boxes appeared at around the turn of the century, and were installed on telephone company or subscribers' premises. An early BPO coinbox, from the collection of the British Telecom Museum in Baynard House, London, is illustrated in Fig. 1. The first coinboxes operated on the post-payment principle: having called the exchange (operator) and obtained the required number, the caller inserted a penny and turned a knob, which deposited the coin and connected a buzzer to the line to signal the payment to the operator. In 1915, this principle was adapted for use on automatic exchanges by the addition of a relay operating in response to a reversal of line polarity. When the call was answered, the relay disconnected the speech circuit, which was restored by the deposit of a coin.

### Pre-payment Coinboxes

In about 1925, the BPO introduced the Box, Coin-Collecting No. 14 (CCB No. 14) for use with automatic and manual exchanges. This was the familiar *Button A and B* pre-payment box (see Fig. 2) in which coins were held in suspense until the called subscriber answered, and were cashed when the caller pressed BUTTON A. The initial insertion of coins connected the dial, but disconnected the microphone: two-way speech was established by the operation of BUTTON A.

The CCB No. 14 accepted 3 denominations of coin but could deal automatically only with single-fee untimed calls; all others had to be connected by an operator. Coin-signalling to the operator was accomplished by means of a microphone sited close to a bell and a gong which were struck by the falling coins.

In many parts of the world there is still a demand for local-calls-only coinboxes, and export versions of the CCB No. 14 are still in production.

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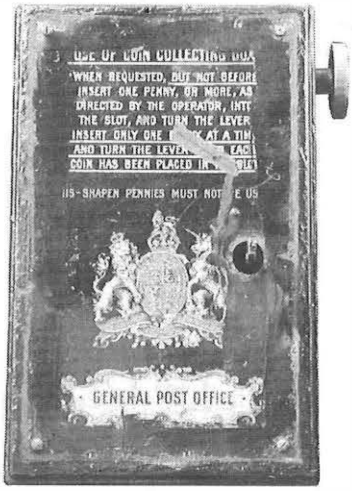
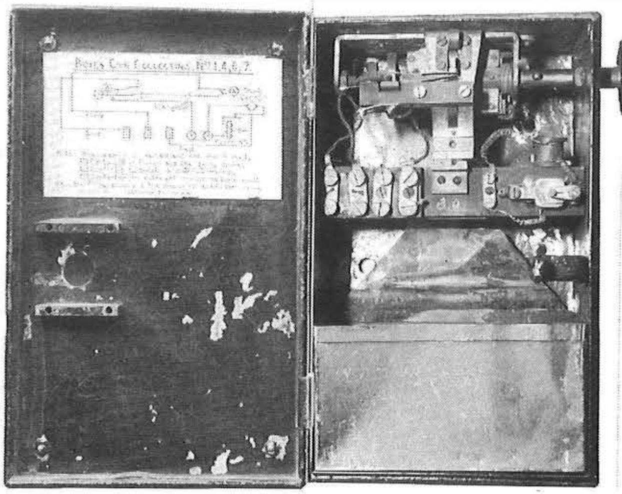



(*a*) Exterior



(*b*) Interior

FIG. 1—Early coinbox

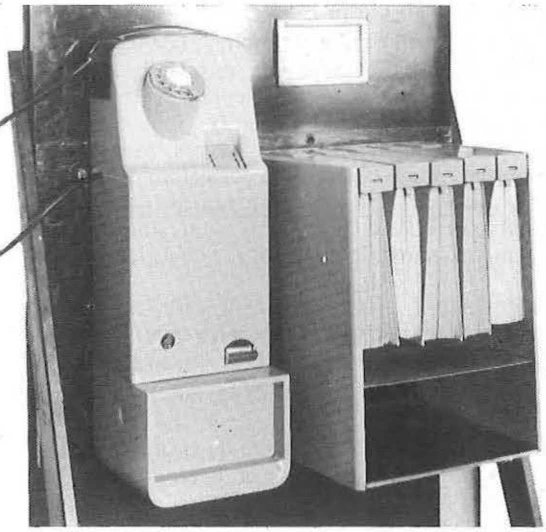
### Pay-on-Answer Coinboxes

When subscriber trunk dialling (STD) was introduced in 1958, there arose the need for a coinbox system which could deal with the new periodic metering for both local and trunk calls. In order to keep the coinbox mechanism as simple as possible so that capital and maintenance costs might be reduced, a post-payment system (known as *pay-on-answer*) was adopted;

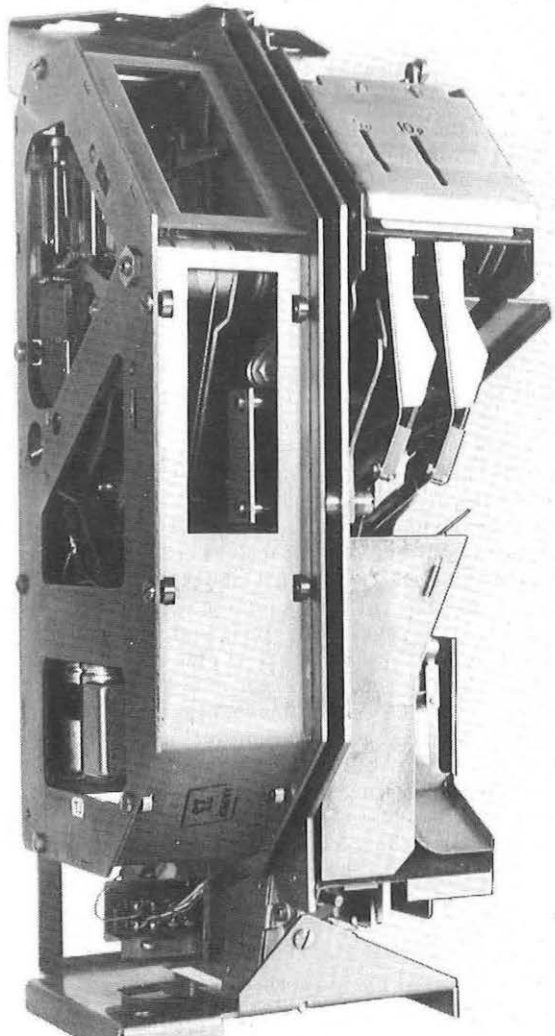


FIG. 2—Box, Coin-Collecting No. 14

coins were cashed on insertion and not held in suspense. A complex piece of apparatus at the local telephone exchange, known as the *coin-and-fee check* (C and FC) relay-set, compares the meter signals from the call-charging equipment with the coin signals received from the coinbox. The C and FC unit controls the opening of the coinslots, gives the customer audible warning when his money has run out, and cuts off the call on expiry of a short period of grace. A POA coinbox and its mechanism are shown in Fig. 3.



(*a*) Strengthened PCO equipment



(*b*) POA coinbox mechanism

FIG. 3—Pay-on-Answer coinbox mechanism

## Self-Contained Coinboxes

While the BPO was developing its POA system, telecommunication administrations and suppliers in other countries were adopting a different approach. The starting point was the local-calls-only coinbox, which differed from the BPO's CCB No. 14 mainly in that the function of BUTTON A was performed by a relay operating in response to a line reversal when the called party answered, and that of BUTTON B was often performed by a linkage connected to the handset cradle.

The next step was the introduction of a store to hold the coins inserted by the coinbox user, from which a coin could be cashed whenever a meter signal was received from the telephone exchange. Thus, the coinbox was able to collect the fees appropriate to dialled calls with periodic metering. These *self-contained* payphones, like the BPO's CCB No. 14, needed no special control equipment at the exchange, but did require a means of providing the operator with a discriminating signal.

The first generation of self-contained coinboxes were fairly simple, accepting a single denomination of coin. But, at a time when electronic components were neither reliable nor cheap enough for inclusion in telephones, the design engineers exercised considerable ingenuity, and soon there appeared payphones having 2 or 3 coinslots. These had mechanical totalizers which enabled the correct number of meter periods to be allowed against the value of the larger coins; and some coinboxes had either visible coin stores or a cyclometer counter to show the value of the coins left unused.

## LIMITATIONS OF THE PAY-ON-ANSWER SYSTEM

The POA coinbox is simple to use but, to the customer making overseas calls or even peak-rate inland trunk calls, it presents some difficulties. Probably the most significant is that conversation is interrupted for several seconds each time a coin is inserted; and, although the coinbox may to some extent be pre-loaded immediately after the call is answered, the frequency with which coins need to be put in makes it inconvenient to use on high-charge-rate calls. Furthermore, the considerable force needed to insert a coin gives difficulty to the infirm or disabled user.

To the Administration, the present coinbox system has many more limitations, of which the 2 most affecting profitability are the lack of flexibility in setting tariffs, and the poor reliability of the system. The user difficulties mentioned above also affect profitability by discouraging people from making high-tariff calls.

The basic difficulty over tariff-setting is that the unit fee must be equal to a single-coin value; and whilst fine adjustments can be made by altering the timing of the meter signals in the network, the unit fee is a significant parameter because a very large proportion of calls last for only one meter period. In times of high inflation, unprofitable tariffs have been retained in deference to external pressure on BT to avoid the large percentage increases in unit fees necessitated by the available coins of the realm.

The combination of a complex relay-set in the telephone exchange and a coinbox mechanism containing several hundred moving parts is an obvious reliability hazard; perhaps less obvious are the difficulties of managing a system where the responsibility for the major parts is divided between the essentially separate internal and external maintenance staffs. The difficulty of attributing faults to the appropriate part of the system is probably the largest contributory factor causing recurrent call failure.

Full cash-boxes have always been a problem, both in rented payphones and in PCOs. It is by no means trivial: a full cash-box generally causes coins to jam, often resulting in a visit by an engineer. Service can often be restored by shaking the coins down and clearing the jam; but unless the cash-box is emptied immediately, the trouble will quickly recur. A number of attempts have been made to detect and report coin jams in POA boxes, with only limited success.

## THE ELECTRONIC PAYPHONE

### Facilities Offered by Modern Payphones

The modern self-contained pre-payment coin telephone can offer its users the following advantages:

(*a*) pressure-free coin insertion,
(*b*) a wide range of coin denominations, inserted through a single slot,
(*c*) no interruption to speech during coin-value signalling,
(*d*) visual display of remaining credit,
(*e*) coins are held in suspense until the end of the call and the payphone selects the coins to be cashed from those inserted so that the customer pays the smallest possible amount needed to cover the cost of the call,
(*f*) the ability to make a series of calls from one large-value coin,
(*g*) visible and audible warning of impending credit expiry, and
(*h*) keypad dialling.

The chief benefits to the administration are:

(*a*) increased reliability, through the use of electronic techniques,
(*b*) built-in diagnostic aids for the service engineer,
(*c*) improved coin validation,
(*d*) flexibility in setting call charges,
(*e*) built-in routine testing coupled with automatic reporting, to a central point, of faults and other conditions such as a full cash-container, and
(*f*) better maintainability through the elimination of complex exchange equipment.

Some of these facilities, however, substantially increase capital costs and may not be incorporated in payphones used at sites where the traffic does not justify their inclusion.

### Techniques used in Modern Payphones

#### *Coin Validation*

In the past, coin acceptors in telephones and vending machines have relied on mechanical measurement of the external dimensions (diameter and thickness) of coins; some mechanisms have, in addition, devices to detect a raised rim, a hole in the centre, milling on the edge, and weight variations. Permanent magnets are sometimes used to reject ferromagnetic discs.

In the 1970s, the European coinbox manufacturers began to introduce eddy-current devices to test the electromagnetic properties of the coins; these devices were added to the conventional mechanical coin checkers.

More recent development work, mainly in the vending-machine trade but also in the payphone and gaming-machine fields, has led to coin validators which rely entirely on a number of electromagnetic or electrostatic tests and dispense entirely with mechanical checks. These methods save money and space by enabling a range of coins to be accepted by a single unit; and through the use of digital processing they can allow changes to the coin-set to be made without any physical modification to the unit.

#### *Control Systems and Power Supplies*

As integrated circuits became less expensive and more reliable, coinbox designers began to use them, at first to supplement the complex electromechanical counting and debiting used in the early long-distance self-contained coinboxes, and later to perform additional tasks. The Autelca AZ44 coinbox—the forerunner of BT's Blue Payphone—is believed to be the first commercial coinbox to use a standard microprocessor, whilst contemporary European coinboxes performed similar functions with custom-designed large-scale-integration metal-oxide silicon (MOS) logic. The introduction of complex control logic, multiple coin runways and light-emitting-diode credit displays led most designers to provide mains-derived power supplies for their coinboxes. This, in turn, allowed them to produce robust and reliable coin-handling mechanisms. However, for most telecommunications administrations, the need for mains power is an operational nuisance in PCOs and may be a deterrent to potential renters; the modern trend is therefore towards completely line-powered payphones.

The line-powered payphone is made technically feasible by the advent of complementary-metal-oxide-silicon (CMOS) microprocessors, and liquid-crystal displays. The design of coin-handling mechanisms needs particular care: reliability being of paramount importance, the right balance must be struck between robustness and low power consumption. The short but relatively large current pulses needed to operate the coin-handling magnets may be provided by batteries or by a capacitive reservoir. At present, secondary batteries are preferred by BT because of the energy needed to cash and refund coins from the store after the line is released: the re-charging time for a capacitive reservoir could restrict the use of the payphone where telephone traffic is high.

### *Call Charging*

The self-contained payphone receives periodic meter pulses from the local exchange: it is connected to ordinary (ORD) gradings and thus the call charges must be based on the same charge-unit durations as those for ordinary lines.

The call charges are in 2 parts: a minimum fee, and a unit fee. In the BT payphones, the minimum fee covers the first metered unit, and subsequent units each cost one unit fee. The ability to charge extra for the first unit is extremely useful because it enables tariffs to be tuned more accurately to the true costs of providing a PCO service; and where a payphone is rented, it allows the renter to obtain a realistic return on his investment.

Once a call is under way, there are 2 basic methods of deducting the charges from the credit established. In the simpler approach, called *direct debiting*, the minimum fee is deducted on receipt of the first meter signal and one unit fee is deducted on each subsequent signal. Note that the unit fee need not be a multiple of any coin value, nor even of one penny; but in practice BT have adopted 1p as the smallest adjustment.

A more complex debiting system, used in the payphones at the top of the BT range, is called *indirect debiting*. After the receipt of the second meter signal, the payphone debits the call charges in 1p or 2p steps at intervals calculated by dividing the measured meter period by the unit fee. This enables the unit fee to be set to a value that is not in whole pence without causing confusing rounding errors on the credit display, and gives the customer the advantage of being able to extend his call by increments that are smaller than the unit fee.

Another feature of the call-charging system is the ability of the payphone to do its own call timing under certain conditions. Because of the usual pattern of usage of payphones, the BT tariffs normally allow a shorter time per unit fee in the local-call cheap-rate period than is applied to ordinary telephones. The payphone applies its own timing when the received meter-pulse interval exceeds a specific value.

Owing to the methods used in the generation of periodic meter pulses, the meter interval can vary from pulse to pulse on a given call; further, there may be a change of tariff period in the middle of a call. The payphone is required to take these variations into account as well as applying indirect debiting and internal timing of local calls. In addition, great care has to be taken not to exceed the published charges, whilst not systematically under-charging. The result is a complex debiting procedure which constitutes a very significant proportion of the control software.

### *Calls via Controlling Operators*

While coins inserted on self-dialled calls are held in suspense, on operator-controlled calls coins must be passed directly to the cash container and their values signalled to the operator. The procedures for the customer and operator are similar to those used in the POA coinboxes: coins are inserted after the operator has established the connection. In addition, the payphone must generate a discriminating tone which identifies the source of the call as a payphone—a function performed in the POA system by the C and FC relay-set.

Clearly the payphone needs to know if a call is being made via a controlling operator, and, in the absence of a discriminating signal from the network, this information must be determined by the payphone from the digits dialled.

It is an advantage to the coinbox user to be able to make calls to the emergency services and to other free services (such as, directory enquiries) without first inserting money; like the operator call procedures, this requires that the payphone examines the dialled digits before allowing the call to proceed.

To meet these needs and to cater for regional variations in the allocation of codes, payphones have been designed so that each dialled 3-digit number from 100 to 199 (the *1XX* codes) may be categorized as *barred*, *free*, *operator-controlled*, or *normal*. The means of setting these categories is described later in this article.

### *Servicing Aids*

The presence of a microprocessor controlling the payphone makes it possible to provide a comprehensive testing program to help the service engineer to locate a fault in the field. Activated by a switch in the mechanism compartment, the program can automatically test the visual displays and tone generators; and under the serviceman's control it can activate coin-handling magnets, test the action of the keypad and hook-switch, and with test discs check the calibration of the coin validator(s). The engineer controls the test program from the keypad and the results are indicated on the visual display. In these tests most of the control logic also is exercised.

### *Automatic Reporting*

Remote detection of full cash-containers has been a long-felt need, both for PCOs and rented payphones. A requirement for all of BT's new coin telephones is that they detect a full cash container and stop accepting any more coins; this prevents damage to the mechanism and loss of coins by the customer. The field trial of the Blue Payphone, however, broke new ground by the introduction of a "fault-reporting" facility. A second cable pair was provided, enabling the payphone to report a full cash-box or a major failure direct to the repair service control. This facility was found to be very useful during the field trial; but it was clear that it would be expensive and often impracticable to provide 2 cable pairs to every coinbox, although a more comprehensive reporting system would be a useful addition to the ability of the control system to detect faults.

One of the problems arising from the use of the self-contained payphones on ordinary lines is that there is no record at the exchange of coins cashed: such a record is essential for auditing the cash collections from PCOs. It was decided that new coin telephones should have the capability of indicating the cash container contents to a central point, and this requirement fitted in well with the fault-reporting feature.

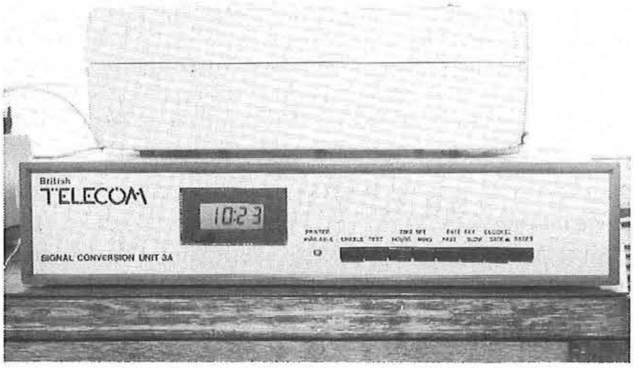
Payphones having this facility will now be able to transmit reports to up to 4 different destinations: faults and cash-box-full reports to an engineering centre; cash totalizer reports to an accounting centre; cash-box 75% full as advance warning to a coin-collection centre; and, finally, burglar alarm reports to a fourth location.

Reports from the payphones are transmitted to a central point where a signal conversion unit (SCU3) rearranges the received messages into a form suitable for printing (see Fig. 4).

The messages sent by the payphone consist of a 2-digit code indicating the type of report, or fault; the identity of the payphone in up to 9 digits; and, in the case of cash audit reports, a 6-digit cash total. The SCU3 inserts the time and date, and tabulates the figures for output to the printer. The output is compatible with Datel modems so that the printer may be sited remotely; or the reports may be sent direct from the SCU to a computer for analysis.

### *Storage of Variable Data*

For the functions described above, the payphone needs to store information that can vary from time to time and from




(*a*) Prototype, with printer

```
DAILY                     SCU
SERIAL                    PORT     PAYPHONE      CASH
NUMBER   DATE   TIME     NUMBER    IDENTITY      TOTAL
0036   29-01   08.25    1  21     2468032      £0025.01
0037   29-01   08.27    1  21     2468156      £0262.25
0038   29-01   08.35    1  31     2461234
0039   29-01   08.35    2  21     2468210      £0503.98
0040   29-01   08.45    1  53     2465031

              REPORT CODE
              21 - CASH CONTAINER CHANGED
              31 - CASH CONTAINER 75% FULL
              53 - COIN CHECKER FAULT
```

(*b*) Format of print-out

FIG. 4—Signal Conversion Unit No. 3

place to place. During the early period of specifying the new coin telephones, it became obvious that even to cater for the range of tariff data needed, the use of straps or plugs or switches would be expensive. Moreover, it had been suggested that the lead time for a tariff change ought, if possible, be reduced to a few weeks, which is similar to the period of notice needed when only the exchange pulse-timing is altered; the production of some 400 000 plug-in items would take too long. The result was a decision to store the variable data in electrically alterable semiconductor memory, and to update it by using a hand-held unit—the Tester 297. This approach provided, as well as the wide range of tariff settings, the flexibility that was wanted in the examination of *1XX* dialling codes and the provision of 4 auto-reporting destinations.

The tariff data, consisting of about 40 bits, are the same throughout the country; the *1XX* codes differ between Telephone Areas, and occasionally within an Area; and the payphone identity is, of course, unique to the payphone.

The Tester 297 plugs into the payphone, which provides it with power (see Fig. 5). A keypad and a 10-digit display enable the installer or service engineer to set up the payphone identity and the telephone numbers for reports. To avoid mistakes with the tariff and *1XX* codes, which together comprise about 250 bits of information, these data are stored in an electrically-programmable read-only memory (EPROM) which is plugged into the Tester 297. This information is transferred to the payphone *en bloc* by pressing 3 keys on the tester. The tester can also be used to read back and check all the stored variable information in the payphone.

The data EPROMs are supplied from a central point, with the appropriate *1XX* codes to suit Area requirements. When a tariff change is made, Areas will be issued with new EPROMs, and, because only one is needed for each tester and not one for each payphone, the lead time will be short. The time taken on site to make the change is reduced to a negligible fraction of the average travelling time between payphone sites.

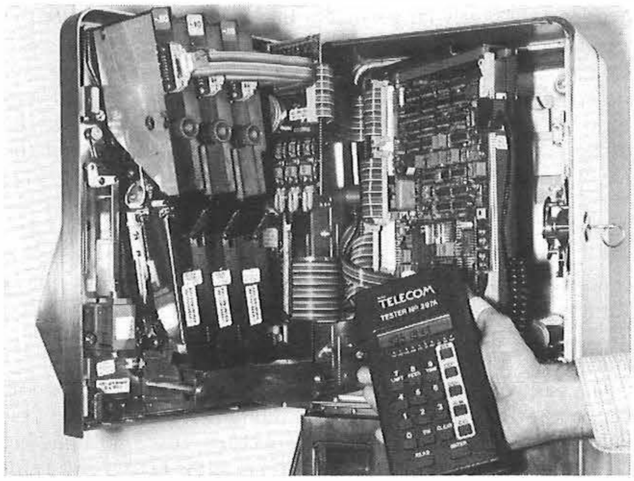



FIG. 5—Tester 297 in use with Coin Telephone No. 22B

In the payphone, the data memory must be electrically alterable but non-volatile; that is, it must withstand a loss of mains supply or line power (a target of 14 days' loss of line power was specified). The uncertain state of the development of "electrically-alterable" and "electrically-erasable" programmable memories led to the adoption of read-write random-access memory (RAM), supported by a battery.

## NEW RANGE OF ELECTRONIC PAYPHONES

The modernization strategy adopted in 1978 was to divide the market into 3 main sectors, each to be served by a distinct design of payphone. The 3 designs had the following main objectives.

(*a*) A payphone suitable for high-revenue PCO sites, offering the best range of customer facilities currently available; to be introduced as quickly as possible to improve the service given; and to enable the potential profitability of these sites to be realized.

(*b*) A payphone for general application in the bulk of existing PCO and renters' sites. This coin telephone was to be as cheap as possible whilst providing a reasonable range of customer facilities and being extremely reliable and easy to maintain. A rugged version for PCOs and a lighter one for renters' sites were to be provided.

(*c*) A portable table-top model with a restricted range of features, suitable for renters' sites having a degree of supervision, to be provided at a very low cost. This application was regarded as a largely new market sector, but naturally it was expected that the payphone would be attractive to some existing renters.

### Blue Payphone

The first of the market sectors identified above is being served by the Coin Telephone No. 22 (CT22) or *Blue Payphone*. (See Fig. 6). In order to achieve the primary objective of a speedy introduction into service, the payphone has been adapted from a Swiss design (the Autelca AZ44) by Aeronautical and General Instruments Ltd. (AGI) of Croydon. After a field trial which started in late-1979, a number of design changes were made, both to improve the servicing aids and to modernize the microprocessor system which had become obsolete. The CT22 is now in quantity production and is entering service throughout the UK.

The CT22 offers all of the facilities listed earlier, except that the 3 denominations of coin (2p, 10p and 50p) are inserted through separate slots and each is validated and stored separately. The coin checkers are mechanical, with a simple electronic material test. The CT22 is mains-powered via an


FIG. 6—Coin Telephone No. 22B with Transformer No. 19A

external transformer, employing an NMOS microprocessor system (8085 family) and very substantial coin-handling actuators. A small amount of line-powered CMOS logic is provided to enable users to make "999" calls when the mains supply fails, and to give a correct refund should the supply fail during a call. The RAM that holds the variable data referred to earlier is maintained by a lithium primary battery, with an expected life of about 5 years (see Fig. 7). This battery can be replaced without losing the stored data; but should the battery and the mains supply fail simultaneously, emergency service only is available.

### POA Replacement

A completely new design of payphone was needed to serve this sector because there were no existing coinboxes that incorporated all of the modern techniques that were thought essential to meet the objectives of high reliability and low cost. The new payphone is being developed under contract by Plessey Telecommunications Ltd. and is scheduled to enter public service in 1983.

The PCO version (designated *CT24*), see Fig. 8, and the renters' model (*CT25*) have been designed with as many common parts as possible. Externally, the only visible differences lie in the size of the cash compartment (which, in both versions, is separate from the mechanism housing for added security) and in the more robust handset of the CT24; but the CT24 has been made very much tougher than its sister by the use of stronger materials and locking arrangements.

The internal mechanisms of the payphones use identical major assemblies, with a few small components (such as, a relay to provide a renters' local cash-box-full alarm) being fitted only in the CT25 or being optional. In addition, the CT24 will have ceramic-packaged integrated circuits to cope with the greater extremes of temperature and humidity, though the printed-wiring boards will be otherwise identical.

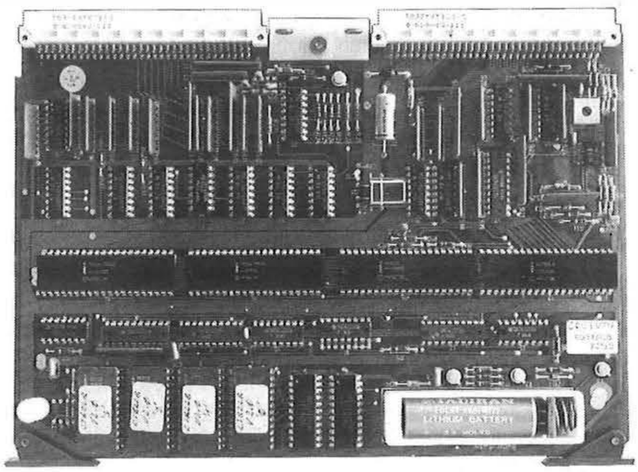


FIG. 7—Coin Telephone No. 22B processor board showing lithium battery

FIG. 8—Public call office payphone (Coin Telephone No. 24)

The CT24/25 will provide all of the facilities described earlier, and employ a single all-electromagnetic coin checker for all coin values from 2p to £1. Like the CT22, a 4-digit display of available credit is provided, and charges are debited indirectly in 1p steps. However, the display on the CT24/25 is much more comprehensive: at the beginning of a call it shows the minimum fee needed, and at the end it indicates how much will be refunded.

The CT24/25 is entirely line-powered, using a CMOS microprocessor (RCA 1802 family) and light but robust coin-handling components. A nickel-cadmium secondary battery maintains the data RAM and supplies current peaks for coin-handling as well as enabling the payphone to operate for short periods with the line disconnected (such as, during cashing and refunding at the end of a call). The battery is trickle-charged from the line during idle periods but receives most of its charge while the line is seized.

### Table-Top Payphone

The CT23 (Fig. 9) is a very compact payphone styled to harmonize with the Ambassador range of telephones, and has been developed under contract by AGI of Croydon. A public-service field trial commenced in BTL/South East Area in October 1981 and the payphone is likely to be available in some Areas in the summer of 1982.

Although this payphone has a restricted range of features, it offers the user a choice of 4 coin denominations (2p, 5p, 10p and 50p) and is, thus, as convenient to use for trunk and overseas calls as are the other new payphones. The main differences for the user are that there is no access to controlling operator positions, nor is there a credit display. The latter is replaced by a light which flashes to indicate that coins should be inserted or that the credit is about to run out; audible warning (*paytone*) is given by all BT payphones.

FIG. 9—Table-top payphone (Coin Telephone No. 23)

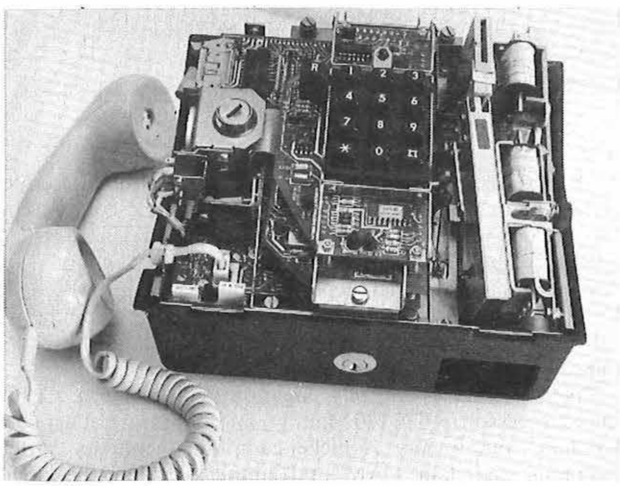


FIG. 10—Coin Telephone No. 23 mechanism

For the renter, a feature new to BT coinboxes is a key-operated switch which changes the instrument from a payphone to an ordinary telephone. In this mode, no coins are needed, and access to *1XX* codes is available.

The cash-box is formed by the lower part of the case: the whole mechanism and lid hinging upwards to provide access for removing coins. Servicing access to the mechanism is gained by removal of the lid moulding. Coins are tested by an electromagnetic validator, and a novel design of runway allows 4 coins to be stored in a very small space. The direct debiting method of call charging is used, and coins are not held until the end of the call but are cashed from the store as they are needed. If the coin cashed is larger than the unit fee, the residual credit is carried over to the next meter period; credit expiry is always calculated exactly for the coins cashed.

Like the CT24, the CT23 is line-powered and uses an 1802 CMOS microprocessor and a nickel-cadium battery. Because numbers beginning with "1" cannot be dialled and there is no automatic fault reporting facility, the data RAM has to store only the tariff information. Instead of using the Tester 297, the tariffs are set by means of the payphone keypad, a sequence of tones in the telephone receiver indicating the values set. Although the CT23 has no in-built diagnostic aids, it is, like the other new payphones, designed for automated testing in repair centres.

## NETWORK ASPECTS

The idea of a self-contained payphone which can be connected to any exchange termination is at first sight attractive to the service planner. On closer examination, the change from the present coinbox system can be seen to have far-reaching effects.

The transfer of payphone traffic from C and FC equipment to ordinary lines will mean changes to forecast growth in existing equipment, from the first selectors in the local exchange, through the segregated 0-level junction groups to the register-access equipment in the group switching centre. Further, the planned replacement of some 400 000 POA coinboxes with self-contained payphones over a period of 10 years requires a significant provision of meter-pulse transmission equipment, at a time when the market for subscribers' private metering (SPM) facilities is expanding rapidly to serve new business communication systems such as Herald and Monarch.

The use of SPM signals for charging purposes, as distinct from simply providing information to the customer, has other repercussions: at present the 50 Hz current for the signal is derived from unsecured mains supplies. Plans are in hand to change to secured supplies where they are available, and for other exchanges such as UAXs, an inverter to supply 50 Hz from the exchange battery is being considered.

## THE FUTURE

### The Impact of System X

The opportunity to do away with cumbersome C and FC relay-sets, special gradings and segregated junction groups has played a major part in the decision to concentrate the intelligence of the payphone system in the terminal apparatus. The introduction of a network of stored-program-controlled exchanges linked by very flexible signalling systems invites speculation about how use might be made of the considerable capabilities of such a network.

For example, the 2 topics that have given rise to the most problems and compromises during the development of the new payphones are the avoidance of fraudulent use, and the provision of operator-controlled chargeable calls. One idea being discussed is to do away with periodic metering and the 50 Hz signalling system—both of which can be viewed as anachronistic in a System X exchange—and to provide, instead, a fast signalling system which may be used to transmit a tariff message to the payphone at the beginning of each call. Such a scheme would, in principle, eliminate the need to visit 400 000 payphones whenever the tariffs are changed. Moreover, an improved signalling system could give operators greater control over the payphone and make the call procedures much simpler for customer and operator alike.

### Cashless Payphone

A public-service trial began in July 1981 of 200 payphones which accept as means of payment, instead of coins, a pre-paid *phone card*. The card is equivalent to a number of tokens: the value encoded on it is progressively reduced by the payphone as it is used.

Cashless payphones have evident advantages to a telecommunication administration: there is no cash to collect and no incentive for theft, and thus there are potential economies in servicing. The pre-paid card, however, is costly to sell; and because it has intrinsic value and is transferable, it has to be resistant to forgery.

Whatever the outcome of the debate on value-encoded cards, there is little doubt that many consumers are expecting to be able to make an ever-widening range of transactions without cash: either by using a form of credit account or by directly debiting a current bank account. There is equally little doubt that the rapidly falling costs of data storage, processing and transmission will in the near future make it feasible to pay for calls from public telephones by one or more of these methods.

### The Friendly Payphone

Nothing provokes an argument more quickly than the question of customer instructions and displays; yet most of the participants in such a debate agree that "no one reads the instructions" or "no one understands them". As the cost of electronic memories falls further, payphones which will present their operating instructions, one step at a time, using either speech synthesis or a high-resolution visual display, will be seen. The techniques are available now—only the costs are prohibitive.

## CONCLUSIONS

British Telecom is replacing a 24-year old mechanical system with fully electronic payphones in a single step: this represents a rate of change that is probably faster than has been attempted by any other administration. The pace is not going to slow down: the lowering costs of electronic devices and systems are opening up many new possibilities, and it is certain that the introduction of the next generation of payphones will not wait for a further 24 years.

## ACKNOWLEDGEMENTS

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# Book Review

*Results of Tests and Experiments with the European OTS Satellite: IEE Conference Publication No. 199.* Institution of Electrical Engineers. viii + 139 pp. 112 ills. £16·50.

This book contains the texts of all the 26 papers that were presented at the IEE's conference on the orbital test satellite (OTS) in April 1981. The subjects covered range from radio-frequency propagation tests, on which there are a number of contributions, to the results of individual experiments on digital transmission, television and data. There is also a section dealing with the earth station techniques related to the experiments.

Although most of the papers are aimed at specialists of satellite systems, quite a few of the remainder should capture the interest of the more casual reader. For example, the paper by Gregory and McLaurin of British Aerospace gives a very clear and readable description of the OTS, and the overview paper of small earth-station technology by Hughes *et al* is another of more general interest in a highly topical area.

The excellent introductory address given by Collette of the European Space Agency, outlining the chequered history of the OTS project from the first tentative proposals in 1966 to the successful completion of the scheduled orbital test programme in 1981, and speculating on future European space activities, would have been very interesting to non-specialist readers. Unfortunately, it has been possible to reproduce this only in the shorthand form of the actual slides used during the presentation; although these can be followed fairly well, it is a pity that the full text was not available for reproduction.

In conclusion, this publication can be recommended as a useful reference book for anyone working in the field of communications satellites, and for those having a more general interest in current activities concerning satellites.

R. J. EATON

# Sidetone and its Effects on Customer Satisfaction

A. E. COLEMAN, C.ENG., M.I.E.R.E.†

UDC 621.395.62: 621.395.667

*The transmission performance of a telephone connection varies, as far as the customer is concerned, not only with the overall loss on the circuit, but also with the amount of sidetone present in the telephone instrument. This article illustrates the different kinds of sidetone and discusses the effect they have on customer opinion.*

## INTRODUCTION

During a telephone conversation, speech enters a talker's ear by 3 paths: an electrical path through the telephone set; a bone conduction path; and an earcap leakage path. Also, during the conversation, room noise enters the listener's ear via 2 paths: the electrical path and the earcap leakage path. These effects are known as *talker sidetone* (speech sidetone) and *listener sidetone* (room noise sidetone) respectively. In addition, there can be an acoustic path through the handset itself resulting from imperfect seals of the transducers, but this effect is small and is usually disregarded. (See Fig. 1.)

In the early years of telephony, the important factor was to be able to communicate over as long a distance as possible. As transmission performance improved by increased sensitivity in transducers, sidetone started to become a problem. During this period, sidetone was compensated for by the fact that the earphone was in a different housing from the microphone (a typical example was the candlestick telephone—the Telephone No. 1) and could be regulated by placing the earphone nearer to or farther away from the ear.

In 1929, the British Post Office (now British Telecom) introduced its first handset telephone—the Telephone No. 162. An important facet of this telephone was the introduction of an early form of anti-sidetone induction coil. Further developments in sidetone suppression, coupled with advances in transducer design, led to the Telephone No. 332 and the Telephone No. 746.

There is rarely any problem in providing enough sidetone in telephone sets and the problem in practice is one of ensuring that there is never too much. Of course, in some speech communication systems, the problem may exist of ensuring that there is sufficient sidetone to give the telephone user the impression that the telephone is live. This will not become a problem in the public switched telephone network until completely 4-wire connections are possible.

Conventional telephone sets connect a 4-wire circuit (that is, microphone and earphone) to the customer's 2-wire line via a hybrid transformer (or impedance matching device) with an associated balance network. Thus, it is obvious that, by using simple balance networks of say 2, 3 or 4 elements, adequate matching cannot be catered for over the wide variety of telephone connections.

An article by E. R. Wigan in 1932[1] highlighted the problems of sidetone and the need to reduce it to a practical minimum; this article presents sidetone and its effects in present-day terms.

† Research Department, British Telecom Headquarters

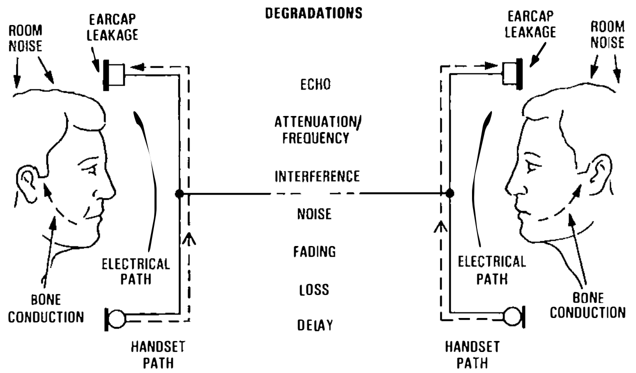



FIG. 1—Sidetone paths

## THE MEASUREMENT OF SIDETONE

At present, the internationally agreed method of determining sidetone leads to a quantity known as *sidetone reference-equivalent* (STRE) according to the CCITT* Recommendation P73[2]. This method only specifies the loudness of the electrical sidetone path, and introduces the inconsistency that the person talking is not the person listening; in practice, the talker is the listener (to his/her own speech). These determinations, because of the nature of measurement, are made at different listening levels and, as it is well known that the ear is a non-linear device, errors are to be expected.

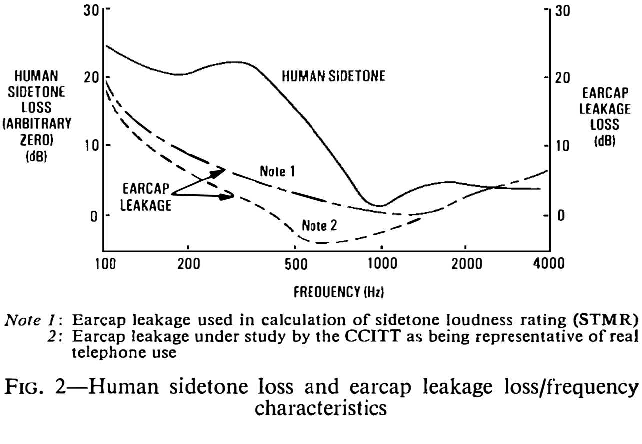
There has been a tendency to assume that all sidetone paths with the same numerical rating are equivalent in all important respects. This is not true; 2 sidetone paths with widely different frequency responses may have the same STRE, and yet one may be much more acceptable than the other in conversation.

A better method of evaluation is currently under review in CCITT Study Group XII. The essential point about this new method, known as the *sidetone loudness rating* (STMR), which includes the effect of masking[3], is that the perceived loudness of the sidetone attributable to the telephone is calculated as the loudness of the speech via the electrical path, masked by the speech via the natural paths (bone conduction and leakage at the ear owing to the coupling). STMR is used throughout this article.

Fig. 2 shows the bone-conduction loss[4] (often termed *human sidetone*) and earcap-leakage loss characteristics[5,6] used in the calculation of STMR.

The other information required for the calculation of STMR is a knowledge of the loss through the electrical

* CCITT—International Telegraph and Telephone Consultative Committee




*Note 1*: Earcap leakage used in calculation of sidetone loudness rating (STMR)
*2*: Earcap leakage under study by the CCITT as being representative of real telephone use

FIG. 2—Human sidetone loss and earcap leakage loss/frequency characteristics

circuit. This can be derived from the formula which defines the electro-acoustic path loss ($L_{MEST}$) between microphone and earphone

$$L_{MEST} = -S_S - S_R + 20\log_{10}\frac{|Z_{SO}+Z_C|}{2|Z_C|} + 20\log_{10}\frac{|Z_L+Z_C|}{|Z_L+Z_{SO}|}\ \text{dB},$$

where $S_S$ is the matched sending sensitivity of the telephone set;

$S_R$ is the matched receiving sensitivity of the telephone set;

$Z_L$ is the impedance of the line, transmission bridge, etc. up to the far-end circuit, as seen by the near-end telephone; this is a function of frequency;

$Z_C$ is the impedance of the telephone as seen by the line, and is a function of frequency; and

$Z_{SO}$ is the impedance that, when connected in place of the line, completely suppresses sidetone, and is a function of frequency.

## INTERMEDIATE REFERENCE SYSTEM

The experiments described below use an intermediate reference system (IRS)[7] which is a telephone selected as being representative of those used in the world. It is used by the CCITT to determine the loudness rating[8] of a connection. These loudness ratings, known as *sending loudness rating* (SLR), *receiving loudness rating* (RLR), and *overall loudness rating* (OLR), have superseded reference equivalents[9] as the basis of the transmission planning standards used by British Telecom.

To enable the results for differing RLRs and noise power levels to be compared, it is desirable to refer the noise to a convenient reference point. This is generally chosen to be the point at which the RLR is 0 dB. The circuit noise power levels are weighted with a psophometric weighting network and are measured in dBmp at the input to the receiving end of the IRS.

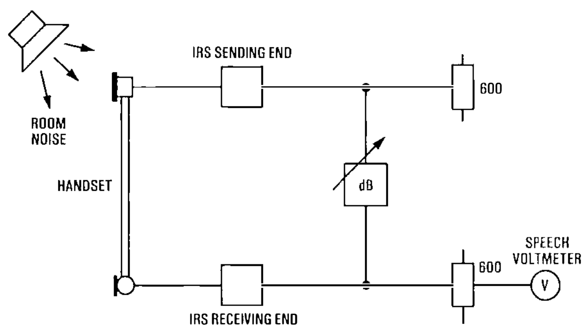
## TALKER SIDETONE

The effect of talker sidetone can be demonstrated by using information derived from the following subjective experiment. Fig. 3 shows the circuit arrangement.

Each subject is asked to hold the telephone in his/her natural talking position and to read aloud, at their natural talking level, a list of 7 short sentences for each of a selected range of sidetone levels. After speaking the passages, the subject expresses his/her opinion of the sidetone, in accordance with the following opinion scale

(*a*) Objectionable.
(*b*) Detectable.
(*c*) Not detectable.

Speech voltage measurements are also made at the output of the IRS sending end.




IRS: Intermediate reference system

FIG. 3—Circuit arrangement to determine talker sidetone

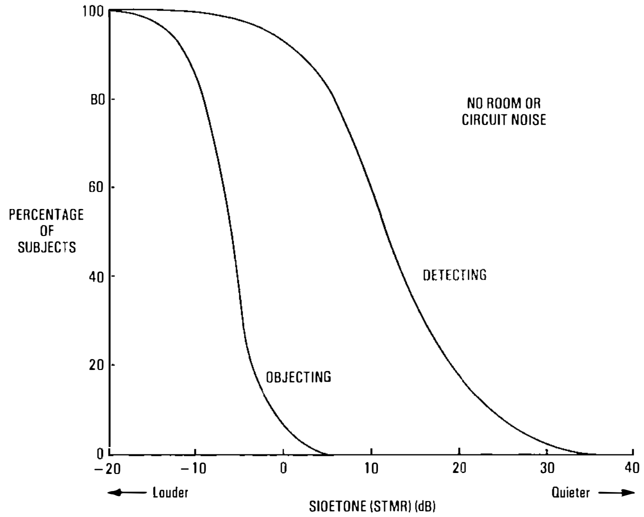



FIG. 4—Effect of sidetone level on detectability and objectionableness

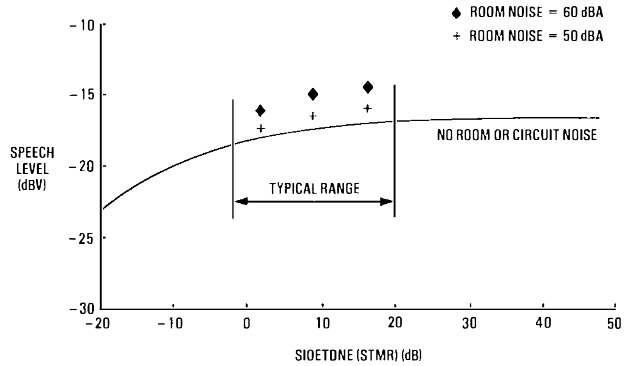



FIG. 5—Effect of sidetone level on speech voltage

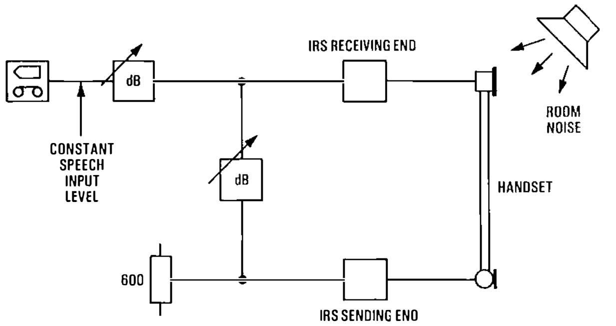
Fig. 4 shows the percentages of subjects detecting and objecting to the sidetone levels presented. It shows that sidetone has to be quite loud for people to find it objectionable, although it is detectable to most people when the STMR is less (that is, sidetone is louder) than 5 dB. However, the effect of sidetone on speech voltage can be seen in Fig. 5. Speech voltage remains fairly constant when the STMR is more (that is, sidetone is quieter) than about 10 dB, but decreases as the STMR is lowered. This indicates that the subjects compensate for uncomfortable sidetone levels by reducing their talking level and/or by taking the handset away from the mouth or ear (thus changing the value of $L_{MEST}$).

Also of interest in Fig. 5 are the speech voltages obtained for increased levels of room noise† which show that the subjects unconsciously raise their vocal levels even though, in this case, they are not communicating with another person.

## LISTENER SIDETONE

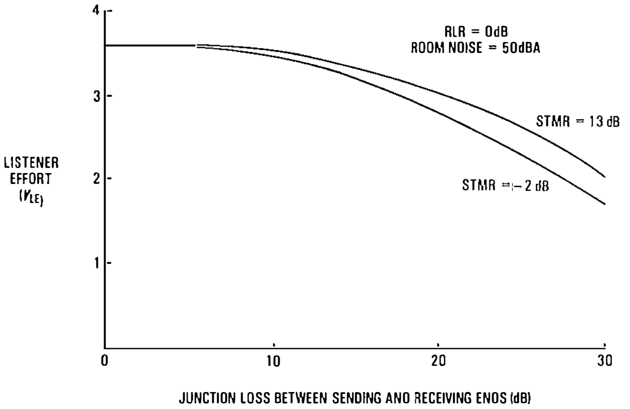
Fig. 6 shows an appropriate test used to demonstrate the effect of listener sidetone. These tests, known as *listening opinion* tests, are conducted by arranging for the listener to hear a succession of groups of 5 pre-recorded short sentences, which have been adjusted so that each group of sentences is transmitted from the tape recorder at the same speech voltage level. Then, for each group of sentences, a circuit parameter is changed, for example, sidetone level, room noise or junction attenuation. After each group, the subject expresses his/her

† Room noise is measured in dBA—the absolute level, measured with "A" frequency weighting, of a sound measured with a sound-level meter complying with the International Electrotechnical Commission (IEC) Publication 179. The datum is 20 μPa at 1000 Hz. This technique tries to represent the sensitivity/frequency characteristic of the ear and sets out to measure what the ear actually hears.



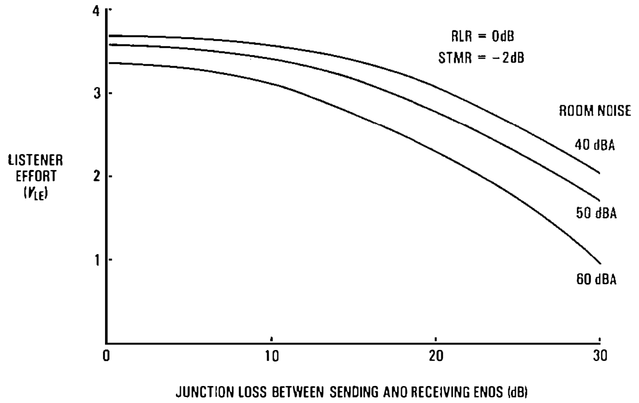

IRS: Intermediate reference system

FIG. 6—Circuit arrangement to determine listener sidetone




RLR: Receiving loudness rating
STMR: Sidetone loudness rating

FIG. 7—Effect of sidetone level on listener opinion score




RLR: Receiving loudness rating
STMR: Sidetone loudness rating

FIG. 8—Effect of room noise on listener opinion score

opinion of the condition in accordance with the following opinion scale

(*a*) Complete relaxation possible—no appreciable effort required.
(*b*) Attention necessary—no appreciable effort required.
(*c*) Moderate effort required.
(*d*) Considerable effort required.
(*e*) No meaning understood with any feasible effort.

The opinions are scored respectively 4, 3, 2, 1, 0, and are then averaged. This particular opinion scale is known as *listener effort* ($Y_{LE}$).

Fig. 7 shows the effect on the subjects' opinion of sidetone level. The effect is that the louder the sidetone, the lower is the opinion score. Fig. 8 shows the effect of room noise on subjects' opinion. Here, as expected, the opinion becomes increasingly worse as the room noise level rises. Now, if the effects shown in Figs. 7 and 8 are coupled, the necessity of ensuring good sidetone suppression if reasonable transmission is to be maintained is demonstrated.

The effect known as *masking* (wanted signal/unwanted noise ratio) is governed mainly by the characteristics of the 2 paths by which room noise enters the user's "telephone" ear; namely, via the electrical sidetone path, and the imperfect seal of the earphone and the ear (earcap leakage path). These paths are, effectively, in parallel and, under practical conditions, the lower part of the frequency range is dominated by earcap leakage, and the upper frequency range by transmission via the electrical sidetone path.

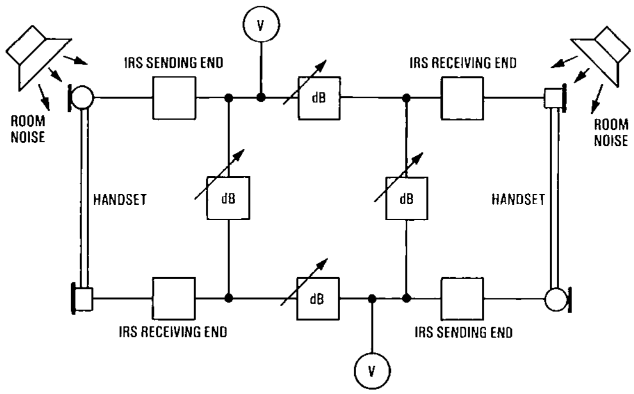
## COMPOSITE EFFECTS OF TALKER AND LISTENER SIDETONE

The 2 previously described experiments are single participant experiments. A more useful type of experiment, which is far more realistic, is the *conversation test*. In this experiment, a pair of subjects converse over a telephone connection and are thus able to help each other by co-operation. Fig. 9 shows the circuit arrangement. This type of test allows the circuit parameters to be controlled, yet permits the subjects the freedom to adapt to the circuit condition. The subjects are asked at the end of each conversation to rate the connection according to the scale

(*a*) Excellent.
(*b*) Good.
(*c*) Fair.
(*d*) Poor.
(*e*) Bad.

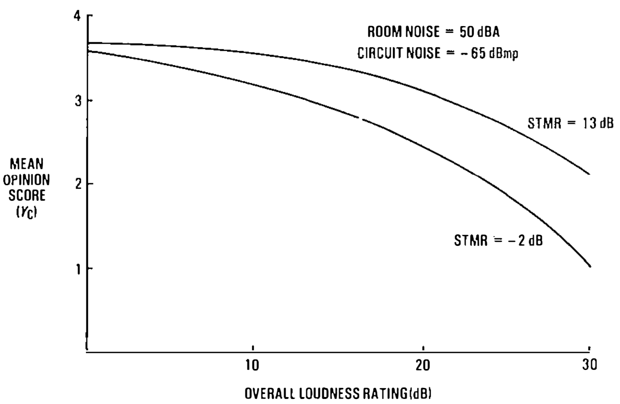
These are scored respectively 4, 3, 2, 1, 0 and averaged to give the *mean opinion score* ($Y_C$). During each conversation, speech voltage measurements are made at the output of each sending system.

The effect of sidetone level on the mean opinion score (see Fig. 10) is that, when sidetone is poor, the opinion score



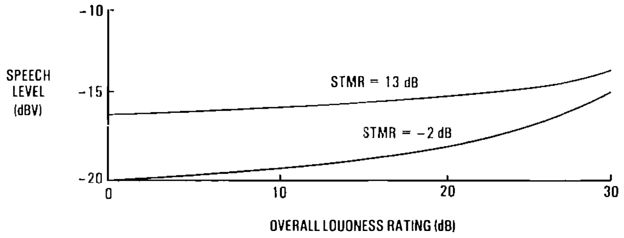

IRS: Intermediate reference system

FIG. 9—Circuit arrangement for conversation test



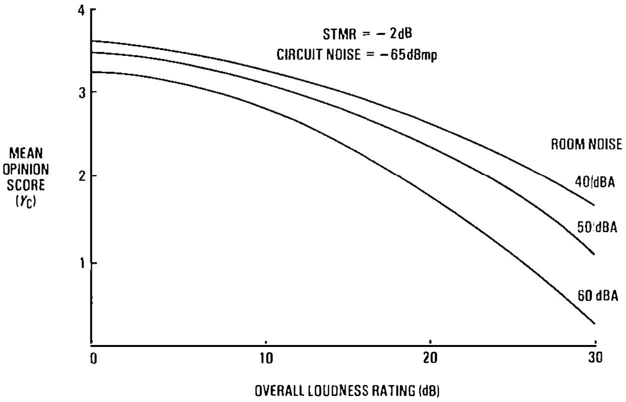

STMR: Sidetone loudness rating

FIG. 10—Effect of sidetone level on conversation opinion score




STMR: Sidetone loudness rating

FIG. 11—Effect of sidetone level on speech voltage




STMR: Sidetone loudness rating

FIG. 12—Effect of room noise on conversation opinion score

quickly deteriorates as the OLR of the circuit is increased. Fig. 11 shows the speech voltages and, with low-loss conditions, the level of speech voltage for loud sidetone is some 3–4 dB less than for the corresponding condition with quiet sidetone: this compares with the 3 dB found in Fig. 5. As more attenuation is introduced into the circuit, the speech voltage increases until the desire to communicate overcomes the need to maintain a comfortable sidetone level, and the speech voltage curves converge. This, however, has repercussions in the opinion ratings which diverge at a greater rate than they do for a listening type of experiment (Fig. 7).

Fig. 12 shows the effect of room noise on opinion score and, if Figs. 10 and 12 are compared, it can be seen that the telephone with an STMR of 13 dB working in a room noise level of 50 dBA (typical room) has a better transmission performance than the telephone with an STMR of −2 dB working in a room noise level of 40 dBA (fairly quiet).

Another interesting result which can be seen from Fig. 10 is that, in order to maintain the same transmission performance, say $Y_C = 2{\cdot}5$ (this implies about 95% of subjects rating the connection fair, good or excellent), the connection with the quieter sidetone can work on connections with some 7 dB extra attenuation. An alternative way of considering the same point is that, for a connection with an OLR of 30 dB (which is approaching the BT planning limit), although both connections would be permissible, the connection with an STMR of −2 dB would be most unsatisfactory, tending towards being unusable (especially at a higher room noise level).

## DISCUSSION

An optimistic look into the future to the introduction of 4-wire connections to the telephone set will pose the question as to whether or not a sidetone signal will be required. Study Group XII of the CCITT is at present studying this problem, and from contributions so far received there appears to be a definite need for a certain amount of sidetone; early estimates appear to suggest a value of 7–10 dB for the STMR.

Sidetone can be improved by paying particular attention to impedance balancing above 800 Hz. This takes advantage of the presence of the human sidetone signal and earcap leakage, which have greatest effect at low frequencies. In any case, it is clear that proper attention must be given in designing new telephone instruments to ensure that the best impedance match is obtained between the balance network, the impedance of the telephone instrument (both under the control of the telephone instrument designer), and the impedance of the network, which can vary from one call to another. It can be seen from the formula (given in the earlier section on measurement of sidetone) that the greatest sidetone loss will occur when $Z_L$ and $Z_{SO}$ are closest in magnitude and phase.

## PRACTICAL EXAMPLE OF THE EFFECT OF IMPROVED SIDETONE

Experiments have shown that, on certain limiting lines using 0·9 mm cable, the performance of the connection is improved if a cable of lighter gauge is substituted; the better impedance match to the telephone reduced the sidetone sensitivity more than enough to compensate for the increased loss. On this evidence, it was decided to phase out both 0·63 mm and 0·9 mm cables for new work, and for all longer lines, to substitute a new 0·6 mm cable having an impedance similar to that of 0·5 mm cable. This change secures a welcome economic advantage as well as an improvement in transmission performance.

## CONCLUSIONS

The experiments detailed in this article show that consideration of the level of sidetone alone is not really sufficient; the STMR has to be considered in association with the overall circuit connection and room noise. Now that British Telecom has lost its monopoly on attachments, and can no longer directly control telephone instruments, it is critical that there is an adequate broad appreciation of the importance of sidetone for transmission performance, and its effect on customer satisfaction. A worsening by a few decibels of sidetone on a lossy connection can mean the difference, for some customers, between being able and not being able to communicate. It must be stressed that, in the short term, the control of sidetone lies firmly in the hands of the telephone instrument designer. As well as considering what is economic, he has to design so that, even in the worst case, sidetone is still reasonable, otherwise communication will be unsatisfactory.

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# The British Telecommunications Human Factors Advisory Service

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UDC 658.3.04: 659.22

*This article* describes the Human Factors Advisory Service offered to British Telecom by its Research Department Human Factors Division. This service provides a convenient means of access to information on the human characteristics that must be considered to ensure that the design of systems or products is successful. The resources available to answer requests for advice and some examples of recent cases are described.*

## INTRODUCTION

The overall performance of a system used by people is affected by the degree to which human capabilities and limitations are taken into account in the system design. The process of investigating relevant human characteristics and applying information about them to system design is called *human factors*, or *ergonomics*. The designers of the increasingly sophisticated equipment and systems used by British Telecom's (BT's) staff and customers need access to human factors advice to ensure effective design.

Within the Research Department of BT, a Division of about 40 people, including psychologists, ergonomists, computer scientists, engineers and technicians, is exclusively engaged upon human factors studies. Also, to facilitate experimentation, a purpose-designed Human Factors Research Unit has been established at Ipswich, the nearest centre of population to Martlesham Heath. This unit provides accommodation for several simultaneous experiments, with laboratory and computing facilities, and is staffed by the research teams from Martlesham, together with a full-time receptionist. Access to volunteers to participate in the experiments is ensured by maintaining a subject panel of about 1500 members of the public. Similar facilities exist at the BT Research Laboratories at Martlesham Heath, where acoustically controlled environments are available, together with computers, laboratories and access to about 1000 members of staff who have registered themselves as prepared to participate in experiments.

## THE HUMAN FACTORS ADVISORY SERVICE

The main work of the Human Factors Division is directed towards the support of about 12 major projects, and embraces literature searches and interpretation, field studies, and the conduct of experiments. Some projects of a more fundamental nature are managed within the Division, while others are part of larger exercises involving several headquarters departments. In addition, there has always been a steady demand for advice on a smaller scale; over the years this has cost relatively little in terms of resources, but has contributed substantially to the furtherance of BT's business objectives. The growth of the advice service is illustrated in Fig. 1 by a histogram of numbers of cases dealt with. In 1978, the availability of the Human Factors Advisory Service was made more widely known within BT by the issue of a Telecommunications Instruction (TI K7 B0002). Afterwards, an increase in the rate of requests for advice was noted. This, together with the introduction of more comprehensive record keeping, is reflected in Fig. 1.

Each request for advice is initially addressed to one of the group leaders in the Human Factors Division. Based upon an assessment of the expertise and resources required, the group leader allocates the case to the most appropriate member of the Division's staff. Sometimes a site visit is needed to clarify the exact nature of a problem, to make observations, or to take measurements of work-place or environmental factors. Fig. 2 shows the widespread distri-

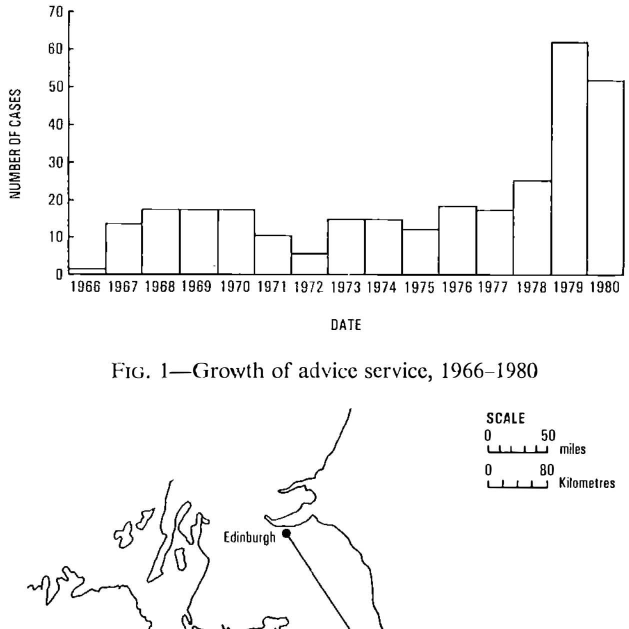


FIG. 1—Growth of advice service, 1966–1980

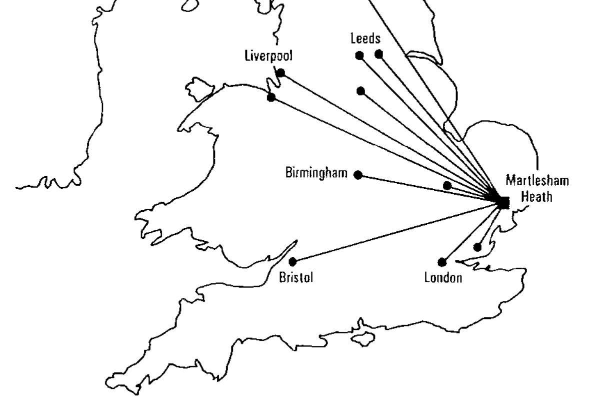


FIG. 2—Distribution of site visits

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* This article is based upon a paper presented at the Ninth International Symposium on Human Factors in Telecommunications held at Red Bank, New Jersey, USA, September 1980.

bution of the site visits that have been conducted during the last few years.

In some cases, reference to previous work can produce the answer. With the accumulated experience of the Human Factors Unit a number of questions can be answered in this way. Other cases call for a review of the relevant literature, and so a human factors library has been established, consisting of human factors journals and about 350 text books. This library complements the resources of the BT Research Department Library, with its extensive collection of technical literature and information gathering services.

Human factors is a broad field and is the concern of many units other than the Human Factors Division. Thus, some requests for advice can be channelled to an appropriate expert in other parts of the organization. In some circumstances, the expertise of the Medical Research Council's Applied Psychology Unit (APU) is required. A consultancy arrangement exists to allow access to APU experts or, via the APU, to other Medical Research Council units.

Finally, some requests are for information that must be determined by experimentation. Although human factors experiments can be relatively expensive and time-consuming, it is often feasible to add a small experimental task to the sessions of one of the experiments in progress for the main project work. If such an arrangement is possible, data can usually be obtained quickly enough for the unit initiating the request for advice without excessive man-hour costs being incurred.

## TYPICAL EXAMPLES OF WORK

The nature of the requests for advice received recently and the responses of the Human Factors Advisory Service are illustrated by the following examples.

(*a*) *Biological Effects of Magnetic Fields* A review of the literature was conducted.

(*b*) *Legibility of Print* Several queries concerned with print legibility have been dealt with. Typically, print size, ink density and paper reflectance have been measured and comments provided, together with recommendations on topics such as layout of information, choice of fount and character size.

(*c*) *Colour of New Exchange Equipment* Comments on the effect of reflectance of new equipment panels on the visual environment were provided, and arrangements were made for the query to be followed up by a representative of BT's Marketing Executive Design Division.

(*d*) *Ergonomics of New Customers' Apparatus* A range of queries on new customers' apparatus has been answered; typically, these involved comment on controls, displays, panel layout, operating procedure and instructions for use.

(*e*) *Use of Colour in an Alarm Display* Comment was made on the choice of colour in an alarm display, together with recommendations on the use of a flashing display and the choice of character size. Copies of relevant publications were also made available.

(*f*) *Use of Visual Display Units* (*VDUs*) Many requests for advice on the human factors aspects of using VDUs have been dealt with. Typically, a site visit is made to determine such things as office layout, position of lights and windows, details of procedures, and categories and numbers of staff. Recommendations or comment on the hardware, environment, work-place design and work organization are then made.

(*g*) *Design of Test Equipment* One example in this category was where the designer of a phase jitter meter needed to know the best up-date rate for the digital display. A simulation was programmed on a desk-top computer and an experiment was conducted to gather the speed, accuracy and opinion data needed to answer the question. Other cases have involved advice on panel layout, anthropometry and work-place design.

(*h*) *The Effect of Static Electricity on People* A literature survey was conducted on this topic.

(*i*) *Presentation of dialling codes* This case involved the redesign of a matrix of dialling codes for the Isle of Man telephone directory. The advice of an expert on information design from the APU was obtained.

(*j*) *Crane Control Labels* This query was also referred to the APU. Comments on the symbols for the various crane movements and the arrangements of the controls were provided.

## DISCUSSION

The Human Factors Advisory Service is of value only to the extent that it meets the needs of its customers. This means that responses to customers' queries must be tailored to their time-scales and resources. General guidelines must be interpreted specifically to match each particular case. This does not imply that the service offers the facility to rubber-stamp proposals, although it has occasionally been asked to do so. The situation where a proposal is too far advanced for human factors input to have any significant effect does arise from time to time. To avoid this problem a continuous campaign is necessary to encourage the involvement of human factors at the earliest feasible point in a project.

To determine when to press for the best human factors standard, or when to accept the priority of other considerations calls for careful judgement. Not to insist on the recognition of human needs when fully justified can lead to poorer equipment or services, whereas being too rigid in less important cases could well lose goodwill. The availability of external consultants helps to maintain the fine balance between human needs and engineering or operational expediency.

A multi-disciplinary human factors advisory service could possibly be seen as a competitor to other specialist units, although in practice this problem has not arisen to any significant extent. Co-operation is enhanced by the involvement of members of appropriate specialist units in cases where they have a contribution to make. There are many instances when other specialist units have asked the Human Factors Division for a second opinion, or for information that fell outside the expertise of the specialist team, or for an investigation to be conducted using the experimentation facilities available only at Ipswich. In addition to the foregoing considerations, there is an over-riding conviction that there are sufficient human factors and related problems to keep all the specialist units fully occupied for a long time.

Providing an easy route for accessing human factors information increases the chances of avoiding design errors in systems, equipment and facilities, and makes possible the maximum involvement of human factors in the design process. The awareness of the role that human factors should have in any development is increased as more and more people come into contact with the discipline. The informal contacts established between members of the design teams and the Human Factors Division promotes more effective liaison between them. Often, areas that require a more extensive investigation are identified as a result of a request for advice. This can lead to additional major human factors project work, with increased benefit to the performance of the resulting system.

## CONCLUSION

Human Factors input is a vital component of the design of systems that interact with people. The Human Factors Advisory Service exists to provide a convenient access route to the relevant information and expertise. Hundreds of requests for advice on a wide range of topics have been answered over the years. It is hoped that the designers of the increasingly sophisticated systems used by BT's customers and staff will continue to make good use of this service.

# The Lessons of the Introduction of Prestel for British Telecom Engineers

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UDC 025.3: 681.31

*This article outlines the policies adopted by British Telecom (BT) for the introduction of Prestel, discusses the experience gained in operating these policies, and comments on the implications for future BT operations in a competitive environment.*

## INTRODUCTION

Prestel was announced to the public in September 1975 and the first limited public service opened in September 1979. By December 1980, the service was available to 62% of the telephone subscribers of Britain. This is a short time-scale judged by the standards of the telecommunications industry and the service introduction was characterised by several features which, although novel at the time, appear likely to become typical of British Telecom (BT) services—or at least of British Telecommunications Enterprises (BTE) services—after the British Telecommunications Act of 1981.

From the outset, Prestel has operated its own liberal attachment policy; any Prestel terminal that gained BT attachment approval could be supplied, installed and maintained by private companies. Integral modems were allowed in the television set and private competing viewdata services were permitted. In addition to this national competitive situation, international competition was unusually strong. UK viewdata systems have been sold abroad to 7 countries and this has provoked the strongest possible competition from other national suppliers, notably in France and Canada. Thus, the Prestel research and development engineers have either chosen, or been forced, to operate in a highly competitive environment from the outset. The purpose of this article is to recount some of those experiences and to comment on the lessons learnt, although the opinions expressed below are those of the author.

## THE PROVISION OF PRESTEL SETS

The Prestel policy directives were clear. Any manufacturer could provide, install and maintain Prestel equipment provided that he obtained the approval of the then British Post Office (BPO). This approval was limited to matters of electrical safety to protect the network from the high voltages that exist in the sets, and to ensure that the frequency spectrum of signals transmitted fell within defined templates to prevent crosstalk and interference with signalling equipment. No attempt was to be made to judge how well the terminal worked, or indeed if it worked at all. Manufacturers could incorporate within the television sets all the required circuits, including the modem and the auto-dialler—a radical departure from previous policy.

It is useful to recount the arguments that were made for this change of policy. It was thought that: the private provision of television sets would lead to a more vigorous and rapid penetration of the market than could be obtained if BT undertook the task; moves to nationalise the television set in the home would be controversial; and the provision of external modems and cables would be unattractive to the market (precedence in the *HiFi* market was quoted). Also, the provision of external modems would have required BT to estimate the number of sets likely to be sold by private suppliers and invest to provide a similar number of modems.

The advocates of a more traditional approach argued that: safety standards were higher in BT than in the private sector; problems would arise from mixed maintenance responsibilities; and these would result in either an unworkable system or in BT bearing a totally disproportionate share of fault investigation. They also argued that the BT main network was both highly complex and continually changing, and that it was necessary to retain total control of the overall system to protect the customer from the consequences of a diversity of network phenomena, ranging from shared service to the introduction of MF4 signalling. Examples of rare transmission paths were also quoted, (always, it seemed to the author, either in central London or in the Outer Hebrides).

## EXPERIENCE OF PRESTEL POLICY

So how has the Prestel experience endorsed or refuted these various arguments? Consider first, the most important issue—safety. BT safety standards are undoubtedly high and the network operates basically at a low voltage. Electric shock, apart from its intrinsic danger, could well cause a lineman to be thrown from a pole. When these points were put to the British Radio Equipment Manufacturers' Association (BREMA), the reply, in slightly hurt tones, was that they too were well used to complying with very stringent British Standards Institution (BSI) standards for the provision of domestic equipment, and that aerial riggers also worked aloft when aligning the aerial. They argued that accidents involving riggers being thrown from house roofs through electrocution were not a common occurrence. The negotiations on safety standards between BREMA and the BPO were some of the most protracted on the project, but, as a result, the BPO became the first telephone authority in the world to permit the widespread attachment of privately supplied domestic television sets to its network.

After 2 years of service, the indications are that this has been achieved without substantial risk to the safety of either BT staff or its customers, and this is a credit to both the BT attachment approval engineers and to set designers in industry. Indeed, at a recent conference, a BREMA spokesman praised the role of the BPO, and expressed concern about the future of attachment approval under BSI. Although the initial engineering standards of television sets could be verified, one fear was that BT had no safeguard against inadequate maintenance during the life of the set. With the oldest Prestel sets only 2–3 years old, this point cannot be said to have been resolved finally, but the indications are that no serious problem exists.

One interesting footnote on this discussion relates to lightning, for it was argued that lightning strikes or surges through the aerial could represent a serious risk to BT plant, against which no practical electrical protection would be effective. In fact, a strike did occur quite early in the service

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trial, and has become known in the trade as *the incident at Newton Flotman*. Detailed investigations failed to establish whether the lightning had struck BT plant first and then damaged the set, or had struck the aerial first and then damaged the BT plant. In general, though, lightning strikes have not proved to be a problem so far.

Just as safety problems appear to have been resolved without serious long-term difficulty, (if not without short-term tribulations), so most of the other problems appear to have been surmountable. The so-called *short-haul* transmission scheme, under which down-rated performance modems are used for economy, works well in most situations; indeed, sets built to this standard are frequently successfully used over transmission routes that fall outside the design plan. There is every indication that the private market will respond, when it judges the market fit, to changes in the network interface, such as presented by MF4 signalling. It is true that industry has yet to provide a standard Prestel set that will work to the type of PABX serving BT Headquarters in London, even though a specification has been provided. However, this is a continuing minor embarrassment to Prestel engineers, rather than a commercial embarrassment to the Prestel accountant.

The problems of mixed maintenance responsibility seem to be soluble by a judicious combination of Prestel test procedures and reasonable training on behalf of the television dealers. Prestel sets on the market are of varying quality and have worked, with one notable exception. The exception was a device having the user identity stored in dynamic memory, which was maintained by a chip-support battery when the set was not in use. If the device was not used for longer than about a week, the user identity was erased and the set could not be used by the customer without Prestel re-registering it at a cost of several pounds. Thus, a technical mechanism that could have confirmed the worst fears of the pessimists was identified; fortunately, this was removed by co-operation between Prestel and the manufacturer.

## THE THREAT OF COMPETITION

If the worst fears about a liberal attachment policy are not confirmed by the above events, it must also be said that the claims by private-sector suppliers to be able to provide and sell sets in very large volumes have not been realised either. This may be due, in part, to the economic circumstances prevailing today, which are very different from the oil-boom economy that was foreseen when the decisions to proceed with Prestel as a public service were taken. However, in the opinion of the author, some sections of the industry could have displayed more vigour in the manufacture and marketing of Prestel sets. Ironically, in the broader BT context, this is encouraging, for it could be concluded that, although the products produced by companies who will be BT's future competitors are generally sound, well engineered and represent no serious threat to the operational safety of the network, the companies' commercial performance is not such that it cannot be matched by BT if it responds vigorously to competition.

## SPECIALIST EQUIPMENT FOR INFORMATION PROVIDERS

The discussion so far relates to the Prestel customer terminal, but there is one interesting area where the lessons are ambivalent; this is the provision of the specialist equipment by information providers to create the Prestel pages. This equipment falls into 2 categories: a simple keyboard used for data entry; and the more elaborate computer-based intelligent editors, which are connected to special high-speed data ports at the Prestel Centre. In both of these areas, problems were more numerous. The keyboard editors are often connected to a Prestel computer port via the public switched telephone network (PSTN) for most of the working day. As business users, they are very aware of the cost of wasted time and some problems were caused in the early days by noise. This arose partly because of the performance of the low-cost modems, although these are adequate for normal customer use. The software interface and protocols used by the intelligent editors also produced some problems, and arguments arose between BT and the manufacturers about whose computer software was at fault.

Solutions to both of these problems were soon found; by the provision of conventional modems in the former case, and by improved specifications and testing facilities in the latter. The experience does indicate that network interfaces with professional computer users cannot be treated in the same relaxed manner that proved successful for the domestic and general business market. This conclusion (which the author is sure will not be new to, say, colleagues dealing with the packet-switched service (PSS)) may prove significant as BT faces the need to accommodate privately-operated value-added networks, and as customers begin to use the integrated services digital network (ISDN) for applications such as intercommunicating word processors.

## EXPERIENCE WITH BT SUPPLIED EQUIPMENT

Prestel terminal equipment is supplied and maintained by private manufacturers, but Prestel has also provided some interesting experience with equipment that is maintained by BT. Two items of central computer equipment are relevant and their development was handled in different ways.

The first was a low-cost computer-end modem incorporating circuits that rendered the provision of a relay-set unnecessary. The circuits were devised in BT's Research Department and passed on for development in what was then the traditional way. This involved further development work on the prototype, a field trial, then procurement and installation for service. The initial design was completed in 1977, but the development and field-trial stages took so long that the requirement disappeared. First, stock of an older modem had to be used before it became economic to install the new modem, despite its reduced requirements for power and accommodation. Then, a reduction in the requirement for Prestel ports rendered further development uneconomic. If the equipment had been installed in a timely manner, it would have made a substantial contribution to the cost-reduction exercise that eventually caused its own demise.

In contrast, equipment known as *viewdata access monitoring and priority indicator reporting equipment* (*VAMPIRE*) was put into service in a relatively trouble free way. VAMPIRE is a microprocessor that monitors the computer ports with respect to occupancy, fault status etc., and feeds the information to the Prestel operations centre. After the original circuit design, Research Department placed the initial production contract with a medium-sized electronics manufacturing firm.

However, it should not be implied that there were no difficulties. After the contract had been placed, it was discovered that the specification for printed-wiring board (PWB) design did not meet BPO requirements regarding inflammability. This caused PWBs worth about £4000 to be thrown away, and installation was delayed by about 8 weeks while new boards were manufactured. The first reaction of the staff concerned was one of embarrassment and it was thought that an error of this nature should be concealed as far as possible.

Seen in retrospect, the price of the error was small compared with the benefits of getting the equipment in service quickly. While not advocating waste, the author regards the story as indicative of the future in the new competitive environment. BT must introduce new equipment quickly and deliver the goods; if staff are trusted regarding design matters, then small errors can readily be forgiven.

Slightly more worrying at the time were teething troubles when the equipment first entered service. The traditional BPO development programme, for all its drawbacks with respect to time-scales, did ensure that field maintenance staff took over equipment that was largely error free and well documented. However, the field staff themselves appeared not to mind the problems too much, and it may even be that there is potential job enrichment for staff if they have to maintain prototype equipment in a less spoon-fed way than has previously been the case. Despite the theoretical advantages claimed by management scientists for job enrichment, it has not always proved possible for the BPO deliberately to enrich jobs by extending the range of equipment that they have to maintain. It is likely that the trend in electronics technology towards unit replacement will be to reduce job satisfaction in some areas, and the involvement of field staff in the rapid introduction of prototype equipment could be a timely way of increasing it.

Research Department also developed Prestel; television manufacturers sent staff to work in the laboratories at Martlesham to learn the circuit technology. The early development of VAMPIRE was controlled by Research Department, and a joint Research Department/Data Processing Executive programming team set up to implement the software. These arrangements, which at the time of writing (October 1981) are coming to an end after 4 years, enabled the system to be introduced quickly, and the concept of rolling research and development teams, with researchers taking products into development phases has much to commend it. At the end of the exercise, research staff can go back to start on a completely new product.

## CONCLUDING REMARKS

To what extent have these methods of working been successful? After the publication of Sam Fedida's original viewdata report, the research and development team had 3 objectives set by the (then) Telecommunications Marketing Department. These were, not necessarily in priority order:

(*a*) the creation of telephone traffic—the engineers were advised to regard themselves as salesmen of telephone calls;
(*b*) the furtherence of British industrial interests; and
(*c*) the production of a profitable service for BT.

The first 2 of these objectives have already been achieved. A flourishing market in private viewdata systems exists, with about a dozen manufacturers who have sold an estimated 100 systems to private buyers. Since these systems, when they are installed in the UK, use the BT network, substantial revenue accrues to BT. However, in future, it will not be safe to assume that privately-owned viewdata systems will automatically use a BT network; they may use one belonging to a competitor. As future generations of viewdata system are developed, BT must be more careful about the way in which the knowledge is disseminated to ensure that the revenue accrues to BT's own networks—PSTN, PSS, ISDN or whatever.

British industry has been helped in 3 ways. The Prestel software has been sold to 7 nations, and this has resulted in the installation of about 20 British made computer installations abroad. The private viewdata industry has also exported several systems and the companies were often helped to establish their markets by demonstrations of Prestel by BT Research Laboratories and Prestel staff. Finally, the success of the British Broadcast Teletext system in Europe, which has resulted in substantial exports of large-scale integration decoders by a British manufacturer, is due in part to help from BT in the international standards arena. The number of customers using Prestel is lower than the original BREMA forecasts, but this service too is now proving successful in the business market and has over 13 000 customers.

# The Sixth International Conference on Computer Communication

British Telecom will be the host for the sixth International Conference on Computer Communication (ICCC '82), which is to be held in the City of London's Barbican Centre for Arts and Conferences from 7–10 September 1982 under the chairmanship of Mr. J. S. Whyte, Managing Director (Major Systems) and Engineer-in-Chief, British Telecom.

The theme of the conference will be *Pathways to the Information Society*, and the conference will open with a plenary session chaired by Mr. Whyte with the following speakers:

*Keynote Address* Kenneth Baker MP, Minister of State for Information Technology, British Government.

*Social and Human Factor Implications* Murray Laver, Pro-Chancellor, Exeter University, UK.

*Service and Business Aspects* Torsten Larsson, Deputy Director General, Swedish Telecommunications Administration.

*System Technology* Ian Ross, President, Bell Laboratories, USA.

Approximately 150 papers are expected to be presented at ICCC '82 during some 40 sessions, each chaired by a recognized expert in the field, and emphasizing the international interest in computer communication. The sessions will cover the following topic areas:

Public data networks
Integrated services digital networks (ISDN)
Teletex
Intelligent network services
Network architecture
Protocol proving and validation
Network routeing
Switch architecture
Human factors
Applications in banking, education and medicine
Network management
Transmission technology
Office systems
Local-area networks
Videotex
Open-systems interconnection
Protocols
Distributed systems
Network performance and monitoring
Network interconnection
Satellites
Social implications
Regulations and public policy
Optical systems
Economics

Registration for the conference (delegate fee £150 before 31 July 1982) may be obtained from the ICCC '82 Office, PO Box 23, Northwood Hills, Middlesex HA6 1TT.

# Installation of Telephone Systems in Business Premises

D. R. WILTSHIRE†

UDC 621.395.2

*A new approach to the installation and wiring of telephone systems in business premises is described in this article. The new installation practice makes use of a standard internal cable distribution scheme and introduces insulation displacement termination techniques using a new range of wires, connectors and associated frames and boxes.*

## INTRODUCTION

The methods that had been used by British Telecom (BT) for the installation of telephone systems in customers' business premises had not changed for many years, and were becoming unsatisfactory in every respect. Installation techniques were slow, very little off-site preparation work was possible, and the installation hardware was unattractive to customers. A great deal of criticism had been voiced by the suppliers of proprietary PABXs on the grounds that the techniques used by BT were well behind world standards. In addition, as a result of the decision to increase the density of the distribution cabling in large buildings, the number of wires to be terminated was to be increased.

Changes to the installation methods had been under consideration for some time, but the introduction by BT of the Herald and Monarch call-connect systems, in particular, gave the necessary impetus to resolve the problem. Compared with the Strowger systems that they replace, these modern microprocessor-controlled switching systems are smaller and neater in appearance. Testing and development work with the objective of improving the installation methods resulted in new practices being introduced for the installation of these systems and the provision of the extension wiring. After a successful trial, the new methods, known as the *Rapide* connection system, were adopted for all new installations.

## NEW INSTALLATION METHODS

The principles that have been adopted for the new approach to the installation of telephone systems in business premises are that

(*a*) buildings are cabled for telephone services in accordance with a defined internal cable distribution (ICD) scheme,

(*b*) all wiring is terminated by using insulation displacement terminations (IDTs),

(*c*) customer's systems are made plug compatible wherever possible,

(*d*) cables and cordage having a discrete colour code on each wire to allow the pair wiring to be more readily identified are used throughout the installation,

(*e*) factory or workshop manufactured wiring harnesses are used to interconnect items of equipment wherever possible, and

(*f*) maximum use is made of aids for fast wiring and cabling.

### The Internal Cable Distribution Scheme

In accordance with the recommendations contained in a BT Management Services Department efficiency report, customers' buildings are cabled at a wiring density of one pair per 5 m$^2$. This scheme is designed to minimize future additions and alterations, which are costly and cause inconvenience to the occupant of the building.

The ICD scheme permits one flexibility point only for cross-connection jumpering. Large distribution schemes use a building distribution frame (BDF): medium and small distribution schemes use a connection box at this point.

Telephone switching systems are connected to the ICD scheme at the flexibility point; for convenience, this is referred to as the system connection point. Where the system is remote from the flexibility point, a link cable is used for the interconnection, and a test jack frame (TJF) is provided adjacent to the system to give service facilities. No flexibility is provided at the TJF. This arrangement is designed to allow future replacement and removal of systems, particularly in multi-occupier buildings, without constant re-arrangement of the extension wiring.

Disconnect-type jacks, for test and isolation purposes, are provided at the system connection point, the TJF and the point of entry of external cables. Facilities are provided at the BDF or connection box for fitting gas-discharge tubes on those circuits requiring over-voltage protection.

The multiple cabling for key systems does not form part of the ICD; therefore, these systems are still locally wired.

### Insulation Displacement Terminations

A number of IDT systems have been available for many years. In the USA, it is becoming the most common technique for terminating telephone wiring. The prime advantages are the high speed of termination, compared with soldering or wire wrapping, and the simplicity of training for wiring operatives.

The most common type of IDT is a simple slotted beam commonly called a *bifurcated tag*. The mechanical resistance to opening the slot, when the wire is pushed in, gives the force necessary to crush and displace the insulation, and remove any resistive film on the conductor. The elastic deformation of the tag maintains the contact pressure as long-term relaxation occurs. Tags of various materials are used; phosphor bronze, alloys of brass, and copper, which may be tin or silver plated, are common. Wires can be terminated either individually or *en masse* as the application demands; both methods are used in the new range of customer apparatus.

In 1967, the first steps were taken by BT (then the British Post Office) to introduce IDT techniques for the termination of distribution wiring in customers' premises. The system used was similar to the original Bell/Western Electric Co. tag[1]. New terminal blocks and connection boxes were developed (Block Terminal Nos. 67A, 68A, 69A, and Box Connection Nos. 11A and 12A). However, these developments did not include new distribution frames, and no provision was made for disconnect test jacks or protection devices in the system. For this reason, and because the introduction of new installation hardware was given low priority, the development was not pressed forward and the termination system was not introduced after the trial stage.

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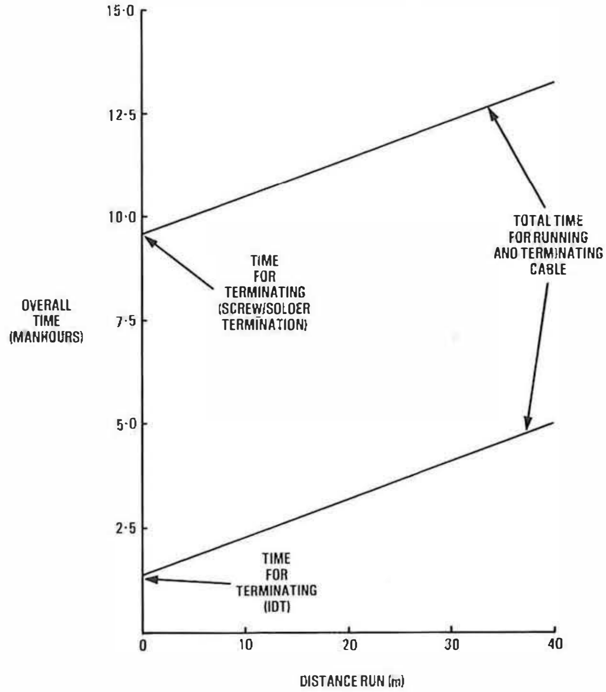



IDT: Insulation displacement termination

FIG. 1—Expected effect of IDT on the manhours expended in running and terminating an 80-pair cable

The Management Services Department's report that led to the introduction of the ICD scheme also recommended the use of IDT techniques for terminating the cables, where it was predicted that substantial savings in terminating time could be achieved (see Fig. 1). As other telephone administrations were known to be developing IDT systems, it was decided to undertake an urgent appraisal of these systems with a view to adopting a system that would meet BT's requirements. The most promising system studied was a development, by the Krone company of Berlin, which was suitable for use in connection boxes and distribution frames. This system was introduced in 1978 and is known as the *LSA plus system*.

Because the LSA plus system included facilities that were not available on other developments, interest centered on this system. A test programme was initiated by BT to evaluate the wire termination. These tests were designed to simulate the life cycle of the termination over a period in excess of 25 years, and measured the effect of corrosion, differential expansion and stress relaxation of the termination. The methods used to test the termination were the usual accelerated ageing tests, which include thermal shock, thermal ageing and exposure to industrial atmosphere. A difficulty at this stage was the lack of a specification for IDT techniques except for use in connector termination applications. A BT specification (D 2920) has now been produced by BT Technology Executive so that future evaluation of other terminating systems will be more straightforward.

In the LSA plus system, the plastic housing plays an important part in the mechanism of the termination, and so particular attention was paid to this. The original polyester material used was not of a flame retardant grade and, because large numbers of modules can be used on a system, the use of a material meeting BT's requirements for flammability was specified. When these modules are tested, care has to be taken in the accelerated ageing tests so that the plastic material is not damaged by using too high a temperature; the ageing tests are temperature/time related, and the use of a lower temperature consequently leads to a longer test cycle.

The evaluation testing proved that the termination system, with minor changes, would meet BT's requirements. After a successful field trial of the system, commercial negotiations with Krone led to an agreement by the company to set up a manufacturing facility in the UK. A decision was then taken to adopt this system for use throughout customers' premises.

The LSA plus system incorporates an insulation displacement tag that is different from others currently available; a feature of the design is that the termination tag is held in a plastic-moulded housing at an angle of 45° to the line of wire entry. The housing also serves as a reaction point at the edge of the tag. When the wire is forced into the tag, the tag limbs both open and twist. This introduces a torsional force into the deformation of the tag, which significantly contributes to the contact pressure (see Fig. 2). This design of the tag allows for variations in wire size, and increases the number of reterminations that are possible without the tag being damaged or the performance of the termination being reduced. The design of the tag is unique in that it allows for the termination of up to 2 wires of the same conductor diameter in the same tag slot. The wire termination module is known as *Strip Connection* (SC) *No. 237*.

Wires are terminated one at a time by using a spring loaded tool, known as an *Inserter Wire No. 2A* (see Fig. 3), which forces the wire into the tag slot. The wire is trimmed to length at the end of the insertion stroke by means of a scissor-action blade. The nose of the tool is polarized to prevent reversal of the tool causing the wire to be cut on the wrong side of the tag. A plastic stop to disable the scissor action can be fitted to the tool to allow for the termination of through wires.

Wires are removed by simply pulling the wire out of the tag in the opposite direction to wire insertion. The handle of the tool contains a foldaway hook device for this purpose.

## Connection of Systems to the Distribution Cabling

As a first step towards improving the techniques for the

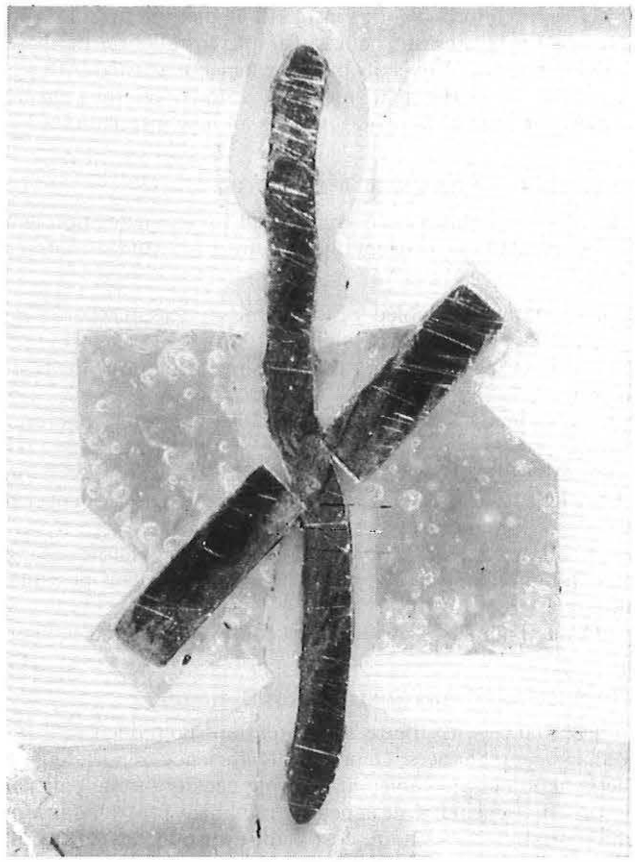


FIG. 2—Section through IDT termination showing deflection of tag and indentation in wire

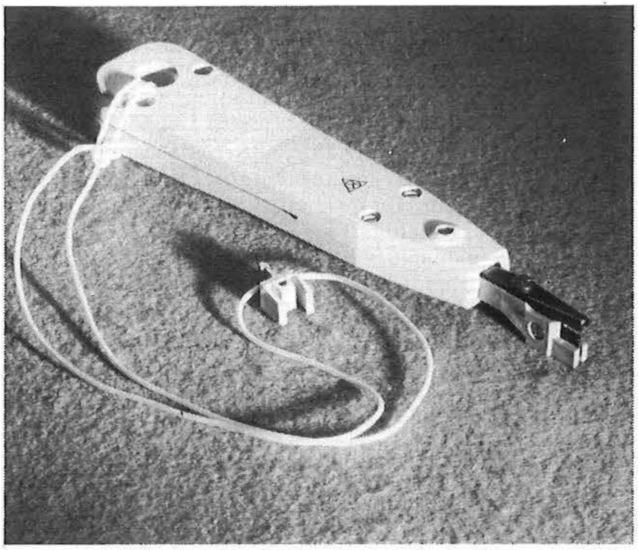


FIG. 3—Inserter Wire No. 2A

installation of telephone systems in buildings, it is desirable, wherever possible, to make the system plug compatible at the system connection point. This facilitates the preparation and testing of systems in installation workshops before they are delivered to site. The site wiring can also be prepared and tested during the construction of new buildings without the complication of trying to keep systems free from building dust. When the customer is ready for service, the system can then be easily installed and commissioned.

## NEW INSTALLATION HARDWARE

### Strips Connection No. 237 and Accessories

*Construction*

The new wiring system is designed on a modular basis, the basic wiring module being a plastic housing with a capacity of 40 IDT tags; these are arranged in 2 rows of 20 tags, one above the other, giving a capacity of 10 pairs in and out on each SC. Each module is 120 mm long by 20 mm high and 40 mm deep. Additional features such as disconnect test jacks and commoning strips are included in some SCs.

The plastic material used for the shell moulding is either a polycarbonate acrylonitrile/butadiene/styrene (ABS) blend or polybutylene terephthalate (PBT), both of which are flame retardant materials meeting BT's requirements. The termination tag is formed from a modified brass (73·5% copper, 3·4% aluminium, 0·4% cobalt, 22·7% zinc); the tags are then silver plated.

Each tag is held between castellations in the plastic moulding, which serve to support the tag at an angle of 45° to the wire slots, guide the wire to the tag at the correct angle, and position the insertion and cutting tool. All wires are terminated at the front of the module. Permanent wiring is terminated on the top row of tags, a ring at the back and projections on top of the moulding serve as a strain relief and fanning strip for these wires. This allows the wires to be identified and formed before termination. Pair numbers 1–10 are marked on the front of the moulding, but because of insufficient space the 1 is omitted on pair 10. Split rings are provided at each end of the module and serve as guides for jumper or distribution wiring, which is connected to the bottom row of tags. Normally, wiring to pairs 1 to 5 is taken via the left-hand end ring and to pairs 6 to 10 via the right-hand ring.

*Ratings and Facilities*

The SC No. 237 can be used to terminate solid copper wires with plain or tinned conductors 0·4–0·63 mm in diameter, and having an overall insulation diameter of 0·7–1·4 mm using polyvinyl-chloride (PVC), nylon-coated PVC, irradiated PVC or polyethylene terephthalate (PET) insulation. The termination resistance is less than 5 mΩ after ageing and up to 100 reterminations can be made on any one tag.

Test access, with or without a disconnection facility, is provided. The termination tags are recessed in a plastic moulding, which ensures that there is no electrical or mechanical safety hazard. Over-voltage surge-protection devices can be fitted to the module.

A range of modules to meet different system requirements are available; these are listed in Table 1.

**TABLE 1**
**Range of Wire Termination Modules**

| Strip Connection No. | Capacity | Applications | Protection Capability |
|---|---|---|---|
| 237A | 10 pairs | Terminating cables on distribution frames and box connections when disconnect test access using plugs is required. | Yes |
| 237B | 10 pairs | Terminating cables on distribution frames and box connections when tee-on test access using plugs is required. | Yes |
| 237C | 20 pairs | Terminating cables on distribution frames and box connections at high density when test access using plugs is not required. Also used to replace conventional wiring blocks in systems. | No |
| 237D | 76 wires | Earth common. Used in box connections to distribute recall earth to PBX extensions. | – |
| 237E | 20 wires | Same as SC No. 237D, but with reduced capacity. | – |

Where voltage-surge protection is required on circuits, a Protector Mounting No. 5A is plugged into the front of the SC No. 237A or 237B. This provides facilities for plugging in 3-pole gas-discharge tubes (Protector No. 14A) to individual circuits as required (see Fig. 4). The earth for the protection devices is connected via spring contacts to the backmount

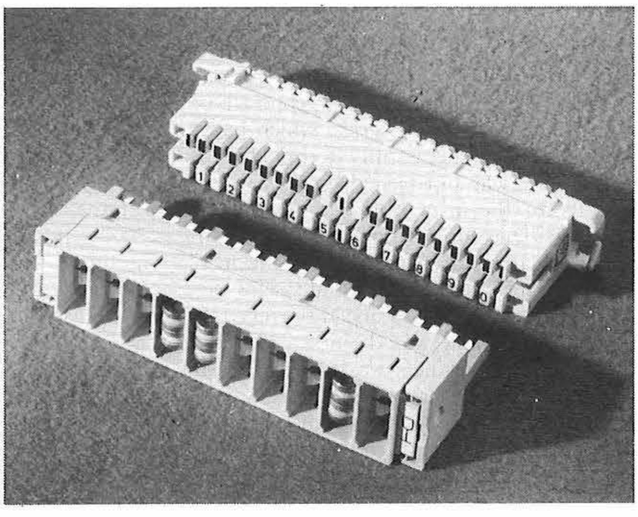


FIG. 4—Strip Connection No. 237A and Protector Mounting No. 5A with Protectors No. 14A fitted

frame, which is wired to the protection earth. In order to insert test plugs, it is necessary to remove temporarily the protection module.

The SC No. 237 is designed to clip on to a metal backmount frame by means of a latched slot at each end of the module. The modules are designed for horizontal mounting for ease of wiring, but can be mounted vertically in exceptional circumstances.

The backmount frames for SC No. 237 (Frames Mounting No. 5/···) are made in the form of an open-fronted cable trunking section, with projections at the front to take the modules. Cabling to the modules for termination on the top row of tags can therefore be routed to the modules within the backmount frame. Cables usually enter the backmount frame at the top or bottom openings, although frames manufactured more recently have additional cable entries in the sides and back.

The backmount frames have slotted fixing holes in the base to allow for considerable flexibility in the mounting arrangements, including the fixing to a standard conduit box outlet. The backmount frames are made from stainless steel to ensure good earth continuity when used for earth bonding, and to ensure good electrical contact when Protector Mountings No. 5A are used.

### *Accessories*

A full range of accessories for use with SC No. 237 is available; these include: test plugs and cords; isolation and blind wedges, both single and multiple types; and a range of label holders. Of particular interest for labelling purposes is the Strip Designation No. 51A, which plugs into the front of a SC No. 237 to allow individual marking of the modules. It has a lift-up flap with a perspex covered label carrier on each side. Software support systems can be used to generate label printing programs for individual customers' systems. These labels are then inserted in the carrier; this is done, for example, in the Herald call-connect system.

### *Limitations on use*

When IDTs are subjected to retermination, damage to the tag can result from loss of plating material, wear on the sharp insulation cutting edge, and permanent relaxation of the elastic properties of the tag material. For this reason, Specification D2920 classifies IDTs on the basis of the number of reterminations that can be made without loss of performance of the termination. As previously stated, Strips Connection No. 237 are suitable for 100 reterminations; in the unlikely event that this number is exceeded, the module can be changed.

Certain wire (for example jumper wire) has specially toughened insulation to prevent abrasion when the wire is pulled through the jumper rings of a distribution frame; this requirement conflicts with the requirements for an IDT. When initial evaluation tests for Strips Connection No. 237 were carried out, Wire Jumper 6000 series, which has nylon-coated PVC insulation, was successfully terminated. Subsequently, this jumper wire was superseded for new work because the flammability of the insulation material did not meet the latest standards. The superseding item Wire Jumper 7000 series is treated by irradiation to toughen the insulation. Initial test results for terminating this jumper wire were not satisfactory, and investigation led to the discovery that the wire used in the test programme was the first batch from a new supplier. The insulation hardness was found to be far in excess of the requirement. Further tests of wire samples from different manufacturing sources using all of the approved polymers were then made, and the stringent requirements of the termination tests were fully met. To prevent any possibility of the re-occurence of this problem, the specification for Wire Jumper 7000 series is to be amended to include a dynamic cut through test for the insulation, and in this way the maximum hardness will be brought under control. This problem underlines the importance of the interaction of the component parts of an IDT wiring system, and it is for this reason that the Wire Connector series of specifications was introduced where these considerations are taken into account.

In order that the investigation and remedial action referred to did not delay the introduction of Strips Connection No. 237, Wire Connector 9000 series was introduced for use on customers' distribution frames.

At present, aluminium alloy wires commonly used for external cables cannot be satisfactorily terminated by using insulation displacement techniques without recourse to very special plating materials on the tags, a more complex tag design or the use of silicone sealers; none of these solutions is entirely satisfactory, and research and development work to overcome this problem is continuing. In the meantime, the practice of providing a copper-conductor cable tail before termination on distribution frames is being continued.

### *Further Developments*

A number of wiring modules using an IDT tag derived from the one used in the SC No. 237 are being developed. The first is a low-profile IDT suitable for printed-wiring board (PWB) mounting. The tag is used in the new generation of telephone line jacks, and a range of small terminal blocks is now being introduced[2]. The tags can be used to advantage for strapping options on equipment PWBs and similar applications. The tags are mounted in 3- or 4-way housings, and are called *SC No. 238A and SC No. 239A* respectively.

Two new low-profile wiring modules are being developed. They are intended for use in situations where small size is important, such as, small distribution boxes, under-floor wiring systems or inside office furniture. They are known as *SC No. 241A* (10 pairs) and *SC No. 242A* (20 pairs).

## Connector No. 226

The adoption of plugs and sockets for systems necessitated the introduction of a reliable low-cost connector available in a number of sizes and forms. The connector chosen for this purpose is a standard item in the USA, and was readily available as a commercial item in the UK, but there were considerable incompatibilities between different manufacturing sources, particularly in the areas of fixing and mounting arrangements. Manufacturers of the commercial connector were approached and an agreement for a harmonized design was reached. The connector is known as *Connector No. 226* (see Fig. 5).

The Connector No. 226 is manufactured in sizes from 14 to 64 ways, arranged in the form of 7 to 32 pairs. The connector is available, as both male and female types, in PWB, panel wired, round and flat ribbon cable versions. The wired versions use insulation displacement techniques, the wires are terminated simultaneously. As the insulation displacement tag slot design is, in most cases, of the conventional type, the connector slot sizes are matched to the wire size.

A number of different tools are available for terminating cables on the connectors; these include simple hand tools, bench tools, and semi-automatic tools for use where large quantities of harnesses are constructed.

Polarization of the connector is achieved by the shape of the shell. There may be small physical differences between connectors from different manufacturers, but compatibility between different suppliers is ensured by the approval procedure.

Stranded flexible cables of special design (for example, Cable Cordage No. 1000 series) can also be terminated on the connector. However, the long term reliability of IDTs with stranded conductors is not as good as that for solid wires; therefore, its use is restricted to customer apparatus or applications where a shorter life can be tolerated. Where there is an overriding requirement to use flexible stranded cables on

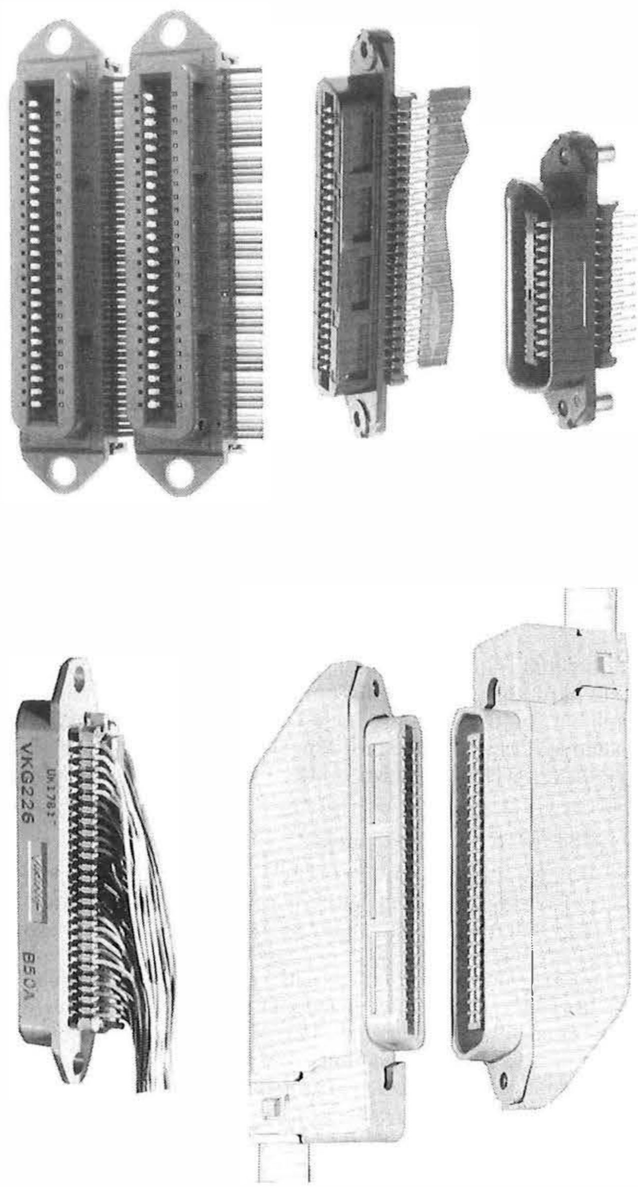


FIG. 5—Various types of Connector No. 226

high-reliability long-life (25 years) equipment, solder versions can be used. A form of coding is used for the connector and covers all the variables that can be used; this includes type, fixed or free, male or female, number of ways, wire size, and type of cover. A typical code would, therefore, be Connector No. 226 C 50 A B, which is a free, female 50-way type suitable for 0·5 mm solid wire IDT, with a side-entry cover with screw lock.

A full range of accessories for mounting and fixing the connectors is available. Connectors with side-entry covers have no screw retention feature at the cable exit end of the cover. Where it is necessary to anchor firmly the cable, a Plate Cable-Fixing No. 1B is mounted under the lower screw head holding the fixed connector. A suitable releasable cable fixing strap is threaded through the plate slots and secured around the cable. For some applications a moulded cover is used; the terminations on the connector are first sealed with a resin and then a cover is injection moulded on to the connector and cable end. This makes an extremely robust harness, which is particularly suitable for connectors that may be subjected to rough usage.

It is anticipated that most connectors will be wired by system manufacturers, BT Factories or central workshops. To enable local workshops to terminate connectors and for on-site work, application tools are being developed that will terminate connectors from different manufacturing sources.

Typical applications for the Connector No. 226 are

(*a*) connection of multi-line systems to the distribution cabling,

(*b*) interconnection of separate items of equipment such as racks, panels, key-and-lamp units using cable-to-cable or cable-to-panel types,

(*c*) pre-wiring of switchboard jack multiples,

(*d*) under-carpet cabling using special flat cable with ribbon cable versions of the connector, and

(*e*) temporary removal of equipment during building operations.

## Connection Boxes and Building Distribution Frames

A completely new range of connection boxes and BDFs for use in customers' business premises has been developed using the new terminating devices and connectors; they are arranged in groups that give either similar facilities or use the same basic parts.

### *Box Connection No. 100 Series*

This series of connection box, which uses the existing box connection plastic cases fitted with SC No. 237 and Connectors No. 226 was introduced as a temporary measure. They are used for the Herald and Monarch systems for example, but do not allow for all of the available accessories to be used. Boxes in this series are being phased out as the new range of connection boxes, having housings specifically designed for the new installation hardware, become available.

### *Box Connection No. 200 Series*

A range of small connection boxes, fitted with IDTs, is being developed to replace Block Terminal Nos. 27, 36, 37, and 45. These new boxes will use SC Nos. 238A, 239A, 241A, or 242A as required, and will be available in late-1982.

### *Box Connection No. 300 Series*

In order to meet the requirements for distribution wiring and the interconnection of many different systems, a large range of connection boxes is required. Boxes must also provide facilities for growth or change of a system with minimum inconvenience to the customer. In addition, physical limitations are often imposed by the accommodation available in the customers' premises. Boxes may need to be installed in building risers, where width is limited, or under low windows, where height is restricted.

The cost of plastic injection-moulding tools for large connection boxes can be in excess of £50 000. Problems of shrinkage and distortion frequently occur with mouldings of this size. Where a range of different sizes of box is required, the cost of the tooling can become prohibitive. As alternatives to plastic moulding, other methods such as fabrication from metal can be used, but the unit cost of these items tends to be high for boxes at the lower end of the size range.

One solution to the problem is to use a modular approach, taking advantage of the low-cost injection-moulding technique for a basic unit, and use these units in multiples to build up boxes to meet the requirements of the larger systems. An advantage of this approach is that sufficient flexibility can be built-in to the construction and usage to allow the particular requirements of individual sites to be met. The modular solution is considered to be acceptable for up to about 6 units, after which fabricated steel enclosures are recommended.

A modular connection box based on the principles described above has been introduced to mount SC No. 237 and Connector No. 226. It is known as *Box Connection No. 300A*. Moulded into the base unit are fixings for the accessories that can be used with the box (see Fig. 6(*a*)). These include:

(*a*) Frames Mounting No. 5/··· for SC No. 237,

(*b*) moulded plastic press-fit pillars to mount Connectors No. 226,

(*c*) moulded plastic jumper rings,

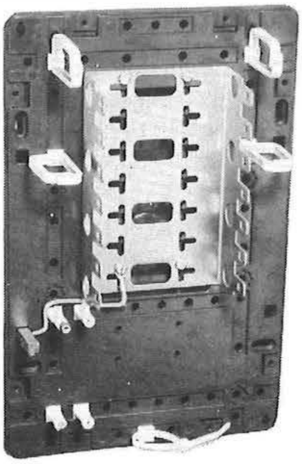
(*d*) earth terminals for up to twelve 1·5 mm earth wires,

(*e*) cable tie anchors, and

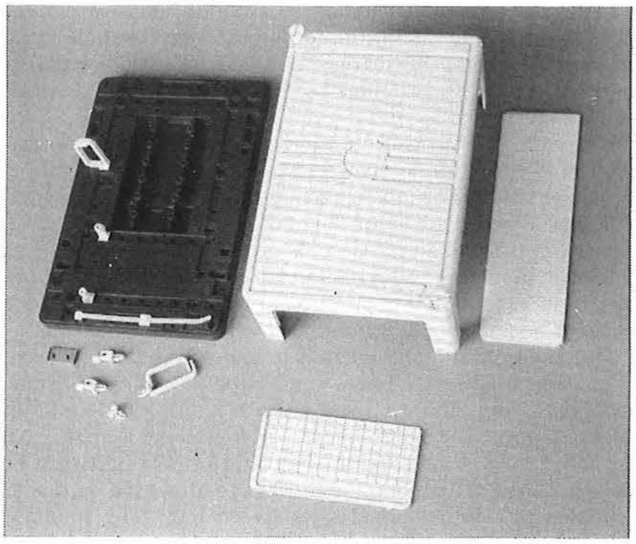
(*f*) base clamps which are used to fix units together when boxes are used in combination.

The cover has end and side panels that are removed between adjacent boxes to allow for wiring and jumpering between boxes. The end panels also have weakened cable breakout sections for cables or system cords entering the box. As all covers may need to be removed to gain access to the box, large-headed quick-release screws are used for the cover fixing. The cover (see Fig. 6(*b*)), is moulded in a light grey colour and the base in dark brown.

To overcome the problems of diagram and plan storage on site, a document storage unit occupying one base size is available. This will accept an A4 size soft-cover book or suitably folded diagrams.



(*a*) With accessories fitted



(*b*) Showing cover and removable panels

FIG. 6—Box Connection No. 300A

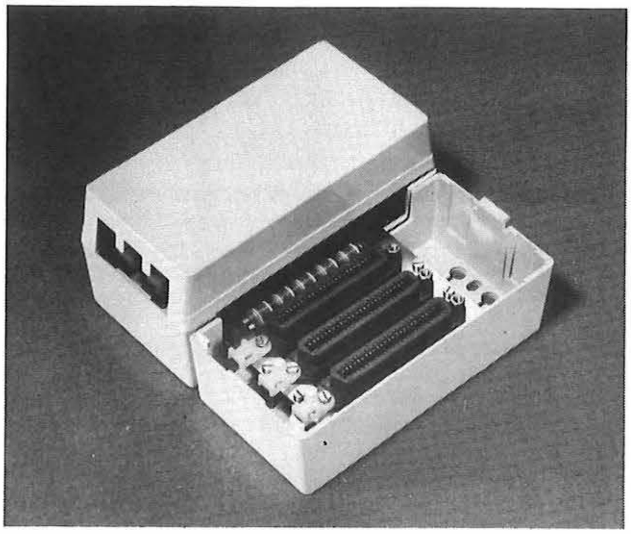


FIG. 7—Box Connection No. 406A with one cover removed

Pre-wired system connection cable harnesses and conversion cable harnesses to cater for future growth in the system are available for use with the Box Connection No. 300 series. System connection boxes, for which there is a large demand, are stocked with the system cable harness already fitted.

### *Box Connection No. 400 Series*

The Box Connection No. 400 series is intended primarily to mount ribbon-wired Connectors No. 226 for use on parallel-wired systems such as small key-and-lamp systems and similar applications.

As in the case of the 300-series boxes, a modular approach has been adopted; a single plastic housing accommodates up to 3 connectors, which can be any size from 24 to 64 way. Requirements for multiple units of 6, 9 or 12 connectors are met by connecting single housings together using the connector mounting rail. A ribbon cable fitted with the requisite number of connectors is then fitted into the box (see Fig. 7).

The box can also be used when conversions of cable type are required in a system; for example, round solid cable to round flexible cable, round cable to under-carpet flat cable, and similar applications.

### *Box Connection No. 500 Series*

To complete the range of new connection boxes, 3 large light-weight steel enclosures have been introduced. Known as *Box Connection No. 500* series, these boxes have generous provision for cable entry at the top and bottom. System connection cables from the Connector No. 226 mountings leave the box via the bottom cable entries. Positions for cable-tie anchors are provided at the cable entry points. The boxes have self-sealing rubber glands where cables enter to keep the box reasonably dirt free. The door is both removable and reversible for left- or right-hand hinging, and a lock is provided for security purposes. Large knock-out blanks are provided at both sides of the box to allow cables and jumpers to pass between boxes when they are used in multiples. A container for document storage is provided in the door. A flange kit is available to allow the box to be flush mounted. The pre-wired system connection cable harnesses used in the modular 300-series box can also be fitted in the 500-series units.

### *Frames Distribution Nos. 100A and 105A*

Two new BDFs have been introduced to mount SC No. 237. The first is a large conventional-type double-sided frame intended for use as the main building distribution flexibility and system connection point for large ICD schemes. It is known as a *Frame Distribution No. 100A*. Each section of frame is 1050 mm long, 2600 mm high, 650 mm wide. As many sections as required can be bolted together to give the desired capacity.

The line side has 5 verticals at a pitch of 210 mm. Each vertical will take 4 Frames Mounting No. 5/60/21A, which can carry 80 SC No. 237 and 4 Strips Designation No. 53A or 54A per vertical. This gives a capacity on each vertical of 800 pairs, using SC Nos. 237A or 237B, giving each section a total capacity of 4000 pairs. However, if SC No. 237C are used, the capacity on the line side can be doubled for the internal cable distribution where disconnect-type test jacks are not required, but this is achieved at the expense of plug-in test access and can cause congestion in the jumper field. Cables to the SC No. 237 are run inside the backmount frame and can be fed from either the top or bottom of each vertical.

The equipment side is arranged in 6 horizontal levels, with each level having 6 positions for Frames Mounting Nos. 5/22/8A or 5/22/10A per section, and provides a capacity of 3600 pairs per section. Cables to the equipment side SC No. 237A can be fed horizontally on supports suspended below the horizontal jumper bed.

A second new double-sided modular distribution frame has been developed to mount the SC No. 237; it is titled a *Frame Distribution No. 105A*. It is intended to serve as the main building distribution flexibility-and-system-connection point for medium-sized distribution schemes, or as a TJF for large PBXs sited remotely from the BDF. Each frame section is 500 mm long, 2000 mm high and 300 mm wide. The narrow width allows its use as a single-sided frame, using suitable braces, if required. The backmount frames are used to provide the frame support structure.

The frame has 2 identical verticals on each side per section; a section at the top and bottom of the frame on each side are reserved to allow jumpers to pass along the length of the frame. When used as a BDF, this arrangement suits the termination of two 320-pair distribution-wiring-type cables per vertical with full test access and protection capability.

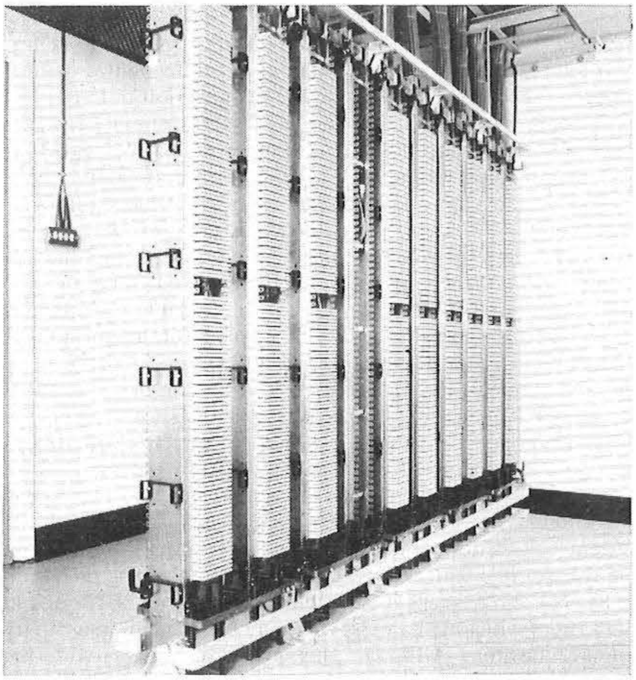


FIG. 8—Frame Distribution No. 105A used as a double-sided TJF for a large digital PABX

When used as a TJF for stored program control (SPC) PABXs, the arrangement suits the connection of two 256-line groups per vertical using SC No. 237A with 8 pairs of each 10-pair module used. As in the case of the Frame Distribution No. 100A, the terminating capacity can be doubled on the line side at the expense of plug-in test access and protection.

### Test Jack Frames

To meet the requirements of the ICD scheme where a PBX is situated remotely from the flexibility point of a building distribution scheme, the PBX is wired to the flexibility point, which may be a BDF or connection box, by using a link cable. A TJF is fitted immediately adjacent to the PBX. SC No. 237A giving test and isolation access are to be provided at this point. A Frame Distribution No. 105A (see Fig. 8) or connection box may be used for this purpose. In the case of proprietary PABXs, the TJF may be housed in a cabinet made to match the PABX cubicles. No cross-connection flexibility is provided at the TJF, and the wiring layout of the PBX system is extended to the equipment side of the flexibility point of the building distribution scheme.

## NEW CABLES FOR CUSTOMERS' SYSTEMS

### Difficulties With Existing Cables

The problems of wire identification using existing BT colour codes are well known. The most obvious problem is confusion between the plain white wires in a cable. When the cable sheath is removed, great care has to be taken not to disturb the wires (the next operation is usually to twist each pair of wires together to keep them in association). Despite this, a large number of wiring errors leading to leg-and-leg reversals are made. Continuity testing of cables to check that the right selection has been made is commonplace. The problem is accentuated when wires are terminated at high density; for example, on a Connector No. 226. A change to the IEC† colour code, which has the plain colours in groups of five, leads to only a small improvement as most leg-and-leg reversals occur between adjacent pairs.

When cabling between separate buildings on a customer's site, it is usually necessary to change from internal to external-type cables. There are restrictions on the distance that external polyethylene-sheathed cables can be run inside buildings and this can make additional joints necessary; if these cables also have aluminium conductors, a transition to copper joint has to be made at each end to allow for termination on a connection box or BDF. Internal cables are not as durable as external cables and do not normally have the black colouring, which prevents degradation of the PVC sheathing caused by the ultra-violet radiation present in sunlight. However, the distances involved in customer distribution schemes are often small, and minor improvements in internal distribution cables can allow their use externally in the more protected environment of a customer's premises.

For facilities such as PBX recall and metering, a signalling earth is connected to points within the distribution scheme. This earth has in the past been provided as a separate wire run in addition to the distribution cables.

To overcome these problems a completely new range of cables has been introduced for use in customers' premises.

### Cable Equipment No. 2000 Series

Cable Equipment No. 2000 series has been introduced to overcome some of the difficulties encountered in customers' premises with earlier types of cable. In the new cable, every wire is marked throughout its length with 2 colour bands, a *base* and a *ring* colour, in the ratio 3:1 repeated over a 16 mm length of wire. Both wires of a pair use the same 2 colours,

† IEC—International Electrotechnical Commission

**TABLE 2**
**Cable Colour Code**

| Cabling Element | Colour of Insulation | |
|---|---|---|
| | A-wire | B-wire |
| 1 | WHITE–blue | BLUE–white |
| 2 | WHITE–orange | ORANGE–white |
| 3 | WHITE–green | GREEN–white |
| 4 | WHITE–brown | BROWN–white |
| 5 | WHITE–grey | GREY–white |
| 6 | RED–blue | BLUE–red |
| 7 | RED–orange | ORANGE–red |
| 8 | RED–green | GREEN–red |
| 9 | RED–brown | BROWN–red |
| 10 | RED–grey | GREY–red |
| 11 | BLACK–blue | BLUE–black |
| 12 | BLACK–orange | ORANGE–black |
| 13 | BLACK–green | GREEN–black |
| 14 | BLACK–brown | BROWN–black |
| 15 | BLACK–grey | GREY–black |
| 16 | YELLOW–blue | BLUE–yellow |
| 17 | YELLOW–orange | ORANGE–yellow |
| 18 | YELLOW–green | GREEN–yellow |
| 19 | YELLOW–brown | BROWN–yellow |
| 20 | YELLOW–grey | GREY–yellow |
| 21 | VIOLET–blue | BLUE–violet |
| 22 | VIOLET–orange | ORANGE–violet |
| 23 | VIOLET–green | GREEN–violet |
| 24 | VIOLET–brown | BROWN–violet |
| 25 | VIOLET–grey | GREY–violet |

*Note:* Base colour (wide band) shown first

but the base and ring colours are reversed to permit identification of the A and B wires.

By using the colours blue, orange, green, brown, grey, with white, red, black, yellow and violet, a discrete identification of 50 wires in a make up of 25 pairs can be achieved (see Table 2). For cables larger than 25 pairs, a unit construction is used, with the first group being repeated in each cabling unit. Cables in sizes commonly used for internal cable distribution use the first 20 pairs as a unit repeated as necessary. In addition, to simplify the connection of the signalling earth to points throughout the distribution scheme a 1·38 mm earth wire is included in these cables. The cables are to be available with a white or black sheath; cables with a black sheath are used for external cables within a customer's distribution scheme. This makes it unnecessary to change to external type cable with aluminium conductors that require copper tails for termination on BDFs etc.

To cater for the interconnection of modern electronic call-connect systems, cables have been introduced based on 16-pair units. These cables use the first 4 pairs from each of the first 4 colour groups. Cables are available in 16, 32, 64, 128, 256-pair sizes.

### Cable Cordage 1000 Series

The use of stranded conductors with IDTs (for example, on a Connector No. 226) can pose problems because of the difficulty in positioning the wire strands in the IDT slot so as to achieve a satisfactory termination. To overcome this problem a new cordage, known as *Cable Cordage No. 1000 series*, has been introduced. This cordage has conductors with a specially laid stranding of 6 strands round one central strand, the lay of the strand not exceeding 8 mm. This has been found to produce a satisfactory termination on an IDT.

The new cordage is used to connect desk-mounted systems (such as, Herald and the PMBX 2/··· series switchboards) to the distribution cabling by using Connectors No. 226. The colour code used is the same as that used for Cable Equipment No. 2000 series.

Where cords of between 25 and 50 pair need to be terminated on 2 Connectors No. 226, a figure-of-eight cable is used. This is made up from two 25-pair cords joined with a small web between the sheathing of each cord. When the cords are terminated, the web is slit to allow each 25-pair branch to be taken in to its separate connector. This technique overcomes the need to separate a larger cable and fit heat shrink or similar sleeving to the divided end.

### Wire Connector Nos. 1000 and 9000 Series

For wiring applications within equipment and box connections using high density IDT techniques, a range of wire using the new colour code has been introduced. The wire is titled *Wire Connector No. 1000* series.

For cross-connection jumpering using IDTs, Wire Connector No. 9000 series has been introduced. The insulation is of the same type, but thicker than that used on Wire Connector No. 1000, and is not radiation hardened in a similar manner to Wire Jumper No. 7000 series. The insulation material used on these wires does not have the anti-abrasion qualities of Wire Jumper No. 7000, but BDFs and connection boxes in customers' premises are not usually as large as main exchange MDFs and therefore the problems of the insulation being damaged when it is pulled through the jumper rings are not so severe. However, after the successful termination tests on Wire Jumper 7000 series referred to earlier, a composite specification may now be issued. The 2-band colour code is used for this wire, and for the one-pair size the colours YELLOW–blue, BLUE–yellow are used. For small connection boxes, Wire Connector No. 1000 or stripped Cable Equipment No. 2000 can be used for the cross-connection jumpering. As the insulation is thinner than on jumper wire, the space taken up by the jumper field is reduced.

## SYSTEM DESIGN CONSIDERATIONS

### System Circuit Layout on BDFs, TJFs and Box Connections

In order to reduce installation time for telephone systems in customers' premises, it is necessary to consider installation carefully at the design and development stage. Modern equipment practices with systems building up on a plug-in unit basis are ideally suited to fast installation, but the connection of the system to the distribution wiring often leaves much to be desired. It has to be remembered that installation staff, who are not necessarily familiar with all of the intricacies of a particular system, are called upon to connect exchange lines, extensions and inter-PBX circuits to the system. It is important, therefore, that a reasonably easy to recognize pattern of circuits is presented at the system connection point.

In conjunction with the changes in the installation hardware, improvements are also being made in the way that systems are presented at the system connection point. New call-connect systems tend to have very flexible equipment provisioning arrangements and in many cases exchange lines, extensions and private circuit plug-in units, sometimes in combination, are completely interchangeable throughout the system. Care has to be taken to ensure that full advantage is taken of this flexibility, without the circuit layout at the system connection point being unduly complicated. To meet this requirement, the arrangement of the plug-in units, PWB layouts and allocations of circuits to connectors for all the possible variants of the system and, in particular, growth steps need to be considered in conjunction with the installation hardware that is to be used.

Although the SC No. 237A, which will be used at the system connection point, is basically a 10-pair module, in many cases it is better to use only 8 pairs so that the provision of SC No. 237A keeps in step with the build-up of circuits in the system which will almost certainly be growing in a binary number fashion. Although this may appear wasteful, the improvement in circuit layout at the system connection point will reduce installation time. Eight-pair versions of the SC No. 237A are under development and will be available in 1982.

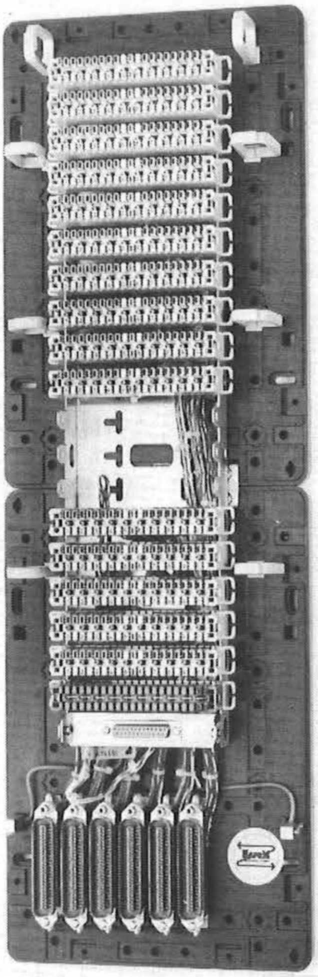


FIG. 9—Herald 60-port connection box

### Herald Box Connections

A practical example of the application of the new principles is the arrangement made for the system connection point (see Fig. 9) for the Herald call-connect system. With this system there are 4 different plug-in units:

(*a*) four 4-wire extension circuits,
(*b*) one exchange line plus two 4-wire extensions,
(*c*) two exchange lines, and
(*d*) two Signalling System DC No. 5 (SSDC 5) or SSDC 10 circuits.

At the system connection point, one SC No. 237A is allocated to each plug-in unit position within the system so that only 4 different wiring layouts appear on the SC No. 237A, one for each variant. Any plug-in unit can be changed at a later date to a different type, the label in the Strip Designation No. 51A fitted to the SC No. 237A being changed to suit the new unit. If all of the wiring capacity of the SC No. 237A had been used, wiring to some plug-in units would have been distributed over 2 SC273A and the system layout and labelling would have been more complicated.

### Choice of Connector Size

Although system designers at present tend to use the 50-way Connector No. 226 for the connection of the system cables to the distribution wiring, a change to 64-way connectors could be advantageous. The pre-made system connection harnesses referred to earlier could then be made up with 4 SC No. 237A using 8 pairs on each wired to a 64-way Connector No. 226. This would suit many different SPC systems, and a large degree of standardization of system harnesses could be achieved.

## CONCLUSIONS

The new installation techniques are proving to be both popular with the users and effective in speeding up on-site installation. The termination system used has been found to be extremely reliable and suitable for extensive further development to meet new applications. The flexibility of the new box connections has already been proved with the introduction of new systems that have taken place during the development period.


## ACKNOWLEDGEMENTS

The introduction of such a large range of new products in so short a period of time was made possible only by the very considerable efforts of many people in BT and Industry. The author wishes to acknowledge their invaluable contribution to the improvement in installation techniques and thank them for the generous help given by many of those involved in the preparation of this article.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# Visual Services Trial—The British Telecom System for Teleconferencing and New Visual Services

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*The Centre for Visual Telecommunications was created within British Telecom (BT) in 1980 jointly by the Director of Research and the Director of Business Systems to create and retain a BT presence in the visual services marketplace pending future establishment of a more formal product marketing structure.*

*The Centre has been responsible for the planning and is proceeding with the implementation of a range of visual services extending in picture standards from colour Confravision to slow-scan transmission of 313-line monochrome images. In particular, the visual services trial planned for 1983 will provide private visual teleconference terminals on a switched low-capacity main network of 2 Mbit/s digital transmission. Coupled with trials of still-picture television for surveillance and audiographic teleconference, the results should allow co-ordinated product definition and pricing for the visual services of the mid-1980s.*

*Based upon a presentation to the 1981 Digital Satellite Conference in Genoa—which itself included videoconference sessions with London and Clarksburg—this article briefly describes a new terminal and the coding techniques used to achieve moving-picture transmission at 2 Mbit/s. It reviews the European collaboration which has created the opportunity for international experiments, and the parallel developments in digital satellite technology which have led to engineering tests during 1982 with Canada, France, Italy, Netherlands, USA and West Germany.*

## INTRODUCTION

Audio communication and discussion between separated groups of people has been possible for decades by means of the loudspeaking telephone (LST), but the terms *teleconference* and *electronic meeting* are relatively recent. Reducing cost and increasing complexity of new technology have certainly transformed the LST, but the trend is more than technological. Teleconference heralds a social change in working habits.

Automation has progressed so that fewer people actually make things and more people are finding less opportunity for individual action and decision. Group discussion and communal decision-making are syndromes of contemporary business behaviour—acceptable in conditions of growth and a healthy economy, but embarrassing in their inefficiency at a time of recession and rising costs. As salaries increasingly dominate the overheads which keep production or service costs high and uncompetitive, reductions in personnel "out of office time", fatigue, distraction, and even counterproductive attempts by staff to justify travel by creating further meetings, all contribute to an encouraging climate for growth in electronic meeting.

Clearly, many face-to-face meetings cannot be substituted; sensitive negotiation, some interviews, and meetings which generally depend for their success on the most subtle aspects of human interaction will still be necessary. However, the majority of business meetings which involve travel, once forecast[1] to reach a staggering 172 million a year in Britain by 1990, are very likely to be substitutable by audio teleconferencing supplemented, where necessary, by visual aids.

Vision clearly enhances the quality of communication, and interactive systems like the electronic blackboard or moving-picture television considerably reinforce the participants' sense of "presence", giving confidence that a meeting is more likely to achieve a successful outcome.

This, then, is the field of teleconference, and it extends from purely audio communication systems (such as, the BT ORATOR[2]), through audiographic conference with visual aids (such as, slow-scan television, telewriters or Facsimile), to a wideband moving-picture videoconference system like Confravision[3].

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## AUDIOGRAPHIC TELECONFERENCE

In 1980, the Centre for Visual Telecommunications (CVT) implemented a slow-scan television trial[4] to test as many applications as possible for low-rate picture transmission. Pictures were stored and transmitted with only 313-line definition, but conventional 625-line television cameras and monitors were used, effectively in a field-repeating mode. Transmission times of 5 s and 50 s were provided respectively over 48 kbit/s and 4·8 kbit/s public switched telephone network modems, and a subsequent statistical coding option which recoded the differential pulse-code modulation (DPCM) codewords with variable length gave up to 20% reduction in transmission. Strong market potential was demonstrated for the surveillance and security applications and there was considerable interest for telemedicine and teleconference—somewhat surprising in view of the limited picture definition.

A Mark II version capable of colour and full 625-line television definition is now being developed and will probably be used later in the year to transmit pictures of objects or drawings in association with the ORATOR audioconference system. In anticipation of this development, the CVT sponsored a human-factors trial in 1981 of audiographic conference equipment within the Open University[5]. Known as *CYCLOPS*, the equipment allows interactive drawing on the face of a television screen by means of a light pen and the exchange of simple slow-scan images, drawings or alphanumeric characters. The trial was welcomed because of the genuine need of students in several study centres to have collective but close contact with a remote tutor. Fifteen terminals, as shown in Fig. 1, have been installed for a 2-year trial, which is intended, particularly, to compare the telewriting technologies of the light pen and the digipad. The latter takes co-ordinates from a stylus over a writing tablet and stores the written points in a video memory.

## CONFRAVISION

Paradoxically, although videoconference is more consumptive of expensive resources and might be expected to become cost effective later than its audio counterpart, it has the longest history in the UK. In fact it is over 10 years since Confravision[3] was opened as a public service between Manchester, London, Birmingham, Bristol and Glasgow. Now, 8 terminals are in

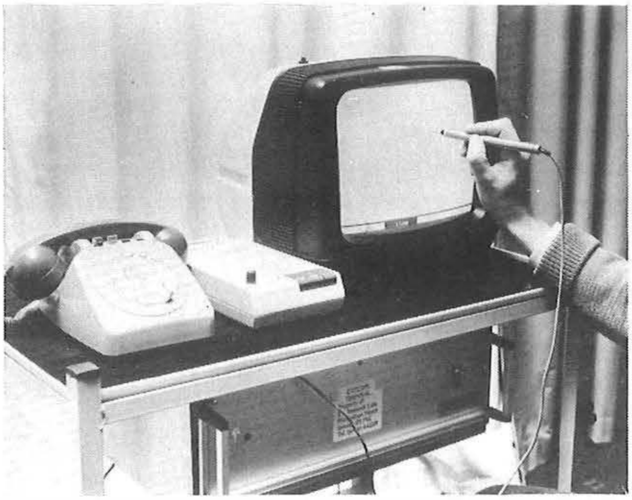


FIG. 1—CYCLOPS audiographic terminal used in the Open University trial, 1981–82

**TABLE 1**

**Confravision Charges**

| Confravision Link | Charge per 30 minutes |
|---|---|
| 2-Way Calls—varying with the distance between the studios | |
| Calls up to 200 km | £80 |
| Calls over 200 km | £120 |
| 3-Way Calls—Leeds not available except by special arrangement | |
| London–Birmingham–Bristol | £170 |
| London–Birmingham–Manchester | £210 |
| Birmingham–Manchester–Bristol | £210 |
| All other 3-way calls | £250 |

operation—recently added locations being Leeds, Martlesham and a second London terminal—and additional trials have involved transportation of mobile studios to customers' premises. Over the past 2 years, a second network, known colloquially as *System X Teleconference*, has also been installed to connect manufacturers' sites in Taplow, New Southgate, Liverpool, Poole and Coventry with BT studios in London and Ipswich.

Experimental Confravision connections have been made to corresponding systems in Australia, Sweden and Holland, and demonstration calls have been made to Canada and Switzerland. However, the prohibitive space-segment charge for wideband satellite transmission has so far precluded the establishment of an international service, and the schedule of national charges for Confravision provides at best a marginal cost advantage over the alternatives of business travel.

A number of start-up problems may be identified for the Confravision service, both by the customer and by BT. For the customer these are

(*a*) terminals may not be convenient (only 8 exist and these were generally chosen to be near existing network switching centres of the broadcast-television network),

(*b*) calls must be booked, though with a minimum of only 2 hours notice, since broadcast protection circuits are used for transmission,

(*c*) calls are not seen to be cheap by a new market even though tariffs (Table 1) equate currently to as little as 10 times peak telephone charge, reducing to only 5 times under contract for repeated use, and

(*d*) it is necessary to be selective in the type of meeting which may be relegated to teleconference; psychological as well as economic factors are relevant[6].

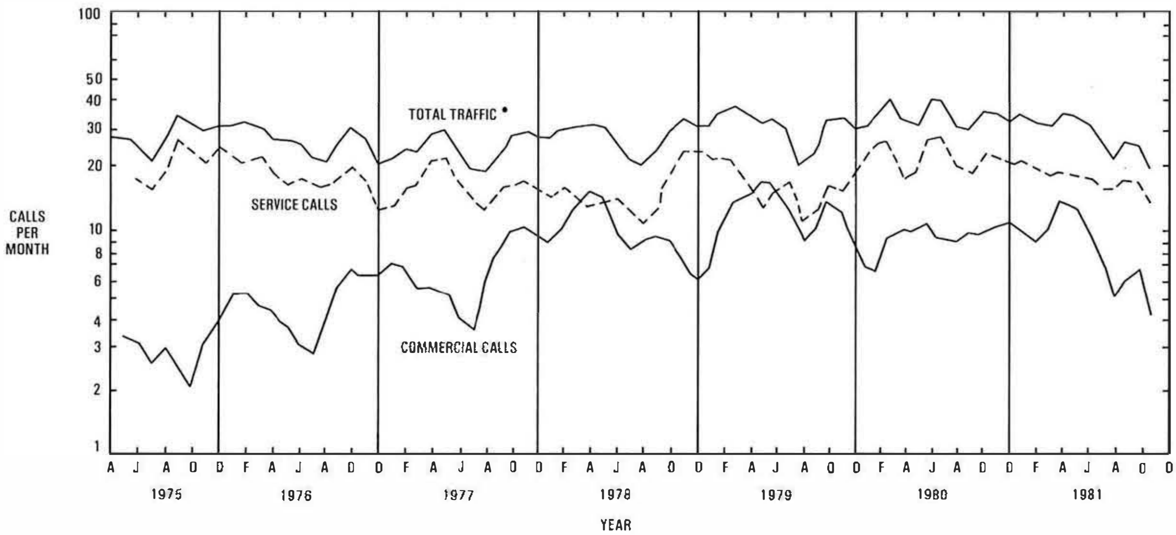
For BT, the problems are

(*a*) growth in the number of terminals and grade of service is severely constrained by the small number and location of trunk circuits,

(*b*) provision of a wideband network for non-voice services is expensive and risky without reliable indicators of the market, and

(*c*) by its nature, a secure business service yields limited feedback on the human factors of terminal design. Questionnaires are a disincentive to repeated use and data collection is limited to numbers of meetings, meeting size, facilities used, etc. Fig. 2, for example, records Confravision usage separated into commercial and BT sponsored meetings. Following healthy growth and the expected seasonal fluctuation up to mid-1979 the service has clearly suffered from lack of positive marketing and deepening recession.

Even though the service has not been marketed to realise its full potential, it is planned, during 1982, to convert Confravision to colour operation and to incorporate split-screen and double-monitor displays to improve exploitation of the




* Includes demonstration calls and calls at the commercial introductory tariff

FIG. 2—Use of the Confravision network, 1975–81

FIG. 3—Martlesham Heath Confravision studio

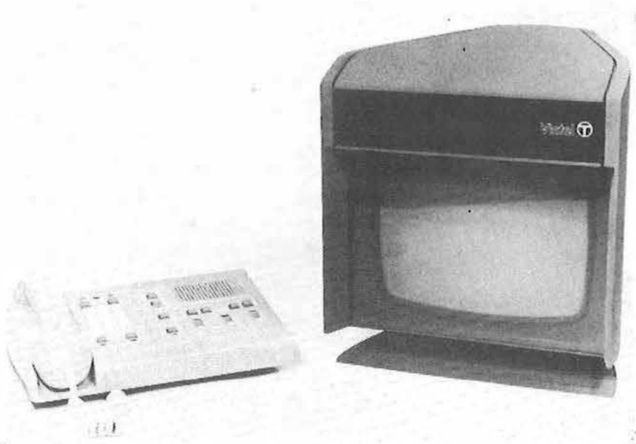


FIG. 4—Composite visual teleconference equipment and control unit

5 MHz transmission bandwidth. Fig. 3 illustrates the split-screen configuration of the Martlesham Confravision studio. Consequently, within the constraints mentioned, Confravision will continue to provide operating experience of an up-market teleconference service.

## VISUAL SERVICES TRIAL

A decision was taken in 1979 to develop terminal and transmission equipment for a visual services trial, to be held during 1983, which would supplement Confravision with a much broader study of possible down-market services. It includes the concept of a less-formal lower-cost teleconference terminal on customers' premises and would work on a switched network of digital trunks.

The trial network, geographically planned on the results of considerable market research, will be computer controlled and monitored so that the trials can yield behavioural information on reservation activity and terminal usage. Potential customers will be studied for their opinions on quality standards (including the need for colour, required picture definition and update time, etc.) ancilliary equipment and related services, terminal design, and tariffs.

## VIDEOCONFERENCE TERMINAL

The new teleconference terminal, developed for the 1983 trial, is illustrated in Fig. 4. Based upon 625-line monochrome television technology, a composite camera/monitor equipment is intended to provide similar technical performance to Confravision, but for smaller groups of people (nominally 3 per terminal) and at a fraction of the equipment cost. It is designed for ease of use in convenient accommodation on customers' premises without the need for special lighting or acoustic treatment. By referring the overhead costs of the room to the customer and attempting to ensure that the location of the instrument is in an open-access area (that is, an existing conference room, general office, etc), it is hoped to make the videoconference service more generally available to all levels of a business having a potential need for visual telecommunications—with a consequent improvement in its cost effectiveness.

Local transmission to the terminal will in general be analogue and to the full 5·5 MHz, 625-line television standard. However, it is inherent in this cost-reduced videoconference concept that trunk and international transmission at 2 Mbit/s involve considerable reduction of the redundancy within the picture. Some reduction of definition occurs during the coding of moving images and this is reflected in the design of the composite instrument which is based on a 310 mm (12 in) display. The equipment is compact, unobtrusive and also relatively easily transported. Its size also encourages reduced viewing distance and more convenient operation in the graphics mode, for which an alternative lens and optical/electronic zoom facility allows an area immediately below and in front of the instrument to be displayed.

An additional monitor in the same design style is also provided where a larger 620 mm (24 in) display is required, perhaps, by larger groups of people (see Fig. 5). A separate camera can also be connected to the service unit that provides the network interface, either as an addition or as an alternative to the composite equipment for more diverse television applications.

Ease of use without training is deemed to be of paramount importance. The system is controlled with the aid of a microprocessor from a simple control unit, which has an integral soft-switching loudspeaking telephone, and provides 4-wire sound transmission between terminals by digital sound-in-vision techniques. Each terminal also has a viewdata decoder and auto-dial facility, which gives access to the user-friendly microprocessor reservation system located at Martlesham. Connected by a packet-switched data network to the national system of trunk switches, this system will also establish connections and gather information on current state and overall use of the trial system. Booking for calls can be

FIG. 5—Visual services trial equipment (camera/monitor) for larger group presentations

immediate (if the channel is free) or up to 3 months ahead. The viewdata decoder can also be used with the Prestel system or other private viewdata system for general information retrieval.

## DESIGN OF THE TRIAL NETWORK

### Customer Selection

Initially, 50 of the terminals illustrated in Fig. 4 will be offered to 20 customers for up to one year's (nominally) free trial. The triallists were selected by an iterative procedure based upon a convincing need for visual teleconference (for example, a large company with split locations), a knowledge of the available and planned 2 Mbit/s main network, and the possibility of local access to shared coding equipment in BT buildings.

Adding to an already substantial list of companies which had either approached BT during the 1970s to request visual services or were known to have interest in television applications, an initial market survey was commissioned from National Opinion Polls (NOP) during 1980. A random selection of 246 UK companies from the "Times Top 1000" was made and interested respondents were shown and allowed to use a working simulation of the system of Fig. 4. They were also shown a video tape of the quality expected from picture processing and coding. Questionnaires and telephone interviews followed to ascertain interest and the tariff that potential users might be prepared to pay. Representatives from the 30 most promising companies were finally invited, in October 1981, to actual demonstrations of the terminal and 2 Mbit/s transmission, and 20 were eventually signed up for the 1983 Trial.

The corresponding network configuration, which is currently being planned, is shown in Fig. 6. This diagram indicates terminal and codec locations and also shows the sites of Confravision and System X videoconference studios which can, if required, be interconnected to the private composite terminals.

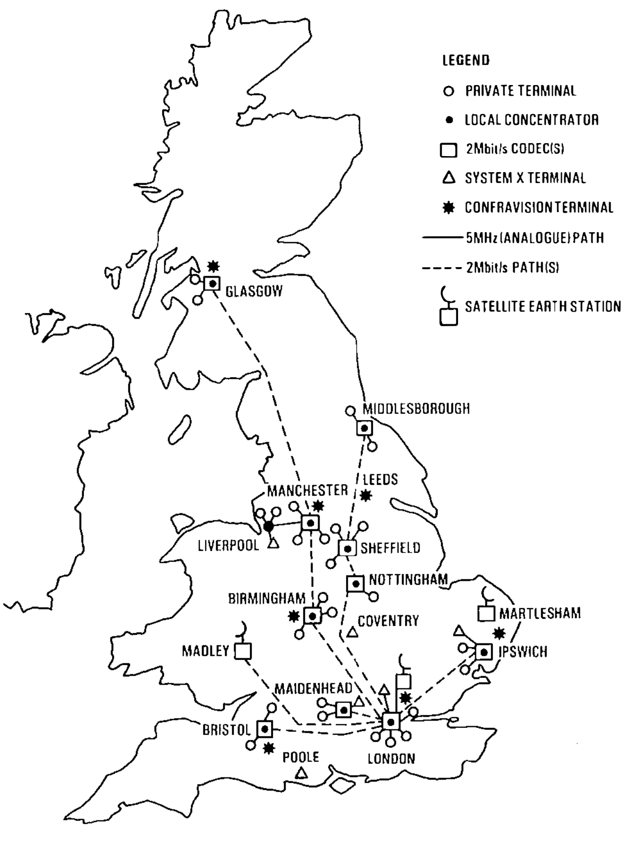



FIG. 6—Videoconference network proposed for 1983

### Transmission Technology

Almost until the end of 1981, it appeared that the visual services trial would have to rely for its trunk transmission on spare capacity in the London–Manchester 60 MHz FDM coaxial-cable system. In preparation for this, dual-mode analogue standards conversion equipment had been developed corresponding to the alternative transmission requirements of the face-to-face and graphics terminal modes in a 1 MHz bandwidth. Three 1 MHz signals were to be accommodated within one 4 MHz hypergroup. However, following rapid acceleration of the UK network digitalization programme, this analogue bandwidth reduction system was abandoned and the main network transmission system of Fig. 6 will now rely entirely on 2 Mbit/s capacity and the deployment of some 15 codecs to principal shared locations.

The codec is currently the most costly single item in the videoconference system and the trial concept is based on local analogue transmission to concentrators and shared codecs in BT buildings. This allows the dedicated customer's local end to be as cheap as possible and readily able, if necessary, to carry a colour signal. It also allows early upgrading or relocation of codecs, as the codec will also be the area for most rapid technological development.

Local transmission is planned to exploit a mixture of technologies. About 10 terminals will fall within 1·5 km (radial) from the nearest switch and will be served by conventional polyquad cable. A cost reduced optical-fibre system using pulse-frequency modulation was specified[7] and developed for the trial, but only 4 equipments have so far been allocated to terminals falling in the appropriate 2–6 km (route distance) range. Most London terminals will be served by a new VHF carrier system on existing cable. Finally, fifteen 29 GHz radio links (also developed for the trial) will serve many of the provincial terminals and allow temporary advanced connection when cable routes cannot be completed in time.

International connections will be provided to Europe via the Orbital Test Satellite (OTS) and small-dish earth stations at Fleet Exchange (London) or Martlesham. North American connections will later be possible using INTELSAT IV or V via 2 Mbit/s paths to the Madley (large) earth stations.

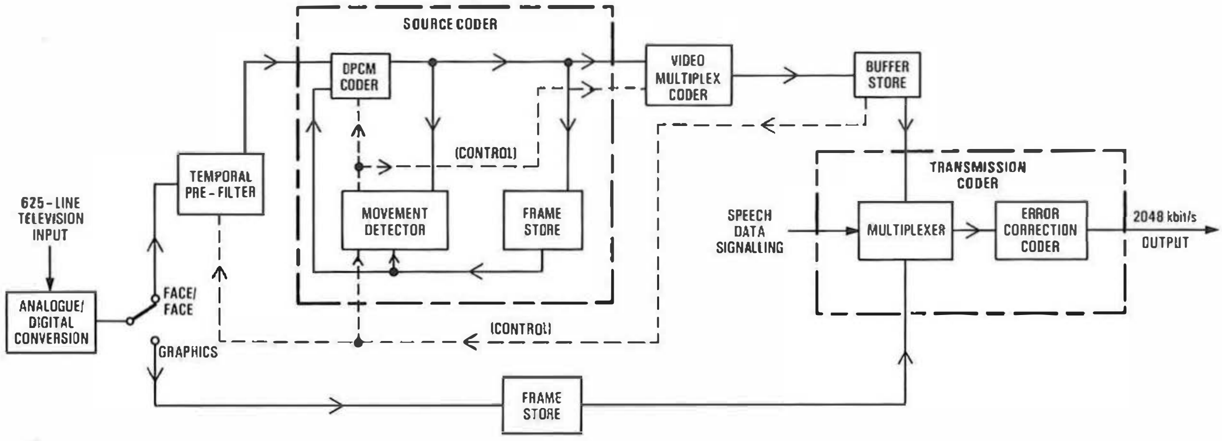
Basically, there are 2 levels of switching involved for the UK network: local exchanges and concentrators will switch in analogue form at 5 MHz; and main network exchanges will handle the 2 Mbit/s signal. Initially there will be full local exchanges only in London (Baynard House and the BT Tower), Birmingham and Manchester—other locations having concentrators which will be parented on one of these four.

## THE 2 Mbit/s CODEC

The codec has 2 modes of operation, automatically selected according to use of the graphics and face-to-face modes of the videoconference terminal.

In the latter (moving picture) mode, the coding technique is known as *conditional replenishment*[8], whereby a single frame of television is stored and only subsequent moving parts of the picture are detected and transmitted using predictive encoding. Fig. 7 indicates the codec principle and shows how a buffer store is used to average bursts of data resulting from picture movement into the fixed-rate 2 Mbit/s channel. As movement increases and the buffer state of fill rises, algorithms are progressively introduced to control movement detection, element and field subsampling, quantization and coding, such that quality gracefully reduces within the constraining 2 Mbit/s transmission. A spatio-temporal pre-filter[9], also partially controlled by buffer state, preconditions the image by noise stripping and improves performance of subsequent movement detection and subsampling. The filter is an essential component of the overall design, which is adapted to the objective of transmitting moving pictures.

There is no spatial filter in the alternative graphics mode of




DPCM: Differential pulse-code modulation

FIG. 7—Block Diagram of the 2 Mbit/s encoder

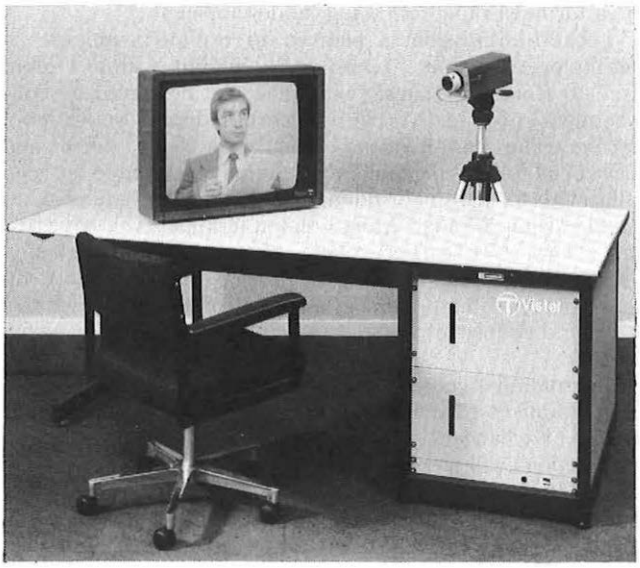


FIG. 8—Possible studio version of the 2 Mbit/s encoder/decoder equipment

the codec where a higher 12·5 MHz sampling frequency and 8 bits/sample PCM coding ensures high quality reproduction of a stored 625-line television frame. Using the maximum 29½ time slots of the 32-time slot (2 Mbit/s) transmission framing structure, the graphics mode transmits one frame in 1·6 s or continuously at 0·6 Hz. Viewed continuously in the graphics mode, moving objects appear blurred but are adequately defined to allow pointing or drawing.

The codec is destined, initially, to be located in BT exchange buildings, but Fig. 8 illustrates the size of the equipment in an alternative studio version.

The moving-picture codec is the result of the collaborative European research programme known as *COST*† *211*[10] and has itself been developed largely as the subject of international videoconference. Since June 1980, on some 80 days, the OTS has been used to connect laboratories through the prototype codecs in Martlesham, Paris, Oberpfaffenhofen (near Munich) and Fucino (near Rome) which have provided testbeds for evaluation and improvement of coding algorithms. Five years after the project was joined in Brussels by 7 countries, COST 211 is now in the process of transferring its codec design to the Videophone Sub Group of the CEPT* Telecommunications Commission. Following considerable argument on the way in which the integrated services digital network (ISDN) is expected to develop towards switched 2 Mbit/s services, some changes had to be made to the COST 211 transmission structure before a CEPT recommendation could be obtained.

Table 2 shows how encoded video data is now to be contained within the 32-time slot (TS) 256 bit frame structure that conforms to the CCITT†† Recommendation G732. Three options remain for choice according to future wideband switching strategy, but equipment is currently being manufactured to option (*i*) which corresponds to call set-up information being carried outside the 2 Mbit/s signal. Option (*iii*) is

**TABLE 2**
**Allocation of the 32-time slot Framing Structure for 2·048 Mbit/s Transmission**

| Transmitted Information | Bit Rate | Time Slot Allocation (within the 256 bit frame) | | |
|---|---|---|---|---|
| | | Non Switched | Switched | |
| | | (*i*) | (*ii*) | (*iii*) |
| Frame alignment, network alarms, etc. | as in Recommendation G732 | 0 | 0 | 0 |
| Speech information | 64 kbit/s | 1 | 1 | 1 |
| Codec-to-codec information | 32 kbit/s | 2 | 2 | 2 |
| Signalling information (subscriber-network) | 16 kbit/s | – | 16 | 0 |
| FAX, DATA, etc. (optional) | up to 2 × 64 kbit/s | 17 and/or 18 | 17 and/or 18 | 17 and/or 18 |
| Encoded video information | 26·5 × 64 kbit/s minimum | 3 to 16 + 19 to 31 + Half 2 | 3 to 15 + 19 to 31 + Half 2 | 3 to 16 + 19 to 31 + Half 2 |

† COST—*CO*-operation in *S*cientific and *T*echnical Research.

* CEPT—Conference of European Postal and Telecommunications Administrations

†† CCITT—International Telegraph and Telephone Consultative Committee

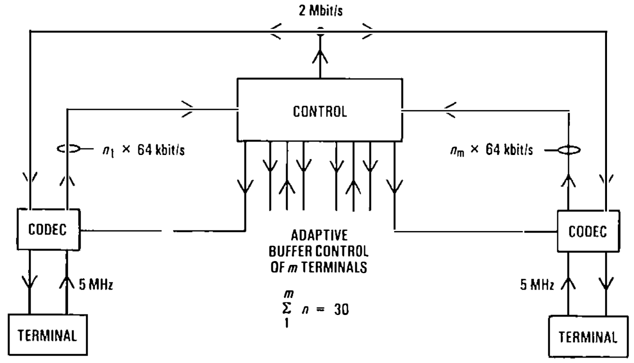



FIG. 9—A possible future multipoint conference configuration

preferred for the possibility of a future switched service where signalling is required to be carried inside the structure since customer to network signalling can be transmitted (nationally) in the redundant half of TS 0. Using TS 16 and (optionally) 17, 18 and the remaining half of TS 2, the maximum video transmission rate is $29\frac{1}{2} \times 64$ kbit/s, or 1·888 Mbit/s.

Forward error correction is accommodated, optionally, by a 64-bit block of data at the end of each 4096 bit multiframe and will derive from a quadruple BCH correction algorithm (after Bose, Chaudhuri and Hocquenhem) implemented by the Heinrich Hertz Institute of Berlin.

*Multipoint operation* is recognized as an essential feature of 2 Mbit/s teleconference. Already some 10% of all Confravision calls are 3-way. The block diagram in Fig. 7 and the flexible frame structure detailed in Table 2 indicate that the conditional replenishment technique lends itself well to dynamic multiplexing and to a potentially elegant concept of multipoint conferencing.

Buffer control allows the codec to generate just $n$ time slots of video information where $0 < n \leqslant 29\frac{1}{2}$. Fig. 9 shows how an $m$-way conference could be organized through subdivision of a common 2 Mbit/s channel by constraining each station to fill just $n$ time slots of the channel—depending on talker activity, movement activity and/or priority as deemed by a chairman, subject to the constraint:

$$\sum_{m} n = 29 \cdot 5 \text{ across all stations,}$$

where $m$ is the number of terminals.

Experience with Confravision has confirmed that such a "see all of the people all of the time" facility for a limited number ($m$) of stations would be far preferable to a voice switched arrangement where only the talker and previous talker can be seen. However before this ideal situation can be developed, early conferences will probably operate by open mixing of the sound channels in TS 1, and chairman selection of 2 seen terminals through the initializing protocols and earth station transmit instructions contained in TS 2.

## NORTH AMERICAN STANDARDS

Connection to the emerging teleconference services in North America[6] is seen to be crucial to the early success of the UK system. Again, codec control through the buffer memory can be used to ensure that only 24 of the possible 32 time slots are occupied at the origination of any signal which will ultimately require onward transmission at 1·544 Mbit/s through the terrestrial networks of USA and Canada. Likewise, an incoming 1·544 Mbit/s signal can be built up to 2·048 Mbit/s for transmission from Madley to a UK decoder, where just 24 time slots are decoded for sound and vision.

Television standards conversion between 625/50 and 525/60 presents little difficulty since the codecs have much in common already with inter-continental broadcast-standards converters. PAL/NTSC colour incompatibility can also be avoided by encoding colour signals in component rather than composite form.

## ENGINEERING TRIALS

Under COST 211, 2-way exchange of video and sound at 2 Mbit/s first took place between Martlesham and Brittany in October 1980. The success of the subsequent COST 211 collaboration has demonstrated strongly the advantage of audio-visual communication over simple audio in a genuine problem-solving situation, and is very encouraging to the future of international visual teleconference.

Teleconference trials, as distinct from codec trials, are due to begin between the Administrations (PTTs) of UK, Netherlands, France, Italy and W Germany in April 1982 and to proceed at the rate of one week per month using the OTS until the end of 1982. This European videoconference experiment (EVE) is then planned to move into a commercial phase during 1983 when triallists in the UK visual services trial and others will be able to experience international teleconferences to connected parts of their organizations in selected cities of the 4 other countries.

For North America, engineering tests using Confravision studios have begun with TELEGLOBE Canada using INTELSAT analogue paths as a prelude to similar commercial trials later in 1982. Solutions to the 1·5/2 Mbit/s standards problems may be difficult, however, in view of the expected proliferation of incompatible 1·5 Mbit/s picture-coding algorithms in North America. It is to be hoped, however, that some progress will have been made by the time INTELSAT V satellites can offer relatively cheap digital paths around 1984.

## CONCLUSION

The transmission rate of 2 Mbit/s has recently acquired considerable significance since it is now expected to allow:

(*a*) subjectively acceptable quality of a teleconference image;

(*b*) an attractive tariff for national and international service compared with previously prohibitive analogue channels, and with the equivalent cost of business travel; and

(*c*) the possibility of rapid growth and penetration of switched service arising from current plans for the UK network and digital satellite services.

Commitment to the visual services trial appears justified by a number of observations and with a confidence generated by a number of related activities as follows:

(*a*) Based on independent estimates[1] of typical business travel behaviour, even a 1% substitutability of visual teleconference for travel by 1990 would present now an impossible growth requirement for UK national wideband network to satisfy the market.

(*b*) Study Group XV of the CCITT has recommended parameters[11] for visual teleconference incorporating bandwidth economy for early low-cost service.

(*c*) Within Europe, the CEPT sub working group TR/SG1 (Visual Telephone) has recommended 2 Mbit/s for the international rate for visual teleconference[12] and has commenced planning for a European videoconference experiment. COST 211 provided a framework for collaborative research on 2 Mbit/s coding techniques and a specification is generated on which a future standard might be based.

(*d*) By 1983, European and INTELSAT satellites could provide 2 Mbit/s paths, possibly by time-division multiple-access (TDMA), at a space-segment charge that appears likely to be attractive for teleconference.

(*e*) Enquiries are being received at a steady rate—and still without market stimulation—for private teleconference services, particularly for international communications.

All of these observations are, however, fairly general indicators of demand. Questionnaires and demonstrations are notoriously unreliable considering the risks attached to launching a new service with such expensive technology. Consequently, the principal justification for the visual services trial is to bring hands-on experience to potential customers. It is relevant to state that perhaps the single most significant conclusion of NOP in 1980 was that even after demonstration and persistent questioning it was almost impossible to obtain the corporate view of a potential customer organization of the product value of teleconference. Long experience of use is needed before the product can be identified and the competing alternatives evaluated. Only with such experience and a reasoned assessment of tariffs can the intuitive substitutability of teleconference for travel in a world of increasing energy conciousness be vindicated.

In summary, the visual services trial is intended to give answers on psychology, economics, engineering and subjective design for the definition of products in an unknown market for an expensive technology. Is transmission cost the dominant parameter in the equation for viable service or is there a quality threshold below which a conservative workforce would prefer the travel alternative? Will employers force their staff to use electronic means wherever possible or will staff adopt the new service voluntarily for the improved quality of life brought by shorter and more predictable hours of work?

The aspects of the visual services trial reported here are concentrated on the large market created by small business meetings involving travel. A related market is being stimulated by the commercial self-interest, or desire for prestige, of learned conference organizers and hoteliers who will ensure a growing number of large teleconferences over the next 2 or 3 years. Larger operating budgets allow consideration here of up-market technology such as large-screen projection television, broadcast-production technology and special effects. Quality dictates may also eventually lead to digital transmission at 8 Mbit/s or higher. Bordering on developments in direct broadcast satellites and subscription television, it promises a future where individuals or organizations may be able to be present at the ever-increasing number of professional conferences through a concept of "subscriber teleconference"—a switched network giving instantaneous access to conference centres and institutes.

These are exciting prospects, but are dependent critically on attitudes and economics! The visual services trials are expected to evaluate these aspects for planning of the national and international circuits, which will make such services possible by 1984.


## ACKNOWLEDGEMENT

The ability of BT to mount trials of visual services mentioned here is largely the result of the wide ranging skills and commitment of the whole staff of the Visual Telecommunications Research Division and their predecessors. Their assistance and the solid support of the Directorate is gratefully acknowledged.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# British Telecom Press Notice

## MARTLESHAM ENTERPRISES

British Telecom (BT) in partnership with merchant bankers Lazard Brothers has set up a company to sponsor and finance commercial ventures in high technology. This is the first venture of its kind initiated by BT under recent legislation which, while modifying the telecommunications monopoly, allows BT to form partnerships in commercial enterprises.

The company, which is called *Martlesham Enterprises*, has Mark Burrell, a director of Lazard Brothers, as its Chairman; it will concentrate on exploiting spin-off ideas from BT's Research Laboratories at Martlesham Heath, Ipswich. The Company has an issued ordinary share capital of £250 000, and its shareholders are BT with 30%, Electra Investment Trust with 25%, Lazard Brothers with 20%, Raeburn Investment Trust, managed by Lazards, with 20%, and Thompson Clive and Partners with 5%.

The first idea under discussion for exploitation is a new materials process, invented by a Martlesham scientist, for improving semiconductors.

Martlesham Enterprises is a financial holding company, for identifying and sponsoring new ventures; in the first 2 to 3 years it will probably be responsible for setting up several companies.

It is anticipated that, when a company is formed, Martlesham Enterprises will hold a financial interest in it, and that its shareholders will have preferential rights to subscribe for new capital; it is hoped that the inventor will retain a significant interest. These companies will be able to call upon Martlesham Enterprises for advice or financial support, and Martlesham Enterprises' interest will be in the form of royalties and/or a shareholding. Once the companies can stand on their own feet to the point of a stock exchange quotation, Martlesham Enterprises will decide whether or not to retain its financial interest.

Individual shareholders in Martlesham Enterprises will be free to provide funds for the setting up and growth of the venture companies, as well as the holding company itself. The inventor of the idea or process will normally leave BT to join the new company.

BT's laboratories and test facilities can be made available to Martlesham Enterprises companies on a commercial basis, and land is available near the Martlesham centre if any of the companies wish to establish premises nearby.

# Prestel Terminals

G. P. HUDSON, B.SC., C.ENG., M.I.E.E.†

UDC 025.3: 681.31

*This article outlines the technical requirements of a Prestel terminal. It goes on to describe the operation of a terminal together with some of the proprietary methods adopted to achieve this operation.*

## INTRODUCTION

Viewdata was invented less than a decade ago in British Telecom's Research Laboratories (BTRL)[1]. British Telecom's (BT's) Prestel was the world's first public viewdata service[2, 3] when it was launched in 1979. There are now over 200 000 pages of information on Prestel, which can be accessed by over 15 000 terminals (see Fig. 1). In July 1981, Prestel became a worldwide service when access was provided via the international telephone and packet switched data networks.

For a public viewdata service to be successful, there should be a large number of users, which means reducing terminal costs to a minimum. To achieve this, viewdata utilises a domestic-quality television receiver to produce a low-cost information display. For minimum cost, the electronics needed should be integratable as far as possible. Another way in which the terminal cost can be reduced is by using the same display format, and hence electronics, as the television broadcast information system, teletext.

During the development work for the Prestel service, BTRL designed and constructed experimental terminals to demonstrate the potential capabilities of the service and to assist in the evolution of a standard. BTRL then produced a Prestel-terminal specification and liaised with industry over the design of commercial terminals. This function has now been passed to Prestel.

## TERMINAL SPECIFICATION

From the outset Prestel operated in a non-monopoly situation for the connection of terminals to the telephone network[4].

† Research Department, British Telecom Headquarters

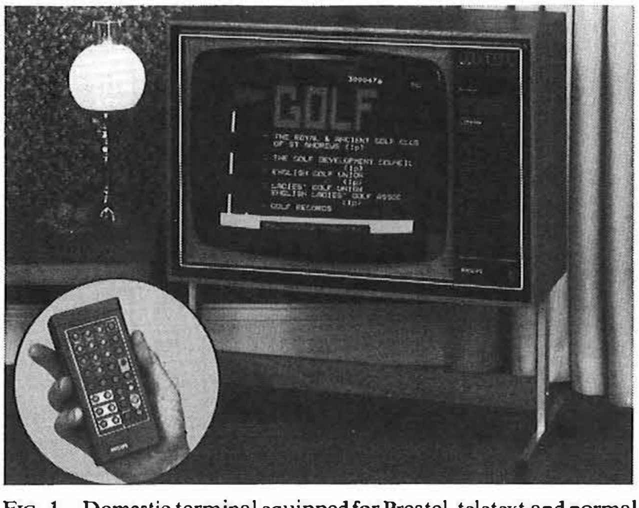



FIG. 1—Domestic terminal equipped for Prestel, teletext and normal television reception

Photograph by courtesy of Philips Ltd.

BT does not manufacture terminals and nor does it rent or sell them. Furthermore, terminal manufacturers are allowed to provide internal modems, whereas, in other countries, the telephone administrations (PTTs) still retain their monopoly on modem provision.

Prestel terminals have to be type-approved for attachment to the telephone network to ensure that they meet BT's requirements for safety, transmission and signalling as described in the Prestel Terminal Specification[5]. Under the new liberalisation policy, attachment approval will in future be specified by the British Standards Institution (BSI) and be performed by the British Electro-Technical Approvals Board (BEAB).

### Safety

The safety requirement ensures that any of the high voltages that are present within a television receiver (for example, mains AC supply and EHT) are prevented, in the case of a fault, from getting onto the telephone line. This isolation barrier must be capable of withstanding a minimum longitudinal voltage of 2·8 kV for 60 s; and transverse voltages in excess of 75 V must not be allowed to pass onto the line.

### Signalling

Connection of a Prestel terminal to the telephone line is via a Plug No. 505 and a Jack No. 96C. In the future, the new 400/600 series plugs and sockets will be used for parallel connected installations. If an external modem is being used, a CCITT* V24 type interface connects the terminal to the modem. Prestel terminals may have manual dialling from an ordinary telephone, but most have built-in auto-dialling facilities. When the terminal seizes the line, the rest of the telephone installation has to be disconnected. The auto-dialler has to allow for a choice of 2 Prestel telephone numbers, the numbers being attempted alternately on each successive call to Prestel. The numbers may be either locally or remotely programmable. A loudspeaker must be provided to monitor the call progress and to ensure that another customer is not called due to an error. Throughout the call, a visual indication has to be given that the line is being held. Whichever method is used to leave Prestel (for example, switching to normal television or disconnecting the mains) the line must be cleared down.

### Data Transmission

Upon connection to the Prestel computer, information is exchanged using an asymmetric (1200/75 baud), full-duplex asynchronous data link using modems of the CCITT V23 type. A Prestel terminal modem, however, is not required to operate over such a diversity of network situations as is called for in Recommendation V23. As the Prestel service is normally

* CCITT—International Telegraph and Telephone Consultative Committee

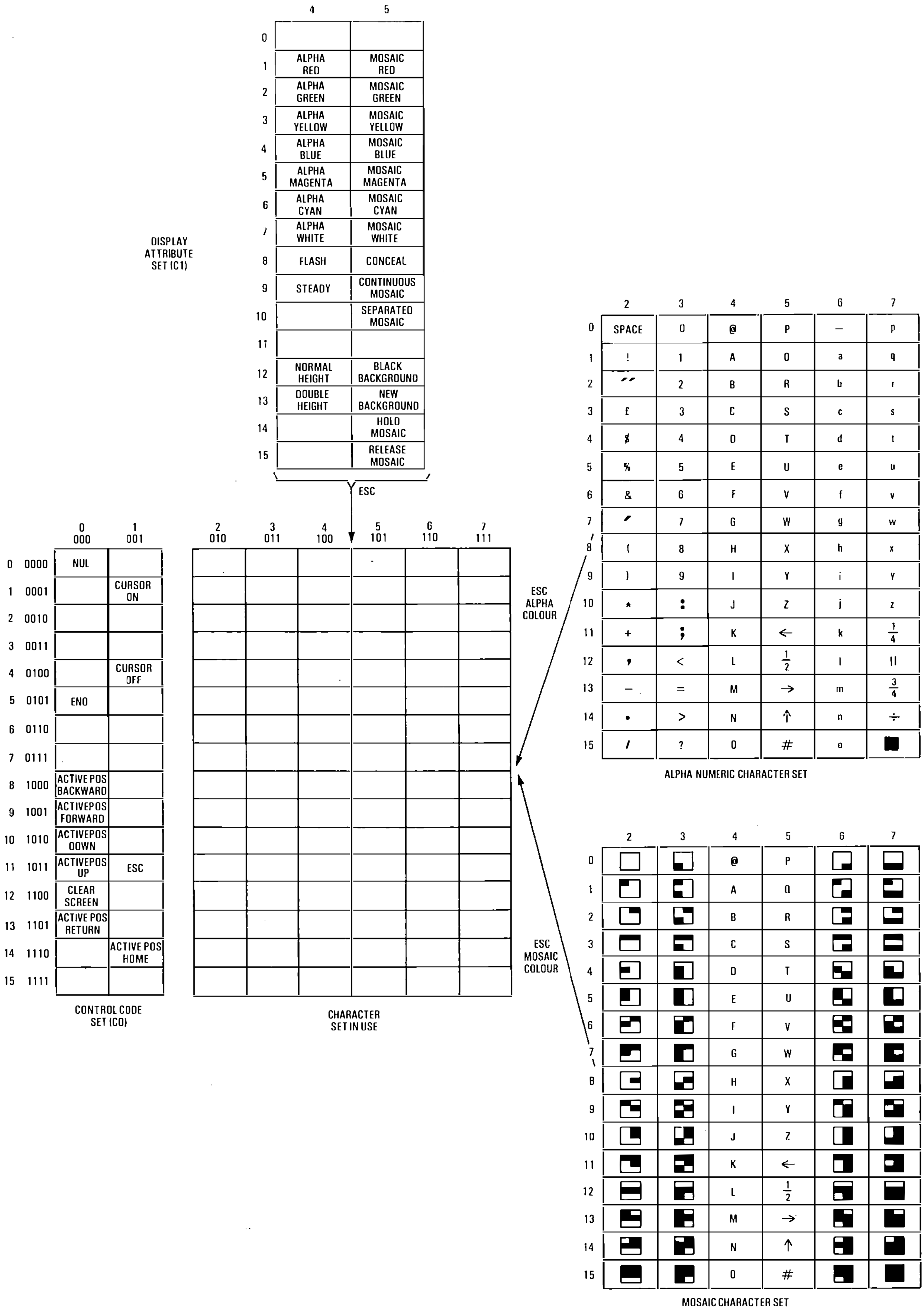



FIG. 2—Prestel character sets

provided to a customer within a local-call radius of the computer centre, a relaxed modem specification can be used.

Frequency-shift-keying (FSK) modulation is used with frequencies of 2100/1300 Hz to receive, and 450/390 Hz to transmit. The maximum input level to the modem is stated to be −13 dBm and the transmission loss is not expected to exceed 26·5 dB. The maximum allowable transmit level is −9 dBm and the minimum acceptable signal at the computer end is −43 dBm.

The serial digital data to and from the modem consists of characters in a 10 bit sequence of start bit, 7 character bits, parity bit (even), and a stop bit.

### Prestel Log-on

When a terminal is connected to the Prestel computer, it is first asked for its identity number (ID) by an *enquiry* (*ENQ*) code. The ID, which is 10 digits, is not displayed during transmission and is remotely programmed into the terminal when it is registered by Prestel. If a user has instigated a personal password (4 digits), a request to enter this is displayed. It is intended to precede the ID request (ENQ) by the character string PRESTEL. Also, a 4 digit mandatory password is to be added after the ID, and both may be known to the user.

### Display Format and Coding

A Prestel terminal can display 24 rows of 40 characters. In practice, the top row of a page is used for a header (information provider's (IP's) name, page number and page charge) and the bottom line may be used for system messages (for example, "Sorry no such page"), so that 22 rows are available for real information. The repertoire of alphanumeric characters is based on the ISO† 646 set[6,7]. For producing simple graphics, a set of characters made up from a mosaic of 3 × 2 elements is provided. Characters are normally referred to in a type of twin hexadecimal notation, which corresponds to their column and row position in the code table shown in Fig. 2; for example, 4/1 = A.

Columns 0 and 1 of the table are termed the *C0* (control nought) set and are used for control purposes; such as, moving the active position around the display, and for changing character sets. (The active position is the position where the next character will be displayed). The *ENQ* code used at log-on and the *NUL* code, which can be used for a time delay, are also in this set (0/5 and 0/0).

The appearance of a character may be changed by a display-attribute code. These codes reside in the C1 set and are invoked by preceding them with an *escape* (*ESC*) (1/11) code. Attribute codes are used to select the colour of characters and to switch between alphanumeric and mosaic graphics sets.

The colours available are the 8 combinations possible (except black foreground) from having the red, green and blue (RGB) display-tube gun either HARD ON or OFF. The *flash* attribute causes the foreground colour of a character alternately to take on the background colour at a rate decided by the terminal (for example, 1 Hz). This can be used to highlight items in text or to create the effect of movement in graphics.

Prestel has serial attributes, which means that an attribute affects the appearance of all subsequent characters on that row or until a contradictory attribute is present further along the row. At the start of a row, the attributes are reset to default values, for example, white characters on a black background. To conform with broadcast teletext, which has a synchronously transmitted fixed-frame format of 960 character codes, each attribute occupies a character position.

A larger range of attributes was introduced in the Broadcast Teletext Specification published in 1976[8]. The new attributes are often referred to as *post 76* codes. The *new-background* attribute sets the character background colour to that of the foreground. A new foreground colour must, therefore, be set for subsequent characters to be visible. Characters may be stretched vertically into the row below by the *double-height* attribute.

In the mosaic-graphics mode, the *separated* attribute causes each mosaic element to become split up by the background colour. This gives a set of large-dot building blocks which have a visual smoothing effect when used for graphics such as maps and portraits. The need to use a space for an attribute code is not a handicap in text because normally they can fit into the spaces between words. The space can be avoided in mosaic graphics by use of the *hold-mosaic* attribute which causes the last graphics character to be displayed in the position of the attribute change.

† ISO—International Organization for Standardization

## OPERATION OF A TERMINAL

The first viewdata terminals incorporating special purpose integrated circuits (ICs) were developed in the mid-1970s. Subsequently, the functions of various circuit modules required in a terminal have become established, and are now described.

### Line Interface

A Prestel terminal has to have a DC connection to the exchange line for signalling, and a voice frequency connection for the transmission of data. An AC connection is normally made via a transformer which provides the mandatory high-voltage isolation. For DC conditions, isolation is provided by the signalling relays. The terminal input/output circuitry can be protected from induced line voltages by a gas discharge tube. See Fig. 3.

Two relays are used for signalling, a loop relay, and a dialling relay. A call is initiated by both relays operating, which disconnects the rest of the customer's installation and closes the calling loop via the transformer. Dialling is produced by the dialling relay releasing to produce the break pulses; if the power is removed, the release of the relays automatically clears the line.

### Modem

Although a standard BT modem can be used for Prestel, their high performance makes them more bulky and expensive. Development work using the latest techniques and technology has resulted in the production of a small low-cost short-haul modem which has played a major part in making Prestel economically feasible.

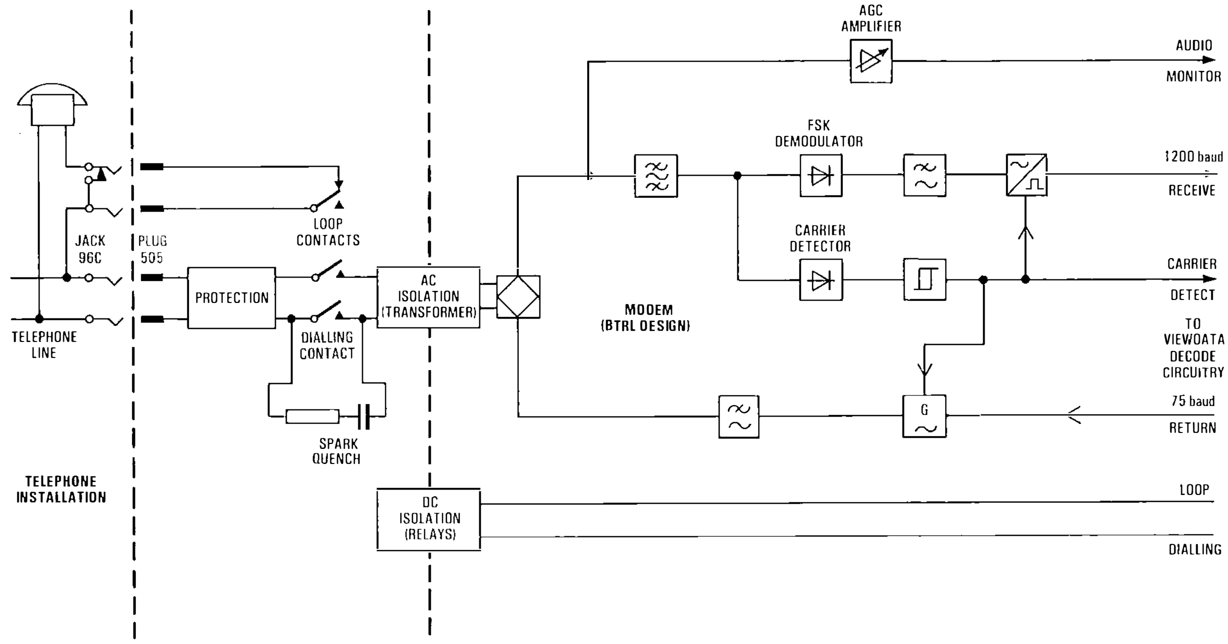
In the modem, the received signal is put through a band-pass filter to attenuate the low-frequency line noise. Demodulation of the FSK signal is achieved by the use of a phase-lock-loop circuit. The loop-control voltage is a function of the difference between the input frequency and the centre frequency and, hence, represents the data signal. A post-demodulation filter removes unwanted harmonics, and a digital output is obtained from a voltage comparator.

To indicate to the terminal's logic when it is connected to the computer's modem, a simple carrier-detect circuit is provided. An audio-monitor output is obtained by passing the received signal through an AGC amplifier.

The FSK transmitter can be constructed from a multi-vibrator, voltage-controlled by the data signal, with a low-pass filter at its output to remove harmonics.

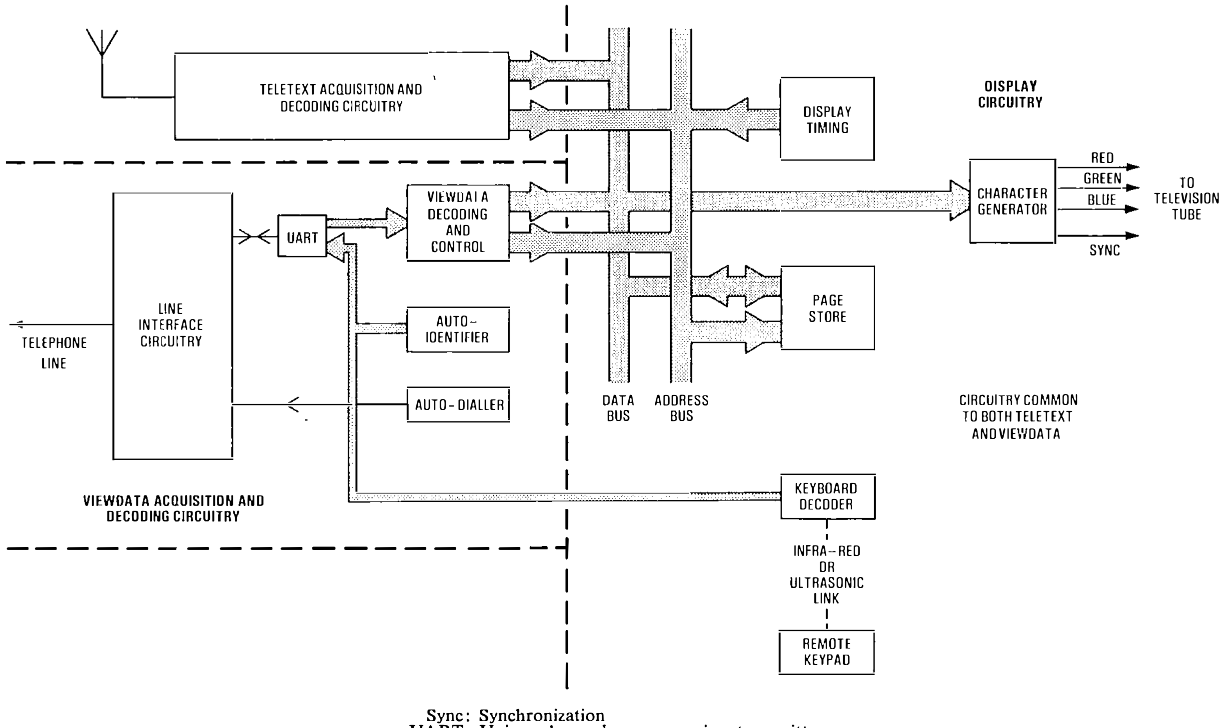
### Data Conversion

Detection of a character from the serial-data stream and conversion to a parallel form is a commonly encountered task which can be performed by a universal asynchronous receiver transmitter (UART) chip. As its name suggests, this device can also produce from codes generated by the terminal, the serial data for transmission.




AGC: Automatic gain control
FSK: Frequency-shift keying

FIG. 3—Block diagram of line interface circuitry




Sync: Synchronization
UART: Universal asynchronous receiver transmitter

FIG. 4—Block diagram of complete viewdata terminal

## Viewdata Decoding and Terminal Control

The viewdata decoding and terminal control functions are now often performed by a single-chip microprocessor; that is, a processor that incorporates its own data and program memory and an input/output port.

The UART is regularly checked by the processor which picks up a character when it is received. If, as is shown in Fig. 4, the display system has a common data and address bus, then the movements of data have to occur during the blanking periods of the display. When a parity error is detected by the UART, the decoder ignores the code and substitutes the *delete* (*DEL*) character (7/15).

The decoder tests a character to establish whether it is a control code, a display attribute or a normal displayable character.

Codes from columns 2 to 7 inclusive of the code table are recognized as displayable characters and are written directly into the page-store memory at the active position (row and column count). Each time a character is entered, the count is incremented.

The cursor controls cause the active position counts to be changed. For example, *active position forward* (horizontal tab) code causes the column count to be incremented. Control codes are acted upon as they are received, and are then lost. Receipt of the an *ESC* code indicates that the next character will specify an attribute change.

Attributes are implemented in real display time by the character generator. The received code from column 4 or 5 is normally translated to a column 0 or 1 code respectively prior to being put in the page store. This is the same format as attributes are transmitted for teletext, in which control codes are not used.

### Page Store

The page store for a display of 24 rows of 40 characters needs 960 locations and, with 96 different characters, needs to be 7 bits wide. In practice, a 1 kbyte random-access memory (RAM) is used. Normally the page store position is generated as a row (5 bit) and column (6 bit) address. The resulting 11-bit address is compacted to give a 10 bit number in the range 0 to 960 of the RAM.

### Character Generator

The main component of the character generator is the character set read-only memory (ROM). Prestel specifies a set of 96 characters, but the dot matrix size and the way the characters are formed is left to the manufacturer. A matrix of 10 × 6 dots is common which, after allowing vertical and horizontal spacing, leaves 9 × 5 dots for the character. The character generator also notes which attributes have previously been set on a row and executes these on the character. For example, the dot colour may be generated by holding the 3 bit foreground and background colours from their invoking attributes (3 least significant bits) on the inputs of a multiplexor, and controlling their selection by the 1 and 0 from the character ROM. Mosaic-graphic characters can be generated directly from the character code as each of the 6 least significant bits refers to one of the mosaic elements. Most character generators provide for character rounding by displacing dots on diagonals half a position on interlace fields.

### Display Timing

The contents of the page store are transferred automatically through the character generator under the control of the display-timing circuit. The timing source is normally a local crystal, sometimes phase-locked to the broadcast synchronization pulses if available. This produces dot pulses at 166 ns intervals, and is divided to produce line-synchronization pulses at 64 μs intervals. These pulses are counted to produce line numbers (1 to 10) and row numbers (1 to 24). The dot pulses are used by the character generator to push out the character dots serially. A composite synchronization signal is also produced to drive the display-raster time-base when there is no broadcast carrier available.

## PROPRIETARY CHIP SETS

### Texas Instruments

The first commercially produced ICs applicable to viewdata terminals were Texas Instrument's teletext display chips incorporated into their Tifax XM11 unit. A number of different IC fabrication techniques were used according to their application, including bi-polar linear and integrated injection logic, but transistor–transistor logic (TTL) predominated. The X908 display chip, in conjunction with an external character ROM (SN 745262), and character-rounding logic, formed the character generator. For viewdata, the Texas TMS 9980 microprocessor, plus several peripheral chips, were added to create the VDP11 system. The microprocessor performs the viewdata decoding and auto-dialling functions. The system has wired inputs for a 16-button keypad arranged as a 4 × 4 matrix.

A second-generation system from Texas has, by further integration, halved the number of chips. The new character generator, TX121, has an internal character ROM and provides for post-76 display attributes. The viewdata module, VDP12, uses the TMS 9940 single-chip microprocessor.

### The General Electric Company (GEC)

The GEC 400 system is based on a self-displaying page-store module (M41–4). This has 3 purpose-built chips: the MA400 character generator; the MA401 address logic; and the MA414 page-store RAM, which are all manufactured using GEC Semiconductors' n-channel silicon process. The module has address, data, and control bus inputs and produces RGB and blanking outputs. The buses are driven by the viewdata input module (M44–1), which incorporates an Intel 8085 processor system to perform auto-dialling, keyboard inputting and viewdata decoding. Telephone numbers and the user's ID are stored in a complementary metal-oxide silicon (CMOS) RAM, supported by a nickel-cadmium battery. Connection to the line is made via a line-connecting unit (LTU11) produced by GEC Telecommunications Ltd. The unit includes the necessary isolation barrier and a modem with active-filter stages.

### Mullard

Two key ICs for viewdata were initially produced by Mullard: the SAA 5020 timing chain; and the SAA 5050 teletext read-only memory (TROM). The latter includes a character-set ROM and a graphics generator, implements all post-76 codes and provides character rounding. It is a widely used device. These Mullard ICs can be used independently or are available incorporated in 3 modules: namely, a line-coupling unit (6400VM), a viewdata acquisition-and-control module (6300VM), and a viewdata-compatible teletext module (6200VM), which together form a complete teletext/viewdata system.

The line coupling unit had a modem originally developed by Pye-TMC Ltd. employing LC filters and CMOS logic. Auto-dialling was performed by dedicated logic. The telephone numbers were programmed on a link field. The early version of the viewdata acquisition and control module used a Signetics 2650 microprocessor, but a later and popular

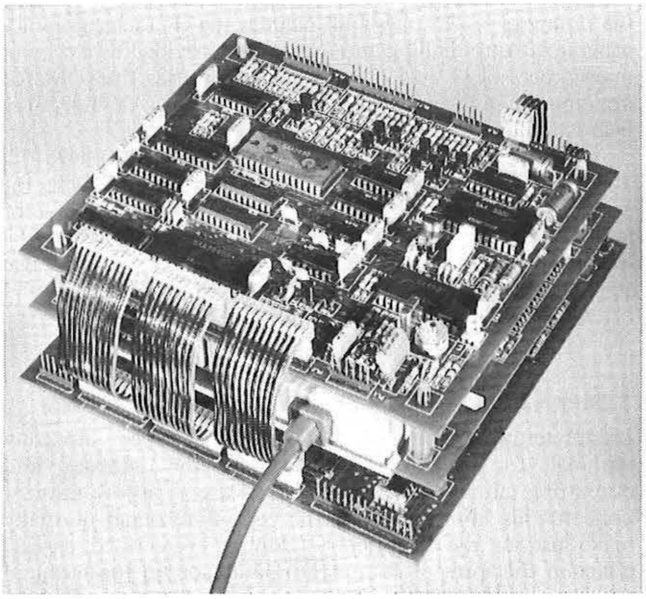


FIG. 5—Complete viewdata and teletext module

Photograph by courtesy of Mullard Ltd.

version (Viewdata 79) used the Intel 8048 single-chip microprocessor. Auto-dialling and log-on are performed by the microprocessor, the numbers being stored in electrically-alterable ROM (EAROM). The system allows for pages to be recorded and replayed on an audio-cassette recorder by commands from a keypad. If no page is requested after 15 minutes, the line is automatically released. The user is informed of events by messages displayed on line 24; for example, line disconnected, tape replay etc. The viewdata-compatible teletext module contains all the circuitry for a standard teletext display, plus logic to switch from the teletext to the viewdata service. The display is produced under the control of the timing chain from codes in the page store being passed through the character generator.

A third generation of viewdata circuitry has recently been produced by Mullard, based on their new chip (SAA 5070) known as *LUCY*. Many of the functions of the earlier line-coupling unit have been put into this IC, which is designed to connect as a peripheral to an Intel 8049 microprocessor. As well as incorporating some of the telephone modem circuit, the chip has a special modem (based on the Kansas City Standard) for more reliable tape recording of pages. LUCY-based systems can have facilities such as, local page storage, abbreviated page keying, multiple ID numbers, and user event messages. A set of modules incorporating LUCY is available, see Fig. 5.

Mullard make 2 pairs of transmitter/receiver ICs (SAA 5000/5012 and SAA 3021/3042) for operating remote-control links. Both can be used for either infra-red or ultrasonic links. The 5000/5012 system allows for 32 commands with a choice of 3 modes: television, teletext, or viewdata. When a key is pressed, the circuitry is powered up and a 7 bit start code and 5 bit command code are transmitted first in true and then in invented form. Logic 0 and 1 are distinguished by the time difference between pulse edges in a fixed window. The 3021/3042 system is intended for situations where several equipments (for example, television, radio, and hi-fi) are all to be remotely controlled, and allows for 128 commands. A command is transmitted as a start bit, followed by 6 command bits. The duration of pulse bursts indicates the logic state.

### General Instrument Micro-electronics (GIM)

GIM's teleview system uses their PIC 1650 microprocessor to control a bus-orientated display. Teletext and viewdata characters are entered into the page store by a data-acquisition chip (AY-3-9710). The video-generator IC (AY-3-9725) controls the timing of the display and includes the character/graphics generator. Auto-dialling and log-on are provided by a second microprocessor (TV-1650Z) system, which uses EAROM for non-volatile number storage. A modem chip (AY-3-9750) is being developed by GIM.

A transmitter and receiver (AY-3-8470 and AY-3-8475) IC are available for an infra-red remote-control link allowing for a normal 32 command system with expansion to 256 commands. A pulse burst is transmitted for each bit and the number of pulses within a fixed window determines its logic state. Each 8 bit command code is transmitted in true and inverted form.

## TERMINALS FOR DIFFERENT APPLICATIONS

Prestel terminals may be divided into 2 types: inputting terminals for IPs to create pages for the database, and outputting terminals which the public use to access and respond to this information. Both types of terminal normally make use of the proprietary chip sets described earlier, either in the form of complete modules or on the terminal manufacturer's own boards, but there are some terminals in service that use their maker's own logic decode and display systems.

### Outputting Terminals

*Domestic Sets*

A Prestel terminal comprises a normal television chassis with the viewdata electronics driving the tube with RGB signals, and has a controlling keypad. The early domestic terminals tended to be modified versions of a manufacturer's top-of-the-range large-screen remotely-controlled colour set, which meant that they were expensive. Most of these domestic sets can also receive teletext as the display circuitry is common to both systems. A wide range of terminals with different screen sizes and at significantly lower prices is now available. The remote keypad, typically with 32 keys, some of them multi-function, controls the normal television functions, teletext and Prestel. Accessing Prestel simply requires pressing the PRESTEL button followed by a choice of the number to be automatically dialled. Sockets are sometimes provided for connection of a full alphanumeric message keyboard and for an audio tape recorder. Some sets now allow for local storage of several pages in memory.

*Business Terminals*

Specialized Prestel-only terminals are available for the business market. These are normally small-screen desk-top units, sometimes with a monochrome display. They may have an integral or a cable-connected numeric or alphanumeric keyboard. A connector is sometimes provided for a printer. See Fig. 6.

*Adapters*

An alternative to the special-purpose Prestel set, giving a lower initial outlay for those already with a television set, is the Prestel adapter. This contains all the viewdata logic and electronics to drive the television receiver via its aerial socket. Because of the limited bandwidth of the demodulating and decoding stages, the resulting character display is not as sharp as that of a purpose-built set, but is still acceptable. Adapters are available with either integral or remote and numeric or message keyboards (see Fig. 7). They are being produced by

FIG. 6—Business terminal with message keyboard

Photograph by courtesy of Sony Ltd.


FIG. 7—Prestel adapter with normal domestic television

Photograph by courtesy of Zycor Ltd.

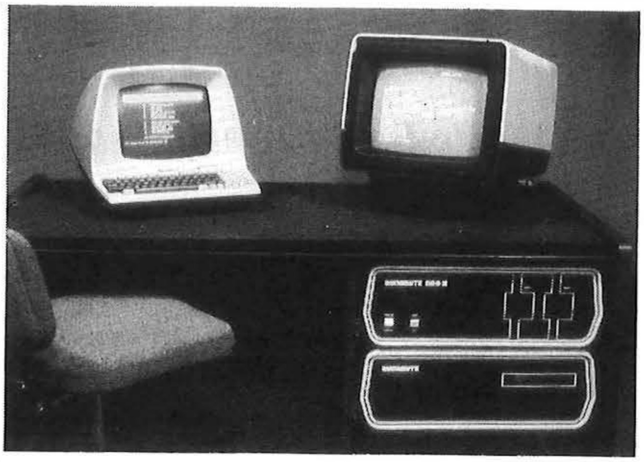


FIG. 8—Information provider intelligent inputting terminal

Photograph by courtesy of Metrotech Ltd.

small specialized companies rather than traditional television set makers. Their introduction at a very low cost has had the beneficial effect of causing the price of Prestel access to be reduced.

### Inputting Terminals

The simplest form of an IP's terminal is a standard Prestel set plus an editing keyboard. The Prestel update computer provides basic facilities for on-line editing. An editing keyboard has alphanumeric keys and special keys for cursor movements and display attributes.

Special-purpose intelligent editing terminals are now available, which allow for off-line editing and storage of several pages. These provide word-processing editing facilities, such as insertions, wrap-around and block moves. A locally-created page can be transferred to the Prestel update computer by the bulk-update procedure at 300 or 1200 baud, although later it is expected that the 300 baud working will be ceased.

For IPs controlling several thousand pages, there are even more sophisticated editing systems, allowing possibly several editing terminals connected to a mini/micro-computer to access a local database stored on disc. See Fig. 8. The creation of pages with mosaic-graphics characters may be simplified by the use of a graphics tablet or a television camera input.

## FUTURE TERMINALS

Prestel runs the public service and performs the liaison with industry over Prestel terminals. To maintain the UK world lead in viewdata, BTRL have continued to work on display enhancements. These include foreign accented characters, non-spacing attributes, dynamically redefinable character sets, and the display of television-broadcast-quality photographic inserts. Experimental terminals to demonstrate these techniques have been taken all over the world to demonstrate the upwards extendability of Prestel when selling systems. Photographic viewdata is possibly the most exciting advance, but owing to their large information content and the low data rates possible on the switched telephone network, only small photographic inserts are practical.

The full potential of photographic viewdata will be released by the high data rates available on the future integrated services digital network (ISDN). A second generation viewdata system proposed for the ISDN will allow a full-screen photograph to be down-loaded in a few seconds. The text and graphics facilities offered will be in line with the evolving CEPT† recommendations and are based on the experimental techniques mentioned above.

† CEPT—Conference of European Postal and Telecommunications Administrations

## CONCLUSION

The development of Prestel terminals is a good example of the close technical collaboration between BT and industry which has resulted in a highly-complex product being available at a reasonable price. To make the set more acceptable to the user and to encourage the dissemination of the product, BT allowed modems to be incorporated into the sets, and for these to be provided by television retailers. This process of co-operation is now continuing in the development of second-generation viewdata terminals.

## ACKNOWLEDGEMENTS

The author is appreciative of the conversations which he has had with Mr. S. Crammond and Mr. R. Ledger, who were involved in the early development and introduction of Prestel terminals.

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# British Telecom Transhorizon Radio Services to Offshore Oil/Gas Production Platforms

## Part 1—Service Requirements and Propagation Considerations

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*This 2-part article describes the provision of communication services to the UK's offshore oil/gas installations. Part 1 of this article describes briefly the British Telecom communication facilities provided for the drilling exploration, discusses the choice of transmission media for the fixed platform services, and examines some of the principles of tropospheric-scatter propagation. In part 2, to be published later, the application of transhorizon radio for services to offshore oil/gas production platforms is presented and the future prospects are discussed.*

### INTRODUCTION

Just over a decade and a half ago, when oil and gas exploration in the UK offshore waters commenced, it was not then realized just how much of these precious energy resources would be discovered or, indeed, just how important a contribution their discovery would make to the UK's economy. At an early stage in the explorations, it was realized that the need for communications would be of paramount importance. The sites, however, because of the nature of their locations, posed an unusual challenge to the provision of high-quality reliable communications. The initial facilities provided by British Telecom (BT), then the British Post Office (BPO), made use of the coast radio services, but transhorizon radio was chosen for the multichannel services to the fixed production platforms.

### COMMUNICATION SUPPORT FOR DRILLING RIGS

To meet the demand, arising in 1965, for communication services to exploration drilling rigs and their support vessels operating in UK offshore waters, BT expanded its coast radio station services in the 2–4 MHz band, and made available some 90 customer-dedicated telegraph circuits together with 5 telephone channels that could be used on a shared basis. The dedicated telegraph services may be routed over private circuits from the coast radio station direct to the customer's inland offices.

The shared telephone channels have access, via a coast radio station operator, to the UK public switched telephone network (PSTN) and thus enables the drilling rigs to have communication facilities with national and international based offices.

The telephone/telegraph communication services to the rigs are arranged as independent-sideband amplitude-modulated (AM) suppressed-carrier radio transmissions. Up to 15 telegraph sub-carrier channels spaced 170 Hz apart, each capable of a 100 baud transmission rate, can be accommodated within a 3 kHz single sideband. Each telegraph sub-carrier is frequency modulated $\pm 42 \cdot 5$ Hz about the centre frequency by the teleprinter signal. Transmitters of 1 kW and 400 W peak envelope power (PEP) respectively are used at the coast radio stations and on the drilling rigs with a requirement that the suppressed carrier level must be $-40$ dB with respect to the transmitted signal.

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### CONSIDERATION OF PERMANENT COMMUNICATION SERVICES

Although BT's coast radio station services provided a satisfactory means of communication to meet the low-speed data and occasional speech requirements for the exploration rigs and their support vessels, it was realized that multichannel high-quality communication systems with a high reliability would be necessary to satisfy the demands of the oil-company operators for efficient operation of the complex and sophisticated oil/gas production platforms.

#### Production Platform Construction

Production platforms, as distinct from exploration drilling rigs, are permanent structures which are secured to the sea bed and which may be either of the steel-jacket or of the concrete-gravity type of construction.

Figs. 1 and 2, respectively, show a typical steel and concrete type of production platform. The steel platform type is a large tower-like structure which, after completion at an inshore base, is floated out to its pre-determined position in the oil/gas field, and then secured to the sea bed by a number of huge piles. Accommodation and processing plant modules are floated out separately and fixed to the steel jacket with the aid of large lifting barges. By contrast, the concrete-gravity platform is almost completely equipped at the shore construction site before being towed out to its resting place in the oil/gas field. The enormous weight of the structure (300 000 t) aided by large ballast and oil-storage tanks around its base is sufficient to secure the platform to the sea bed.

A production platform may serve up to 40 or more well holes which may extend to some 5 km or so into the sea bed: deviation drilling techniques are used in order to reach out into the remote regions of the field. Oil outflow per field, in terms of barrels, may range from a few tens of thousand per day from the smaller fields to several hundred thousand per day from the larger fields. (A barrel is approximately 35 gallons.)

#### Choice of Communication Medium

Consultations with the oil companies who were planning to develop the UK offshore oil and gas fields indicated that a high reliability of service was required for their complex operations.

In general, the oil/gas production platforms that were expected to be installed in the northern North Sea would be too far from land for normal line-of-sight microwave links

FIG. 1—Typical steel-type production platform

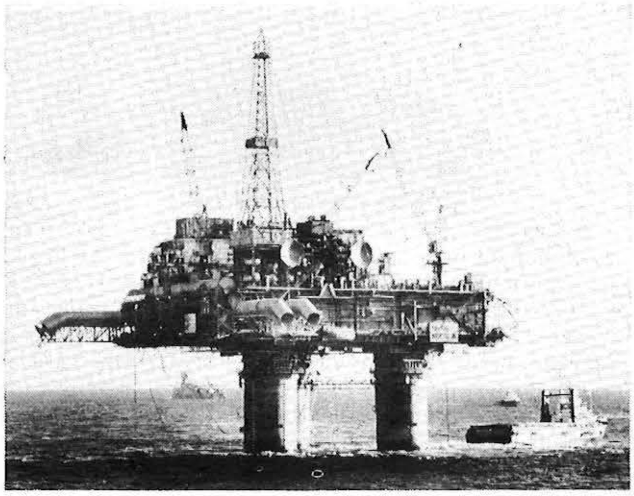


FIG. 2—Typical concrete-type production platform

to be used. The options that remained for the communication links were, therefore, submarine cable, radio satellite, and tropospheric-scatter radio. Submarine cables were rejected by the oil companies because of their high cost, and their extreme vulnerability to damage and long repair time in an offshore scene where numerous large work barges and pipe-laying vessels have a high presence and activity. Suitable satellite facilities were not available at the time and so the tropospheric-scatter mode of radio communication, or trans-horizon radio, was chosen as the method of achieving multi-channel links to certain production platforms which would be suitable as offshore-radio-station terminals. These platform terminals would also act as relay stations, using local line-of-sight microwave links to extend BT's services to other nearby platforms.

## SERVICE REQUIREMENTS

Some experimental work on tropospheric-scatter radio had been carried out by the BPO in the mid-1950s, but this mode of communication had not been used previously on a commercial basis in the UK. The advent of the large North Sea oil/gas platforms with their large staff complements (perhaps 300 or more) and their need to support sophisticated and complex drilling and production operations meant that the communication services required offshore were similar to those required at any inland business premises. These services included direct exchange and Telex line access to national and international communication highways, inter-switchboard extensions between offshore and land-based PABXs with level 9 access facilities, mixed speech and telegraph circuits, as well as facsimile and data transmission rates of 2400 bit/s over private leased circuits.

This requirement for access to the PSTN and Telex networks, coupled with the large number of platforms that were expected to be in operation by the mid-1980s, meant that BT's involvement was essential.

## THE TASK FORCE APPROACH

The North Sea Task Force (NSTF) was set up in 1973 to examine and quantify the possible extent of any development and radio station site procurement that would be necessary to meet the communication services required by the oil company operators for their production platforms. By the mid-1980s, the number of platforms operating in the North Sea was expected to be 50 or more and, clearly, it was imperative for a central authority to have oversight of the planning and provisioning of the multichannel radio systems, and to evolve co-ordinated network plans based on good radio-frequency management to conserve the limited spectrum available.

## TARGET TRANSMISSION STANDARD

Like most transmission mediums which carry public telephone, Telex and data services, the North Sea transhorizon radio links were planned and engineered to meet transmission performance objectives based on recommendations published by the CCIR†. Table 1 lists the transmission standard that was agreed between the Home Office and the BPO in 1973.

† CCIR—International Radio Consultative Committee

**TABLE 1**

**Transmission Standard for Transhorizon Radio Links**

The transmission standard requirements (*i*) to (*iv*) for a BT transhorizon radio link are specified in terms of noise power in the worst telephone channel at a zero level point relative to 1 mW and based on an acceptable relaxation of CCIR Recommendation 397–3.

The standard is assumed independent of route length up to 250 km. It is also assumed that in practice the number of transhorizon links in tandem will not exceed three. Requirements (*i*) and (*ii*) are weighted one minute mean values, and requirement (*iii*) is unweighted 5 ms mean value. It is assumed that the diversity combiner time constants are such that a 5 ms and one minute mean value would be substantially the same.

(*i*) 10 000 pWp of noise power not to be exceeded for more than 20% of the worst month.
(*ii*) 100 000 pWp of noise power not to be exceeded for more than 0·2% of the worst month.
(*iii*) $2 \times 10^6$ pW of noise power not to be exceeded for more than 0·02% of the worst month.
(*iv*) Hourly mean data element error rate not to exceed 1 in $10^5$ for more than 0·02% of the worst month for a transmission speed of 2400 baud.

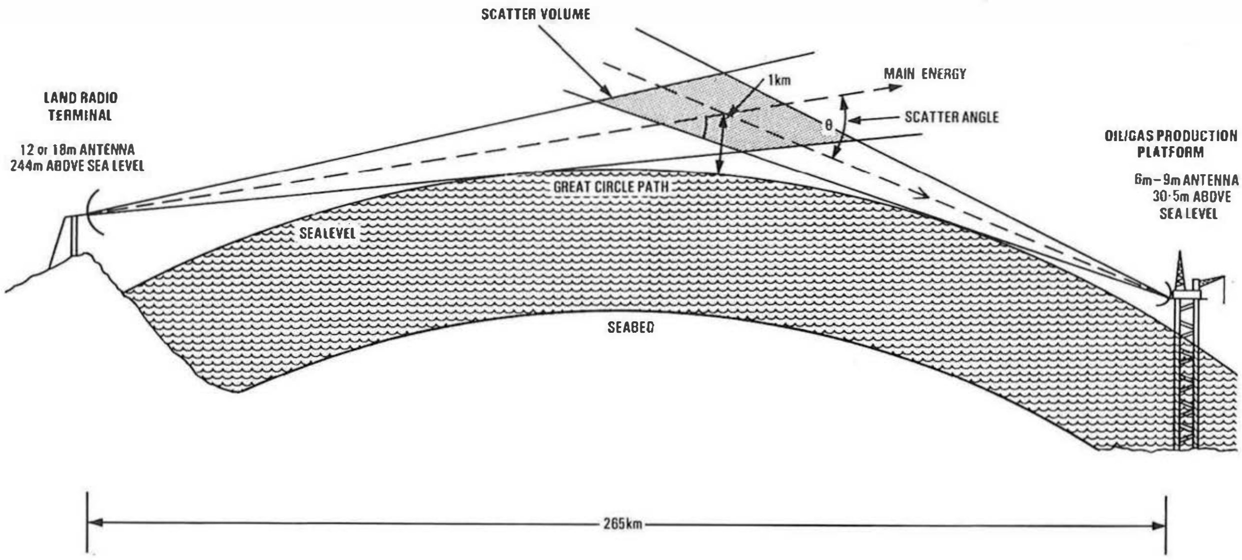



FIG. 3—Path geometry of tropospheric-scatter propagation

Changes in this target transmission standard have been made recently to bring them into line with a more practical approach to system performance assessment at the commissioning stage. These changes are:

(*a*) requirement (*iii*) is now expressed as "$1 \cdot 125 \times 10^6$ pWp and is a weighted one minute mean value", and

(*b*) requirement (*iv*) is now expressed as "the mean hourly data element error rate must not be greater than one in 100 000 for 99·98% of the worst month over minimum measurement periods corresponding to 1 000 000 data elements, at a transmission speed of 2400 baud with the data signal level set at −15 dBm0".

## BASIS OF TROPOSPHERIC-SCATTER RADIO PROPAGATION

Unlike microwave line-of-sight radio links, or indeed satellite links, which normally operate with an unobstructed view between the 2 radio terminals, tropospheric-scatter, or trans-horizon radio links, operate with the 2 terminals well beyond the optical horizon and out of sight of each other. In the case of line-of-sight and satellite radio links, where the strength of the transmitted signal decreases with distance according to an inverse square law, a coherent signal exists at all points on the wave front which impinges on the receive-antenna aperture. In the case of a tropospheric-scatter radio link, the received signal is made up of a large number of very weak vectors which have a random phase and amplitude relationship.

Fig. 3 illustrates the path geometry and basis of tropospheric-scatter propagation. A large amount of radio-frequency energy, which has been modulated with the information to be transmitted, is radiated from a large antenna in a narrow beam towards the horizon. Beyond the horizon, and in the lower region of the troposphere (which extends from the Earth's surface upwards to a height of about 10 km), the solid angles formed by the beam-cones of the transmit and receive antennas intercept each other and form a common volume known as the *scatter volume*. Although scattering takes place all along the transmit path, it is within this common scatter volume that most of the tropospheric-scatter mode of propagation takes place. A high proportion of the transmitted radio-frequency energy is lost in the forward direction, but a small fraction of the energy is refracted and reflected towards the receive antenna. For example, at the shore station, 1 kW of radio energy at the prescribed frequency is focussed by an 18 m billboard antenna (see Fig. 4) into a beam 0·5° wide, and radiated towards the horizon. When waveguide and other equipment losses are taken into account, this transmitted radio energy is equivalent to an isotropically radiated power of 60 MW. At the receive terminal, only a single picowatt of energy is required to produce a good-quality speech circuit. In fact, the sensitivity of a transhorizon-radio receiver may be effective down to a level of −136 dBW when special receiver-threshold extension devices are used.

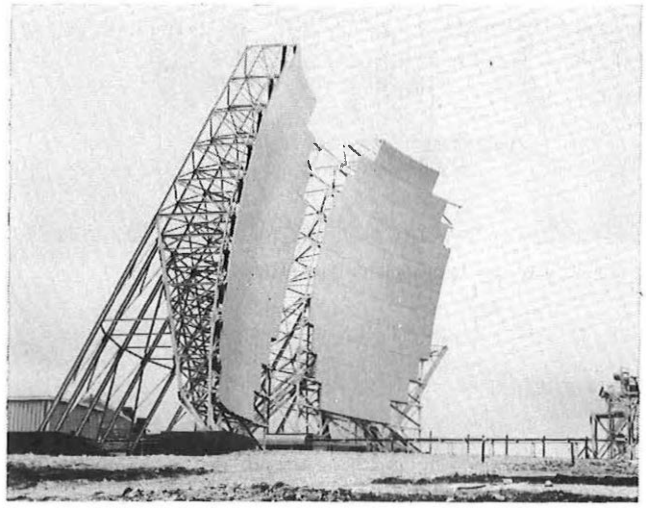


FIG. 4—18 m billboard antenna

A salient feature of the radio-path geometry of a transhorizon radio link is the scatter angle shown as $\theta$ in Fig. 3. It is essential to keep this angle as low as possible in order to reduce path attenuation and, therefore, the need for the radio terminals to be on high ground is apparent. An increase of 1° in the scatter angle corresponds to an increase of approximately 10 dB in radio path attenuation.

## ATMOSPHERIC EFFECTS ON THE PROPAGATION OF MICROWAVE RADIO SIGNALS

Meteorological conditions of temperature, pressure and humidity play a vital role in determining the propagation characteristics of the troposphere. Propagation of microwave radio signals over a smooth earth becomes more difficult as the radio path is extended beyond the horizon and the non-optical distance between transmitter and receiver increases. Beyond the horizon, a diffraction loss occurs that is additional to the free-space loss, which is a function of frequency and distance only. The diffraction loss also depends on frequency and distance but, in addition, the ground electrical constants influence the amount of attenuation. As the non-optical distance between transmitter and receiver increases, the diffraction loss increases rapidly at first, but eventually the rate of change of attenuation versus distances decreases; propagation of radio signals is then due to a scattering process from atmospheric refractive inhomogeneities produced by spatial and time variations of temperature, pressure, and water vapour content creating blobs of different refractive index.

Changes in the atmospheric refractive index with height above the Earth's surface amount to only a few parts in a million, but, nevertheless, the effect on microwave radio signals is such that refraction, or bending, as well as scattering takes place.

Because the atmospheric refractive index is so close to unity, it is customary to refer to the *refractivity* value ($N$) which is related to the atmospheric refractive index ($n$) by the equation

$$N = (n - 1) \times 10^6.$$

A typical value of atmospheric refractive index for a temperate climate such as experienced in the UK is 1·00032 which converts to a refractivity of 320.

The manner in which temperature, pressure, and water vapour content affect atmospheric refractivity can be deduced from the equation which relates these parameters, namely

$$N = 77 \cdot 6 \frac{P}{T} + \frac{3 \cdot 732 \times 10^5 W}{T^2},$$

where $N$ is the atmospheric refractivity
$P$ is the atmospheric pressure in millibars
$T$ is the atmospheric temperature in degrees Kelvin
$W$ is the atmospheric water vapour pressure in millibars.

This expression for $N$ may be considered to consist of 2 constituent parts; a *dry* part, and a *wet* part represented respectively by the first and second terms on the right-hand side of the equation.

At the low temperatures experienced during winter months, the wet component of the atmospheric refractive index is reduced considerably because of the inability of the atmosphere to retain moisture. This, in turn, results in a reduction of the radio-wave scattering effect and a decrease in the received signal level. The difference in the monthly median signal level corresponding to winter and summer months may be as much as 6 dB for North Sea transhorizon radio paths.

Refractivity values through the troposphere in temperate climates follow approximately an exponential law with respect to height above the Earth's surface although, for the first 1–2 km, a roughly linear relationship between refractivity and height may be assumed. A refractivity function corresponding to the atmosphere for the UK sector of the North Sea area may be defined as

$$N(h) = 320\mathrm{e}^{-h/7 \cdot 16},$$

where $N(h)$ is the refractivity at a height $h$ km above the Earth's surface. It is, however, not so much the absolute value of the refractivity which produces the refraction, or bending, of microwave radio signals in the troposphere, but rather the refractivity gradient, or $\mathrm{d}N(h)/\mathrm{d}h$.

## RADIO PATH PROFILES

To facilitate the plotting of microwave radio path profiles, it is usual to consider that the radio wave travels in a straight line from the transmitter to the receiver, and to modify the Earth's radius so that the difference in the curvature between the actual curved path of the radio wave and that of the Earth is preserved. The radio path geometry of Fig. 3 is based on the concept of a modified Earth's radius factor (see Appendix).

## ASSESSMENT OF RADIO PATH ATTENUATION

Like any other transmission medium, a basic requirement in order to engineer a transhorizon radio link is an assessment of the transmission loss between the send end (transmitter) and receive end (receiver). The overall radio path transmission loss includes losses due to reflection, refraction, diffraction and fading.

Radio signal fading on a transhorizon radio link is very substantial and may extend over a range of some 40–60 dB at a rate of 3 to 5 Hz. When signal enhancement due to duct propagation conditions is included, the received signal may extend over a total range of 100 dB or more. Signal enhancement is a phenomenon of a reversal and change of lapse rate of the atmospheric refractivity which occurs during anticylonic weather conditions and gives rise to the creation of a surface or elevated duct. Radio signals can get trapped in such an atmospheric duct and, in so doing, may be propagated over vast distances, and produce interference in distant radio receivers.

Signal enhancement usually occurs during the summer months when high atmospheric pressure areas predominate accompanied by temperature inversions. This can be explained by considering a layer of air in contact with the ground to absorb heat, to expand, and to rise because it becomes less dense. If during this process it expands adiabatically, the layer will eventually reach a height when the air above it is warmer and more dense. Periods of greatest signal variability may occur also during the summer months.

Because signal fading on a microwave radio path follows a statistical pattern, it is necessary for the systems engineer to predict this pattern in order to determine an availability figure for a given radio path length, taking into consideration such factors as topographical features, antenna gain, antenna height above sea level, transmitter power, and the scatter angle. Performance predictions usually refer to the month of worst propagation.

Any prediction of the overall transmission loss is compounded by the problem of antenna-to-medium coupling loss which is a feature of transhorizon-radio links and arises because of the absence of phase coherence over the aperture plane of the receive antenna.

Examination of the fading pattern of a transhorizon radio link reveals a combination of slow and rapid variation of the received signal level. The slow variations, in general, follow a log-normal type of distribution about a long-term hourly median level while the rapid variations in amplitude follow a Rayleigh type of distribution. Fig. 5 shows a typical tropospheric-scatter signal received over a 265 km path length.

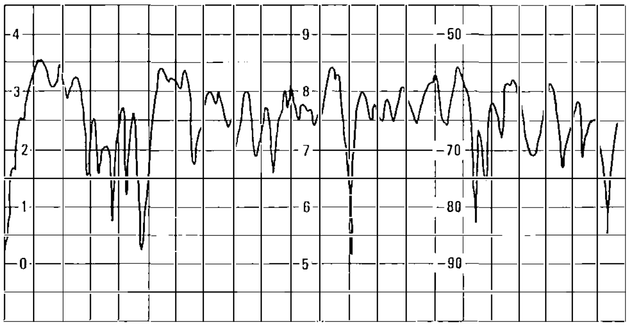



FIG. 5—Typical tropospheric-scatter received signal (single path)

A convenient way of assessing the overall transmission loss of a transhorizon-radio path is to assume that it consists of a *free-space loss* and a *scatter loss*. Free-space loss is a concept of signal attenuation in a transmission medium free of objects that could absorb or reflect radio-frequency energy and is associated with the inverse square law of optics which states that the intensity of illumination at a point varies inversely as the square of the distance from the source. For a given frequency of operation and radio-path distance, the free-space loss is invariate, provided these parameters remain unaltered. Scatter loss, on the other hand, does not remain constant but varies from instant-to-instant over a wide range, and accounts for the fading pattern.

## Free-Space Loss

Line-of-sight microwave radio links are also engineered on the free-space loss concept which is the basic transmission loss between isotropic antenna situated at each end of the radio path and is defined as the ratio of $\dfrac{\text{power transmitted}}{\text{power received}}$ using isotropic antenna at both the transmit and receive terminals.

If $P_t$ is the power transmitted by an isotropic radiator at the centre of a sphere, then the power flux density ($P_r$) received at a distance $d$ metres on the surface of a sphere is given by

$$P_r = \frac{P_t}{4\pi d^2}\,\mathrm{W/m^2},$$

and since an isotropic antenna has an effective capture area given by

$$A_e = \frac{\lambda^2}{4\pi}\,\mathrm{m^2},$$

then the power received is

$$\frac{P_t}{4\pi d^2} \times \frac{\lambda^2}{4\pi} = \frac{P_t\lambda^2}{(4\pi d)^2},$$

and, therefore, the free-space loss

$$\frac{\text{power transmitted}}{\text{power received}} = \left(\frac{4\pi d}{\lambda}\right)^2$$

which may be expressed as $20 \log \dfrac{4\pi d}{\lambda}$ dB.

It is customary and more convenient in microwave radio link performance calculations to express the free-space loss, or radio-path attenuation, in the following form

$$\text{free-space loss} = 32{\cdot}45 + 20 \log d + 20 \log f \text{ dB}$$

where $f$ is the frequency of operation in megahertz and $d$ is the distance between terminals in kilometres. Thus it is seen that the radio path attenuation is proportional to $d^2$, and doubling the radio-path length will increase the attenuation by 6 dB. A transhorizon-radio path of 200 km will have a free-space attenuation of 144·5 dB at 2 GHz.

## Scatter Loss

Several prediction methods have been evolved to estimate the log-normal type of fading that is characteristic of the scatter loss associated with transhorizon-radio links. The scatter loss depends upon the scatter angle $\theta$, the frequency of operation, and the amount of atmospheric inhomogeneities present in the scatter volume. An empirical formula, based on experimental evidence, has been derived by Yeh[1] to predict the long-term median scatter loss $L_s(50)$ and is given by

$$L_s(50) = 21 + 0{\cdot}57\theta + 10 \log_{10} f - 0{\cdot}2\,(N_s - 310) \text{ dB}$$

where $\theta$ is the scatter angle in milliradians
$f$ is the frequency of operation in megahertz
$N_s$ is the surface refractivity.

From an analysis of the received signal level recorded over a period of 12 months for a 265 km transhorizon-radio link using 1 kW transmitters and 18 m diameter antennas, the long-term monthly mean was found to correspond to a median scatter loss of 63·8 dB which was within 3·1 dB of the median scatter loss estimated from the application of Yeh's formula, and within the 84% confidence limit. Fig. 6 illustrates the monthly mean value variation of the received signal level, and Fig. 7 shows how the monthly standard deviation of the log-normal distribution curve varies over the same period. It also demonstrates how a much wider variation of received signal level occurs during the summer months.

From the studies carried out by BT/NSTF, a cumulative log-normal distribution curve has been derived which represents the fading pattern experienced over the North Sea. Because the 2 propagation mechanisms which determine the received signal level under ducting conditions and under tropospheric scattering from atmospheric inhomogeneities are so very different, their respective log-normal distributions are also different and, therefore, the cumulative distribution curve given in Fig. 8 has been drawn to take this into account. Between 50% and 99·99% of the month, a standard deviation ($\sigma$) of 6 dB is appropriate to take account of the scatter mechanisms of propagation, and between 0·01% and 50% of the month, a standard deviation of 11 dB is appropriate to take account of duct propagation effects, which produce enhanced signal levels at the receiver. (Each case implies a different month.)

Estimating the transmission performance of a transhorizon radio link includes the concept of prediction error which is basically the application of another distribution at each point on the original distribution curve to produce a bivariate type of distribution.

Application of the formula

$$\sigma = \sqrt{(13 + 0{\cdot}05\,Y^2)} \text{ dB}$$

to any point on the log-normal distribution curve will give an

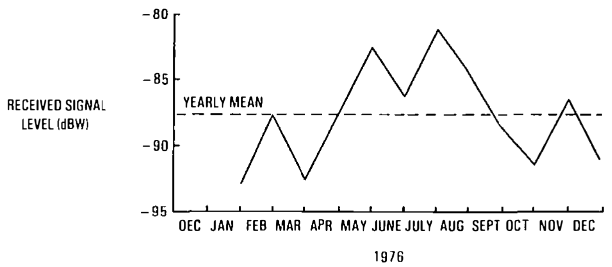
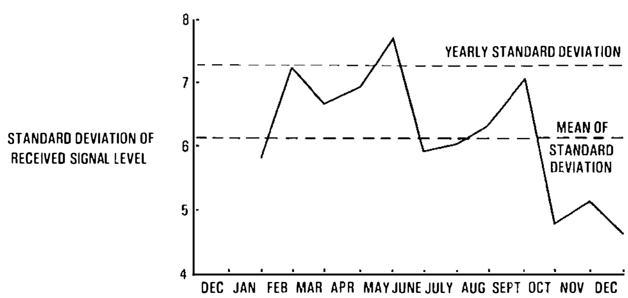



Fig. 6—Variation of monthly mean received signal level




*Note:* Path details of this system are given in Table 2

Fig. 7—Monthly standard deviation of received signal level

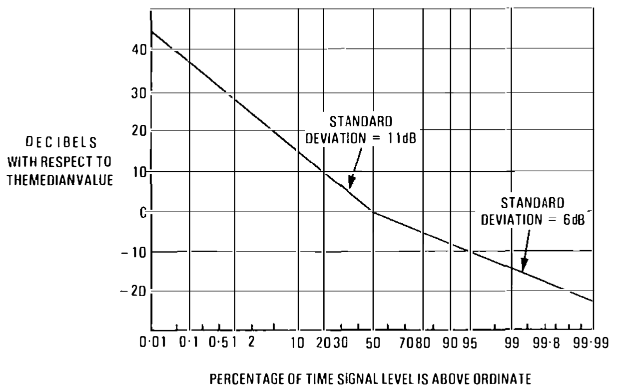



FIG. 8—Cumulative distribution for North Sea transhorizon links

84% confidence figure or prediction error in decibels; where $Y$ is the difference in decibels between the 50% and the $Y$%-of-the-time points taken from Fig. 8.

For example, it is usual to include the 84% confidence limit when predicting the tropospheric-scatter loss for a given radio link, and, at the 50%-of-the-time point, the value of $Y$ from Fig. 8 is zero and, therefore,

$$\sigma = \sqrt{(13 + 0 \cdot 05 \times 0^2)} = 3 \cdot 6 \text{ dB}.$$

At the 99·99%-of-the-time point on the curve, the value of $Y$ from Fig. 8 is 22 dB and

$$\sigma = \sqrt{(13 + 0 \cdot 05 \times 22^2)} = 6 \cdot 1 \text{ dB}.$$

Thus, in order to express an 84% confidence limit to the predicted values of scatter loss taken from the cumulative distribution curve of Fig. 8, it is necessary to add 3·6, 3·8, 4·8 and 6·1 dB respectively to the 50%, 80%, 99% and 99·99% scatter-loss figures.

## TYPICAL SYSTEM PARAMETERS

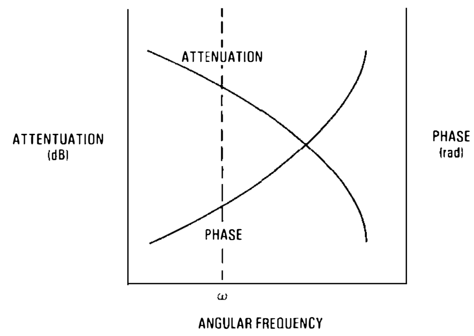
The typical parameters of a transhorizon-radio link to an offshore production platform are given in Table 2. When the scatter loss (Fig. 8) and the prediction-error loss are added to the free-space loss, an overall loss is obtained. For example, the 0·01% and 99·99% of the month figures, corresponding to enhanced and poor propagation conditions respectively, give a transmission loss difference of about 84 dB.

Unfortunately, the wide variations in received signal level precludes the use of a single tropospheric-scatter radio path as a communication medium because the rapid signal fluctuations mostly extend beyond the reception threshold of the receiver. For a radio link using frequency modulation techniques the threshold is about 10 dB above the basic receiver input thermal-noise level which is defined as $KTBN_F$, where

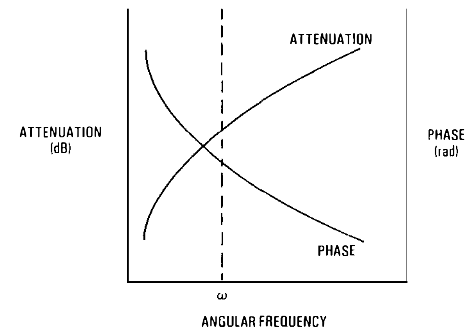
- $K$ is Boltzmann's constant $= 1 \cdot 38 \times 10^{-33}$ J/K
- $T$ is the receiver temperature in degrees Kelvin
- $B$ is the receiver bandwidth in hertz to the 3 dB points
- $N_F$ is the receiver noise factor defined as the ratio of $\dfrac{\text{signal-to-noise ratio at the receiver input}}{\text{signal-to-noise ratio at the receiver output}}$, and is a measure of the receiver's contribution to the total noise power at its output terminals.

A 10 dB margin above the receiver input thermal-noise level is necessary in order to ensure that the noise peaks which occur from time-to-time do not exceed the wanted signal level at the discriminator input. If this does occur, the noise peaks will cause loss of signal tracking, and excessive noise will be produced in the discriminator output with complete loss of intelligibility of the baseband signal. In general the noise is assumed to follow a Gaussian type of distribution.

As a transmission medium, the tropospheric-scatter radio path is restricted in bandwidth by intermodulation distortion which arises owing to frequency selective fading and the variations in the attenuation and phase characteristics. Fig. 9 illustrates how the attenuation and phase characteristics can vary from instant $t_1$ to instant $t_2$ at a given frequency $\omega$. These variations in the attenuation and phase characteristics produce distortion of the received radio-frequency spectrum and in turn this gives rise to intermodulation noise in the traffic baseband signal. The use of large antennas with their consequential narrow beamwidths minimizes the radio path length differences traversed by signals passing through the common scatter volume, and in turn this limits the amount of path intermodulation distortion noise appearing in the traffic baseband spectrum.




(*a*) Characteristic at instant $t_1$




(*b*) Characteristic at instant $t_2$

FIG. 9—Attenuation/phase characteristic variations

**TABLE 2**

**Typical parameters of a Transhorizon-Radio Link**

| | |
|---|---|
| Transmitter output power = 1 kW | 30 dBW |
| Transmitter/receiver feeder loss etc. | 5 dB |
| Transmit antenna gain at 2 GHz (18 m diameter) | 49 dB |
| Receive antenna gain at 2 GHz (9 m diameter) | 43 dB |
| Scatter angle | 16·2 mrad |
| Great circle distance | 225 km |
| Transmitter antenna height above mean sea level | 220 m |
| Receiver antenna height above mean sea level | 40 m |
| Free space path loss at 2 GHz | 145·5 dB |
| Median scatter loss | 62·2 dB |
| Scatter loss not exceeded for 99·99% time | 84·7 dB |
| 84% confidence limit at 99·99% time | 6·1 dB |
| Receiver threshold (single radio path) | −126 dBW |

Part 2 of this article will examine some of the critical features of a transhorizon-radio system and illustrate how these systems are configured to provide high-quality circuits to the offshore oil/gas industry.

*To be continued*

### References

1 YEH, L. P. Simple methods for Designing Troposcatter Circuits. I.R.E. Trans. on Communication Systems Sept. 1960.

## APPENDIX

### Earth's Radius Factor

In plotting microwave path profiles it is usual to modify the Earth's radius so that the radio path may be considered as a straight line, but the difference in curvature between the actual curved path of the radio wave and that of the Earth is preserved.

Curvature is defined as the reciprocal of the radius to a point on the curve and is derived from $r\delta\theta = \delta s$, where $r$ = radius and $\delta\theta$ is the angle subtended by the length of arc $\delta s$. Therefore, since $\delta\theta$ represents the total angle a tangent would turn through if rolled along the arc $\delta s$, the average curvature of the arc $\delta s$ is

$$\frac{\delta\theta}{\delta s} = \frac{1}{r}.$$

Reference to Figs. 10(*a*) and 10(*b*) will show that for the relationship $\frac{1}{r_e} - \frac{1}{r_r} = \delta$ curvature = constant, $\delta h$ must be the same in each case to satisfy both figures, where $r_e$ is the radius of the Earth and $r_r$ is the radius of the ray path.

From Fig. 10(*a*),

$$(r_r + DC)^2 = r_r^2 + d^2.$$

$$\therefore \quad 2r_r DC = d^2, \quad \text{since } DC^2 \ll 2r_r DC,$$

$$\text{or,} \quad DC = \frac{d^2}{2r_r},$$

$$\text{Similarly,} \quad AB = \frac{d'^2}{2r_e}, \quad \text{since } AB \ll 2r_e AB,$$

and assuming $d$ and $d'$ are approximately equal.

From Fig. 10(*a*),

$$h + \delta h = h - \frac{d^2}{2r_r} + \frac{d^2}{2r_e}.$$

$$\text{Hence,} \quad \delta h = \frac{d^2}{2r_e} - \frac{d^2}{2r_r}. \quad \ldots\ldots (1)$$

From Fig. 10(*b*),

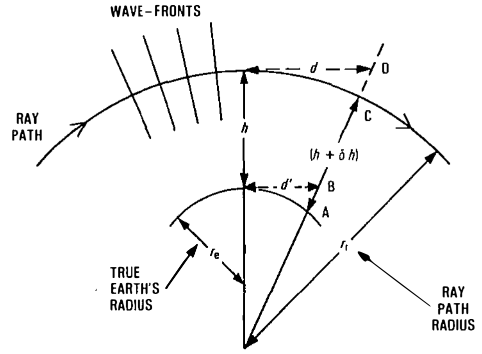
$$(Kr_e + h + \delta h)^2 = (Kr_e + h)^2 + d^2.$$

$$\text{Hence,} \quad \delta h = \frac{d^2}{2(Kr_e + h)} = \frac{d^2}{2Kr_e}, \quad \ldots\ldots (2)$$

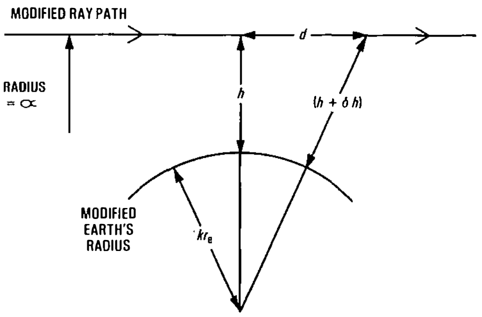
since $h \ll Kr_e$.

Combining equations (1) and (2),

$$\frac{1}{r_e} - \frac{1}{r_r} = \frac{1}{Kr_e}. \quad \ldots\ldots (3)$$




(*a*) Actual curved-path profile




(*b*) Modified straight-line-path profile

FIG. 10—Radio wave path profile

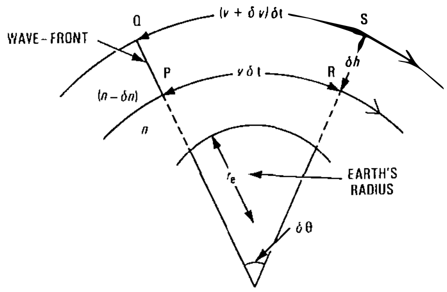



FIG. 11—Effect of refractive index on radio wave path

The difference in curvature between the true Earth and the ray path is given as $1/Kr_e$, which is a constant. The Earth's radius factor, $K$, modifies the true Earth's radius so that a straight line between the transmitter and the receiver can be used to represent the signal path. This relationship can also be deduced from Fig. 10(*b*) since the straight line between the transmitter and the receiver has zero curvature and, therefore, to preserve the same constant curvature difference for a modified Earth's radius $r_{em}$

$$\frac{1}{r_{em}} - \frac{1}{\infty} = \frac{1}{Kr_e},$$

$$\text{Hence,} \quad \frac{1}{r_{em}} = \frac{1}{Kr_e}.$$

In order to show how the $K$ factor is determined by the Earth's atmospheric refractive index gradient, it is necessary to consider 2 distinct wave-fronts represented by $PQ$ and $RS$ in Fig. 11. Because the radio wave-front crosses an interface between 2 mediums of atmospheric refractive index, $n$ and $(n - \delta n)$, the wave-front is refracted away from the normal. The velocity of the radio wave in the less dense medium speeds up from $v$ to $(v + \delta v)$ and consequently in time interval $\delta t$, the wave-front at P travels a distance $v\delta t$ and the wave-front at Q travels a distance $(v + \delta v)\delta t$. These distances are represented by $PR$ and $QS$ respectively in Fig. 11.

From Fig. 11 the following relationships hold

$$r_r\delta\theta = v\delta t, \quad \ldots\ldots (4)$$

$$\text{and,} \quad (r_r + \delta h)\delta\theta = (v + \delta v)\delta t.$$

$$\text{Hence,} \quad \frac{\delta\theta}{\delta t} = \frac{\delta v}{\delta h}. \quad \ldots\ldots (5)$$

But in a medium of refractive index $n$, electromagnetic waves have a velocity given by

$$v = c/n, \quad \ldots\ldots (6)$$

where $c$ is the velocity of light in a vacuum.

Differentiating the left-hand side of equation (6) with respect to height $h$ gives

$$\frac{dv}{dh} = -\frac{c}{n^2}\frac{dn}{dh},$$

$$= -\frac{v}{n}\frac{dn}{dh},$$

$$= -v\frac{dn}{dh},$$

since $n$ is approximately equal to unity.

From equations (4) and (5)

$$r_r = v/\frac{\delta\theta}{\delta t} = v/\frac{\delta v}{\delta h} = -1/\frac{dn}{dh} \quad \text{as limit } \delta t, \delta h \to 0.$$

Substituting for this value of $r_r$ in equation (3) gives

$$\frac{1}{r_e} + \frac{dn}{dh} = \frac{1}{Kr_e},$$

$$\text{or,} \quad K = \left(1 + r_e\frac{dn}{dh}\right)^{-1},$$

which indicates that the value of $K$ depends on the gradient of the atmospheric refractive index, and since $N = (n - 1) \times 10^6$,

$$K = \left(1 + r_e\frac{dN}{dh} \times 10^{-6}\right)^{-1},$$

when $r_e$ is expressed in kilometres and $dN/dh$ is expressed in units per kilometre.

For the UK North Sea area, the refractivity gradient, $dN/dh$, may be taken as $-39$ units per kilometre which is equivalent to an Earth's radius factor, $K$, of 4/3, giving an effective Earth's radius of $4/3 \times 6370 = 8493$ km.

# British Telecom Sets New Optical-Fibre Record

BRITISH TELECOM PRESS NOTICE

In February this year, a research team at the British Telecom Research Laboratories (BTRL) demonstrated the transmission of 140 Mbit/s signals over a continuous 102 km length of monomode optical fibre. It was the world's farthest transmission at this pulse rate achieved without intermediate regenerators, and was twice as far as BTRL's previous best achieved in an experiment last year. This achievement was made possible by a number of technical advances in optical fibre, lasers, and detectors. The experiment illustrated the advanced state of the component technology which exists in the UK and has major implications for future system development.

It is expected that this achievement will help BT to make substantial economies in transmission—currently one of the most expensive elements in financing a national telecommunications network. BT, which already has £25 M worth of optical-fibre systems installed or on order, will be able to get even greater benefits from this new technology. It is also expected that these systems will help British Industry establish a leading position in an area increasingly subject to strong international competition.

Current optical-fibre systems now being installed in the network need regenerators spaced at 7–10 km intervals. These are necessary because the light pulses transmitted along the fibre become both attenuated and distorted over such distances so that to go further would lead to severe degradation of the signal. In comparison, conventional coaxial cable, needing amplifiers every 2 km, is even less efficient.

The breakthrough achieved by the BTRL opens the way for practical, reliable optical-fibre transmission systems which will span distances of 30 km or more without intermediate repeaters.

For the land network, this would bring major benefits:

(*a*) significant savings in capital costs could be made;

(*b*) the problem, and cost, of manhole access for maintenance or repair would be eliminated; and

(*c*) electronic equipment would be housed in existing BT buildings so that it would be easy to install, maintain and protect from the elements.

There would also be substantial reductions in the cost of undersea cables, which, at present, need repeaters about every 5 km. Transoceanic fibre cables would need fewer repeaters, and they could be eliminated completely from many cross-channel links with Europe. The new microchip devices and high-quality fibre produced by the BTRL could also be expected to contribute towards lower running costs in future systems, by increasing capacity, improving performance, reducing maintenance costs and extending equipment life.

Present optical-fibre systems use graded-index fibre which allows the light to travel in more than 200 different ray paths or modes. Because these travel at slightly different speeds, pulses of light travelling in such a fibre become spread out in time and eventually would overlap. Also, at the wavelength of light used (850–900 nm, which is just outside the visible range), the attenuation of the fibre ranges from 2–5 dB/km. Over a 10 km length of fibre, the received signal is over 100 000 times less than the power launched into the fibre.

The BTRL experiment used monomode fibre, which has a much smaller core diameter, so that the light-carrying region can only support one ray path or guided mode. This reduces the pulse spreading in the fibre, from around 1 ns/km in graded-index fibre to as little as 10–100 ps over 30 km of monomode fibre.

A further benefit was gained by moving to a longer wavelength, which reduced power loss. At a wavelength of 1300 nm, monomode fibres have an attenuation of about 0·4–0·5 dB/km; this falls to 0·25–0·35 dB/km at the 1500 nm wavelength used in the experiment. The total loss over the 100 km link (which included 11 joints) was measured to be only 33 dB. The fibre was made at Martlesham.

Although monomode operation virtually eliminates pulse spreading due to mode dispersion, it has much less influence on that due to another factor—material dispersion. This arises because radiation of different wavelengths travels at different speeds in glass. Although pulse spreading from material dispersion falls to nearly zero at 1300 nm, at 1500 nm it is about 18 ps/nm for every kilometre of fibre. This means that fast pulses from a laser source of 4 nm linewidth would be broadened by about 7 ns over 100 km, which is unacceptable for 140 Mbit/s transmission.

Pulse spreading due to material dispersion is kept within acceptable limits by using transmitters of greatly reduced spectral linewidth output. This is achieved by injection locking, using 2 lasers.

The first laser is run continuously under carefully controlled conditions so that it produces a stable single-wavelength output. Some of the power of this first laser is focussed into the second laser which is pulsed on and off to generate the signal. When the second laser starts to oscillate, it automatically locks to the injected single wavelength, so that power pulses of light, which are essentially of single wavelength, are generated. In some versions of this transmitter, linewidths as narrow as $10^{-3}$ nm have been observed, and this means that over distances of 100 km pulse spreading is neglible. The design has been pioneered by BTRL and is crucial to the achievement of the necessary performance.

At the receiver end of the fibre, the world's most sensitive receivers for the 1500 nm wavelength were used. These were also designed and built at Martlesham. They use pin detectors fabricated from GaInAs material with GaAs field-effect transistor (FET) amplifiers in a hybrid integrated package.

While the 100 km experiment demonstrated the remarkable potential of optical technology, plans to use monomode fibre systems in BT's main network call for 30 km repeater spacing. With that in mind, a prototype repeater section has been cabled at Martlesham. It consists of 31·6 km of monomode fibre, has joints at 2 km intervals, and has an insertion loss of 17 dB at 1300 nm and 16 dB at 1500 nm. The joint losses average 0·17 dB at 1300 nm and 0·11 dB at 1500 nm.

These figures are important for 2 reasons. Firstly, they were obtained by using a fully automated splicing jig designed at Martlesham for application in the field. Secondly, the joint losses were much lower than had been expected; it had been thought that the tiny core diameter of monomode fibre (5 μm) would give rise to virtually insuperable problems in field jointing.

The low figures resulted from the good dimensional control achieved in the fibre, the precision of the fibre-end preparation tool and the detailed design of the automated fusion splicing jig.

In other experiments, the 100 km fibre has been used to carry broadcast quality television pictures in pulse-frequency-modulation format. The equipment used for this was developed from an earlier Martlesham design similar to that being used in some CATV applications.

This 31·6 km prototype repeater section has been used for studies of transmission at rates higher than 140 Mbit/s (1980 telephone channels). Operation at 565 Mbit/s (7680 telephone channels per fibre) has been successfully demonstrated.

In summary, the 30 km repeater spacing objective for production systems for the land network in the mid-1980s is seen to be readily achievable given good production control. Such systems should also be readily upgradeable to the next higher capacity level (7680 channels). In the market for undersea systems, great scope exists for exploiting even longer repeater spacings, which will lead to more cost-effective equipment and the possibility of unrepeatered links between islands or the UK and Europe.

# The Relationship Between Traffic and Grade of Service

C. B. MILNE, B.A., M.SC.†

## INTRODUCTION

The present procedures for detecting congestion are based on certain fundamental assumptions about the behaviour of telephone traffic. For example, it is assumed that customers make calls during a busy hour at random moments, with no knowledge of each other's actions; and the holding times of different calls are assumed not to influence each other.

In practice, these assumptions may or may not be valid. If they are valid, at any rate approximately, then the predictions of a mathematical theory derived logically from these assumptions will also hold true. A cornerstone of this mathematical theory (known as *teletraffic theory*) is Erlang's well-known loss formula*, which gives the probability of a call being lost through congestion when random traffic is offered to a full-availability group of circuits. Many of the traffic-capacity tables in use at present were calculated by using Erlang's loss formula and related formulae. The purpose of this article is to draw attention to some features of the behaviour of overflows which are predicted by Erlang's loss formula.

This article only considers what happens during a single busy hour, when Erlang's loss formula will usually give a good description of the expected behaviour of overflows from a full-availability group. The extension of these ideas to a collection of several busy hours (which is needed when, for example, overflow meters are read weekly) is beyond the scope of this article.

## EFFICIENCY OF FULL-AVAILABILITY GROUPS

Large full-availability circuit groups are more efficient than small ones in that, for any particular grade of service, more traffic per circuit can be offered to (and carried by) a large circuit group than a small one. Fig. 1 shows the relationship between traffic offered and the grade of service calculated from Erlang's loss formula, for various sizes of circuit group. It is worthwhile to point out certain features:

(*a*) *Small Circuit Groups* Small groups of circuits are extremely inefficient, especially when provided to good grades of service. This is the situation that tends to arise, for example, with international call-timer groups, where common sense may rebel against a group of 5 circuits being declared congested when carrying less than one erlang of traffic altogether.

(*b*) *Large Circuit Groups* A large circuit group may be heavily loaded while still giving a perfectly acceptable grade of service. However, the greater efficiency of large groups of circuits comes with the proviso that they are also more vulnerable to overload. A small percentage increase in the traffic offered can cause a large degradation in the grade of service of the group.

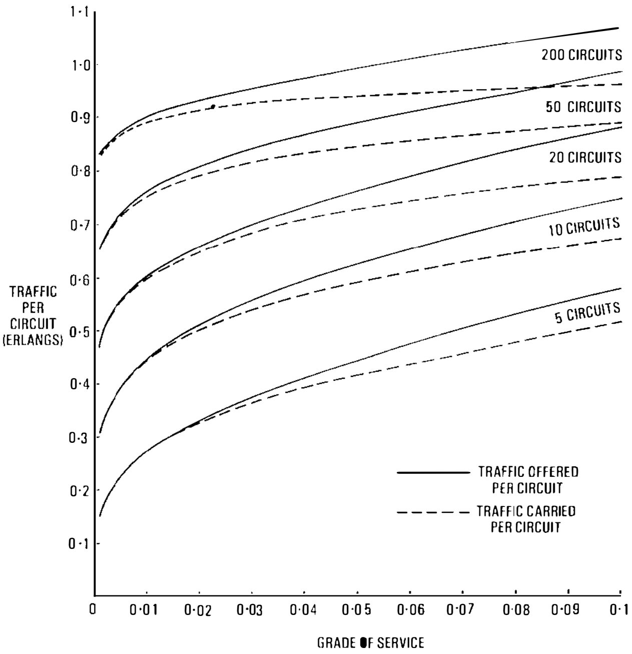



FIG. 1—Relationship between traffic offered and grade of service for a full-availability circuit group

## PERFORMANCE OF CIRCUIT GROUPS UNDER TRAFFIC OVERLOAD

Table 1 shows more fully the effect of an increase in the underlying mean traffic offered to a full-availability group of circuits. The table shows the factor by which the grade of service will be increased when there is a 10% or 20% increase in the traffic offered. These figures (10% and 20%) have been chosen because they are often used when the overload performance of circuit groups is specified. Two criteria that are

**TABLE 1**

**Degradation in Grade of Service caused by 10% and 20% Traffic Overloads**

| *N* | 5 | | 10 | | 20 | | 50 | | 100 | | 200 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Overload / E(*N*, *A*) | 10% | 20% | 10% | 20% | 10% | 20% | 10% | 20% | 10% | 20% | 10% | 20% |
| 0·001 | 1 | 2 | 2 | 3 | 3 | 6 | 5 | 14* | 8 | 28* | 13* | 51* |
| 0·002 | 1 | 2 | 2 | 3 | 2 | 5 | 4 | 11* | 6 | 20* | 10* | 32* |
| 0·005 | 1 | 2 | 2 | 3 | 2 | 4 | 3 | 8 | 5 | 12* | 7 | 17* |
| 0·01 | 1 | 2 | 2 | 3 | 2 | 4 | 3 | 6 | 4 | 8 | 5 | 10* |
| 0·02 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 4 | 3 | 5 | 3 | 7 |
| 0·05 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 4 |

* Serious congestion (degradation factor of 10 or more)

† South Western Telecommunications Board Headquarters

* Erlang's loss formula is:

$$E(N, A) = \frac{\dfrac{A^N}{N!}}{\displaystyle\sum_{i=0}^{N} \frac{A^i}{i!}},$$

where E($N$, $A$) is the grade of service on a full-availability group of $N$ circuits when offered $A$ erlangs of random traffic.

The carried traffic is the offered traffic minus the lost traffic, and is therefore given by $A\{1 - E(N, A)\}$.

often used are that the grade of service of groups with such a 10% and 20% overload shall not be worse than 2·5 and 6·25 times, respectively, the worst grade of service permitted at normal loads. From Table 1 it can be seen that these criteria can affect the number of circuits provided only for large circuit groups designed to good grades of service. However, in looking at a table of this kind, it is important to remember that traffic levels on small groups are much more volatile than those on large groups. The probability of a 20% overload occurring through chance variation on a group of 100 circuits is, in fact, rather small, while such an overload would be commonplace on a group of 5 circuits. However, overloads attributable to a changed growth rate may occur on any size of group.

The term *serious congestion* is sometimes used to refer to the condition when overflows reach 10 times their critical value. For simplicity, this will be regarded as equivalent to a tenfold degradation of the grade of service, which is approximately true. (To be accurate, the number of overflows increases with the traffic as well as the grade of service, but the first factor is always much less significant than the second.).

It is apparent from Table 1 that the percentage traffic overload needed to reach a state of serious congestion also varies according to the size of the group and the grade of service. Table 2 shows the approximate percentage traffic overload which it takes to reach serious congestion. This also shows that small groups, at relatively poor grades of service, are actually rather stable under overload. For example, it takes a 68% increase in traffic to drive a group of 10 circuits at a grade of service of 0·01 as far as serious congestion. This sort of overload will rarely occur through chance variation in traffic; it is more likely to be the result of unforeseen high growth.

## PERFORMANCE OF CIRCUIT GROUPS WITH CIRCUIT DEFICIENCIES

In fact, of course, it is known that most cases of serious congestion occur not through massive unforeseen traffic overload, but through failure to provide circuits to known requirements. Table 3 shows the factor by which the grade of service increases when a group is lacking 10% or 20% of its proper quota of circuits.

As expected, the general appearance of this table is similar to that of Table 1, which shows the effects of 10% and 20% traffic overloads. The groups with serious congestion (indicated by asterisks) are again clustered in the upper right-hand corner of the table, where large groups of circuits are provided to good grades of service. Each individual entry in the table is greater than the corresponding entry in Table 1. This is in part a consequence of the greater efficiency of larger circuit groups. For example, a 10% deficiency in circuits creates a smaller circuit group, and, therefore, must cause worse congestion than a 10% traffic overload.

The lower left-hand portions of Tables 1 and 3 show the comparative stability of smaller circuit groups at poorer grades of service. But though service may degrade by a factor of only 2 at (say) 20% overload on a group of 10 circuits at a grade of service of 0·05, the grade of service that then results is 0·1, which is an extremely poor level. Of course, the actual grade of service will always be better on a larger circuit group offered any given traffic, even if the degradation against planned grade of service is far worse.

Conversely, congestion may not cause great concern on groups planned for very good grades of service where, despite a sizeable degradation, the actual grade of service given is still good. It must be borne in mind, however, that any given switching stage may be only one out of many involved in a complete connection. For the overall grade of service (which is what the customer experiences) to remain acceptable, each contributory stage should conform to the standards planned for it.

**TABLE 2**

**Percentage Traffic Overload causing 10-fold Degradation in Grade of Service**

| E(N, A) \ N | 5 | 10 | 20 | 50 | 100 | 200 |
|---|---|---|---|---|---|---|
| 0·001 | 79 | 44 | 28 | 17 | 12 | 9 |
| 0·002 | 84 | 48 | 31 | 19 | 14 | 10 |
| 0·005 | 96 | 57 | 37 | 24 | 18 | 14 |
| 0·01 | 112 | 68 | 46 | 31 | 24 | 19 |
| 0·02 | 142 | 90 | 64 | 45 | 37 | 32 |

**TABLE 3**

**Degradation in Grade of Service caused by 10% and 20% Circuit Deficiencies**

| N planned | | 5 | 10 | | 20 | | 50 | | 100 | | 200 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Deficiency | | 20% | 10% | 20% | 10% | 20% | 10% | 20% | 10% | 20% | 10% | 20% |
| N actual | | 4 | 9 | 8 | 18 | 16 | 45 | 40 | 90 | 80 | 180 | 160 |
| E(N, A) | 0·001 | 7 | 3 | 9 | 4 | 15* | 7 | 31* | 11* | 53* | 19* | 82* |
| | 0·002 | 6 | 3 | 8 | 4 | 12* | 6 | 21* | 9 | 33* | 13* | 48* |
| | 0·005 | 4 | 3 | 6 | 3 | 8 | 4 | 13* | 6 | 18* | 8 | 24* |
| | 0·01 | 4 | 2 | 5 | 3 | 6 | 4 | 9 | 4 | 11* | 6 | 14* |
| | 0·02 | 3 | 2 | 4 | 2 | 5 | 3 | 6 | 3 | 7 | 4 | 8 |
| | 0·05 | 2 | 2 | 3 | 2 | 3 | 2 | 4 | 2 | 4 | 2 | 4 |

* Serious congestion

## RECOVERY FROM SERIOUS CONGESTION

Finally, suppose that through some combination of traffic overload and circuit deficiency a state of serious congestion has been reached. Table 4 gives an indication of how many circuits are required to restore service to the planned level. As expected, more circuits are needed on larger groups, and at the worst grades of service. The number of circuits needed, expressed as a percentage of the existing number, falls as the size of the group increases (for a given grade of service). Again, this is a consequence of the greater efficiency of large groups. For example, 4 circuits (or 40%) must be added to a group of 10 circuits to restore a 0·005 grade of service from serious congestion, but 16 (or only 16%) must be added to a group of 100 circuits.

**TABLE 4**

**Number of Circuits needed to Restore Service from a State of Serious Congestion**

| *E(N, A) \ N | 5 | 10 | 20 | 50 | 100 | 200 |
|---|---|---|---|---|---|---|
| 0·001 | 2 | 3 | 4 | 7 | 10 | 16 |
| 0·002 | 2 | 3 | 5 | 8 | 12 | 19 |
| 0·005 | 3 | 4 | 6 | 10 | 16 | 26 |
| 0·01 | 3 | 5 | 7 | 13 | 22 | 36 |
| 0·02 | 4 | 6 | 10 | 20 | 34 | 60 |

*Planned grade of service

## CONCLUSION

In reality, the behaviour of telephone traffic is always more complicated and more difficult to deal with than any theory of it. Customers will behave differently when routes are congested; traffic levels will vary without apparent reason; measuring equipment and procedures are all fallible. However, consideration of the simple underlying theory is still useful as one strand in understanding the behaviour of overflows.

# Lightning Damage to Coaxial Cables

M. DOHERTY†

In the early-1970s, it was decided to install a new coaxial cable on the Manchester–Birmingham and Birmingham–High Wycombe–London routes, with a spur from High Wycombe to Reading. The new 18-coaxial-pair cable, the largest coaxial cable in the country, was designed to carry nine 60 MHz transmission systems each with a capacity of 10 800 circuits on 2 coaxial pairs.

In 1974–75, 6 km of this 18-coaxial-pair 2·6/9·5 mm lead-sheathed polyethylene-protected cable was laid alongside a main road between High Wycombe and Reading, and used as a pilot scheme to give the contractors some handling and jointing experience before they installed cable on the remainder of the routes. After trials had been carried out successfully, the cable was left in the ground until it was required for the High Wycombe–Reading section of the London–Birmingham 60 MHz system. In October 1976, before the remainder of the High Wycombe–Reading system was cabled, this cable was retested and 4 coaxial pairs were found to be short circuited and to have low insulation resistance due to water penetration. Measurements were carried out and the fault was localised to a point which was 24 m from a joint and just beside a newly erected road sign; at first mechanical damage was suspected.

A split was found in the bottom of the polyvinyl-chloride (PVC) duct at this point, but there was no other external damage. However, a circular hole and severe indentation was found in the sheath (see Fig. 1), just as though a spike had been driven into the cable, but the hole was in the bottom of the cable as it lay in the duct. Inside the polyethylene protection there were signs of the vapourisation of the bitumen coating between the polyethylene and the lead sheath, which suggested that lightning had been the cause of the damage. There was only very slight evidence of electrical burning on the damaged coaxial pairs, but 4 pairs were completely flattened and a further 4 pairs were dented (see Fig. 2). The hole in the sheath had enabled water to enter the cable core but a complete repair was effected by the replacement of 25 m of cable back to the nearest joint. A new manhole was built at the fault joint.

In the latter part of 1980, during routine tests on spare coaxial pairs in the Birmingham–Manchester section of the cable, one coaxial pair was found to be short circuited between Manchester and Burbage. Preliminary tests indicated that the fault was in an extremely exposed and isolated section of the route. However, as there was no air loss from the pressurised cable, the detailed location and clearing of the fault was deferred until reasonable weather conditions were expected.

Further tests were carried out in May 1981 over the 1·5 km between amplifier access points (APs), and these indicated that the location of the fault was 256 m away from one AP. To increase the accuracy of location, the joint at a point 349 m from the AP was opened and the tests were repeated; these gave a new fault location at a point 252·8 m from the AP and 96·2 m from the joint.

At this position a hole was found in the duct but, as no piece fitting the hole was found, it was assumed that the duct had been damaged before it was laid. There was no evidence of physical damage to the exposed cable within the excavation. A section of protection and lead sheath was removed but no sign of any damage to the cable core was found. A spare coaxial pair was crushed and the location of

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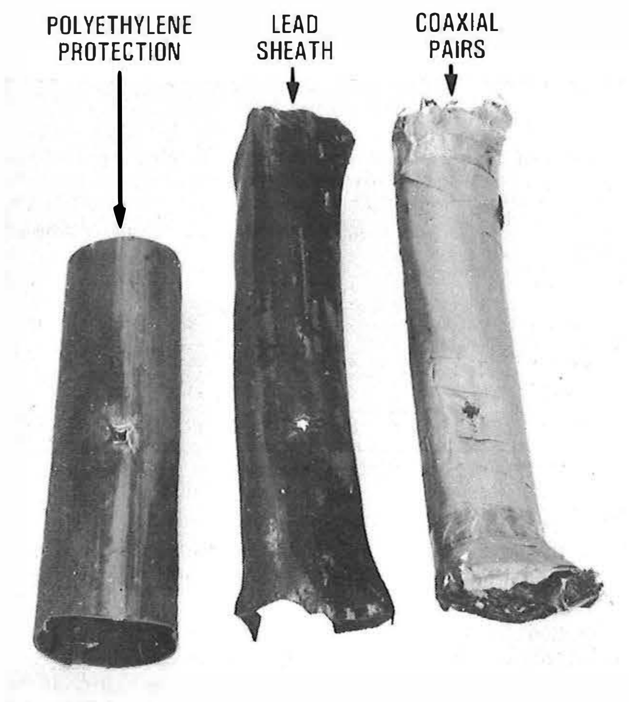


FIG. 1—Lightning damage to a coaxial cable

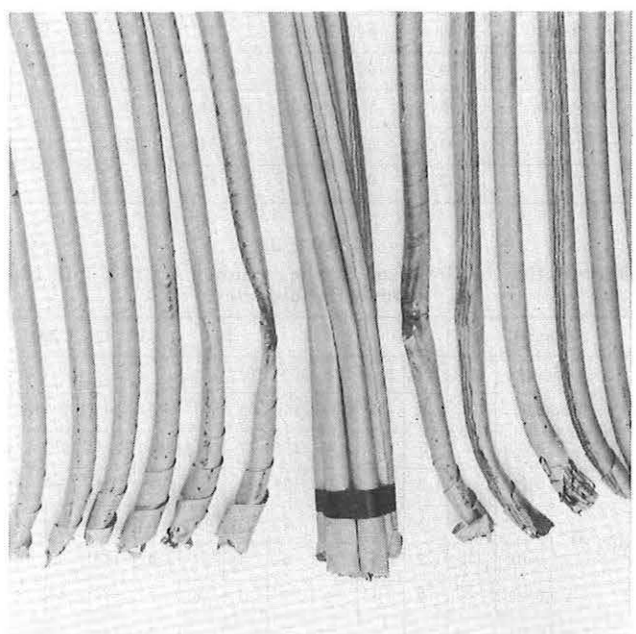

FIG. 2—Damage to coaxial pairs

this damage observed on the trace of a pulse-echo tester. Comparison with similar tests carried out on the original faulty coaxial pair indicated that the actual position of the fault was some 0·5 m away. The polyethylene protection at this new point was removed, and the familiar denting of the sheath and evidence of the vapourisation of the bitumen coating was found. On this occasion, however, the sheath was not punctured. Again a new manhole was built to enclose the repaired joint.

The fault was undoubtedly caused by lightning but, as it had only affected a spare coaxial pair, it was not possible to determine when the fault actually occurred. It is, however, interesting to note that severe thunderstorms in the North-West of England affected service at 2 TXE4 exchanges in the Manchester director area: Woodley exchange in Manchester South Telephone Area on 5 June 1980 and Broughton exchange in Manchester North Telephone Area on 25 June 1980. The question was whether either of these 2 storms could have caused the damage to the coaxial cable.

Because of the limited amount of damage that had been caused, it appeared that in neither of these cases had the cables been directly struck by lightning. A probable cause of the faults is that the lightning had grounded in the vicinity of the cable and had raised the local earth potential to a very high level. The cable sheath was well insulated from the local earth by the polyethylene protection and the PVC duct, but it was connected to earth at each AP. Hence there would have been for an instant, a very high potential difference between the cable sheath and the local earth in the vicinity of the lightning strike, and when this difference was high enough (30–50 kV) the polyethylene would have broken down and a spark would have flashed between the sheath and earth. It is significant that there was evidence of duct damage at the fault point in both cases. The spark would have vapourised the bitumen and, as in one case, part of the lead sheath, and would have caused a small explosion. The expanding gases trapped under the polyethylene protection would have forced the cable sheath inwards and collapsed the coaxial pairs immediately underneath.

These incidents show that the forces of nature can undoubtably play havoc with the designs of man, but they also raise the question of whether the bitumen coating provided as a seal between the lead sheath and the polyethylene protection was a contributory factor in extending the lightning damage.

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# British Telecom Press Notices

## X-STREAM CAPTURES THE CUSTOMERS

Preliminary orders worth £750 000 a year in rental charges have already been received for the advanced new digital communication services that British Telecom (BT) is launching this year as part of its contribution to the promotion of information technology in the UK.

The new services, to be marketed under the general title of *X-stream*, are being made possible by the steady spread of digital transmission through Britain's cable, microwave and optical-fibre network. The new services are known as *Megastream*, *Kilostream*, *Switchstream*, and *Satstream*.

Digital transmission offers many advantages; for example, improved speech quality, savings on the cost of equipment and greater flexibility in the use of the network. It is of special benefit to business customers, because it makes it easier to combine a variety of services, such as vision, music, high-speed data, graphics and facsimile as well as speech, for transmission over the same cable, microwave or optical-fibre carrier. Initially, the X-stream services will consist of digital private circuits. The first being offered is Megastream, which will transmit at 2 or 8 Mbit/s.

A basic form of Megastream is already working on the special London overlay network which started in September 1981 with the connection of Chase Manhattan Bank. The overlay uses 2 Mbit/s links capable of carrying 30 telephone conversations simultaneously. Customers can rent a full 2 Mbit/s carrier, or part of it comprising a group of 6 telephone channels. This latter facility will form part of the national Kilostream service described below.

About 30 orders for the basic 2 Mbit/s service are now being processed. Customers, which include banks, finance houses and industrial firms, will start to be connected very soon; and many other firm enquiries are being processed.

Megastream 2, the 2 Mbit/s service, can be linked directly to modern digital office telephone switchboards. BT's own such unit, the Monarch 120, will soon have this capability.

By the end of this year Kilostream will be added; it will offer digital services at 2·4, 4·8, 9·6, 48 and 64 kbit/s on a special private circuit network.

The Kilostream network will interlink the London overlay, which covers 45 exchanges in the capital, with 30 towns and cities in the rest of Britain; it will be extended to cover nearly 200 business centres by 1985. New multiplexing equipment will combine up to 31 individual Kilostream services into a single stream, which can then be sent over a 2 Mbit/s link. At the far end, other multiplexors will work in reverse to unscramble the 2 Mbit/s stream and recover the individual Kilostream services.

In late 1983, the Kilostream and Megastream private-circuit services will be augmented by a pilot digital-switched service, Switchstream, which will give users much greater flexibility in digital communications. It will combine digital transmission links with the System X digital telephone exchange to create an integrated-services digital network. The pilot Switchstream, with capacity for about 250 business customers, will be based on the large local System X exchange in Baynard House in the City of London.

BT will also be starting, in late 1983, a fourth digital service, Satstream, which will use small-dish terminals beamed to the European communications satellite; it will be offered for private business communication across Europe.

## NEW LINK-UP BETWEEN PRESTEL AND GEC COMPUTERS LTD.

Since British Telecom (BT) launched the Prestel pilot trial in the UK in 1976 and sold its first overseas system in 1977, world interest in viewdata has increased. Public videotex services or trials are currently in operation in 16 countries, and 7 of them are being supplied by GEC Computers Ltd. (CL) computers and BT software. Systems compatible with Prestel are now in operation in more than 20 countries.

In addition to sales of BT software and GEC CL computers, many British manufacturers of private videotex systems are benefiting from the growth in this sunrise industry. Prestel terminals are now available from more than 50 companies, and 700 independent companies are currently contributing data to Prestel.

In the new climate of competitive telecommunications introduced by the passing of the British Telecommunications Act, BT has decided that as from the beginning of this year the software for Prestel will be marketed throughout the world by GEC CL with the full support of BT. This agreement applies to the sales of private and public videotex systems using a combination of GEC CL hardware and Prestel software and to their enhancements, which will normally be introduced into the UK service first.

# Repair of Duct Line after Road Collapse

J. MOORHOUSE†

At 16.00 hours on Friday 20 November 1981, a telephone call was received in the Manchester South Telephone Area External Plant Maintenance Centre from a local authority contractor who was installing a new sewer pipe. The message indicated that a hole, approximately 0·6 m in diameter, had appeared in the carriageway of a road in Stockport, Cheshire, and that a British Telecom (BT) duct line could be seen.

A plant protection officer was sent to investigate, but shortly after his arrival at the site another hole appeared a short distance away and the road surface in the immediate area became unstable. At approximately 16.45 hours, the road surface collapsed into a crater some 3·7 m deep and 9·2 m in diameter, and a BT duct line, which was comprised of a 6- and 9-way multiple duct, was left without any means of support other than the cables inside them. The duct line carried main underground coaxial cables to the Midlands, a good proportion of the junction links into and out of Stockport, and approximately 7000 main distribution pairs feeding the north side of the exchange area. The situation had all the ingredients for a major breakdown.

At this stage, the local authority contractor refused BT access to the exposed plant because of 2 very obvious dangers:

(*a*) water was still coursing through the cavity because of the total collapse of the existing sewer, and

(*b*) the collapse had left an overhang of road surface material of approximately 2·4 m over the duct line and this was in danger of falling into the cavity.

The first priority was to over pump the section to allow it to dry out and to prevent further ground erosion. This work was carried out overnight and additional pumping equipment had to be brought onto the site. By mid-morning on Saturday 21 November, BT was in a position to be able to provide some temporary support for the duct line from underneath (see Fig. 1). This had to be done as effectively and as quickly as possible because of the continuing threat from the overhang, which was being held up only by a bridge formed from the concrete used as back-fill when the duct line had been installed. Where duct collars had broken, cables were inspected and they appeared to be undamaged. Neither pressure faults nor electrical faults were reported and so it seemed that the immediate danger was over.

The next step, as far as BT was concerned, was to transfer the temporary support of the duct line, from underneath, to a pole bridge set up above the cavity, in case heavy rain returned and the water flow through the cavity outstripped the over-pumping capacity. To achieve this, the road surface overhang had to be knocked down to allow slings to be placed under the duct and around the pole bridge.

FIG. 1—Initial support given to the duct line

On Sunday 22 November 1981, after the duct line was suitably protected, the overhang was demolished without any further damage to the duct line being incurred. On Monday 23 November, a pole bridge, comprising two 11 m poles battened together, was placed in position and the duct-line support transferred.

The permanent restoration of the duct line then had to be considered. A method of repair which used longitudinally cut Duct No. 54D and Strips, Duct No. 54D, described in an earlier issue of this *Journal**, was chosen. With the exception of the duct carrying the largest cable (approximately 76 mm in diameter), repairs were carried out in the recommended way. The duct carrying the 76 mm diameter cable was repaired by using the Duct No. 54D in 3 sections to enable the duct to be passed around the cable.

The local authority's contractor provided a stable bed for the duct line to rest on by filling the cavity with a lean mix concrete to within 200 mm of the underside of the duct line. The BT contractor then filled the remaining space with quality F concrete and this was allowed to harden. The spare bores of the duct line were satisfactorily test rodded, the support slings cut away, and the duct line was encased in concrete with reinforcement bars in box formation placed at 1·5 m intervals.

† Manchester South Telephone Area.

* PARSELL D. F., and MILLS, T. E. Fitting PVC Ducts on In-situ Cables. *Post Off. Electr. Eng. J.*, July 1978, 71, p. 130.

# Institution of British Telecommunications Engineers

*(formerly Institution of Post Office Electrical Engineers)*

General Secretary: Mr. R. E. Farr, BTHQ/TE/SES5.3, Room 458, 207 Old Street, London EC1V 9PS; Telephone 01-739 3464 Extn. 7223

(Membership and other local enquiries should be directed to the appropriate Local-Centre Secretary as listed in the October 1981 issue of the Post Office Electrical Engineers' Journal)

## AMENDMENTS TO THE RULES OF THE INSTITUTION

Council has agreed the following amendments to the Rules of the Institution. These amendments, certified by the Chairman of Council as not affecting the intended operation of the Rules in accordance with Rule 33, put into effect the change of title of the Institution and introduce some minor editorial and administrative changes. The amendments became effective on 1 April 1982.

*Rule 1* Amend to read:
"The name of the Institution (formerly known as the Institution of Post Office Electrical Engineers) is 'The Institution of British Telecommunications Engineers' ".

*Rule 2* Amend the first paragraph to read:
"The objects for which the Institution is established are to promote the general advance of engineering in the British Telecommunications Corporation, its Subsidiaries and the Post Office . . .".

Amend paragraph (d) to read:
"Control the publication of British Telecommunications Engineering, hereafter referred to as the 'Institution's Journal' or the 'Journal' ".

Amend paragraph (g) as follows:
"IPOEE" to read "Institution", and delete all after "character".

*Rule 15* In the second paragraph delete "POEE".

*Rule 32* Amend last sentence to read:
"A copy of the Annual Report shall be forwarded to the Chairmen of the British Telecommunications Corporation and Post Office Boards".

*Rule 37* Delete "POEE" (first 2 appearances in first paragraph and only appearance in second paragraph) and substitute "Institution's". Delete "POEE" (third appearance in first paragraph) and substitute "said".

*Rule 47* Delete "in Post Office Headquarters, or elsewhere".

*Rule 48* Amend to read:
"The sessions of the Institution shall . . . terminate no later than the end of May in the following year. . . ."

*Rule 50* Amend to read:
"The Annual General Meeting of the Institution shall be held in conjunction with a meeting of the London Centre not earlier than the last week in April nor later than the last week in May. . . ."

## INSTITUTION AWARDS

The Institution's Rules stipulate that medals shall only be awarded on the basis of an adjudication of the printed papers, associated with lectures presented at Institution meetings, which are recommended by Local-Centre Committees for consideration. For the second year in succession a lack of such papers has meant that no medals can be awarded. Council is considering alternative proposals for the future award of medals.

## INSTITUTION TIES

There is no intention to change the design of Institution ties, which are still available at £2·40 each, while present stocks last. There are 2 patterns, both bearing the Institution's logo: green with narrow red diagonal stripes, or plain blue. The ties may be obtained from Local-Centre Secretaries or direct from Mr. J. E. Short, BTHQ/SO3.1.2, Room 601B, 90–91 Wood Street, London EC2V 7JS, telephone 01-432 4904. Cheques should be made payable to "IBTE".

## RETIRED MEMBERS

The following members have retained their membership of the Institution under Rules 11(a) and 13:

| | |
|---|---|
| J. E. Adams | "Joladima", Crockford Road, West Grinstead, Sussex |
| M. Allchin | "Liechtenstein", New Road, Wonersh, Guildford GU5 0SF |
| M. E. Allwood | 87 Fairwater Road, Llandaff, Cardiff CF5 2LG |
| G. K. P. Ayrton | 28 Craigmount Loan, Edinburgh EH12 8DJ |
| W. R. Bartlett | 31 Church Road, Brandon, Suffolk IP27 0JB |
| M. W. Bayley | 11 Church Road, Whitchurch, Cardiff CF4 2DX |
| H. S. Beddus | 27 Duncan Road, Sheffield S10 1SN |
| N. Bell | 8 Hoblands End, Chislehurst, Kent BR7 6HH |
| R. J. Boggis | 44 Pickhurst Rise, West Wickham, Kent BR4 0AL |
| J. L. Bridgwood | 46 Rolwood Lane, Macclesfield, Cheshire |
| E. Broadbent | 1 Appledore Close, Bromley, Kent |
| K. H. Cave | 14 Upper Church Park, Mumbles, Swansea SA3 4DD |
| R. Clark | 77 St. Austell Drive, Wilford, Nottingham NG11 7BT |
| W. C. J. Claydon | 26 Wivenhoe Road, Alresford, Colchester CO7 8AD |
| A. A. Clift | 1 Byepass Road, Chilwell, Beeston, Nottingham NG9 5BN |
| D. W. R. Cobbe | 18 Olivia Drive, Leigh-on-Sea, Essex SS9 3EG |
| R. F. Coleman | 24 Pencisely Rise, Llandaff, Cardiff CF5 1DX |
| F. B. Corner | 169 Elgar Avenue, Surbiton, Surrey KT5 9JX |
| J. W. Cowley | 39 Sandygate Park Road, Sheffield S10 5TX |
| A. J. Davies | 3 Howard Avenue, Lymm, Cheshire WA13 9EQ |
| D. H. Davies | 67 Darley Avenue, Manchester M21 2GP |
| W. Davies | 101 Conway Road, Knypersley, Stoke-on-Trent |
| E. Davis | 36 Marlings Park Avenue, Chislehurst, Kent BR7 6QW |
| D. G. Earle | 27 The Grove, Hipperholme, Halifax, West Yorkshire HX3 8JN |
| D. G. Elliott | 23 Paddock Heights, Twyford, Reading, Berkshire RG10 9DP |
| J. Farrand | 228 Rocky Lane, Perry Barr, Birmingham B42 1QX |
| J. E. Felgate | 31 Melbourne Road, Ipswich, Suffolk |
| H. W. Fensom | 8 Springfield Avenue, Felixstowe, Suffolk IP11 9JZ |
| J. Foster | 60 Hillbury Avenue, Kenton, Harrow, Middlesex HA3 8EW |
| S. A. Foulkes | "Lorelei", Tiddington, Oxford OX9 2LQ |
| J. A. T. French | 39 Oundle Avenue, Bushey, Watford WD2 3QG |
| J. H. Glanville | 40 Lesser Foxholes, Shoreham-by-Sea, West Sussex BN4 5NT |
| G. J. Gough | 15 Browns Coppice Avenue, Solihull, West Midlands B91 1PL |
| L. Hadkiss | 12 Kensington Close, Toton, Beeston, Nottingham |
| E. J. Harris | 60 Hill View, Henleaze, Bristol BS9 4PX |

| | |
|---|---|
| A. D. Hastings | 4 Barnfield Road, St. Albans, Hertfordshire AL4 9UG |
| J. A. Hayward | 463 Coxford Road, Lordswood, Southampton |
| B. Henshall | 8 Mendip Road, Stourbridge, West Midlands |
| J. D. Hitchcock | 80 Corringway, Ealing, London W5 3AD |
| R. Hough | 93 Glanfield Road, Beckenham, Kent BR3 3JT |
| D. A. Huckle | 1 Heathfield, Bedford, MK41 8EY |
| A. V. Hughes | 330 Hempstead Road, Watford, Hertfordshire WD1 3NA |
| D. R. Hunt | 20 Langdon Road, Bromley, Kent BR2 9JS |
| F. G. Jackson | 33 Abbots Close, Shenfield, Brentwood, Essex CM15 8LT |
| R. T. Jenks | 48 Campbell Road, Market Drayton, Shropshire TF9 1QZ |
| O. W. Kendall | Teats Hill House, Parr Street, Coxside, Plymouth PL4 0LA |
| E. Lancaster | 27 Wesley Place, St. Ives, Cornwall |
| J. E. Little | "The Pantiles", Uffington, Oxfordshire, SN7 7RY |
| R. A. Llewellyn | 10 Chelston Avenue, Hove, Sussex BN3 5SR |
| H. W. N. Long | 24 Priory Court Road, Westbury-on-Trym, Bristol |
| A. A. Mills | 8 Waverney Grove, Clayton, Newcastle-Under-Lyme ST5 3PN |
| R. G. Morris | 34 Grange Road, Dorridge, West Midlands B93 8QS |
| W. W. Neil | 2 Old Rectory, The Street, Fetcham, Leatherhead, Surrey TT22 9QT |
| T. Nicholson | 17 Dennis Lane, Stanmore, Middlesex HA7 4JR |
| J. E. Officer | 58 High Elm Road, Halebarns, Altrincham |
| A. Paget | 9 Eddisbury, Sydenham Hill, London SE26 6TZ |
| T. J. L. Painter | 10 Eden Avenue, Uplands, Swansea SA2 0PS |
| G. F. Parker | 37 Beverley Road, Swinton, Manchester M27 1HZ |
| F. N. Parkinson | 9 Eden Road, Walthamstow, London E17 9JS |
| G. Parry | 11 Holt Coppice, Aughton, Ormskirk, Lancashire L39 6SD |
| L. R. Porter | 33 Sutherland Crescent, Blythe Bridge, Stoke-on-Trent ST11 9JT |
| W. A. R. Ramsey | 193 Newbridge Road, Bath, Avon BA1 3HH |
| J. H. G. Rees | "Goodwood", 485 Hendrefoilem Road, Killay, Swansea SA2 7NU |
| C. J. Roberts | 14 Whitby Crescent, Crownhill, Plymouth PL6 5LD |
| G. H. Rouse | 15 Wentworth Close, Menston, Ilkley, West Yorkshire |
| S. Shaw | 7 Hilbert Close, Ferndale, Tunbridge Wells, Kent TN2 3SN |
| D. H. Sparrow | 2 Mushroom Field, Kingston, Lewes, East Sussex BN7 3LE |
| H. J. Spencer | 1 Oaklands Close, Ascot, Berkshire SL5 7NG |
| K. E. Spurlock | 24 Llyswen Road, Cyncoed, Cardiff CF2 6NH |
| P. E. Starkey | 50 Summerfield Avenue, Whitstable, Kent CT5 1NS |
| J. A. Stevens | 54 Broadhurst, Ashtead, Surrey KT21 1QF |
| C. Tame | 10 Orchard Court, Butley, Southampton SO3 2DX |
| R. C. Taylor | 117 Queens Park Road, Heywood OL10 4JR |
| R. J. Teunion | 13 Wilmot Way, Banstead, Surrey SM7 2PZ |
| J. F. P. Thomas | 24 Shepherds Way, Rickmansworth, Hertfordshire |
| M. G. Thomas | 89 Frampton Road, Corseinion, Swansea |
| N. M. Thomas | 518 Chepstow Road, Newport, Gwent NP1 9DA |
| W. E. Thomson | "Woodhaven", Leiston Road, Aldeburgh, Suffolk, IP15 5PX |
| H. Tompkins | 3 Wellhouse Avenue, Leeds LS8 4BY |
| A. S. Turner | 56 Tranby Gardens, Wollaton, Nottingham NG8 2AB |
| T. F. A. Urben | 219 Cleveson Road, Tickenham, Clevedon, Avon BS21 6RX |
| R. L. Uren | "Trevaylor", Palace Road, St. Austell PL25 4BP |
| P. H. Wade | 17 Park Avenue, Shelley, Huddersfield HD8 8JG |
| H. E. Westaway | 233 Springbank Road, London SE13 6ST |
| J. B. Williams | 12 Creek End, Emsworth, Hampshire PO10 7EX |
| P. L. R. Wiltshire | 21 Greenways, Southampton SO2 2NY |
| G. Wilson | 9 Wayland Avenue, Ward Green, Barnsley S70 5HY |
| B. V. S. H. Wood | 62 King George V Drive, The Heath, Cardiff CF4 4EF |
| R. L. Woodhams | 13 Henre Gardens, Llandaff, Cardiff |
| B. F. Yeo | "The Beeches", Brick Kiln Lane, Great Horkesley, Colchester, Essex CO6 4EZ |

Members about to retire are reminded that they, too, may secure life membership of the Institution at a once-and-for-all cost of only £3·50 (under the Rule-change proposals put to the Membership in February it was proposed to increase this fee to £8·00 from 1 July 1982). Retired members cannot be included in the circulation of technical periodicals but, apart from this, they may continue to enjoy all the facilities provided by the Institution, including a free copy of *British Telecommunications Engineering* posted to their home address.

Enquiries should be directed to the appropriate Local-Centre Secretary; members living in, or moving to, an area served by a different Centre from that to which they currently belong may find it more convenient to arrange a transfer to the new Centre's membership list before retirement in order to ensure advice of local activities.

## THE FEDERATION OF TELECOMMUNICATIONS ENGINEERS OF THE EUROPEAN COMMUNITY (FITCE)

The subscription for membership of the FITCE Group of the Institution for 1982/83 has been fixed at £5·00 for both existing and new members. Existing members are being contacted individually.

The 1982 Congress and General Assembly will be held at Bordeaux, France, during 5–11 September. Details will be supplied to members in due course.

R. E. FARR
*Secretary*

# THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

*(formerly The Institution of Post Office Electrical Engineers)*

## SUITABLY QUALIFIED CORPORATE MEMBERS

**of**

## THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

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## MEMBERSHIP

**of**

## THE FEDERATION OF TELECOMMUNICATIONS ENGINEERS OF THE EUROPEAN COMMUNITY (FITCE)

FITCE is an organization with similar objects to IBTE and draws its members from the public telecommunications administrations of Belgium, Denmark, Eire, France, Italy, Luxembourg, the Netherlands, the UK and West Germany. Greece and Spain are negotiating affiliation. FITCE publishes a quarterly Journal from its Brussels headquarters, sponsors multi-national study groups (Commissions) to enquire into and report on problems of general interest, and each year organizes a General Assembly/Congress in one of the member countries at which members are invited to present papers.

Full membership of FITCE in the UK is available only through IBTE. Members and Affiliated Members of IBTE who hold a University science degree or who are Chartered Engineers may join through the FITCE Group of IBTE. The annual subscription for 1982/83 has been fixed at £5·00; this covers local administration expenses as well as the per-capita contribution to FITCE funds, and thus ensures that no charge proper to FITCE affairs will fall upon the general membership of IBTE. Membership forms are available from your Local-Centre Secretary (see p. 304 of the October 1981 issue of this Journal) or direct from the General Secretary.

**THIS IS YOUR OPPORTUNITY TO PLAY AN ACTIVE PART IN CO-OPERATION WITH TELECOMMUNICATIONS ENGINEERS FROM OTHER EUROPEAN COUNTRIES**

# British Telecommunications Engineering

## REPRINTS OF

# System X

## ARTICLES

The 26 articles on System X which appeared in the *Journal* between January 1979 and April 1981 have been reprinted as a single 160-page book.

(*a*) The concepts of System X and its use in the UK telecommunications network.
(*b*) The principles of the system, including aspects related to digital switching, common-channel signalling, and processor control.
(*c*) The individual subsystems.
(*d*) The hardware and software.
(*e*) The design and support of modern switching systems.

The articles were written over a period of 3 years whilst the initial stages of development of System X were proceeding. As a result of advances in technology since the start of development, many significant changes have taken place within the subsystem designs. Specifically, the processor subsystem has been revised to take advantage of new technology, whilst still retaining a multi-processor form. The one processor architecture is used throughout the system family. The overall system concepts and the network applications still remain as described in the articles.

The cost of this book is £3·00 including post and packaging (the cost to British Telecom (BT) and British Post Office (BPO) staff is £1·20).

If you wish to order copies of this book, please complete the appropriate section of the order form below and send it to the address shown. (Cheques and postal orders, payable to "*BTE Journal*", should be crossed "& Co." and enclosed with the order. Cash should not be sent through the post.)

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### ORDER FORM (BT AND BPO STAFF)

To: *British Telecommunications Engineering Journal* (Sales),
2–12 Gresham Street, London EC2V 7AG.

Please supply.......................copies of the reprint of System X articles at £1·20 per copy. I enclose a cheque/postal order to the value of.......................

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### ORDER FORM (EXTERNAL TO BT AND BPO)

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Please supply.......................copies of the reprint of System X articles at £3·00 per copy. I enclose a cheque/postal order to the value of.......................

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# Notes and Comments

## CONTRIBUTIONS TO THE JOURNAL

Contributions to *British Telecommunications Engineering* are always welcome. In particular, the Board of Editors would like to reaffirm its desire to continue to receive contributions from Regions and Areas, and from those Headquarters departments that are traditionally modest about their work.

Anyone who feels that he or she could contribute an article (short or long) of technical, managerial or general interest to engineers in British Telecom and the Post Office is invited to contact the Managing Editor at the address given below. The editors will always be pleased to give advice and try to arrange for help with the preparation of an article, if needed.

## GUIDANCE FOR AUTHORS

Some guiding notes are available to authors to help them prepare manuscripts of *Journal* articles in a way that will assist in securing uniformity of presentation, simplify the work of the *Journal's* editors, printer and illustrators, and help ensure that authors' wishes are easily interpreted. Any author preparing an article is invited to write to the Managing Editor, at the address given below, to obtain a copy.

All contributions to the *Journal* must be typed, *with double spacing between lines*, on one side only of each sheet of paper.

As a guide, there are about 750 words to a page, allowing for illustrations, and the average length of an article is about 6 pages, although shorter articles are welcome. Contributions should preferably be illustrated by photographs, diagrams or sketches. Each circuit diagram or sketch should be drawn on a separate sheet of paper; neat sketches are all that is 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. Good colour prints and slides can be accepted for black-and-white reproduction. Negatives are not required.

It is important that approval for publication is given at organizational level 5 (that is, at General Manager/Regional Controller/BTHQ Head of Division level) and authors should seek approval, through supervising officers if appropriate, before submitting manuscripts.

Contributions should be sent to the Managing Editor, *British Telecommunications Engineering*, NEP 12, Room 704, Lutyens House, Finsbury Circus, London EC2M 7LY.

## SPECIAL ISSUES AND BACK NUMBERS

Copies of the April 1974 issue covering sector switching centres and the October 1973 special issue on the 60 MHz transmission system are still available.

Copies of the October 1981, IPOEE 75th Anniversary, special issue are still available; a summary of the contents of the issue and an order form are printed on page 60 of this issue of the *Journal*.

Back numbers can be purchased, price £1·30 each (including postage and packaging), for all issues from April 1974 to date, with the exception of April and October 1975 and April and October 1976.

Orders, by post only, should be addressed to *British Telecommunications Engineering Journal* (Sales), 2–12 Gresham Street, London EC2V 7AG. Cheques and postal orders payable to "*BTE Journal*", should be crossed "& Co." and enclosed with the order. Cash should not be sent through the post. A self-addressed label accompanying the order is helpful.

## ISSN

Each issue of the *Journal* carries on its spine a code known as the *international standard serial number (ISSN)*. With the change of name of the *Journal* to *British Telecommunications Engineering*, it was necessary for a new number to be assigned, ISSN 0262-401X.

ISSNs are allocated by the UK National Serials Data Centre at the British Library, and each ISSN is unique to the publication to which it is assigned. This means that ISSN 0262-401X identifies *British Telecommunications Engineering* in any language in any part of the world. The value of the ISSN is that it is particularly useful to libraries having computerized acquisition, loan, and catalogue reporting and listing systems.

A new number, ISSN 0262-4028, has been assigned to the *Supplement*, and this is shown on the title page.

# Forthcoming Conferences

Further details can be obtained from the conference department of the organizing body.

*ICCC '82*, PO Box 23, Northwood Hills, Middlesex HA6 1TT
Telephone: 09274 27511. Telex: 25198

**Sixth International Conference on Computer Communications (ICCC '82)**
(host—British Telecom)
7–10 September 1982
Barbican Centre, London

*FORUM 83 Secretariat*, International Telecommunications Union, CH-1211 Genève 20, Switzerland.
Telephone: +41–22–995190

**Fourth World Telecommunications Forum, Part 2, Technical Symposium**
29 October–1 November 1983
New Exhibition and Conference Centre, Geneva
Papers: Summaries by 1 November 1982

*Institution of Electrical Engineers*, Savoy Place, London WC2R 0BL. Telephone: 01-240 1871

**International Conference on Man/Machine Systems**
6–9 July 1982
University of Manchester, Institute of Science and Technology

**Optical Communications**
18–23 July 1982
Vacation school at the University of Essex

**Switching and Signalling in Telecommunication Networks**
5–11 September 1982
Vacation school at the University of Aston

**Stored-Program Control of Telephone Switching Systems**
13–17 September 1982
Vacation school at the University of Essex

**1982 International Symposium on Subscriber Loops and Services (ISSLS 82)**
20–24 September 1982
The Toronto Hilton Harbour Castle Convention Centre, Toronto, Canada

**Third International Conference on Electrical Safety in Hazardous Environments**
1–3 December 1982
Institution of Electrical Engineers

**Second International Network Planning Symposium (Networks '83)**
21–25 March 1983
University of Sussex

**Fifth International Conference on Software Engineering for Telecommunications Switching Systems**
4–8 July 1983
Lund, Southern Sweden
Papers: Synopses by 20 September 1982

# OCTOBER 1981 SPECIAL ISSUE

**The October 1981 special issue contains articles on the following topics:**

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TELECOMMUNICATIONS AND SOCIETY
THE INLAND NETWORK
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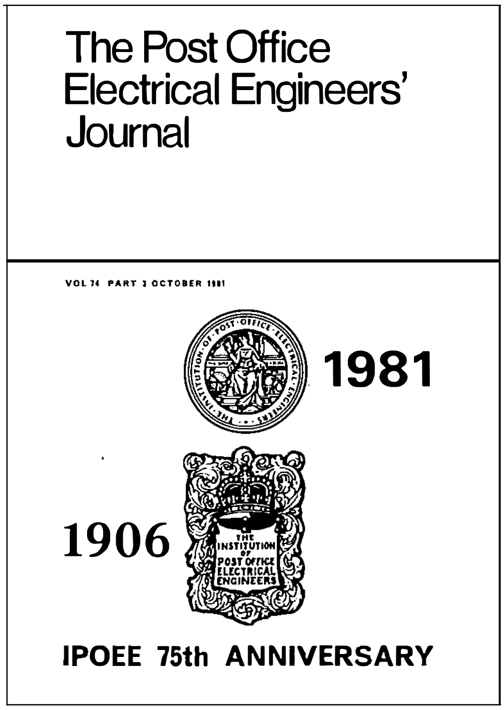


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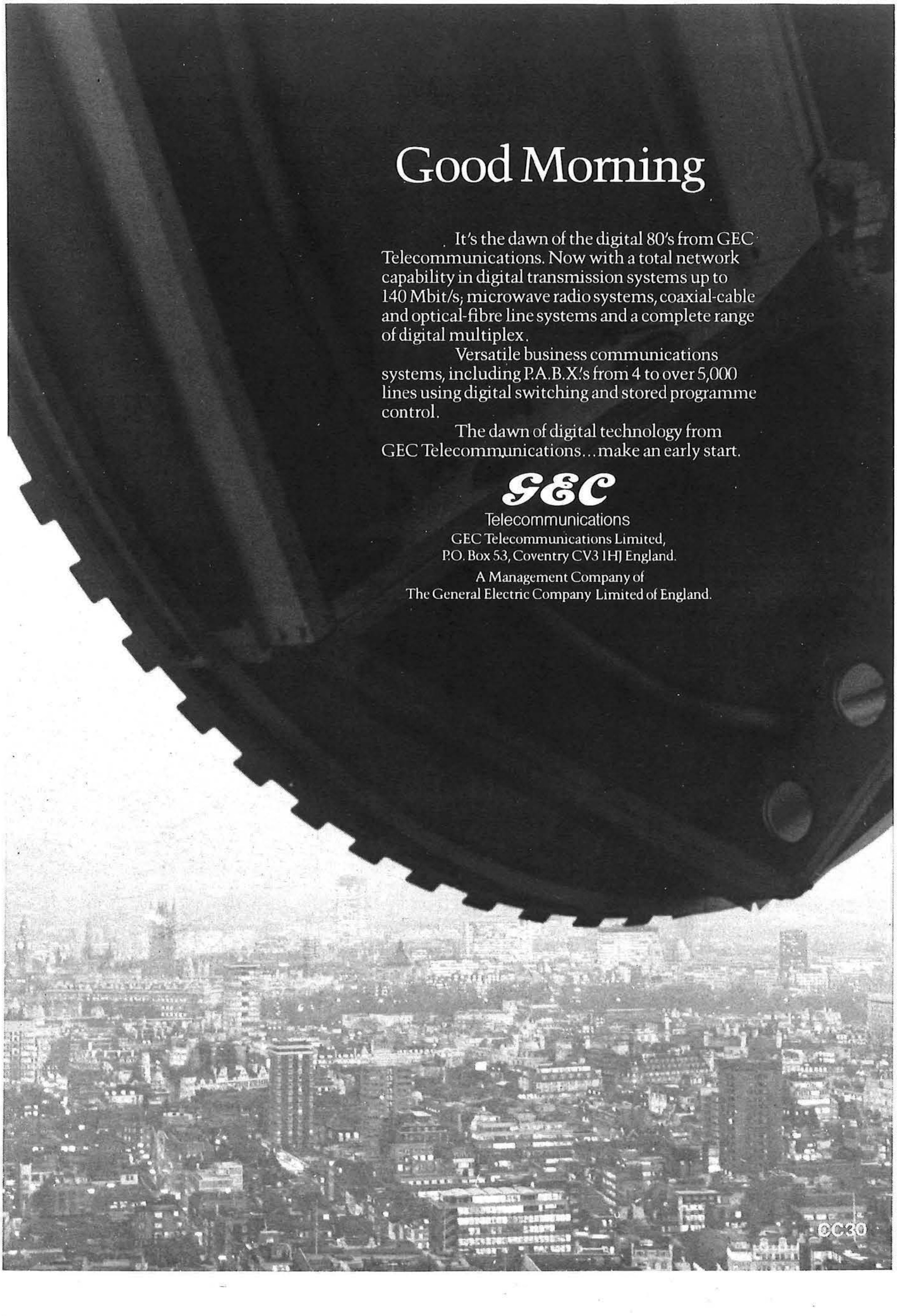
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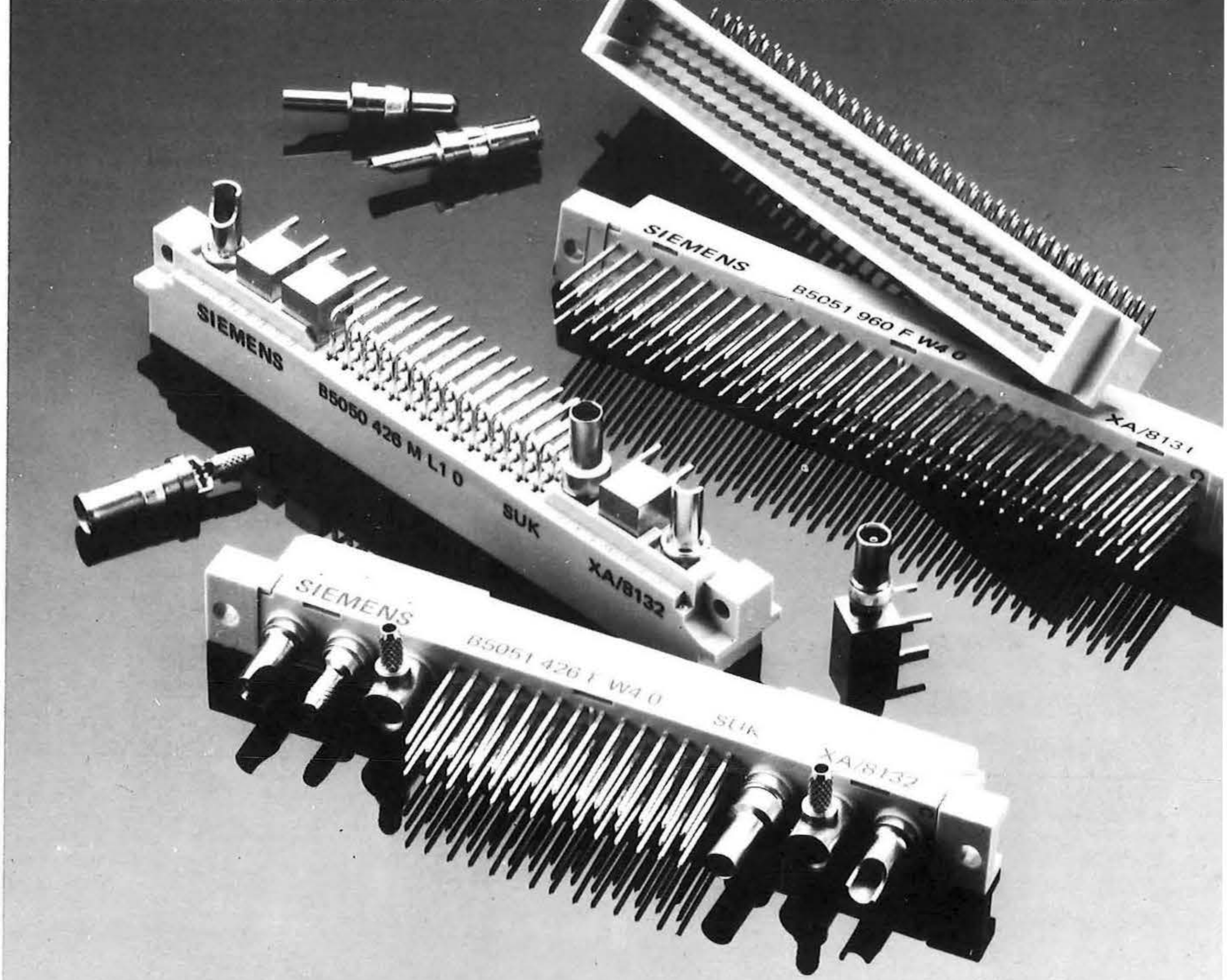


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